<u>Attachment 01</u>

ESE Indicator Summary Table

Element Type	Element Name	Indicator Name
Ecosystem	Acidic Cove Forest	Percent of ecosystem dominated by characteristic canopy species
Ecosystem	Acidic Cove Forest	Percent of ecosystem exhibiting old growth conditions
Ecosystem	Acidic Cove Forest	Percent of ecosystem exhibiting young forest conditions
Ecosystem	Acidic Cove Forest	Percent of ecosystem occupied by nonnative invasive plant species
Ecosystem	Acidic Cove Forest	Total open road density within the acidic cove forest ecosystem
Ecosystem	Beech Gap/Boulderfield Forest	Percent of ecosystem dominated by characteristic native vegetation
Ecosystem	Beech Gap/Boulderfield Forest	Percent of ecosystem NOT occupied by invasive species
Ecosystem	Calcareous Oak-walnut Forest	Percent of ecosystem dominated by characteristic native vegetation
Ecosystem	Calcareous Oak-walnut Forest	Percent of ecosystem NOT occupied by invasive species
Ecosystem	Carolina Hemlock Forest	Percent of ecosystem NOT occupied by invasive species
Ecosystem	Carolina Hemlock Forest	Percent of ecosystem occupied by Carolina Hemlock
Ecosystem	Carolina Hemlock Forest	Percent of ecosystem representing high quality habitat
Ecosystem	Carolina Hemlock Forest	Percent sites not impacted by hemlock wooly adelgid
Ecosystem	Caves and Abandoned Mines	Percent of known caves and abandoned mines identified as Biologically Significant
Ecosystem	Caves and Abandoned Mines	Presence of WNS in bat populations within abandoned caves and mines
Ecosystem	Caves and Abandoned Mines	The percent of occupied mines or caves (by rare bats) adversely impacted by
Ecosystem	Dry Oak Forest	Percent of ecosystem dominated by the ecologically characteristic canopy species
Ecosystem	Dry Oak Forest	Percent of ecosystem exhibiting old growth conditions
Ecosystem	Dry Oak Forest	Percent of ecosystem exhibiting young forest conditions
Ecosystem	Dry Oak Forest	Percent of ecosystem in open canopy condition
Ecosystem	Dry Oak Forest	Percent of ecosystem NOT occupied by invasive species
Ecosystem	Dry Oak Forest	Total open road density within the dry oak forest ecosystem
Ecosystem	Dry-mesic Oak Forest	Percent of ecosystem dominated by the ecologically characteristic canopy species

Element Type	Element Name	Indicator Name
Ecosystem	Dry-mesic Oak Forest	Percent of ecosystem exhibiting old growth conditions
Ecosystem	Dry-mesic Oak Forest	Percent of ecosystem exhibiting young forest conditions
Ecosystem	Dry-mesic Oak Forest	Percent of ecosystem in open canopy condition
Ecosystem	Dry-mesic Oak Forest	Percent of ecosystem NOT occupied by invasive species
Ecosystem	Dry-mesic Oak Forest	Total open road density within the dry-mesic oak forest ecosystem
Ecosystem	Floodplain Forest	Percent of ecosystem dominated by the ecologically characteristic canopy species
Ecosystem	Floodplain Forest	Percent of ecosystem exhibiting old growth conditions
Ecosystem	Floodplain Forest	Percent of ecosystem exhibiting young forest conditions
Ecosystem	Floodplain Forest	Percent of ecosystem NOT occupied by invasive species
Ecosystem	Floodplain Forest	Total open road density within the floodplain forest ecosystem
Ecosystem	Floodplain Pools	Percent of ecosystem NOT occupied by invasive species
Ecosystem	Floodplain Pools	Percent of floodplain pools experiencing at least one flood annually
Ecosystem	Grassy Balds	Percent of ecosystem in open canopy condition
Ecosystem	Grassy Balds	Percent of ecosystem NOT occupied by invasive species
Ecosystem	Grassy Balds	Percent of ecosystem occurrences within 100 feet of road or trail
Ecosystem	High Elevation Granitic Domes	Percent of ecosystem NOT occupied by invasive species
Ecosystem	High Elevation Granitic Domes	Percent of ecosystem occurrences within 100 feet of road or trail
Ecosystem	High Elevation Red Oak Forest	Percent of ecosystem dominated by the ecologically characteristic canopy species
Ecosystem	High Elevation Red Oak Forest	Percent of ecosystem exhibiting old growth conditions
Ecosystem	High Elevation Red Oak Forest	Percent of ecosystem exhibiting young forest conditions
Ecosystem	High Elevation Red Oak Forest	Percent of ecosystem in open canopy condition
Ecosystem	High Elevation Red Oak Forest	Total open road density within the high elevation red oak ecosystem
Ecosystem	High Elevation Rocky Summits	Percent of ecosystem NOT occupied by invasive species

Element Type	Element Name	Indicator Name
Ecosystem	High Elevation Rocky Summits	Percent of ecosystem occurrences within 100 feet of road or trail
Ecosystem	Low Elevation Glades	Percent of ecosystem burned at desired return interval
Ecosystem	Low Elevation Glades	Percent of ecosystem NOT occupied by invasive species
Ecosystem	Low Elevation Glades	Percent of ecosystem occurrences within 100 feet of road or trail
Ecosystem	Low Elevation Granitic Domes	Percent of ecosystem NOT occupied by invasive species
Ecosystem	Low Elevation Granitic Domes	Percent of ecosystem occurrences within 100 feet of road or trail
Ecosystem	Low Elevation Rocky Summits	Percent of ecosystem NOT occupied by invasive species
Ecosystem	Low Elevation Rocky Summits	Percent of ecosystem occurrences within 100 feet of road or trail
Ecosystem	Low Elevation Rocky Summits	Percent of system acres burned at desired return interval
Ecosystem	Mesic Oak Forest	Percent of ecosystem dominated by the ecologically characteristic canopy species
Ecosystem	Mesic Oak Forest	Percent of ecosystem exhibiting old growth conditions
Ecosystem	Mesic Oak Forest	Percent of ecosystem exhibiting young forest conditions
Ecosystem	Mesic Oak Forest	Percent of ecosystem in open canopy condition
Ecosystem	Mesic Oak Forest	Percent of ecosystem NOT occupied by invasive species
Ecosystem	Mesic Oak Forest	Total open road density within the mesic oak forest ecosystem
Ecosystem	Montane Calcareous Cliffs	Percent of ecosystem NOT occupied by invasive species
Ecosystem	Montane Calcareous Cliffs	Percent of ecosystem occurrences within 100 feet of road or trail
Ecosystem	Montane Cliffs	Percent of ecosystem NOT occupied by
Ecosystem	Montane Cliffs	Percent of ecosystem occurrences within 100 feet of road or trail
Ecosystem	Montane Red Cedar Hardwood Woodlands	Percent of ecosystem NOT occupied by invasive species
Ecosystem	Montane Red Cedar Hardwood Woodlands	Percent of ecosystem occurrences within 100 feet of road or trail
Ecosystem	Northern Hardwood Forest	Percent of ecosystem dominated by the ecologically characteristic canopy species
Ecosystem	Northern Hardwood Forest	Percent of ecosystem exhibiting old growth conditions

Element Type	Element Name	Indicator Name
Ecosystem	Northern Hardwood Forest	Percent of ecosystem exhibiting young forest conditions
Ecosystem	Northern Hardwood Forest	Percent of ecosystem NOT occupied by invasive species
Ecosystem	Northern Hardwood Forest	Total open road density within the northern hardwood forest ecosystem
Ecosystem	Pine Oak-Heath Forest	Percent of ecosystem dominated by the ecologically characteristic canopy species
Ecosystem	Pine Oak-Heath Forest	Percent of ecosystem exhibiting old growth conditions
Ecosystem	Pine Oak-Heath Forest	Percent of ecosystem exhibiting young forest conditions
Ecosystem	Pine Oak-Heath Forest	Percent of ecosystem in open canopy condition
Ecosystem	Pine Oak-Heath Forest	Percent of ecosystem occupied by invasive species
Ecosystem	Pine Oak-Heath Forest	Total open road density within the pine oak-heath ecosystem
Ecosystem	Rich Cove Forest	Percent of ecosystem dominated by the ecologically characteristic canopy species
Ecosystem	Rich Cove Forest	Percent of ecosystem exhibiting mature forest characteristics
Ecosystem	Rich Cove Forest	Percent of ecosystem exhibiting old growth conditions
Ecosystem	Rich Cove Forest	Percent of ecosystem exhibiting young forest conditions
Ecosystem	Rich Cove Forest	Percent of ecosystem occupied by invasive species
Ecosystem	Rich Cove Forest	Total open road density within the rich cove forest ecosystem
Ecosystem	Rocky Bars and Shore	Percent of ecosystem experiencing periodic flooding
Ecosystem	Rocky Bars and Shore	Percent of ecosystem NOT occupied by invasive species
Ecosystem	Seeps	Percent of ecosystem NOT occupied by invasive species
Ecosystem	Seeps	Percent of ecosystem occurrence within 100 meters of road or trail
Ecosystem	Serpentine Woodlands	Percent of ecosystem burned at desired return interval
Ecosystem	Serpentine Woodlands	Percent of the ecosystem with unpermitted rock or mineral harvest
Ecosystem	Shortleaf Pine Forest	Percent of ecosystem dominated by the ecologically characteristic canopy species
Ecosystem	Shortleaf Pine Forest	Percent of ecosystem exhibiting old growth conditions

Element Type	Element Name	Indicator Name
Ecosystem	Shortleaf Pine Forest	Percent of ecosystem exhibiting young forest conditions
Ecosystem	Shortleaf Pine Forest	Percent of ecosystem in open canopy condition
Ecosystem	Shortleaf Pine Forest	Percent of ecosystem occupied by invasive species
Ecosystem	Shortleaf Pine Forest	Total open road density within the shortleaf pine ecosystem
Ecosystem	Shrub Balds	Percent of ecosystem in open canopy condition
Ecosystem	Southern Appalachian Bogs	Percent of ecosystem NOT occupied by invasive species
Ecosystem	Southern Appalachian Bogs	Percent of ecosystem occurrences within 100 feet of road or trail
Ecosystem	Southern Appalachian Bogs	Shrub to herbaceous species ratio
Ecosystem	Spray Cliffs	Percent of ecosystem NOT occupied by invasive species
Ecosystem	Spray Cliffs	Percent of ecosystem occurrences within 100 feet of road or trail
Ecosystem	Spruce-fir Forest	Percent of ecosystem exhibiting old growth conditions
Ecosystem	Spruce-fir Forest	Percent of ecosystem exhibiting young forest conditions
Ecosystem	Spruce-fir Forest	Percent of the ecosystem dominated by the ecologically characteristic canopy species
Ecosystem	Spruce-fir Forest	Percent of the ecosystem impacted by balsam wooly adelgid
Ecosystem	Spruce-fir Forest	Total open road density within the spruce-fir forest ecosystem
Ecosystem	Swamp Forest-bog Complex	Percent of ecosystem NOT occupied by invasive species
Ecosystem	Vernal Pools	Percent of ecosystem NOT occupied by invasive species
Ecosystem	Vernal Pools	Presence of fish in seasonal wetlands
Ecosystem	White Pine Forest	Percent of ecosystem dominated by the ecologically characteristic canopy species
Ecosystem	White Pine Forest	Percent of ecosystem NOT occupied by invasive species
Ecosystem	Woodlands and Shale Slopes	Percent of ecosystem burned at desired return interval
Ecosystem	Woodlands and Shale Slopes	Percent of ecosystem NOT occupied by invasive species
Ecosystem	Woodlands and Shale Slopes	Percent of ecosystem occurrences within 100 feet of road or trail

Element Type	Element Name	Indicator Name
Species Group	Bark and Leaf Epiphytes	Ecological system acres in late and old growth seral classes (mesic ecozones)
Species Group	Bark and Leaf Epiphytes	Ecological system acres with mid-aged trees (mesic ecozones)
Species Group	Closed Canopy Associates	Percent of NP with at least moderately closed canopy
Species Group	Coarse Woody Debris and Downed Wood Associates	CWD density
Species Group	Dispersal-limited Species	Barriers to Aquatic Species Movement
Species Group	Dispersal-limited Species	Barriers to movement of small-ranging species (gap size)
Species Group	Dispersal-limited Species	Barriers to movement of small-ranging species (road density)
Species Group	Dispersal-limited Species	Potential effects of forest management on TE/SCC
Species Group	Dispersal-limited Species	Potential effects of forest management on terrestrial salamanders
Species Group	Fire-adapted Species	Percent ecozone burned at desired return interval (Buck Creek Serpentine Barrens)
Species Group	Fire-adapted Species	Percent ecozone burned at desired return interval (Low Elevation Glades)
Species Group	Fire-adapted Species	Percent ecozone burned at desired return interval (Low Elevation Rocky Summits)
Species Group	Fire-adapted Species	Percent ecozone burned at desired return interval (Woodlands and Shale Slopes)
Species Group	Fire-adapted Species	Percent open forest conditions within fire-adapted ecozones
Species Group	Fire-intolerant Species	Acres burned within mesic ecozones
Species Group	Forest Edge and Transition Associates	Acres of edge and transitional habitat
Species Group	Forest Edge and Transition Associates	Miles of forest edge
Species Group	Hard and Soft Mast Dependent Species	Miles of forest edge (soft mast)
Species Group	Hard and Soft Mast Dependent Species	Percent of oak ecozones in mid- and late-seral forest
Species Group	Hard and Soft Mast Dependent Species	Pounds per acre of acorn production (hard mast)
Species Group	Interior Forest Associates	Acres of interior forest habitat
Species Group	Interior Forest Associates	Edge to Interior Forest Ratio
Species Group	Interior Forest Associates	Percent of Forest with Canopy Cover >/= 60%
Species Group	Old Growth Forest Associates	Percent of each ecozone contributing to old growth forest characteristics

Element Type	Element Name	Indicator Name
Species Group	Recreation Traffic Sensitive Species	Cave/Mine Gate Indicator
Species Group	Recreation Traffic Sensitive Species	Roads & Trail Indicator
Species Group	Road Density Sensitive Species	Open road density
Species Group	Road Density Sensitive Species	Percent of animal element occurrences (T&E/SCC) within 100 feet of an open road
Species Group	Snag and Den Tree Associates	Snag Density
Species Group	Species Persistence and Recovery	Amount of NHNA (top 3 ranks) in MA Group 1 (or density estimate)
Species Group	Species Persistence and Recovery	Dam and Stream Crossing Density
Species Group	Species Persistence and Recovery	Riparian Road and Trail Density
Species Group	Species Persistence and Recovery	Roads & Trail Indicator
Species Group	Species Persistence and Recovery	Salamander core habitat and connectivity
Species Group	Species Persistence and Recovery	Susceptibility to Climate Change
Species Group	Species Persistence and Recovery	Susceptibility to Forest Management
Species Group	Woodland Associates	Percent of acres burned at desired return interval
Species Group	Woodland Associates	Percent of acres burned at desired return interval (Buck Creek Serpentine Barrens)
Species Group	Woodland Associates	Percent of NP exhibiting open forest characteristics
Species Group	Young Forest Associates	Percent of NP exhibiting open forest characteristics
Species Group	Young Forest Associates	Percent of NP exhibiting young forest characteristics

Attachment 02

ST-Sim Charts

STSimObservations

STSimTables 2 through 5

STSimTables 6 through 14

December 2021

Kauffman ; Hayden

Sensing Project: Seral States using ST-Sim (initial estimate)

Introduction

Over the timeframe for addressing public comments on the NP Plan and Draft EIS, we were assigned the project of re-considering how natural disturbances were addressed in the analysis. To do this, we attempted to re-construct the disturbance regime over the past 50 years and apply that historical period for the near future. This was deemed a reasonable approach since the timeframe for the decision is 10-15 years, and that, the likelihood of disturbance patterns of the near future would mimic the disturbance regime of the recent past. A set of scenarios that varied the disturbance regime was then applied in order to evaluate the sensitivity and uncertainty in the disturbance regime assumptions. Alternative disturbance regimes for the scenarios were evaluated in separate runs using the Spectrum model. Further explanation of this approach is documented in FEIS, Appendix D and process record Development of Disturbance Scenarios.

We were curious what the pattern of seral states would be using ST-Sim and the disturbance probabilities assumed for the historical range of variability (HRV) for ecozones. However, the timeframe to restart an entire new approach was not feasible. Instead, we have taken an incremental approach to building out ecozone models with ST-Sim over time, as such, this is an initial estimate. What follows is the status of ecozone modelling using with ST-Sim. The results of any analyses are preliminary, as we have not performed error checking and verification, but instead, we considered this exercise as an initial sensing project.

Model Development

The first step was to get the ecozone models used for the HRV assessment running in ST-Sim. The Landfire staff (Jim Smith, Kori Blankenship) generously took on the task of updating the ecozone models with the most recent SyncroSim software.

Next, the initial conditions in the HRV model needed to be updated to reflect the conditions of the NP lands. The original HRV assessment used the entire western NC region with equal proportions of the 7 seral states for each ecozone model. The estimated amount of each seral state for each ecozone was updated for the initial conditions on the NP. These initial conditions were consistent with acreages used in the ESE evaluation. An updated run using initial conditions was made and reported, along with the original HRV estimates in Table 6 through 14.

The next step was how to modify the existing models to include management activity. To do this, additional information about model behavior was needed. Assistance was provided by Jim Smith (TNC, Landfire), Kori Blankenship (TNC, Landfire), Leonardo Fried (Apex RMS), and Jennifer Costanza (SRS). At this stage, it was decided to keep the models as non-spatial, keep it simple, and learn how to include harvests in the model. We decided to take the Alternative E runs of Spectrum harvest outputs and attempt to crossover into ecozone models using ST Sim.

The crossover from Spectrum outputs to ST-Sim inputs was difficult because there is no direct link to the land stratifications used for each model, and therefore assumptions about a crosswalk were necessary. Spectrum modelling used FIA forest types because reliable plot data from FIA was used to generate tree growth and yields for outputs. ST-Sim modelling uses ecozones that rely on a 3rd approximation model. The assumptions in Table 1 were used as first estimate of FIA types to Ecozones. As such, an exact match of Alternative E Spectrum harvest outputs using the ecozones in ST-Sim is not possible.

The amount of harvest was computed from the Spectrum Alt E (Tier 1 & Tier 2) for the forest types in Table 1 and distributed across the ecozones. The harvest amount was assumed to be the regeneration acreages, including the openings created by group selection. The harvest amount was divided by 200 and set as an annual transition target in ST-Sim with a probability of 1. The 200 timesteps in ST-Sim was used to be consistent with the planning horizon used in Spectrum. This is another deviation from how Alt E is modelled in ST-Sim vs. Spectrum, which has a set of timing combinations and schedules that is selected by the algorithm to meet the objectives and constraints in the model, rather than, an annual even-flow used in ST-Sim.

The next step was developing a method to confine harvests to a portion of the land base. Most of the harvests in Spectrum are constrained for the matrix and interface management areas. These management areas are grouped into what is called Management Area Group 1. A description of the management area groups is documented in the FEIS, Terrestrial Ecosystem Section.

Table 2 (attachment) displays the assumptions about where harvests are likely to occur as well as burning for young forest. These assumptions were applied as transition targets in ST-Sim. Most harvests are confined to management area group 1, along with a much lower amount in management area group 2. No harvesting was estimated for management area groups 3 & 4. In addition, no harvesting was estimated in the designated old growth network.

Tables 3 through 5 show the estimated probabilities that harvesting would occur in different age groups. The first row shows our initial estimates, and the modified row is our revised estimates of the likelihood of tree ages that would be harvested. The tables that follow have used the modified probabilities. The transition pathways in ST-Sim were updated with these age groups and probabilities.

The models were run for “no harvest”, “Tier 1”, and “Tier 2” using 200 timesteps. Tables 6 through 14 shows the results of the seral states at timesteps 10, 50, 100, and 200 years. The “proportion” measure is used rather than acres because the HRV assessment used a different land area that was larger than the NP.

Table legend: Tables 6 through 14

Row 1: Identifies the ecozone model for making the scenario runs

Row 2: Identifies the type of run, HRV = Historic Range of Variability; Update Initial = re-assigned initial conditions for the amount of land on the NP; Scenario = the scenario used to calculate the seral states; Year = the specific timesteps by seral state; Early = young forest; Late1 = late successional stage; Late2= old forest; Mid1= mid successional stage. Cls=closed canopy; OPN = open canopy; All= both open and closed.

Discussion

Tables 6 through 14 are arranged by moisture class from mesic to moderate to dry. For the drier ecozones, it is not appropriate to review the open states because the prescribed burning has not been introduced into the models yet. Prescribed burning is one of the next steps in the model build out process.

General observations

Model Behaviors

Spectrum : The models using spectrum software use 20 timesteps that are 10-year increments. This is favorable for modelling forestry operations as a 10-year order of entry has been the usual practice for managing forest stands. However, with only 20 timesteps, it limits the amount of temporal variability that could be predicted. The ten-year timesteps also limit the flexibility of when forest succession occurs, such as when some ecozones have young forests that succeed to mid-age at year 15.

Also, the models have prescription allocations and timing choices. When allocated to a prescription, lands must stay in that management mode for the entire planning horizon. For example, when allocated to a prescribed fire prescription, lands stay locked in to that management mode and will not be regenerated throughout the planning horizon. Those lands would change the state from closed canopy to open canopy, but would continue to age throughout the planning timeline, and never have the opportunity of contributing to young forests. Also, the timing choices in these models tend to have wider high and low variations (wide swings) in activity for a forest type from one planning period to another.

In Alternative E, with a high amount of prescribed fire and a disturbance regime that is close to recent observations, the xeric forest types have fewer acres of young forests and an overabundance of lands that age over time. The mesic forest types also have fewer acres of young forest and the aging tends to occur rapidly, especially after 50 years.

In Scenarios 2,4, and 5 that adjusted the disturbance regimes, the models had to be reformulated because there were too little amounts of xeric forest types to handle the amount of disturbances from the expansive wildfire predictions. The reformulated models had to dampen the wildfire effects on xeric types but increase the effect on moderate moisture classes. More scenarios of different disturbance regimes could be examined. There are endless possibilities of what could be predicted, however, the purpose of the analysis was to provide a broad range potential effects.

ST-Sim: The models in the HRV assessment were revived using updated software in SyncroSim. The HRV models used 1000 years (timesteps), so they are adjusted to use 200 timesteps that is comparable to the planning horizon used in Spectrum. The regeneration harvest amounts that reset the age to zero for Alt E were estimated for the ecozones, but as noted earlier, there is not a direct crossover of forest types to ecozones. The regeneration amounts were estimated annually over the 200 timesteps. This is not a likely management mode, but this assumption allowed for a way to get the models up and running.

Each ecozone has its own model, and regeneration harvests were allocated to nine of the 11 ecozones (Spruce Fir and Floodplains were excluded). The initial conditions in each model had to be adjusted to estimate current conditions by intersecting the ecozone model and FSVeg database age classes . And, the cove model, that had both rich and acidic cove, had to be split into two models. Given that more activities occur in rich cove forest compared to acidic cove forest, the harvest runs utilized 80% of the Spectrum cove harvest outputs for the rich cove model and 20% for the acidic cove model (Table 1). For Alt E with 2 tiers, there were 18 harvest model runs. The HRV runs tend to have some wide swings early in the timeline but stabilize quickly. For the harvest scenarios given the even-flows, the seral states tend to stabilize quickly as well.

The HRV disturbance regime affects the xeric ecozones as there is a relatively high proportion of young seral states, and then, with harvests the young seral states can be as much as 15 percent. Young forest is higher within these types with more historic replacement fires compared to current rates of stand replacement fires. This tends to modulate the mid and older seral states of xeric ecozone models.

The mesic ecozones also have a moderate proportion of young seral states, which also tends to modulate the mid and older seral states. The rich cove and mesic oak harvest scenarios tend to have higher proportions of young forest in comparison with HRV runs.

Next Steps We have not made direct comparisons of the results from the model runs between Spectrum and SyncroSim ST -Sim because the assumptions are different in model formulations and model behaviors. Instead, we provide a range of possible outcomes in the face of uncertainty, especially with the expectations of a changing climate.

If the monitoring program and the development of monitoring guides call for continuation of building out SyncroSim to include prescribed fire, it could be useful for predicting and tracking of seral stages through the monitoring program. It would also be useful in wildfire predictions. Several SRS scientists have expressed interest in working with us on future wildfire predictions using SyncroSim.

A possible follow-up could be another iteration of disturbance patterns that reflect more recent observations as well as factoring in the human effects of land use changes using SyncroSim. This could provide useful predictions and help with formulating mitigation strategies and guidance on how to work with the flow of change.

Table 2. Assumed amounts of harvest amounts occurring by Management Area Group

	Harvest	**Burning for Young Forest**
Management Group 1	85-90%	0
Management Group 2	10-15%	33-40%
Management Group 3	0	60-66%
Management Group 4	0	0

Table 3. Probability of harvest occurring by age group for 7 ecozones.

	50-70	71-120	121-140	140+
Rich Cove, Acidic Cove, Northern Hardwood, Mesic Oak, Dry-Mesic Oak, High Elevation Red Oak, Shortleaf Pine	0.1	1	0.5	0.1
Modified	0	1	0.1	0

Table 4. Probability of harvest occurring by age group for Pine-Oak/Heath Ecozone

	60-70	71-120	121-130	111-130	131+
Pine-Oak/Heath	0.1	1	0.5	0.1	0
Pine-Oak/Heath Modified	0	1	0.1	0	0

Table 5. Probability of harvest occurring by age group for Dry Oak ecozone.

	60-70	71-100	101-110	111-140	141+
Dry Oak Typical	0.1	1	0.5	0.1	0
Dry Oak Modified	0	1	0.1	0	0

Table 6. Rich cove forest model state class percentages in selected years under different scenarios from historical range of variation (HRV) to management under Tier1 or Tier2 objectives.

MODEL: Rich Cove	HRV, even start, Scenario 12598	HRV, existing conditions, Scenario 13010	No Harvest, Scenario 12996				Tier1, Scenario 13003				Tier2, Scenario 13004			
	Year		Year				Year				Year			
State Class	200	200	10	50	100	200	10	50	100	200	10	50	100	200
Early1:ALL	4.7%	5.0%	4.3%	4.6%	5.1%	5.1%	5.3%	5.9%	5.6%	6.0%	8.3%	8.3%	7.8%	7.5%
Late1:CLS	9.7%	10.0%	24.5%	22.6%	13.5%	10.0%	23.6%	19.1%	10.3%	9.4%	23.5%	13.9%	6.0%	7.4%
Late1:OPN	1.4%	0.7%	1.8%	1.8%	1.4%	0.9%	1.9%	1.7%	1.0%	0.8%	2.3%	1.0%	0.7%	0.6%
Late2:ALL	50.0%	50.1%	9.6%	28.9%	46.5%	48.6%	9.7%	28.5%	42.0%	43.4%	9.0%	26.7%	33.2%	32.9%
Mid1:CLS	29.0%	31.7%	54.8%	38.2%	30.8%	32.3%	54.3%	40.8%	37.4%	37.2%	51.8%	45.4%	47.6%	47.1%
Mid1:OPN	5.3%	2.6%	5.1%	3.9%	2.8%	3.1%	5.2%	4.0%	3.6%	3.3%	5.1%	4.7%	4.7%	4.6%

Table 7. Acidic cove forest model state class percentages in selected years under different scenarios from historical range of variation (HRV) to management under Tier1 or Tier2 objectives.

MODEL: Acidic Cove	HRV, even start, Scenario 12598	HRV, existing conditions, Scenario 13009	No Harvest, Scenario 12999				Tier1, Scenario 13005				Tier2, Scenario 13006			
	Year		Year				Year				Year			
State Class	200	200	10	50	100	200	10	50	100	200	10	50	100	200
Early1:ALL	4.7%	4.7%	5.1%	4.8%	4.7%	5.2%	5.0%	5.1%	5.3%	5.4%	5.5%	5.3%	5.8%	5.2%
Late1:CLS	9.7%	10.3%	23.8%	22.4%	13.9%	10.0%	23.8%	22.1%	12.9%	10.0%	23.7%	20.8%	11.8%	9.8%
Late1:OPN	1.4%	0.8%	2.0%	1.8%	1.3%	0.8%	1.6%	1.6%	1.1%	1.0%	1.9%	1.8%	1.0%	0.6%
Late2:ALL	50.0%	48.8%	8.7%	28.5%	46.0%	50.5%	9.1%	28.4%	44.7%	48.2%	9.6%	28.3%	44.2%	45.9%
Mid1:CLS	29.0%	32.2%	55.3%	39.0%	31.3%	30.6%	55.3%	39.4%	32.9%	32.3%	54.7%	39.7%	34.5%	35.7%
Mid1:OPN	5.3%	3.2%	5.1%	3.6%	2.8%	3.0%	5.2%	3.5%	3.0%	3.0%	4.7%	4.0%	2.7%	2.9%

Table 8. Northern hardwood forest model state class percentages in selected years under different scenarios from historical range of variation (HRV) to management under Tier1 or Tier2 objectives.

MODEL: Northern Hardwood																		
	HRV, even start, Scenario 12702	HRV, existing conditions, Scenario 12973		No Harvest, Scenario 13002					Tier1, Scenario 13007					Tier2, Scenario 13008			
	Year			Year					Year					Year			
State Class	200	200		10	50	100	200		10	50	100	200		10	50	100	200
Early1:ALL	6.3%	6.1%		4.6%	5.9%	6.1%	6.1%		6.7%	8.7%	9.7%	8.3%		5.5%	7.1%	6.6%	8.1%
Late1:CLS	13.2%	12.8%		53.9%	12.5%	9.1%	12.2%		50.3%	9.7%	10.3%	12.0%		51.9%	12.1%	8.4%	13.3%
Late1:OPN	2.3%	2.4%		4.2%	3.0%	1.4%	2.8%		4.2%	1.4%	1.6%	2.8%		4.2%	2.1%	1.1%	2.6%
Late2:CLS	46.1%	45.9%		22.2%	49.7%	50.4%	47.5%		22.9%	46.4%	41.5%	38.8%		24.0%	49.5%	48.0%	41.5%
Late2:OPN	10.2%	10.5%		2.0%	11.8%	10.6%	10.0%		2.3%	9.8%	9.9%	8.2%		2.1%	11.8%	9.8%	8.8%
Mid1:CLS	20.7%	21.1%		12.9%	16.4%	21.3%	20.0%		13.2%	22.8%	25.5%	28.3%		11.5%	16.5%	24.2%	24.3%
Mid1:OPN	1.2%	1.2%		0.3%	0.7%	1.1%	1.5%		0.4%	1.1%	1.5%	1.6%		0.7%	1.0%	1.9%	1.4%

Table 9. Mesic oak forest model state class percentages in selected years under different scenarios from historical range of variation (HRV) to management under Tier1 or Tier2 objectives.

MODEL: Mesic Oak																		
	HRV, even start, Scenario 12834	HRV, existing conditions, Scenario 12974		No Harvest, Scenario 12971					Tier1, Scenario 12976					Tier2, Scenario 12975			
	Year			Year					Year					Year			
State Class	200	200		10	50	100	200		10	50	100	200		10	50	100	200
Early1:ALL	4.6%	5.0%		4.8%	4.9%	5.1%	4.8%		6.0%	5.7%	5.0%	5.5%		8.8%	6.3%	6.6%	6.5%
Late1:CLS	8.7%	8.7%		43.2%	8.2%	7.1%	8.9%		41.3%	5.9%	4.8%	7.1%		39.5%	2.3%	2.8%	5.0%
Late1:OPN	5.8%	5.8%		10.3%	5.3%	4.6%	6.1%		10.3%	4.4%	4.4%	6.1%		9.7%	2.7%	3.9%	5.9%
Late2:CLS	31.3%	31.2%		17.1%	32.9%	32.6%	29.4%		17.1%	31.7%	27.9%	25.9%		17.2%	27.8%	23.4%	18.5%
Late2:OPN	22.8%	22.5%		4.0%	25.4%	23.3%	23.5%		4.2%	22.5%	20.6%	17.9%		3.4%	19.8%	16.9%	13.5%
Mid1:CLS	13.2%	13.0%		17.5%	10.7%	14.1%	13.1%		17.6%	14.4%	19.1%	20.3%		17.9%	23.1%	26.4%	28.6%
Mid1:OPN	13.7%	13.7%		3.1%	12.7%	13.3%	14.2%		3.6%	15.4%	18.1%	17.4%		3.5%	17.9%	20.1%	21.9%

Table 10. Dry-mesic oak forest model state class percentages in selected years under different scenarios from historical range of variation (HRV) to management under Tier1 or Tier2 objectives.

MODEL: Dry-Mesic Oak														
	HRV, even start, Scenario 12835	HRV, existing conditions, Scenario 12906	No Harvest, Scenario 12907				Tier1, Scenario 12919				Tier2, Scenario 12918			
	Year		Year				Year				Year			
State Class	200	200	10	50	100	200	10	50	100	200	10	50	100	200
Early1:ALL	6.3%	6.1%	5.9%	6.4%	6.4%	7.3%	5.8%	7.6%	7.2%	6.6%	6.9%	8.6%	8.0%	7.9%
Late1:CLS	7.7%	7.6%	48.3%	10.9%	7.4%	8.0%	45.7%	7.8%	4.7%	7.2%	43.6%	2.7%	3.7%	4.4%
Late1:OPN	8.3%	8.1%	10.7%	9.4%	6.7%	8.9%	11.2%	8.9%	6.8%	9.7%	10.4%	6.6%	8.3%	10.3%
Late2:CLS	24.7%	25.0%	12.3%	25.1%	26.0%	23.3%	12.5%	23.8%	22.7%	19.3%	12.5%	20.0%	16.6%	14.4%
Late2:OPN	30.0%	30.2%	3.0%	28.0%	30.4%	30.3%	2.6%	27.6%	27.8%	25.9%	3.0%	23.4%	22.2%	19.6%
Mid1:CLS	7.8%	8.1%	16.2%	6.0%	6.8%	8.1%	18.1%	9.9%	12.6%	12.7%	19.5%	18.0%	18.8%	20.9%
Mid1:OPN	15.2%	15.0%	3.6%	14.3%	16.3%	14.2%	4.2%	14.4%	18.3%	18.7%	4.2%	20.8%	22.4%	22.5%

Table 11. High elevation red oak forest model state class percentages in selected years under different scenarios from historical range of variation (HRV) to management under Tier1 or Tier2 objectives.

Model: High Elevation Red Oak														
	HRV, even start, Scenario 12833	HRV, existing conditions, Scenario 12910	No Harvest, Scenario 12911				Tier1, Scenario 12917				Tier2, Scenario 12914			
	Year		Year				Year				Year			
State Class	200	200	10	50	100	200	10	50	100	200	10	50	100	200
Early1:ALL	15.8%	16.0%	9.1%	14.9%	15.1%	13.9%	9.1%	16.0%	16.2%	15.7%	10.5%	14.3%	14.5%	15.3%
Late1:CLS	11.6%	10.6%	6.0%	2.2%	2.8%	3.2%	7.6%	2.1%	2.6%	4.3%	7.6%	1.3%	2.0%	2.6%
Late1:OPN	12.0%	11.5%	49.7%	11.0%	13.4%	21.1%	46.0%	10.3%	12.9%	18.9%	46.8%	10.1%	15.6%	20.1%
Late2:CLS	7.8%	7.4%	3.1%	7.2%	4.3%	3.7%	3.7%	6.0%	5.7%	3.3%	2.6%	5.8%	4.1%	2.5%
Late2:OPN	22.1%	23.0%	25.8%	42.7%	33.6%	26.3%	25.1%	42.0%	28.9%	24.1%	23.0%	39.1%	29.7%	24.9%
Mid1:CLS	18.3%	17.8%	0.7%	4.6%	6.8%	5.9%	1.7%	5.7%	6.8%	7.8%	2.1%	7.7%	6.5%	5.6%
Mid1:OPN	12.5%	13.9%	5.7%	17.3%	24.1%	26.0%	6.8%	18.0%	26.8%	26.0%	7.4%	21.8%	27.8%	28.9%

Table 12. Dry oak forest model state class percentages in selected years under different scenarios from historical range of variation (HRV) to management under Tier1 or Tier2 objectives.

MODEL: Dry Oak														
	HRV, even start, Scenario 12647	**HRV, existing conditions, Scenario 12814**	**No Harvest, Scenario 12842**				**Tier1, Scenario 12823**				**Tier2, Scenario 12822**			
	Year		**Year**				**Year**				**Year**			
State Class	**200**	**200**	**10**	**50**	**100**	**200**	**10**	**50**	**100**	**200**	**10**	**50**	**100**	**200**
Early1:ALL	12.9%	13.3%	6.4%	13.3%	12.7%	12.3%	6.6%	13.6%	11.3%	13.9%	8.5%	17.5%	16.0%	15.9%
Late1:CLS	2.2%	1.6%	20.5%	1.9%	2.3%	2.2%	19.7%	1.5%	2.0%	1.9%	21.2%	1.5%	2.0%	1.9%
Late1:OPN	7.7%	7.6%	10.8%	5.0%	6.4%	8.1%	10.5%	4.0%	7.9%	7.7%	10.4%	3.6%	8.5%	8.7%
Late2:CLS	9.5%	8.4%	33.0%	14.8%	10.9%	9.6%	35.0%	13.2%	8.5%	9.7%	31.9%	10.8%	7.9%	8.4%
Late2:OPN	49.0%	50.2%	17.5%	54.4%	48.5%	48.7%	17.7%	54.5%	47.3%	47.7%	17.0%	50.3%	42.0%	41.2%
Mid1:CLS	3.6%	2.7%	9.2%	1.9%	3.4%	3.6%	8.4%	2.4%	4.6%	3.6%	8.6%	3.5%	4.7%	5.0%
Mid1:OPN	15.2%	16.1%	2.6%	8.8%	15.8%	15.4%	2.1%	10.8%	18.5%	15.5%	2.4%	12.8%	19.1%	18.9%

Table 13. Pine-oak/heath forest model state class percentages in selected years under different scenarios from historical range of variation (HRV) to management under Tier1 or Tier2 objectives.

MODEL:Pine-Oak/Heath														
	HRV, even start, Scenario 12787	**HRV, existing conditions, Scenario 12835**	**No Harvest, Scenario 12845**				**Tier1, Scenario 12834**				**Tier2, Scenario 12833**			
	Year		**Year**				**Year**				**Year**			
State Class	**200**	**200**	**10**	**50**	**100**	**200**	**10**	**50**	**100**	**200**	**10**	**50**	**100**	**200**
Early1:ALL	14.7%	14.7%	14.3%	13.8%	14.5%	13.3%	15.4%	16.0%	14.2%	14.0%	14.3%	15.9%	14.6%	14.9%
Late1:CLS	1.5%	1.7%	41.0%	2.8%	1.8%	2.1%	40.2%	1.9%	1.2%	1.5%	39.3%	2.3%	1.6%	1.3%
Late1:OPN	24.4%	24.3%	14.1%	9.2%	24.7%	23.6%	13.3%	9.1%	24.5%	25.5%	13.8%	9.0%	24.6%	23.6%
Late2:CLS	1.2%	1.5%	12.2%	7.1%	1.8%	1.4%	12.3%	6.2%	1.9%	1.1%	12.2%	6.8%	1.7%	1.2%
Late2:OPN	18.8%	18.5%	3.8%	23.3%	17.4%	19.0%	3.8%	23.0%	16.7%	18.5%	4.1%	21.5%	16.2%	17.4%
Mid1:CLS	1.6%	1.7%	6.5%	1.4%	1.5%	1.6%	6.6%	1.7%	1.8%	2.2%	7.6%	1.8%	1.9%	2.1%
Mid1:OPN	37.9%	37.7%	8.3%	42.5%	38.6%	39.0%	8.5%	42.2%	39.8%	37.3%	8.7%	42.8%	39.6%	39.6%

Table 14. Shortleaf pine forest model state class percentages in selected years under different scenarios from historical range of variation (HRV) to management under Tier1 or Tier2 objectives.

MODEL: Shortleaf Pine	HRV, even start, Scenario 12649	HRV, existing conditions, Scenario 12831	No Harvest, Scenario 12846				Tier1, Scenario 12830				Tier2, Scenario 12829			
	Year		Year				Year				Year			
State Class	**200**	**200**	**10**	**50**	**100**	**200**	**10**	**50**	**100**	**200**	**10**	**50**	**100**	**200**
Early1:ALL	10.7%	11.5%	11.4%	11.6%	12.0%	10.3%	14.8%	11.2%	10.8%	11.3%	14.4%	12.1%	11.6%	11.1%
Late1:CLS	1.5%	1.1%	26.2%	3.7%	2.2%	1.2%	23.0%	0.9%	0.6%	0.4%	22.8%	0.7%	0.5%	0.2%
Late1:OPN	24.0%	23.9%	7.3%	14.9%	23.6%	24.2%	6.6%	13.4%	29.3%	23.6%	6.2%	11.7%	30.3%	25.6%
Late2:CLS	1.8%	1.7%	20.3%	9.2%	3.1%	2.2%	18.6%	6.9%	1.8%	1.4%	19.9%	4.9%	1.6%	0.7%
Late2:OPN	22.6%	22.5%	4.4%	18.0%	16.8%	21.6%	5.1%	15.7%	16.4%	21.3%	4.1%	13.2%	12.3%	20.6%
Mid1:CLS	1.5%	1.2%	16.3%	2.2%	1.7%	1.9%	17.4%	3.2%	2.1%	1.9%	17.9%	3.4%	2.3%	2.5%
Mid1:OPN	37.9%	38.2%	14.1%	40.4%	40.7%	38.6%	14.6%	48.7%	38.9%	40.1%	14.7%	53.9%	41.4%	39.3%

Attachment 03

Statement from Peter White on the Nantahala Pisgah Forest Plan

A statement on the Nantahala-Pisgah Forest Plan

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The Nantahala-Pisgah Forest Plan uses two modeling approaches: 1. the first model is used to determine the natural range of variability (NRV) of this complex forest landscape and 2. a second model (Spectrum) is used to predict the potential future conditions of the landscape and for comparisons with the natural range of variability. As an author who is cited in the Plan ("White 2011" which is: White, P.S; Collins, B.; and Weins, G.R. 2011), especially in Appendix D, I am expressing my concern that the NRV model and Spectrum models are based on different assumptions and that, as a result, a comparison between the two models is misleading and leads to a plan that anticipates a higher creation of early successional habitat than is scientifically justified. The two models have a critical difference that means they should not be used for comparisons that are the basis for forest management actions.

Science tells us that there is an inverse relationship between disturbance magnitude and frequency: larger disturbances are rare and small disturbances are frequent. This scale dependence should be the scientific basis for interpreting natural disturbance probabilities (probability is the inverse of return interval). Looking at the literature used in its derivation, the NRV model uses a disturbance probability based on all disturbance magnitudes, including gap phase dynamics involving the death of one or small groups of trees, a small-scale disturbance that does not create early successional habitat. Thus, the NRV incorporates a disturbance probability that is too high for the purposes of forest planning when the goal of forest planning is to create early successional habitat, because not all of the disturbances on which the NRV is based create early successional habitat and the ones that do create early successional habitat would necessarily have a lower frequency than the frequency based on all disturbance sizes (here size is used as the variable representing disturbance magnitude). In short, gap dynamics does not produce early successional habitat, a key benchmark for forest planning, and yet gap dynamics dominates the disturbance rate in the NRV model.

In contrast to the NRV model, the Spectrum model specifically focuses on the creation of early successional habitat of 0.5 acres or more—the NRV includes no such threshold. The clear danger is that the NRV model is based on a high disturbance frequency that includes all patch sizes, including ones below 0.5 acres, but that high frequency is then used to justify the creation of patch sizes of 0.5 acres. While that 0.5 acre threshold is a good one to have, the natural disturbances that create such successional change are less frequent and have longer return intervals than are used in the NRV model. The danger comes when we use the NRV return intervals to suggest the frequency of creation of early successional communities of 0.5 acre or more. If we do this, we greatly inflate the expectation for the creation of early successional habitat. If used to guide management, the plan will likely decrease the median age of the landscape, as well as the amount of old forest. There is some uncertainty in this, but the two modeling methods appear to be compared in a qualitative way which leaves too much room for interpretation.

In summary, the rate of natural disturbance in the NRV model inflates the expectation for disturbance creation of early successional habitat on the landscape. Further, the rates of natural disturbance in the Spectrum model are too low to achieve the amount of early successional habitat that has been inflated, in part because the NRV model uses natural disturbance rates that are too high. The net result seems to be the potential for harvest to be used to fill in the gap between natural and presumed targets for early successional habitat. My concern is that the flawed comparison between the two models will be used to justify higher rates of forest harvest because the rates of natural disturbance in the Spectrum model will be erroneously judged to be insufficient in the creation of the amount of early successional habitat that is used as a benchmark in this plan based on the NRV model. Apart from this problem, future natural disturbance rates may themselves increase with climate change, an expectation not covered in the USFS NRV analysis—if rates of natural disturbance increase, there will be less need for forest management in terms of the goal of creation of early successional habitat. Thus, an increasing rate of natural disturbance may compound the problem of an increasing rate of harvest to create a presence of early successional habitat that is too high.

Thanks to the large-scale logging of the early 1900s (with Chestnut blight and fire suppression thrown in), the Southern Appalachians have too much middle-aged forest and not enough of either old growth or young (early successional) forest. But it is harder to create old growth than it is to create young growth. And, in general, there was once a preponderance of old forest, so protecting older forests and setting the right goal for the proportion of early successional forest is critical.

Attachment 04

Disturbance Regimes in Temperate Forests

Chapter 2

Disturbance Regimes in Temperate Forests

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I. INTRODUCTION

Different forest types can be characterized by the mortality patterns of their canopy trees. This chapter will begin by defining the parameters necessary to characterize the pattern of death of dominant individuals (canopy trees) in a community, also referred to as that community's "disturbance regime." "Disturbance" is defined here as a force that kills at least one canopy tree. The disturbance regimes of two particular forest types will then be described. Finally, descriptions of natural disturbance regimes will be compared with the results of manipulative studies or artificial disturbance regimes. Special attention will be given to the relative importance of large-scale versus small-scale disturbance.

THE ECOLOGY
OF NATURAL DISTURBANCE
AND PATCH DYNAMICS

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II. COMPONENTS OF A DISTURBANCE REGIME FOR FORESTS

A. Average Disturbance Rates

The average rate at which trees die can have important consequences for the species composition and structure of a forest. High disturbance rates should select for fast-growing species that reproduce early and are short-lived (Grime, 1974, 1977). If disturbance rates are too high, the tree lifeform is no longer viable and community dominance switches to shrub or herb lifeforms. Natural disturbance rates for forests also have theoretical minimum values set by the maximum age and size limits of tree species. As a tree ages and increases in size, its efficiency in transporting water, nutrients, and photosynthate usually decreases (Spurr and Barnes, 1973; Oldeman, 1978). Its roots must support a proportionally greater aboveground biomass (Borchert, 1976), and its photosynthetic tissues must support a proportionally greater mass of nonphotosynthetic tissue (Harper, 1977). These factors, plus the tendency of the tree to develop a more massive crown, render it increasingly susceptible to smaller and more common disturbances. This relationship between the external environment (frequency of disturbances, e.g., wind speeds of a certain magnitude) and the plant itself (the rate at which aging increases its susceptibility to disturbances of smaller magnitude) diminishes the usefulness of terms such as ''allogenic'' or ''autogenic'' in connection with natural disturbances.

As a result of the above factors, forest disturbance rates seem to be constrained to a fairly small range of potential values. As one consequence, forest dominants in most parts of the world have a range of life spans of 100–1000 years (Budowski, 1965; Fowells, 1965; Ashton, 1969). For temperate deciduous forests the normal range is even smaller: 300 years is the age often reached by dominants with few individuals living more than 500 years (Jones, 1945).

The average rate of forest disturbance also shows fairly little variation, despite wide differences in vegetation and types of disturbance. Northern conifer forests affected primarily by fire (Heinselman, 1973; Zackrisson, 1977) and temperate and tropical forests affected primarily by the death of scattered individuals (Leigh, 1975; Abrell and Jackson, 1977; Hartshorn, 1978; Naka, 1982; Runkle, 1982) all show average rates of disturbance of $\approx 1\%$/year (ranging from ≈ 0.5 to ≈ 2.0/year in large samples). Although these forests are different from each other in many ways, they are similar in that most canopy individuals die due to the one mechanism studied—fire or wind throw. Disturbance rates for some specific agents of tree death (e.g., 0.02–0.16%/year for tropical landslides; Garwood *et al.*, 1979) may be lower than $\approx 1\%$ because many trees die due to factors other than the one studied.

Disturbance rates of 0.5–2.0%/year give natural return intervals (average time between disturbances for a given site) of 50–200 years. These values can be reconciled with 300- to 500-year average tree longevities for the following reasons. First, certain trees live longer than average due to their presence in more protected locations or to chance deviations from normal weather conditions. Second, many important forest dominants often persist for many years under a closed canopy, growing very slowly. For instance, using age–size (diameter at breast height, dbh) regressions, trees in mesic sites in the Great Smoky Mountains National Park averaged about 91 years to reach 25 cm dbh, the approximate minimum size at which they reach the canopy (Runkle, 1982). The average time spent by individuals in the canopy, again using age–size regressions, was 127 years, in good agreement with the natural rotation periods noted above.

The somewhat surprising conclusion is that different mesic forests probably do not show very great differences in their average rates of disturbance. Therefore, important differences among the disturbance regimes of different forests are more likely to occur in the distribution of tree deaths in time and space and in the severity of the disturbance.

B. Distribution of Disturbance in Space

Over a broad geographic area, a given level of disturbance can affect either many adjacent individuals, creating a few large disturbed patches, or many scattered individuals, creating many small disturbed patches. Because patch size affects the nature of the vegetation's response to the disturbance, these two alternatives should yield different results (see Section II,B,2).

Before proceeding, one note on terminology is useful. The term ''gap'' was used by Watt (1947) to refer to a site at which a canopy individual had died and at which active recruitment of new individuals into the canopy was occurring. The emphasis was on relatively small within-community disturbance patches. This emphasis has generally been maintained in later usages of the term (see, e.g., Bray, 1956; Williamson, 1975; Whitmore, 1978; Ehrenfeld, 1980; Barden, 1981; Runkle, 1981, 1982; Shugart and West, 1981; Nakashizuka and Numata, 1982a,b). This chapter will retain this usage, although clearly a gradient exists between disturbances affecting a single tree and those affecting many square kilometers of forest.

1. Relation of the Environment to the Size of the Disturbed Area

The physical environment within a small open area surrounded by forest differs from that under the canopy or in a large open area. In a small opening, temperatures fluctuate more and light and soil moisture are both more abundant than under a closed canopy. As the opening size decreases, humidity increases, wind speed decreases, and temperatures remain more constant (Geiger, 1965). Opening size is frequently quantified as the D/H, ratio, where D is the diameter of the open area and H is the mean height of the surrounding stand (Geiger, 1965). Several studies (Jackson, 1959; Minckler, 1961; Berry, 1964; Minckler and Woerheide, 1965; Minckler *et al.*, 1973) have shown light to increase with increased opening size, reaching a maximum when $D/H \approx 2$. March and Skeen (1976) found that differences in light between a small opening and a closed forest persist throughout the growing season. Minckler *et al.* (1973) found the opening size to determine the number of years the increase in soil moisture persists, although not the size of the initial difference. Tomanek (1960) found that the shape and orientation of openings, as well as their size, can be important in determining their microclimate.

2. Relation of Species Composition to the Size of the Disturbed Area

Many forestry studies and general reviews state that the selective cutting of individual trees will favor shade-tolerant species such as American beech (*Fagus grandifolia*), eastern hemlock (*Tsuga canadensis*), and sugar maple (*Acer saccharum*) (see, e.g., U.S. Forest Service, 1973; McCauley and Trimble, 1975; Leak and Filip, 1977; Tubbs, 1977). However, openings as small as 400 m^2 have been found to be sufficient for tuliptree (*Liriodendron tulipifera*) and yellow birch (*Betula alleghaniensis*) to maintain themselves in a forest (Merz and Boyce, 1958; Tubbs, 1969; Trimble, 1970; Schlesinger, 1976; Beck and Della-Bianca, 1981). Tryon and Trimble (1969) found a 1000-m^2 opening sufficient to regenerate several intolerant species, with relatively few adverse affects of border trees on the growth of saplings near the edge of the opening. Runkle (1982, 1984) found significant differences in the response of potential canopy species to differences in gap size for naturally formed gaps ≤ 1000 m^2 and generally ≤ 400 m^2. Williamson (1975) found evidence that gaps 50–250 m^2 were sufficient to regenerate tuliptree and white ash (*Fraxinus americana*).

C. Distribution of Disturbance in Time

A given average annual disturbance rate can be achieved by a low level of disturbance occurring in most years or by occasional years of very high disturbance followed by many years of few or no disturbances. Forests at either extreme are known. On a local level, differences in the periodicity of disturbance often parallel differences in the spatial distribution of disturbance. If most tree mortality is concentrated in a few years, then probably much tree mortality is concentrated in large openings. Therefore, species composition at sites where disturbance is concentrated in time should resemble species composition at sites where disturbance is concentrated in space. The temporal distribution of disturbance is more important on a landscape level than on a local level because it determines the synchrony of the regeneration processes occurring over a broad area. The level of synchrony of regrowth is important because of the close relationship between tree population dynamics and ecosystem changes in biomass and production (Peet and Christensen, 1980; Peet, 1981).

D. Severity of Disturbance

In addition to varying in temporal and spatial distributions, disturbances can vary in their severity. ''Severity'' measures the degree to which the predisturbance vegetation has been damaged and ecosystem properties have been disrupted. It is

equivalent to the term ''magnitude'' used by White (1979). The vegetation of a site will develop more slowly after a severe disturbance than after a mild disturbance. The size and severity of a disturbance are two different properties. It is possible to have a small, severe disturbance or a large, mild one.

Several compilations of species regeneration strategies have been made (e.g., Bormann and Likens, 1979; Oliver, 1981; Canham and Marks, Chapter 11, this volume). In general, individuals growing after disturbance are present at the time of disturbance as suppressed seedlings and saplings, as seeds buried in the soil, or as seeds newly dispersed into the area. The severity of disturbance determines which of these strategies is most likely to succeed. A mild disturbance, e.g., windthrow of just the canopy trees, probably favors the suppressed sapling strategy. A more severe disturbance may eliminate suppressed saplings but leave the soil intact and favor species such as pin cherry (*Prunus pensylvanica*), which are well represented in the seed pool (Marks, 1974). A disturbance that is both very severe, e.g., long-term agriculture (eliminating saplings and the seed pool) and is conducted over a large area (greatly diminishing the potential seed rain) can result in a very protracted recovery time.

Some types of disturbances can enhance the success of certain regeneration strategies through the creation of special microhabitats. Uprooting of trees creates pits and mounds that differ in several properties from soils that have not been overturned (Lyford and MacLean, 1966; Armson and Fessenden, 1973; Stone, 1975). In particular, pits have more litter and standing water and mounds have less than do other soils. Some species differ in the part of the pit and mound surface on which they grow (Hutnik, 1952). Decomposing logs also provide a specialized habitat on which some species, such as yellow birch and eastern hemlock, reproduce (Fowells, 1965). Other examples in which the type of disturbance determines the pattern of species replacement are given by Grubb (1977).

The severity of disturbance can also be measured as the effect on ecosystem functioning. The primary influence is on soil properties and long-term nutrient dynamics. A severe disturbance results in substantial erosion and nutrient losses, which may take decades for the ecosystem to replace (Bormann and Likens, 1979). For example, low-intensity fires may have no long-term effect on ecosystem properties, but intense fires can volatilize much nitrogen, cause severe erosion, and greatly diminish future productivity at the site (Wells *et al.*, 1979).

E. Rates of Recovery from Disturbance

The rate at which a community recovers from disturbance depends upon the characteristics of the disturbance discussed above. For small and mild disturbances, recovery is determined primarily by the rates at which bordering canopy trees expand into the opened area and seedlings and saplings grow into the canopy. For larger and more severe disturbances, a more varied and elaborate process of vegetation development occurs.

In general, the latter process has been studied as ecological succession, while the former has been considered as characterizing gap dynamics. The division between the two processes is arbitrary, with "succession" being used primarily when whole communities change and "gap dynamics" when the disturbances occur within a single community. "Community" here refers to a site of sufficient size to be studied by itself. Dynamics within a gap caused by a single treefall are usually studied in relation to the surrounding forest, whereas recovery of a large area in which trees were blown down by a large storm or burned in a fire is often studied without mention of the surrounding areas.

This section will concentrate on the recovery processes most important in gap dynamics, as defined above, that is, lateral growth of canopy trees bordering the gap and height growth of seedlings and saplings within the gap.

1. Lateral Extension Growth

Several studies differing in location, species, and technique have measured reasonably similar rates of branch growth by trees bordering openings (Trimble and Tryon, 1966; Phares and Williams, 1971; Erdmann *et al.*, 1975; Hibbs, 1982; Runkle, 1982). Average rates generally range from 4 to 14 cm/year. Some trees expand at rates of up to 20 to 26 cm/year. The impact of these branch growth rates on gap regeneration depends upon the rate of sapling height growth and the size of the gap. Smaller gaps have a large ratio of edge to interior. Therefore, lateral extension growth should be proportionally more important in small gaps than in big ones.

2. Sapling Height Growth

The rate at which a gap closes due to the height growth of saplings depends on both the rate of height growth of saplings and the heights of the saplings at the time the gap was formed.

Many species from different areas in the eastern deciduous forest show average growth rates of 0.5–1.0 m/year following cutting or in naturally created (usually large) openings (e.g., Kramer, 1943; Downs, 1946; Kozlowski and Ward, 1957; Tryon and Trimble, 1969; Marks, 1975). Minckler *et al.* (1973) found species height growth to range from 9 to 73 cm/year near the centers of gaps of different sizes (less than or equal to two times the height of surrounding trees). Hibbs (1982) measured sapling height growth (the average of the three largest stems) in a hemlock–hardwood stand in Massachusetts. In small gaps ($\leq$5-m radius), saplings of different species grew 10–50 cm/year; in open field conditions, species grew 25–50 cm/year. Hibbs (1982) related the rates of sapling growth to the rates of canopy branch growth calculated for the same woods and concluded that few or no tree seedlings will reach the canopy in openings with a radius of $<$5 m. Some seedlings may reach the canopy in larger gaps because of the increased time until canopy closure occurs via branch growth.

Small gaps may still close primarily due to sapling height growth if sufficiently large, suppressed saplings are present in the gap when it is formed. Good descriptions of the height distribution of saplings in gaps immediately after formation are not available. However, many forests contain large numbers of suppressed saplings. If the disturbance is mild, then one of these saplings may grow to become the next canopy tree in less time than it would take for a new seedling to reach the canopy, especially if taller individuals grow faster than small ones, as at least occasionally occurs (Laufersweiler, 1955; Burton *et al.*, 1969; Tubbs, 1977).

To include the effects of both initial sapling size distribution and growth rates, Runkle (1982) compared the rate at which the total gap area disappeared for small gaps (average, 100 m^2) with the rate expected if branch growth by canopy trees were the only mechanism of gap closure. After the fifth year, height growth was the primary mechanism of gap closure. Even small gaps can result in successful tree regeneration if they include a large, formerly suppressed individual.

F. Importance of Multiple-Gap Episodes

One last component of a forest disturbance regime is the extent to which a tree may be affected by two or more different gaps in the course of its growth into the canopy. Such multiple gap effects should be more common after mild disturbances than after severe ones, which might kill the regenerating individual. Such multiple episodes are also more important when disturbances are small and scattered rather than clustered. Small, scattered disturbances have the greatest ratio of edge (areas affected but not injured) to internal area.

Such multiple gap episodes may be fairly common. Individuals of several species, notably hemlock, often show multiple release and suppression of ring widths, implying several episodes of gap formation and closure (Henry and Swan, 1974; Oliver and Stephens, 1977). Also, if, as mentioned earlier, average tree mortality rates are approximately 1%/year, repeated disturbances should be fairly common. For example, 36 gaps examined in Hueston Woods State Park, Ohio (Runkle, 1981, 1982) had 257 border trees, or 7.1 border trees per gap. Given those values (1%/year, mortality; 7.1 border trees per gap), about half of the gaps should be affected by a new disturbance (death of at least one border tree) within 10 years of initial gap formation. The Hueston Woods gaps were revisited 4 years after their original census (Runkle, 1984); 11 border trees had died or become moribund during that time, a value close to the 10 predicted from average rates of disturbance. Therefore, for this forest, return rates of disturbance may be common and generated primarily by deaths not influenced by the proximity of a previous tree death. In other forests, e.g., high-elevation forests of balsam fir (*Abies balsamea*) (Sprugel and Bormann, 1981), repeated disturbances are even more common because the environment next to a disturbed area is more severe than elsewhere, and so new tree deaths occur primarily among border trees.

That such multiple-gap episodes are common for at least some forest types may be very important for forest regeneration and species evolution. Species may be able to reach the canopy fairly often by using a series of small gaps rather than a single large one.

Species specializing in this mode of reproduction should be able to take advantage of temporary openings in the canopy and then should suffer only slightly after the canopy closes, thereby increasing the chance that they will still be able to respond while awaiting a new gap in the vicinity. High rates of multiple gap occurrence can also imply that individuals of tolerant species will usually be exposed to one or more gaps at some stage before reaching the canopy.

The question of whether understory-tolerant species can occasionally reach the canopy without benefiting from gaps is not resolved. To my knowledge, no species under a closed canopy has been shown to have a steady increase in height to reach canopy status. Several lines of evidence suggest that this phenomenon will rarely if ever occur. Seedlings and saplings in complete shade grow very slowly. For example, Morey (1936) found that on average it took beech 12 years and hemlock 29 years to reach a height of 1.2 m. Sugar maple and beech seedlings in Ontario grew only 2–4 cm/year both under shaded conditions and in a 200-m^2 gap (Cypher and Boucher, 1982). In small gaps (10–50 m^2), Hibbs (1982) found hemlock to grow only 10–20 cm/year. Presumably growth under a closed canopy would be even less. As a result of these very slow growth rates, these species would take ≥200–300 years to reach the canopy without occasional spurts of faster growth. This time interval is at the outer limit of the lifespan for most of these species (Fowells, 1965). Similar conclusions can be reached for diameter growth. Many tolerant trees show little or no diameter growth under shaded conditions. For example, one study in Pennsylvania found a 9-cm dbh beech missing rings for 46 of the previous 70 years and a hemlock missing rings for 39 of the previous 70 years (Turberville and Hough, 1939). Given the rates of disturbance that occur in these forests, however, the probability that a gap will affect one spot at least once within a 100- to 300-year period is extremely high.

III. NATURAL DISTURBANCE REGIMES FOR SPECIFIC TEMPERATE FORESTS

Workers in the eastern deciduous forest of North America have had several advantages in the determination of natural disturbance regimes. Although the majority of the original forest has been logged or severely disturbed, several remnants do remain on which the formerly widespread processes of forest regeneration can be studied. Historical records of other primeval forests and natural disturbances exist. Some of these historical records are remarkably quantitative, such as those of the General Land Office Survey (Bourdo, 1956). Also, North American plant ecologists have long been interested in the processes of forest disturbance and succession, and so much information is available in the literature.

This section will describe the disturbance regime associated with two different forest types and locations. The cove forests of the southern Appalachians are affected almost entirely by small-scale, mild disturbances. The forests of the Allegheny Plateau, in Pennsylvania, are affected by both small-scale and large-scale, usually mild, disturbances. The description of the Allegheny forests will also include the distribution of disturbances over the landscape, including the effect of topographic position on both disturbance regime and vegetation.

A third type of disturbance regime exists in the white pine (*Pinus strobus*)–northern hardwoods section of northern Minnesota and adjacent Canada. For these forests, fire is the primary source of large-scale forest disturbance (Frissell, 1973; Heinselman, 1973) and has been important for 10,000 years (Swain, 1973). Heinselman (1973) found average rates of burning of ≈1%/year before widespread fire suppression was adopted. Disturbance was clumped in time and space, with most of the area burned in one of only a few major fire years. All present stands within the 415,782-ha Boundary Waters Canoe Area owe their origin to fire. Therefore, small-scale disturbances seem to be relatively unimportant. Because this disturbance regime has been adequately summarized elsewhere (Heinselman, 1973, 1981a), it will not be discussed further here.

A. Cove Forests of the Southern Appalachians

Cove forests occur in sheltered areas near creeks at middle elevations throughout much of the southern Appalachian mountains (Braun, 1950; Whittaker, 1956; Golden, 1981). They are dominated by differing combinations of mesophytic tree species, particularly sugar maple, yellow buckeye (*Aesculus octandra*), yellow birch, American beech, silverbell (*Halesia carolina*), white basswood (*Tilia heterophylla*), and eastern hemlock.

The disturbance regime for the cove forests is determined by their regional and local topographic positions. Fire occurrence rates on a county basis are very low to moderate for most of the mountainous counties of eastern Tennessee and western North Carolina, in contrast to higher rates nearer the coast (Nelson and Zillgitt, 1969). Within the mountains, fires are uncommon, occurring primarily on south-facing slopes near ridge tops, especially on lower ridges (Barden and Woods, 1976; Harmon, 1982). North-facing lower slopes and sheltered ravines have the lowest incidence of fire (Harmon, 1982).

Wind-related disturbance tends to be dominated by small-scale events. Glaze storms are more common than large-scale, damaging tropical storms (Nelson and Zillgitt, 1969). Tornadoes are not as common or severe as they are in most of the rest of the eastern deciduous forest (Fujita, 1976). Occasional tornadoes do occur, however.

Human disturbance of most sites once dominated by mixed mesophytic species has been extensive. Therefore, most work on the long-term dynamics of mixed mesophytic forests has been done in one of the remaining old-growth remnants, either the Great Smoky Mountains National Park (GSMNP) of Tennessee and North Carolina or unlogged coves in one of the nearby national forests. These areas were protected from extensive logging by their regional inaccessibility until about 1900 and by the formation of the GSMNP in 1940. Between 1900 and 1940, however, virgin timber was removed by commercial loggers from most of the present-day park. Also, substantial areas of the GSMNP had been cleared and selectively cut by local people (Frome, 1966). Despite these human influences, enough undisturbed forest remains at middle and high elevations to allow a meaningful characterization of the natural disturbance regime.

The exact locations of the sites to be discussed below were further constrained by two additional factors. Most sampling was done far enough away from streams or near small enough streams so that *Rhododendron maximum* was nearly or entirely absent. The presence of a dense shrub layer of rhododendron influences regeneration by greatly diminishing the success of an advance sapling regeneration strategy. As a consequence, cove forests with rhododendron have more red maple (*Acer rubrum*) and more hemlock and *Betula* spp., which regenerate on fallen logs, and less sugar maple, yellow buckeye, beech, silverbell, and basswood, all of which depend on advance sapling growth than do cove forests without abundant rhododendron (Oosting and Bourdeau, 1955; Barden, 1979, 1980; Lorimer, 1980). The second local restriction in sampling was to avoid slope communities in which American chestnut (*Castanea dentata*) had been important before its demise (Woods and Shanks, 1959).

The disturbance regimes of the cove forests are thus influenced by their regional and local positions. Deaths of canopy trees occur primarily as scattered small-scale disturbances affecting only one or a few trees at a time in any one location. Likely causes of tree mortality are glaze storms, lightning strikes, or occasional very high winds. Disturbances are not very severe. Surrounding vegetation diminishes the loss of nutrients from the site, so that long-term ecosystem functioning should not be harmed. Many saplings and other advance regeneration are present, so vegetation recovery should proceed rapidly.

The following data on the disturbance regime parameters for cove forests are summarized primarily from Runkle (1982), unless otherwise stated.

Overall, in the cove forests, 0.5–2.0% of the land surface area in individual sites was converted from forest to new treefall gaps per year. The average for all sites studied was 1.2–1.3%/year, in agreement with figures from other forest types, as discussed above. Romme and Martin (1982) found lower disturbance rates (0.25–1.0%/year, depending on the method of calculation) for an old-growth mixed mesophytic forest in Kentucky. They did not include very small gaps created by parts of still living canopy trees, so the two results are not strictly comparable.

Gap areas followed a lognormal distribution, with many small and a few large gaps. The average size of a canopy opening was ~31 m^2 if the very small gaps caused by the fall of large branches or small canopy trees were included. Canopy opening sizes ranged up to 1490 m^2, with ≈1% of the total land area in gaps of >400 m^2. Most gaps were created by the death of single trees, but multiple treefalls accounted for most of the larger gaps. Similar values for gap size in these forests are given in Barden (1981). Similar values for gap size were also found in a climax stand of Japanese beech (*Fagus crenata*) and other mixed mesophytic species in Japan (Nakashizuka and Numata, 1982a,b). Because the gaps were fairly small, with diameter/canopy height ratios <1, the difference in environmental conditions between the gap and the forest understory is smaller than for a forest dominated by large-scale disturbances. However, small gaps have greater edge/area ratios than do larger openings. Therefore, cove forests should contain very large fractions of land area partly affected by disturbance.

Yearly fluctuations in the rate at which gaps are formed occur but are minor. For example, for 10 different sites in the southern Appalachians and for 15 years per site, the maximum fraction of land area per year in gaps was only 7.4%. Every year, several storms in the general area down enough trees to cause notable economic damage (Environmental Data Service, 1975). The rugged topography results in different areas having different peak years of disturbance, with no sign of regional synchrony in gap formation.

A disturbance regime characterized by many small gaps with a large ratio of edge to area might be expected to show high rates of repeat disturbance. New gaps should often form close enough to old gaps to maintain the changed environmental conditions associated with gaps and to slow the processes of gap closure. In one study designed to test this hypothesis (Runkle, unpublished data), high rates of repeat disturbance were found. For 273 gaps revisited 6–7 years after originally being sampled, one or more canopy trees surrounding the gap had died or been severely injured in 114 gaps, a former large stump from the tree creating the gap had fallen in 62 gaps, and new gaps were created near but not immediately adjacent to the original gap 35 times. In only 112 gaps did none of these new disturbances occur. Canopy trees surrounding gaps died at about the same rate as canopy trees in general. Multiplying the number of original surrounding canopy trees by a 1%/year disturbance rate by 6 or 7 years gives a predicted number of deaths of 151 trees versus 164 deaths or severe injuries actually recorded. For these forests, therefore, repeat disturbances are common and are a property of the size and age distributions of gaps. The evolutionarily important consequence of this result is that tree species should be favored whose saplings are able to alternate between periods of moderate to rapid growth while in gaps and periods of slow growth during the times between gaps.

Gaps close both by the branch extension growth of trees surrounding the gap and by the height growth of saplings in the gap. For these small gaps, both processes are important in gap closure. Small gaps close primarily by lateral extension growth, except where large, previously suppressed saplings are present. Large gaps close primarily by sapling height growth.

Species responses to gap size form a gradient. At one extreme are tolerant species, whose life cycle usually includes a lengthy suppressed sapling stage. These species, e.g., sugar maple, yellow buckeye, beech, and hemlock, are adapted to alternating periods of growth and suppression, and therefore seem especially able to benefit from small but repeated disturbances. They can also grow well in some larger gaps. At the other extreme are intolerant species, e.g., tuliptree, which can grow very rapidly in large gaps but cannot grow in small gaps and cannot withstand suppression. These species are therefore restricted to gaps large enough to preclude closure by lateral extension growth or by previously suppressed saplings.

Given these species differences, are processes presently occurring in the range of gap sizes studied sufficient to account for the canopy composition of the stands studied? Is there evidence that episodic large-scale disturbance events need to be involved to generate the species composition present? Runkle (1981) and Barden (1981) both found very good matches between the species composition of saplings in gaps and the species composition of the canopy in several different cove forests. Therefore, small-scale disturbance does seem adequate to perpetuate these forests. The distribution of gap sizes results in forests dominated by tolerant species, with intolerants persisting at low densities.

This analysis suggests that the relative abundance of tuliptree may be a good indicator of the disturbance regime present in a stand. Its importance should be related to the frequency of gaps >400 m^2 or so. Support for this suggestion comes from the fact that of the sites studied by Runkle (1981), Joyce Kilmer had both the largest gaps and the highest importance of tuliptree. Lorimer (1980), in a more intensive study of Joyce Kilmer, found average rates of disturbance (3.8–14.0% of total land area/decade) similar to those of other cove forests but concluded that tuliptree originated primarily after occasional large windthrows. The widespread distribution of tuliptree in climax forests of the Piedmont (Skeen *et al.*, 1980) implies that such intermediate-size disturbances (say, 400 m^2 to 1 ha) are fairly common there. The virtual absence of tuliptree in most cove forests studied in the GSMNP implies that disturbances >400 m^2 are relatively rare there.

B. Forests of the Allegheny Plateau, Pennsylvania

The forests of the Allegheny Plateau in northwestern Pennsylvania differ from the cove forests of the southern Appalachians in their disturbance regime. The Allegheny forests are affected more often by large-scale disturbances. However, small-scale disturbances also occur and are important. Thus, the Allegheny forests represent a disturbance regime intermediate between the cove forests and forests whose dynamics are dominated almost completely by occasional large disturbances, such as the pine-dominated forests of northern Minnesota. Also, the literature on the Allegheny forests relates more clearly how topographic position and soil structure influence the disturbance regime and the vegetation.

The Allegheny Plateau contains broad, level uplands interspersed with narrow river valleys (Hough and Forbes, 1943). The uplands are 600–750 m above sea level south of the glacial border and held up by the hard sandstones of the Pottsville and Pocono series. The valleys are V-shaped, narrow, and winding, with a relief of ≥120–240 m. Slopes are usually steep and rocky. A mantle of surficial materials of varying thickness completely covers the bedrock of almost the whole region, becoming generally thicker on lower slopes (Goodlett, 1954).

Differences in soils and topography are reflected by differences in vegetation. Of several types of presettlement forests that occurred in this area, two will be examined here. Stands dominated by white pine occurred on sandy river flats and terraces and on lower slopes where the soil was loose and sandy, particularly on south-facing slopes (Hough, 1936; Hough and Forbes, 1943; Marquis, 1975b). American

chestnut, red maple, northern red oak (*Quercus rubra*), and white oak (*Q. alba*) were confined mainly to these stands. A second major vegetation type was dominated by eastern hemlock and American beech. This vegetation type was the most widespread climax type, occupying most north-facing slopes and poorly drained upland sites (Hough, 1936; Hough and Forbes, 1943; Marquis, 1975b; Bjorkbom and Larson, 1977). Common associates of hemlock and beech in these stands were sugar maple, black cherry (*Prunus serotina*), and yellow birch.

These two different vegetation types were characterized by substantially different disturbance regimes, which interacted with the soils and topographic positions to determine the vegetation. White pine was associated with disturbances such as fires and windthrows large enough to allow light to reach the forest floor and severe enough to expose mineral soil. Fire frequency in the region is greater than in the Appalachian mountains, although less than in the forests of northern Minnesota (Bormann and Likens, 1979). In sites near Heart's Content, Lutz (1930b) found fire scars on 86 trees, accounting for 41 different years in the interval 1727–1927. Five fire years were noted on six or more trees each. Such fires are thought to have given rise to white pine stands in Heart's Content and Cook Forest, two of the only extant pine stands in the region (Lutz, 1930b; Hough and Forbes, 1943). In other places, white pine originated primarily after windthrows uprooted trees and exposed mineral soil on treefall mounds (Goodlett, 1954). Large white pine stumps are still abundant on treefall mounds in various stages of settling (Goodlett, 1954). This mechanism of establishment also helps explain the existence of white pine in several areas as scattered individuals rather than as a pure stand originating after one large-scale disturbance (Lutz and McComb, 1935; Goodlett, 1954).

The disturbance regime of the moister uplands varied considerably from that of the pine-dominated stands. Fires were rare or absent due to the moist forest floor and lack of inflammable undergrowth (Lutz, 1930a; Hough, 1936; Goodlett, 1954; Bjorkbom and Larson, 1977). Even at Heart's Content, the section without pines, which was cooler and moister than the section with pines, contained no evidence of fires (Lutz, 1930b). Occasional large-scale windthrows do occur (Hough, 1936; Goodlett, 1954). For instance, large storms in 1808 and 1870 uprooted trees in areas many hectares in extent in the Tionesta tracts (Bjorkbom and Larson, 1977). Areas affected by such large-scale disturbances regenerate into stands dominated by species with intermediate tolerance and long-lasting dormant seeds, such as red maple, black cherry, black birch (*Betula lenta*), and yellow birch. Surviving saplings of hemlock, beech, and sugar maple may also be present.

Despite the existence of these large-scale disturbances, "a widespread blowdown during a single intense storm is probably less common than the loss of a single tree here and there throughout the stand over a long period" (Hough 1936, p. 19). Many of the major sources of regional disturbances affect trees singly or in small clumps. Prolonged periodic droughts occur and result in heavy mortality of shallow-rooted trees species such as hemlock and yellow birch (Hough and Forbes, 1943; Bjorkbom and Larson, 1977). However, the effects of such droughts might be expected to be restricted to scattered individuals that are already weakened or located on unfavorable microsites. Similarly, ice or glaze storms occur but cause loss primarily of branches or scattered trees, particularly because the dominant species are fairly resistant to ice damage (Bjorkbom and Larson, 1977).

The regime of small-scale disturbances or gaps presently occurring in protected old-growth hemlock–beech stands is very similar to the one described earlier for the southern Appalachian cove forests (Runkle, 1981, 1982). Gaps were smaller on average than in the cove forests and rates of disturbance were only 0.5% of land surface area per year, near the low end for eastern forests although close to measurements from some parts of the southern Appalachians (Runkle, 1982). This low rate of disturbance is perhaps related to the more complete dominance in the Tionesta sites of two of the longest-lived species, beech and hemlock. Also, occasional cutting or large-scale disturbances may have decreased the number of old trees likely to form gaps. Beech dominated the gap regeneration for all gap sizes, but there was some tendency for hemlock to reach its maximum abundance in small gaps and sugar maple to reach its maximum abundance in intermediate-sized gaps. Overall, the species composition of saplings in gaps was very similar to the species composition of the canopy (Runkle, 1981). Therefore, a disturbance regime characterized by small-scale disturbances seems sufficient to maintain the beech–hemlock forests.

The effect of non-Indian settlement on the area was to disrupt the natural disturbance regime, with major direct and indirect consequences for the vegetation. These disruptions were not uniform, but affected some areas and some species much more than others.

The white pine-dominated areas were the most severely affected. White pine was the most prized timber species and was eliminated from the canopy almost completely by 1900 (Goodlett, 1954; Marquis, 1975b). Extensive fires from the logging slash eliminated the seedling pines (Marquis, 1975b). As a result, white pine is virtually absent from the forests today and is unlikely to return in the foreseeable future. A second important species, American chestnut, has been almost completely eliminated due to an introduced disease. As a result of these two species eliminations, the drier sites today are dominated by various species of oak (Goodlett, 1954).

The effects of human settlement on the upland forests have been less striking and more indirect, but still important. Hemlock remains important but less so than in the primeval forests, due partly to extensive logging for its tannin-rich bark. Hardwoods have increased in relative density due to their ability to sprout or survive as buried seeds following logging and fires (Marquis, 1975b). A large deer herd has become established due both to increased protection from hunting and to abundant forest growth following cutting, resulting in much available browse (Marquis, 1975b). Deer populations are now high enough to impede the growth of seedlings and saplings following natural or human-caused disturbances (Hough, 1965; Jordan, 1967; Marquis, 1974, 1981; Bjorkbom and Larson, 1977; Marquis and Brenneman, 1981). The net impact of deer browsing has been to favor beech at the expense of hemlock and other hardwoods. Because beech is one of the dominant

species, the effect on the vegetation overall may be small. However, the elimination of many small hemlock stems is a concern and may result in sharp decreases in hemlock density in the future. On the other hand, hemlock regeneration in much of the region occurs irregularly, so the species may be able to survive a prolonged period of very little regeneration (Hough and Forbes, 1943).

Another change in disturbance regime affected by human use has been the elimination of large stems and therefore a decrease in the rate of gap formation. Forests characterized by small-scale disturbances have a sizeable fraction of their total area in or near gaps. Repeat disturbances are common. Therefore, saplings of many species are able to become established and be ready to respond to new openings. A second growth stand does not possess as many opportunities for saplings to become established. Unfortunately, especially given high deer-browsing pressure, the success of all cutting methods in establishing a favorable new stand requires that an abundance of seedlings already be established beneath the canopy of the existing overstory (Marquis and Brenneman, 1981). The most effective response of foresters is to mimic the primeval disturbance regime through shelterwood cutting, in which the canopy is removed in stages, gradually increasing light to the understory and increasing the number of saplings available to grow when the last of the old canopy is removed (Marquis and Brenneman, 1981).

In summary, the forest composition of the Allegheny Plateau is determined by the interaction of the natural disturbance regime, topography, and soils. South-facing slopes and sandy soils are affected by fires and blowdowns that uproot trees, both of which disturbances favor white pine and associated relatively shade-intolerant species. Upland moist sites are affected primarily by small-scale disturbances that favor shade-tolerant species. Large-scale blowdowns on these sites favor species of intermediate shade tolerance. Human influences on the area have disrupted the natural disturbance regimes, producing several changes in the species composition of the area.

IV. ARTIFICIAL DISTURBANCE REGIMES

In the preceding section, forest type and disturbance regime were found to be somewhat correlated. The causal relationship is not clear. Do the species otherwise adapted to an area (due to soils, climate, etc.) determine the disturbance regime, or does the potential disturbance regime in an area determine the vegetation? Both factors may interact simultaneously and reciprocally, so that simple causation is impossible to detect. To identify the chain of causation, it would be useful to conduct field studies, varying the disturbance regime to determine whether the pattern of disturbance by itself can affect species composition and the forest as a whole. Fortunately, such studies have been done many times at many different locations by foresters concerned with maximizing the harvest while selecting for a certain species composition in the new growth following disturbance. In the forestry literature, artificial disturbance regimes are referred to as "silvicultural systems."

Many such systems have been proposed and tested for particular locations and particular species (see, e.g., Smith, 1962; U.S. Forest Service, 1973, 1978; Tubbs, 1977). Two examples follow.

Trimble (1965) compared the effects of two different cutting regimes on cove hardwood forests in West Virginia. Uncontrolled clear-cutting on good sites had produced stands that included a high proportion of shade-intolerant species. Tuliptree, northern red oak, and black cherry made up more than half of the stems in the overstory. In contrast, Trimble (1965) used selection cuttings on 40- to 50-year-old stands to harvest individual trees. The trees removed were either large and salable or of poor quality (culls). The result of this cutting regime after 10–15 years was to favor sugar maple, which eventually seemed likely to make up over half of the stand. American beech would also greatly increase, except that it is heavily culled by foresters. The three relatively intolerant species listed above would shrink in importance to ≤20% of the future stand.

Leak and Filip (1977) obtained similar results from a stand of northern hardwoods in New Hampshire subjected to group selection. Groups of trees were removed, leaving openings averaging about 2000 m^2. This disturbance regime was sufficient to allow intermediate and intolerant species to maintain their relative importance in the stand at 25–35%. In contrast, under single-tree selection cuts, tolerant species came to represent 92% of canopy individuals.

One of the general conclusions of these and similar studies is that to reproduce the original species composition of the northern hardwood forest region, it is necessary to use a mixture of selection cuts (of one or a few trees at a time) and larger patch cuts or clearcuts. Selection cuts favor tolerant species such as American beech, sugar maple, and eastern hemlock. Larger cuts favor relatively intolerant species such as yellow birch and tuliptree. This mixture of gap sizes is precisely the one that characterized much of the primeval forest. Another useful silvicultural system for this forest type is the shelterwood system, in which scattered trees remain after the first cut and are removed only when the sapling layer is established. The scattered trees help shade and protect the young saplings. This system seems similar to damage by mildly severe natural windstorms or to glaze storms in which scattered trees are left standing.

The responses of individual species to different silvicultural systems can also be used to estimate the natural disturbance regime of forests originally dominated by those species. For instance, because beech and sugar maple are favored by selection cutting, it seems reasonable to hypothesize that the beech–maple forest region (Braun, 1950) was characterized by a prevalence of small-scale gap disturbance. Also, because beech is very susceptible to damage by fire (Fowells, 1965), the small-scale disturbances most common to this forest region must have been due to wind or glaze storms.

V. SUMMARY

Temperate zone forests such as those discussed here differ in species composition and structure. However, some broad similarities in their disturbance regimes exist.

Usually, these forests are affected by both large-scale and small-scale disturbance, with the relative importance and spatial distributions of each having great consequences for the regional vegetation (Whittaker and Levin, 1977; Pickett, 1980). The interplay of disturbances of different sizes is probably more important than the existence of a single intermediate type of disturbance (to oversimplify Connell, 1978) in determining species diversity and other community properties. Some forest types fit the generalization of Horn (1981a) and Oliver (1981) that large-scale (clumped in time and space and often severe) disturbances occur frequently enough so that most canopy individuals originate following such disturbances. However, small-scale gap disturbance is of primary importance for many areas and forest types. Most forests probably follow the pattern of cyclic development (succession) and steady state (climax) described by Loucks (1970), with great variations in the time and number of canopy tree generations between cycles, ranging from decades to millennia.

Further study is needed to clarify several aspects of the disturbance regimes of temperate zone forests. The primeval and therefore evolutionarily important disturbance regimes for many forest types need to be described in more detail. In North America, oak-dominated forests in particular require more study to determine the relative importance of fire, large- or small-scale windthrows, insect defoliation, and other factors. The effects of disturbance regimes greatly modified by human activity also need to be documented. The disturbance regimes associated with particular successional stages need to be clarified to determine at which successional stage a treefall provides sufficient resources for a sapling to reach the canopy instead of allowing solely for the crown expansion of its neighbors. It is also important to know the tolerance of different species of plants and animals to deviations in their primeval disturbance regimes so as to manage best their continued existence.

In summary, the concept of a disturbance regime has proved a useful way to summarize much information on the natural dynamics and regeneration of temperate zone forests. It also lends itself well to the continued development of a management theory for those forests.

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Attachment 05

Return Intervals spreadsheet

Disturbance Probabilities for transition to young forest

Ecozone	Initial condition	Total probability of age reset	NRV midpoint initial condition by age class	disturbance probability x % of acres to which it applies (CxD)	Sum for each ecozone	Overall return interval for reset event
SF	early	0.001	0.155	0.000155	0.004555	219.5389682
	late closed	0.007	0.1	0.0007		
	late open	0.001	0.065	0.000065		
	old closed	0.007	0.405	0.002835		
	old open	0.001	0.14	0.00014		
	mid closed	0.006	0.105	0.00063		
	mid open	0.001	0.03	0.00003		
HERO	early	0.01	0.16	0.0016	0.0089825	111.3275814
	late closed	0.0106	0.12	0.001272		
	late open	0.0093	0.12	0.001116		
	old closed	0.0106	0.08	0.000848		
	old open	0.0093	0.22	0.002046		
	mid closed	0.0073	0.185	0.0013505		
	mid open	0.006	0.125	0.00075		
NHW	early	0.0015	0.06	0.00009	0.004365	229.0950745
	late closed	0.0045	0.125	0.0005625		
	late open	0.0045	0.025	0.0001125		
	old closed	0.0045	0.45	0.002025		
	old open	0.0045	0.125	0.0005625		
	mid closed	0.0045	0.2	0.0009		
	mid open	0.0045	0.025	0.0001125		
cove	early	0.001	0.045	0.000045	0.004745	210.748156
	late closed	0.005	0.1	0.0005		
	late open	0.005	0.015	0.000075		
	old closed	0.005	0.5	0.0025		
	old open	0.005	0	0		
	mid closed	0.005	0.295	0.001475		
	mid open	0.003	0.05	0.00015		
MO	early	0.0033	0.05	0.000165	0.007115	140.5481377
	late closed	0.0075	0.09	0.000675		
	late open	0.007	0.06	0.00042		
	old closed	0.0075	0.305	0.0022875		
	old open	0.007	0.225	0.001575		
	mid closed	0.0075	0.135	0.0010125		
	mid open	0.007	0.14	0.00098		
DMO	early	0.0033	0.06	0.000198	0.0046305	215.9593996
	late closed	0.005	0.075	0.000375		
	late open	0.0045	0.08	0.00036		
	old closed	0.005	0.25	0.00125		
	old open	0.0045	0.305	0.0013725		
	mid closed	0.005	0.08	0.0004		
	mid open	0.0045	0.15	0.000675		
DO	early	0.04	0.155	0.0062	0.010246	97.59906305
	late closed	0.0063	0.02	0.000126		
	late open	0.005	0.075	0.000375		
	old closed	0.0063	0.105	0.0006615		
	old open	0.005	0.485	0.002425		
	mid closed	0.0033	0.045	0.0001485		
	mid open	0.002	0.155	0.00031		
POH	early	0.033	0.15	0.00495	0.015196	65.80679126
	late closed	0.018	0.03	0.00054		
	late open	0.0133	0.235	0.0031255		
	old closed	0.0213	0.02	0.000426		
	old open	0.0133	0.185	0.0024605		
	mid closed	0.018	0.03	0.00054		
	mid open	0.0083	0.38	0.003154		
SLP	early	0.033	0.105	0.003465	0.0127905	78.18302646
	late closed	0.018	0.025	0.00045		
	late open	0.0117	0.24	0.002808		
	old closed	0.018	0.025	0.00045		
	old open	0.0117	0.225	0.0026325		
	mid closed	0.013	0.025	0.000325		
	mid open	0.007	0.38	0.00266		
FL	early	0.004	0.07	0.00028	0.00776	128.8659794
	late closed	0.008	0.085	0.00068		
	late open	0.008	0.035	0.00028		
	old closed	0.008	0.26	0.00208		
	old open	0.008	0.11	0.00088		
	mid closed	0.008	0.33	0.00264		
	mid open	0.008	0.115	0.00092		

Attachment 06

Natural Disturbances and Early Successional Habitats

Chapter 3
Natural Disturbances and Early Successional Habitats

Peter S. White, Beverly Collins, and Gary R. Wein

Abstract Largely a legacy of stand-replacing human disturbances, today's central hardwood forests exhibit a narrower range of stand ages and structures than those in the presettlement landscape. Although natural disturbance types and frequencies vary within the region, large stand-replacing natural disturbances have always been infrequent; typical return intervals in excess of 100 years are longer than current forests have existed. Many present-day stands are dominated by early to mid-successional species in the overstory and late successional species in the understory; natural disturbances often serve to increase dominance of the understory late successional species, unless they are severe enough to disturb the canopy, forest floor, and soil. In any case, only the most severe natural disturbances or combinations of disturbances (including human disturbance) initiate large patches of early successional vegetation. Will the amount and spatial arrangement of early successional habitats created by natural disturbances be sufficient to meet management goals? We do not have the information to answer this question at present; the answer is further complicated by the potential effects of climate change on the rates and intensities of natural disturbances.

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3.1 Today's Forests – A Legacy of Human Disturbance

Today's central hardwood forests are largely a legacy of stand-replacing human disturbances that began in the 1700s and intensified in the 1800s and early 1900s (Lorimer 2001). Many of these forests owe their origin to large scale logging that took place between 1850 and 1940, while others date from farm abandonment that has occurred, at different times in different parts of our study area, from 1880 to the present (Fralish and McArdle 2009; Hart and Grissino-Mayer 2008). Peak agricultural clearing occurred between about 1880 and 1920, and post-farming stands from that period are similar in age to the post-logging forests.

Logging and agricultural disturbance were often accompanied by soil erosion, so the significance of these disturbances was more than a simple resetting of the successional clock; productivity and successional trajectories were affected on some sites. Burning and understory livestock grazing also were widespread during the 1800s and early 1900s, and occurred over landscapes variously cleared, farmed, or burned by Native Americans (Owen 2002).

Because of their roots in historical, widespread stand-initiating human disturbances, most of today's central hardwood forests are 70–100 years old, creating a landscape with reduced structural heterogeneity and age diversity compared to the presettlement landscape (Shifley and Thompson, Chap. 6). These forests are now reaching sawtimber size over large areas. Some stand characteristics, such as leaf area and basal area, have reached levels similar to presettlement forests, but composition, maximum tree sizes, and downed woody debris remain out of presettlement norms (Flinn and Marks 2007; Trani et al. 2001).

Present day stem densities generally are greater than densities in old-growth forests for three reasons: (1) Trees are mostly only about one-quarter to one-half their maximum sizes and forest understories were more open in the past due to (2) frequent fires, and (3) understory grazing. Shade-tolerant, fire sensitive, and mesic species often dominate in these denser forest understories and the forests are slowly converting from greater dominance by oaks (*Quercus* spp.) and hickories (*Carya* spp.) (with pines (*Pinus* spp.) in some areas) to maples (*Acer* spp.) and beech (*Fagus grandifolia*) as these species regenerate after the death of overstory trees (Cowell et al. 2010; Fralish and McArdle 2009; Hart and Grissino-Mayer 2008; Hart et al. 2008). Nowacki and Abrams (1997) refer to the widespread increase in mesic fire sensitive species across the deciduous forests of eastern North America as "mesophication." Although invasive pests and diseases (e.g., chestnut blight (*Chryphonectria parasitica*), gypsy moth (*Lymantria dispar*)) became important throughout the 1900s, they also served to increase canopy turnover rates and release advanced regeneration rather than initiate early succession composition and structure.

The maturation of central hardwood forests, the roughly synchronous nature of the large scale human disturbances that produced them, and the current smaller-scale disturbance regime, mean that early successional habitats within these forests are declining. This, in turn, raises concerns about the persistence of biodiversity supported by early successional habitats. In this chapter, we address the questions: What natural disturbances are important in these forests? Will these natural disturbances recreate the heterogeneity and patchiness of the past? Do natural disturbances initiate early successional habitats, which we consider to include new stands, young forest patches, or habitat within forests for open site, early successional plants, in the present landscape? Other chapters in this volume focus more specifically on vegetation response to disturbance; for example, Elliott et al. (Chap. 7) examine disturbance effects on herbaceous vegetation composition and diversity, and Loftis et al. (Chap. 5) examine effects of silvicultural disturbances on species composition of regenerating hardwoods.

In addition to natural disturbances within forests, there are other sources of open habitats and the biodiversity they support in the Central Hardwood Region. They include rock outcrops, glades, barrens, fire-dependent prairies that develop on certain bedrocks, and floodplains and stream channels affected by flood scour and beaver populations (Anderson et al. 1999). These habitats have slow rates of succession (rock outcrops, glades, and barrens), high rates of disturbance (floodplains, prairies) or both. For example, frequent fire can expand open grasslands and savannahs beyond the immediate boundaries of the bedrock islands that underlie some of these open communities. These open sites are also early successional habitats, but in this chapter we focus only on early successional habitats within upland forests, including new stands, patches of young forest, or open patches with early successional species. Anderson et al. (1999) have described the other kinds of open and successional communities in the North American forests.

3.2 Natural Disturbances and Early Successional Habitats

Large-scale or intense disturbances above a threshold of severity (Romme et al. 1998; Frelich and Reich 1999) initiate succession or maintain early successional forest habitats and allow the periodic regeneration of shade intolerant species. Frelich and Reich (1999) concluded severe or high cumulative disturbance maintain early successional species or initiate rapid conversion from late successional species to early successional species (a compositional catastrophe). Roberts (2004, 2007) linked disturbance severity to the percent of cover or biomass removed or disrupted through canopy, understory, and forest floor layers. We have adapted the Roberts model (Fig. 3.1, *left panel*) to link natural disturbance type and severity to early successional habitats. Disturbances are likely to have different impacts through forest strata (reviewed by Roberts 2004) and the threshold of severity to initiate succession is likely to differ both among strata and disturbances. For example, fire and flooding are ‘bottom up’ disturbances, with ground layer, understory, and canopy impacts at increasing severity. In contrast, wind disturbance, ice storms, and pathogens are often ‘top down’ disturbances. As windstorm severity increases, effects move from the canopy to soil and understory disturbance through tip-ups, thereby increasing the importance of seed dispersal relative to sprouting and seed bank in recruitment of understory stems (e.g., Busing et al. 2009; Clinton and Baker 2000). In general,

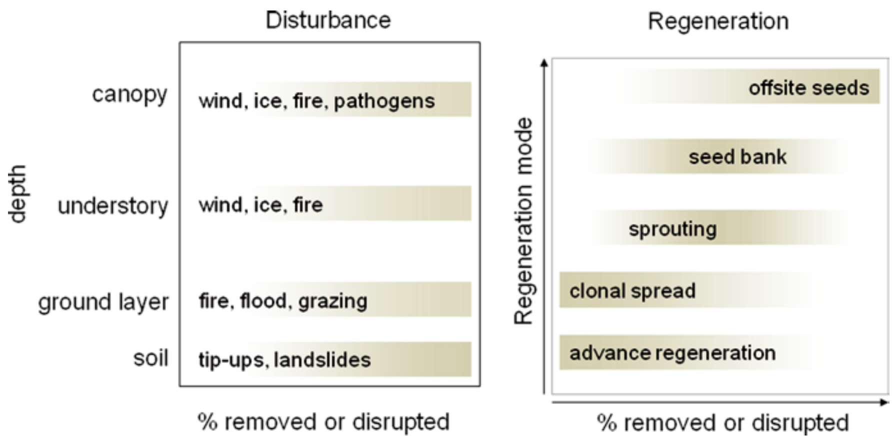


Fig. 3.1 On the *left*, a conceptual model (adapted from Roberts 2004, 2007) relates increasing severity of natural disturbance – as percent cover or biomass removed or disrupted through forest strata – to extent of early successional habitats, which is represented by the progressive shading and includes young forest and open patches with early successional plant species. Disturbance above some threshold of severity (Romme et al. 1998; Frelich and Reich 1999) may be required to initiate early successional habitats. On the *right*, the relative importance (*indicated by the shading*) of different regeneration modes changes with disturbance severity; regeneration from seed sources increases as disturbance severity increases

the establishment of shade intolerant species in the Central Hardwood Region depends on both canopy and ground layer disturbance.

Although severity of individual and multiple disturbances has been related qualitatively to forest conversion or maintenance of early successional species (e.g., Frelich and Reich 1999), few studies have quantified the severity of individual natural disturbance types needed to initiate succession or maintain early successional habitats in upland central hardwood forests. Most evidence is indirect. For example, hurricane damage that resulted, on average, in 25% basal area reduction in a mixed oak-hickory-pine forest did not shift composition toward shade-intolerant tree species (Busing et al. 2009). Natural disturbance alone also had little effect on habitat availability for early successional songbirds in a 60 year simulation study (Klaus et al. 2005). In a west-central Tennessee site that experienced moderate-severity windthrow and limited subsequent salvage logging, establishment of shade-intolerant tree species was more related to pre-disturbance forest composition than to disturbance severity (Peterson and Leach 2008). In contrast, however, Clinton and Baker (2000) found that gaps up to 4,043 m^2 could facilitate establishment of shade-intolerant species in Southern Appalachian forest. Vigorous sprouting (Clinton and Baker 2000) likely contributed to early successional forest structure, since these forests were young enough to have such species in the overstory. Elliott et al. (2002) also found that 84% reduction in basal area, through wind disturbance and subsequent salvage logging, allowed a heterogeneous mix of shade tolerant species, shade intolerant species, and opportunistic early successional understory species to establish in Southern Appalachian forests. Variation in forest composition, differences in disturbance severity over the landscape, and interaction of multiple disturbances (including interactions of natural disturbances and management) are most likely to create within-forest heterogeneity, with local patches of early successional habitats.

Differences in regeneration mechanisms among forest types and over disturbance severity gradients can contribute to the extent and, possibly, duration of early successional habitats. Figure 3.1 (*right panel*) is a conceptual model of the relationship between disturbance severity and predominant regeneration mechanism following disturbance. In general, contribution of seed sources increases with disturbance severity, although contribution from the seed bank will diminish if soil surface layers are removed (Aikens et al. 2007; Clinton and Baker 2000; Harrington and Bluhm 2001; Turner et al. 1998). Greater contribution from seed sources can increase abundance of early successional and shade-intolerant species, many of which regenerate from buried seeds or from seeds carried into the site by wind or animals. For example, regeneration after hurricane disturbance followed by salvage logging was characterized initially by many small-diameter stems and opportunistic species (*Rubus allegheniensis*) that regenerate from buried seeds (Elliott et al. 2002). Sites with a high abundance of species that resprout following disturbance are less likely to have new individuals establish, but may maintain young forest structure if early and mid-successional species dominate the canopy. Regeneration from seeds may also increase the time to canopy closure, when compared to sites with residual plants (those remaining after the disturbance) or a high abundance of species that resprout (Turner et al. 1998).

In general, only the most severe disturbances, such as catastrophic windstorms, fire, or landslides, create extensive early successional habitats. However, repeated natural disturbances, management following a disturbance event, or disturbance following management action could effectively increase disturbance severity or increase the duration of early successional species or structure (Elliott et al. 2002; Gandhi and Herms 2010; Kupfer and Runkle 1996). Frelich and Reich (1999) pointed out the importance of cumulative disturbance severity in maintaining early successional species or initiating catastrophic conversion of late successional to early successional species. Cumulative disturbances also are likely to maintain early successional habitats by preventing establishment of late successional species.

3.3 Disturbance Patterns Within the Central Hardwood Region

Some parts of the Central Hardwood Region are more susceptible than others to particular disturbance types. Understanding the variation in disturbance types and frequencies within the region can guide management actions to promote or sustain early successional habitats (see Shifley and Thompson, Chap. 6).

We used spatial information to examine the patterns of natural disturbances within the Central Hardwood Region. A Geographic Information System (GIS) coverage for ice storm potential (freezing rain) was derived by geo-referencing Fig. 3.1 (a map of the annual number of days with freezing rain as defined by 988 weather stations from 1948 to 2000) from Changnon and Bigley (2005). Line coverage of historical North Atlantic tropical cyclone tracks, 1851–2000 (NOAA 2009) was used to generate a density map of tropical storm occurrence within the region. Tornado density was calculated in ArcGIS (v. 9.3) using United States tornado touchdown points 1950–2004 (NWS 2005). A landslide coverage was based on a spatial index of landslide susceptibility and occurrence (Godt 1997). Raster digital data for mean fire return interval were obtained from LANDFIRE (US Forest Service 2006). The base maps for these disturbances are shown in Appendix I.

To evaluate the patterns of the combined disturbances, we first scaled each disturbance (0–100 scale) among 17 ecoregions (US Environmental Protection Agency 2009) contained within the larger Central Hardwood Region and calculated the mean value of each scaled disturbance weighted by the number of pixels that represented the disturbance within the ecoregion. We used principal components analysis (PCA) to identify linear combinations of the five disturbance types over the ecoregions. It is important to note here that base disturbance intensity differs among the disturbance types. For example, the landslide coverage includes both susceptibility and occurrence; ice storm potential is assessed through data on the days of freezing rain rather than ice storm damage; tropical storms vary in intensity; and mean fire return interval includes a range of severity from understory to stand-replacing fires.

The predominant disturbance type varies among ecoregions within the larger Central Hardwood Region (Figs. 3.2, 3.3). The first two principal components explained 77% of the variance in disturbances among the ecoregions. Axis 1 correlated positively with tornados (0.90) and negatively with landslides (−0.88) and tropical storms (−0.80). This axis represents an east–west gradient (Fig. 3.3) from tropical storms, the predominant disturbance in the east, to tornados in the west (Table 3.1, Fig. 3.2). The frequency of tropical storms decreases from the Piedmont (ecoregion 45, Table 3.1) and adjacent Blue Ridge (ecoregion 66) westward to the Ridge and Valley (67), Central Appalachians (69) and Western Allegheny Plateau (70), which are more susceptible to landslides (Figs. 3.2, 3.3; Table 3.1).

Principal component Axis 2 correlated positively with fire return interval (0.82) and negatively with freezing rain (ice storm potential) (−0.81). Not surprisingly, northern extensions of the region, including the Huron and Erie Lake Plains (57), Southern Michigan and Northern Indiana Drift Plains (56), and Eastern Corn Belt Plains (55) have the highest occurrence of freezing rain (Table 3.1; Figs. 3.2, 3.3). Western regions, from the Central Corn Belt Plains (56) south to the Ouachita Mountains (36), have the highest occurrence of tornados, but areas farther north (56) also experience freezing rain and more southern regions (36, 37, 38) experience frequent fire (5–15 year fire return intervals, Appendix I). The Appalachians and adjacent Plateau regions are an exception to the north – south gradient from freezing rain to high fire return intervals (Fig. 3.3); relatively high rainfall results in

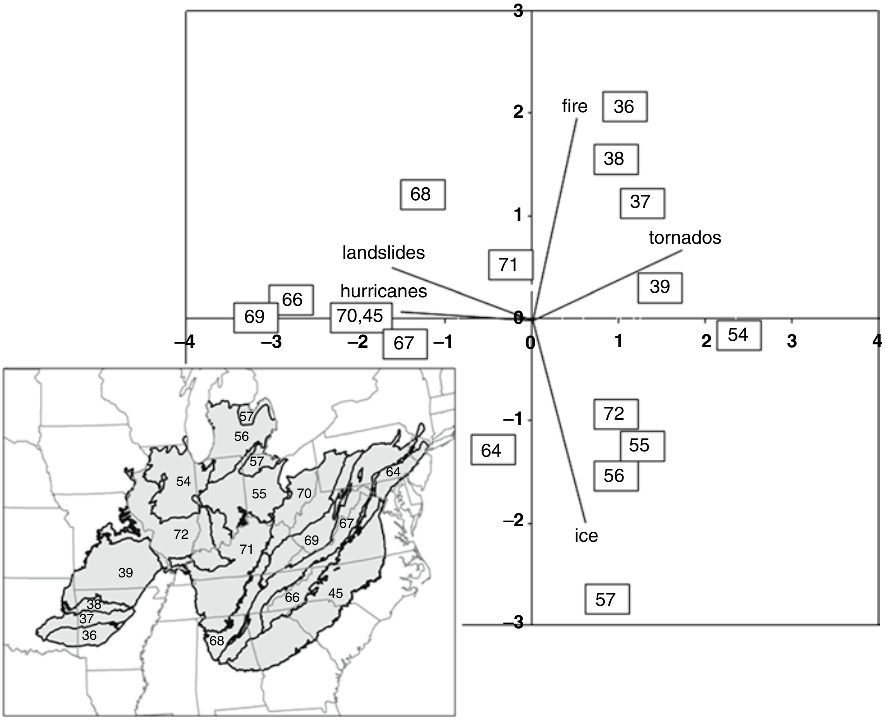


Fig. 3.2 Ecoregions of the Central Hardwood Region and five disturbance eigenvectors (*scaled to unit length*) plotted on the first and second principal component axes. Names of the numbered ecoregions are given in the text

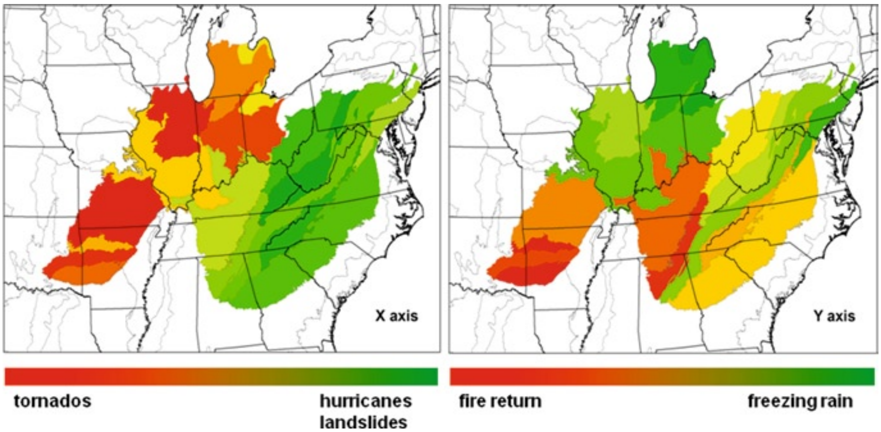


Fig. 3.3 Ecoregions of the Central Hardwood Region color-coded by their PCA scores (*first (X) and second (Y) axes*). First axis scores were positively correlated with tornados and negatively correlated with landslides and hurricanes. Second axis scores were positively correlated with fire return interval and negatively correlated with freezing rain

Table 3.1 The likelihood of experiencing disturbances within each ecoregion

Ecoregion	Freezing rain days/year	Tornados #/ km^2/10 year (×10^{-3})	Trop. storms #/ km^2/10 year (×10^{-5})	Fire return interval (years)
56	3.8	1.8	2.4	14.6
67	2.9	0.9	8.9	9.2
57	3.9	1.6	6.2	23.4
54	4.3	2.6	2.5	3.9
64	3.8	1.9	11.9	8.9
55	4.1	2.0	3.8	14.9
70	2.7	0.6	3.6	8.6
69	2.1	0.3	5.1	12.7
72	3.4	1.7	4.0	12.9
45	2.4	1.2	12.8	7.3
71	1.8	1.5	5.9	9.1
39	3.4	1.5	3.7	4.5
66	3.0	0.4	12.0	7.8
68	1.0	1.5	12.0	8.0
38	2.3	1.0	11.8	3.4
37	2.0	2.7	8.5	7.8
36	1.3	1.2	9.7	5.0

Information about the temporal scale and data sources for each disturbance is included in the text. Qualitative data for landslide incidence and susceptibility could not be averaged and thus were not included in the table. Averages for freezing rain (days/year) and fire return interval (years) were derived from area-based spatial data (Appendix 1) and were weighted by the proportion of area representing different values within the ecoregion. Tornados are the number of touchdowns points per km^2 per decade within the ecoregion. Tropical storm values were derived from storm tracks (line data, Appendix 1), and are reported as the number per km^2 per decade within the ecoregion

longer fire return intervals and higher elevations likely experience more frequent freezing rain or ice (Table 3.1).

Variation in natural disturbances over the Central Hardwood Region is likely to result in different patterns and probabilities of early successional habitats being created or maintained. Catastrophic windstorms, associated with tropical storms and hurricanes in the east and with tornados in the west, can create patchy and sporadic early successional habitats, although research suggests these storms generally are below the threshold needed for the initiation of extensive early successional stands unless followed by management (e.g., salvage logging) or a subsequent natural disturbance (Elliott et al. 2002; Gandhi and Herms 2010; Kupfer and Runkle 1996; Peterson and Leach 2008) that increases disturbance severity. In the Piedmont (eastern) and Ouachita (southwestern) ecoregions, fire is the most likely natural disturbance to act in concert with wind (Fig. 3.3). Historically, these fires were initiated by Native Americans, settlers, or lightning; today they are most likely to be initiated by land managers (see Spetich et al., Chap. 4).

In northern ecoregions, as well as on slopes and ridges of the Appalachians, ice storms are most likely to cause damage to the canopy. Susceptibility to ice storms may be greatest on steep slopes (Mou and Warrilou 2000) and damage can be more intense on edges (Millward and Kraft 2004). However, ice storms often do not lead to change in forest composition, although growth of understory species can slow recovery, especially in larger gaps (Mou and Warrilou 2000). Slopes of the Appalachians and adjacent Plateaus also are susceptible to, and have a high incidence of, landslides. These localized disturbances have high heterogeneity, with patches of unstable exposed soil, erosional and depositional zones, and an initial mix of surviving vegetation and early colonists (Myster and Fernandez 1995; Francescato et al. 2001; Walker et al. 2009). Rates and trajectories of succession can be highly variable on landslides (Francescato et al. 2001; Walker et al. 2009); early successional herbs and patches of shrubs can persist for decades or be replaced more rapidly by forest species (Francescato et al. 2001; Walker et al. 2009).

The presettlement forest landscape, except of course on sites of Native American cultivation, was largely forests whose dominant trees often survived to reach ages of 300–500 years. The mortality of canopy trees therefore occurred at low rates, probably varying from about 0.05% to 2% of canopy trees per year (Runkle 1982; Busing 2005). Large stand-replacing natural disturbances were always infrequent relative to tree lifespans, with return intervals in the 100s of years. Thus, return intervals are longer than the current forests have existed (Hart and Grissino-Mayer 2008; Lorimer 2001; Schulte and Mladenoff 2005). For example, Hart and Grissino-Meyer (2008) found evidence of only one stand release, in the 1980s, in an oak-hickory forest that established in the 1920s. Less severe disturbances, those that do not lead to stand replacement are, of course, more frequent.

Return intervals of particular disturbances at small scales are affected by local factors, such as topography, as well as regional factors such as climate. There are several challenges in predicting natural disturbance return intervals at a local scale. First, they are scale dependent. For instance, the return interval for tropical storms over the last 100 years in the state of North Carolina as a whole (139,396 km^2) is about 1.3 years (www.nc-climate.ncsu.edu). The return interval for Orange County, North Carolina, an inland county of 1,040 km^2 is about 50 years, while the return interval for a particular stand of trees within Orange County is in excess of 100 years (see also Busing et al. 2009). A second challenge is that disturbance rate and severity are contingent, proximately, on current structure and composition and, ultimately, on successional history. Thus, the disturbance rates in the homogeneous forests of the present, with their high densities and uniform canopy of trees that are smaller than old growth forests, are themselves a result of the synchronous origin of these stands some 70–100 years ago. A third challenge is that cumulative effects of repeat or multiple disturbances are more likely to produce early successional habitats than single events (Frelich and Reich 1999). A fourth is that invasive pest species are still spreading in this region. Finally, disturbance rates and severities are likely to change with changing climate and socioeconomic factors. Wear and Greis (Chap. 16) forecast how forest type and age class distribution might change over the next 50 years in response to biophysical and socioeconomic dynamics. Below, we discuss the linkage between natural disturbance and early successional habitats at the landscape scale.

3.4 Natural Disturbance and Early Successional Habitats on the Landscape

At landscape and regional scales, we can ask: how do natural disturbances affect the amount and distribution of early succesional habitats and is this pattern dynamically stable (i.e., in equilibrium and likely to be maintained) over time? A strict definition of equilibrium is "quantitative" equilibrium or "shifting mosaic steady state" in which disturbance rate is constant and the percentage of various patch types and stand ages, including early successional vegetation, is constant through time at large spatial scales. Given all the historic and present disturbances that impact forests of the Central Hardwoods Region, quantitative equilibrium is unlikely. A less stringent form of dynamic stability is "qualitative" or "persistence" equilibrium (see discussion in White et al. 1999) in which the rate of disturbance and size of disturbance patches vary, but within boundaries such that patch types, stand ages, and the species associated with these conditions fluctuate from year to year but do not disappear at large spatial scales. Qualitative equilibrium is more likely, and given that it suggests persistence of species dependent on all patch types, may be a reasonable standard for conservationists and managers.

Given (1) the narrow age range of current forests, (2) observations in the literature which suggest later successional species in understories increase after disturbance, and (3) the low probability of stand-replacing natural disturbances, large patches of early successional habitats may be declining on the landscape. However, disturbances do create edges. Light, nutrient, and seed dispersal gradients across edges allow open-site and early successional species to establish and persist in edge zones. For example, edges between forests and agricultural fields had a greater number of light-demanding species than forests interiors, and south-facing edges were as wide as 23 m (Honnay et al. 2002). In forest edges younger than 6 years, most edge-oriented species were close to the edge, with distributions related to light and light-related variables, but some species had peak density up to 40 m into the forest (Matlack 1994). Species composition and distribution patterns characteristic of edges persisted up to 55 years after edges were closed by succession (Matlack 1994).

Canopy gaps and similar disturbance patches also contain light, nutrient, and seed dispersal gradients that promote early successional forest composition and young forest structure. For example, canopy openness in 3-year-old experimental gaps greater than 20 m radius in bottomland hardwood forest declined linearly from the open center (>20% canopy openness) across the edge (>10% canopy openness) to more than 60 m (<5% canopy openness) into the surrounding forest (Collins and Battaglia 2002). Ten years after the gaps were created, the centers had a young forest canopy; species composition differed from gap centers into the surrounding forest, with wind-dispersed species more common in gap centers (Holladay et al. 2006). In a high-latitude Scots Pine (*P. sylvestris*) and Norway Spruce (*Picea abies*) forest, cumulative photosynthetically active radiation (PAR) was asymmetrically distributed around a canopy gap (deChantal et al. 2003). PAR decreased from 1,100 MJ m^{-2} in the gap to 300 MJ m^{-2} beneath surrounding forest over 20 m on the north side and over 36 m on the south side of the gap. After only two growing seasons, there was evidence that the asymmetric distribution of light and resources could contribute to Scots Pine and Norway Spruce becoming dominant in different parts of the gap.

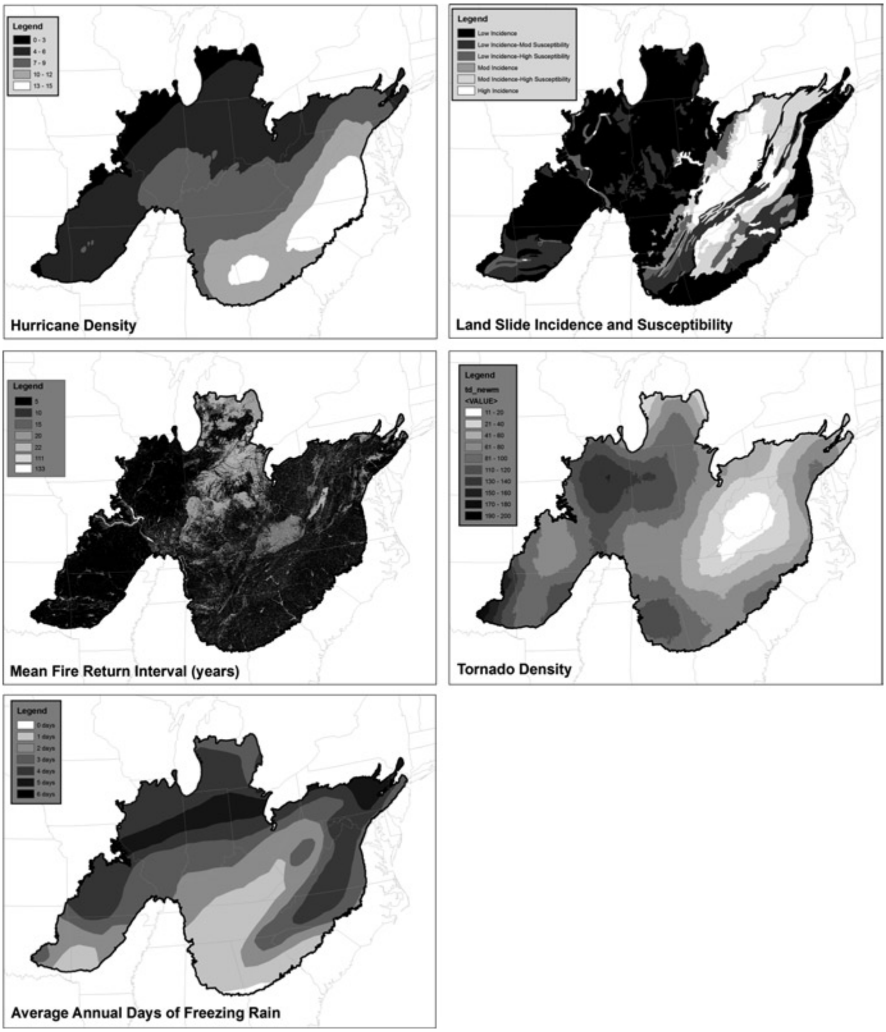
Other mechanisms will also create refuges for early successional species at landscape and regional scales. Habitat fragmentation with urbanization and second home construction will increase edge habitat. Alien pests and pathogens that affect central hardwood forests, such as the emerald ash borer (*Agrilus planipennis*) and hemlock woolly adelgid (*Adelges tsugae*), will continue to create canopy openings. However, the relative homogeneity of stands ages in the Central Hardwood Region and current regeneration patterns in these forests suggest that early successional habitats will decline as these forests age. There are therefore concerns for particular management units, in terms of loss of heterogeneity and early successional habitats. Nonetheless, there are many processes that support the local regeneration of early successional species across this region. Unfortunately, data are not often collected at relevant scales to evaluate the net balance of these sets of processes.

3.5 Conclusion

The synchronous origin and narrow range of stand ages in the Central Hardwood Region will have implications for decades to come (see Shifley and Thompson, Chap. 6). Variation in the types and frequencies of natural disturbances creates a range of early succession and young forest species composition and structure; thus, scattered to connected patches of early successional habitats generated by natural disturbance are likely to be represented in the central hardwood forests of tomorrow. However, the narrow range of stand ages, reduced structural heterogeneity, current successional processes, and low frequency of disturbance at the local scale suggest loss of abundant early successional habitats, at least that generated by natural disturbance alone, at a scale relevant to conservation and management. We do not know if the frequency, patch size, and spatial distribution of natural disturbance-generated early successional habitats will be sufficient to sustain biological diversity (or for any other management goal). Additional research is needed on the scale-dependence of natural disturbance return intervals, the interactions among specific disturbance types, the impact of new invasive pests, and the potential influence of climate change on the frequency and intensity of natural disturbance events.

Appendix I: Base Maps of Natural Disturbances Within the Central Hardwood Region

The map of Hurricane Density within the Central Hardwood Region was derived from line coverage of historical North Atlantic tropical cyclone tracks, 1851–2000 (NOAA 2009). The Landslide map was based on a spatial index of landslide



susceptibility and occurrence (Godt 1997). Raster digital data for Mean Fire Return Interval were obtained from LANDFIRE (US Forest Service 2006). Tornado density was calculated in ArcGIS using United States tornado touchdown points 1950–2004 (NWS 2005). The map of ice storm potential (Freezing Rain) was derived by geo-referencing Fig. 3.1 (a map of the annual number of days with freezing rain as defined by 988 weather stations from 1948 to 2000) from Changnon and Bigley (2005).

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Attachment 07

Landscape patterns of wildfire and prescribed fire on the Pisgah and Nantahala Forests

Landscape patterns of wildfire and prescribed fire on the Pisgah and Nantahala Forests

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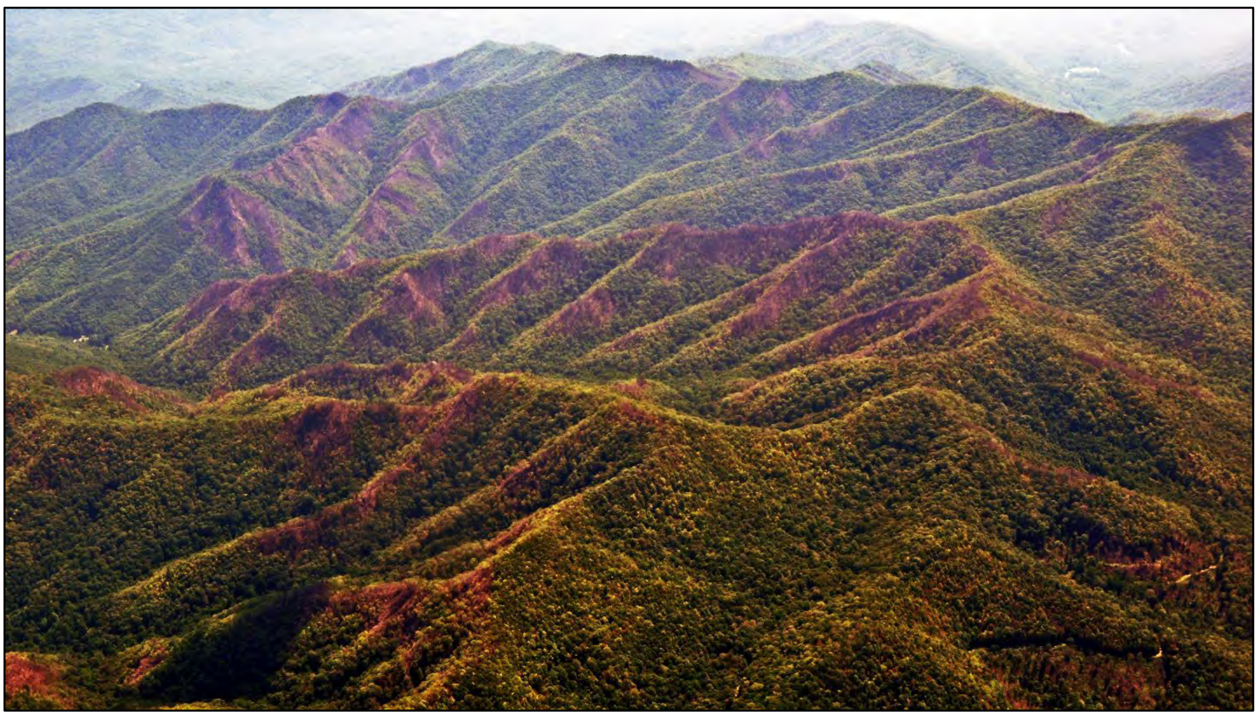
2021
Asheville, NC



Abstract

As wildfire and prescribed fire become more common across western North Carolina there is need for understanding fire effects from a landscape perspective. How do effects differ in these mountains, and why? Where are we moving toward management objectives and where might we be departing from it? What are the risks across jurisdictions, and how does that relate to long-term resilience? To build a foundation for these fundamental and broad questions, this report describes landscape patterns of fire severity for 34 wild and prescribed fires in the Nantahala and Pisgah National Forests that occurred between 1999 and 2019 using remote sensing. This research shows that xeric slopes and vegetation types are more likely to experience a reduction in canopy NDVI by the growing season after fire, while rich coves, in particular, experience little detectable change. Across this xeric to mesic montane gradient, these patterns suggest that canopy change after fire is predictable from an environmental gradient perspective, and that quantification of these patterns through remote sensing can inform basic forest management and planning decisions. For the fires examined, prescribed fire was ten times less likely than wildfire to be severe overall. Large patches were more common in wildfires, particularly those that burned during droughts and in the summer on the Grandfather Ranger District. The sparse and fine-textured canopy change from fire in coves suggests that gap-phase processes dominate there rather than the patch-phase dynamics that are common on xeric slopes and vegetation types. These insights can inform where and how sites are prioritized and managed for fire-associated stand restoration.

Keywords: Wildfire, prescribed fire, early successional habitat, resilience, remote sensing, NDVI, landscape pyrodiversity.

Summary points

- Wildfire and prescribed fire have reinforced existing topographic and vegetational patterns of forest heterogeneity despite the role of chance event-specific factors like fire weather or fire management decisions that also playing a role.

- The effects of prescribed fire in western North Carolina have been proportionately lower than that of wildfire suggesting that repeated burns will be required for targeted landscape restoration efforts to be achieved.

- While severe drought-associated wildfire can rapidly restore some desired forest structural components, they also bring tradeoffs that may erode ecological resilience and threaten the wildland urban interface.

The Author

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Cover photo: The fall 2016 Tellico wildfire on the Nantahala District taken from July 2017 showing a range of fire severities. Photo credit: Kenny Frick, US Forest Service.

Introduction

Wildland fire has a storied ecological and social history across the Southern Appalachians that extends back centuries (Lafon and others 2017). Lightning ignitions do occur, and fires set by lightning during late growing season droughts could have burned for months and spread over vast areas regardless of human influence. Yet as humans have occupied this landscape for thousands of years, their ignitions may have overwhelmed those from lightning in ways that altered fire regimes over vast areas. Despite landscape fire being relatively rare today, these historical fires had complex effects on the region's vegetation because roughly half of the area's forest types harbor dominant species that are either tolerant of fire or that are in some way favored by it.

The flammability of the Southern Appalachians became readily apparent during the hot droughty fall of 2016 when multiple large wildfires burned across tens of thousands of acres of North and South Carolina, Georgia, Tennessee, and Virginia. Unimpeded by terrain, wildfires extended across jurisdictional boundaries and some burned continuously for weeks. As that smoky November came to an end, a season-ending firestorm erupted in the Great Smokies and Gatlinburg, Tennessee that led to the loss of thousands of homes and at least 14 lives. Since that historic tragedy, severe wildfire has been increasingly recognized as a possibility in some parts of the region, even as its likelihood and consequences remain poorly understood.

The paleo-ecological record of past fire from tree rings provides marginal insight into severe fire. For whatever reason, the Southern Appalachians has yielded only a few sites with multi-century-long fire records, only one of which was found in western North Carolina (Flatley and others 2013; Lafon and others 2017). These natural archives from fire scarred pines indicate that those sites burned frequently into the mid-1700s and charcoal records give us a suggestive glimpse into fire regimes going back millennia further (Lafon and others 2017). Frequent landscape fire is consistent with localized historical accounts that date from the late 1700s through the early 1900s—both the Cherokee and subsequent settlers burned until organized fire suppression began in the 1910s (Ayres and Ashe 1905; Bartram 1998; Fries 1922; Lafon and others 2017).

Some of the strongest evidence for regular landscape fire is the region's fire-adapted vegetation and the ubiquity of species that are arguably fire dependent, such as table mountain pine, pitch pine and mountain laurel (Barden and Woods 1976; Williams 1998). Some suggest that high frequency historical fire can help explain the persistence of many of the region's now-diminished treeless balds and canebrakes (Mark 1958; Platt and Brantley 1997). In addition to the presence of fire-associated species and vegetation, fire's prior importance is suggested by how certain vegetation types have drifted compositionally and structurally in the absence of fire. This change includes the successional replacement of oaks and hickories by mesic species and even decay regimes that become less than optimal without regular fire (Abrams 1992; Brose and others 2001; Carpenter and others 2021; Nowacki and Abrams 2008; Vose and Elliott 2016). The most effective way to sustain forest and species diversity in the Southern Appalachians seems to be to restore some fire, so the emerging forest management and planning questions are where to prioritize fire, and how and when to employ it.

Historical conditions provide baseline insights, and they can suggest what is needed to sustain natural systems, but the western North Carolina forests of today are substantially different than they were in the past. Many forests of western North Carolina were logged early in the 20th century about the time that fire exclusion became widespread (Davis 2000; Silver 2003; Newfont 2012; Spencer 2014; Spencer 2017). The widespread loss of American chestnut in the 1930s had additional successional and fire impacts on a scale that is hard to comprehend (Kane and others 2020). With regrowth, it is thought that within the forest, there is now far less early successional habitat than there was historically, and that much of that habitat loss resulted from the exclusion of fire (Harrod and others 2000; Rankin and Herbert 2014; Oakman and others 2019). Open forests may result from a single severe disturbance event or from high frequency disturbance that either leads to progressive canopy declines or that interferes with regeneration. In western North Carolina today, we see both fire effects at work: even-aged cohorts have established after severe fire events, particularly since 2000, and regularly scheduled prescribed fires are gradually creating and sustaining openings (Figure 1).

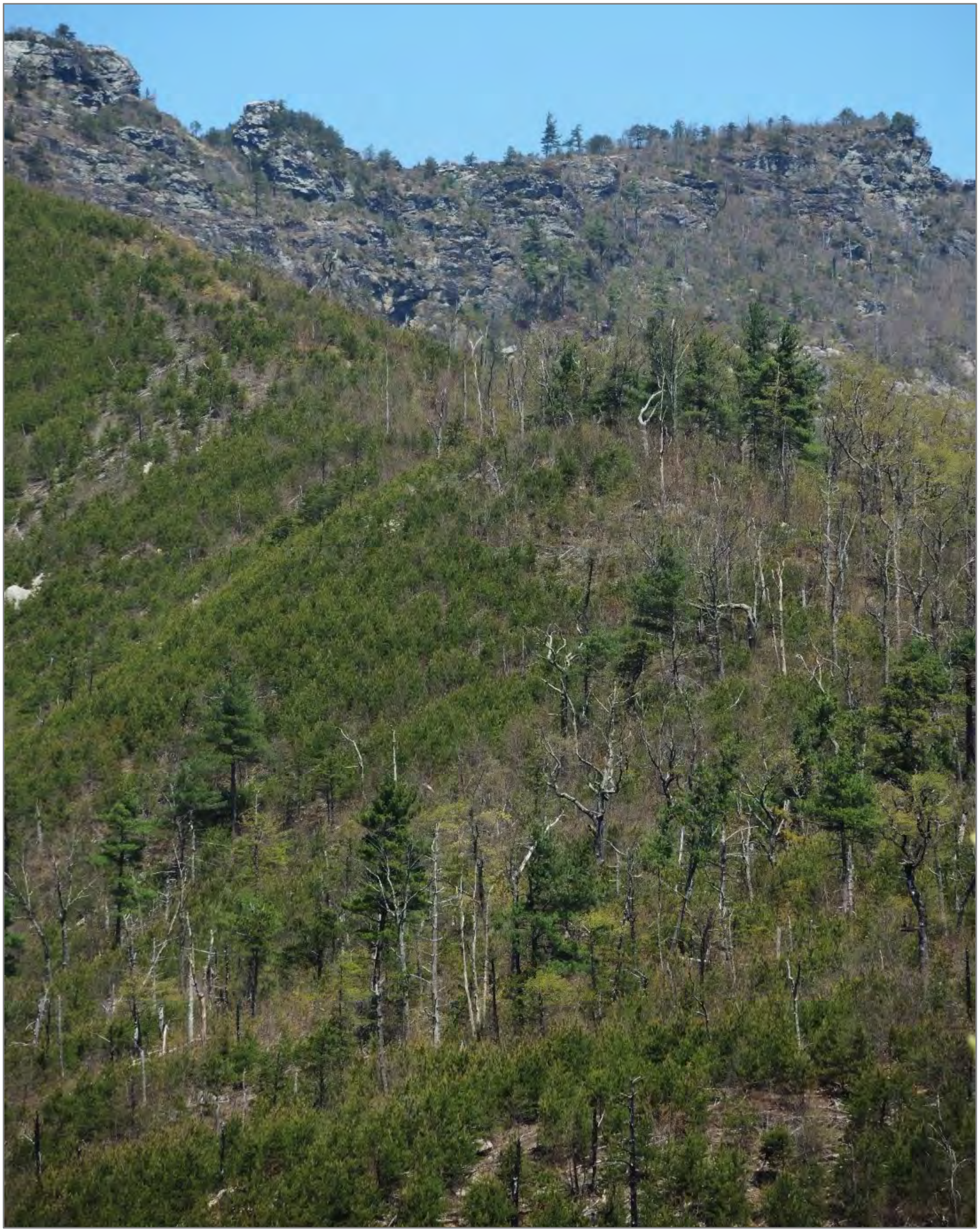

Figure 1: Six and a half years after the November 2013 Table Rock fire in the Linville Gorge Wilderness the even-aged patch regeneration of pine (at left and lower-bottom) stands out against the patch of partial mortality (at right and upper-bottom). Photograph by Steve Norman, US Forest Service, 2021.

Prescribed fire use on the national forests of western North Carolina did not begin until the 1970s. Burn objectives were narrowly defined to restore open habitat for the golden eagle (Barden 1978; Lindsay and Bratton 1979) and, later, to sustain habitat for golden mountain heather (Gross and others 1998). In the late 1970s, a burn was conducted in Madison County to facilitate pine regeneration after extensive mortality from the southern pine beetle, but it was not until 1990 that an experimental prescribed burn was conducted in the region's hardwood forest (Elliott and others 1999). Since then, the area burned by prescribed fire has greatly increased so that some mixed pine-hardwood units receive scheduled reburns at regular frequency.

As wildfire and prescribed fire becomes more common in this landscape, the effects of both on forest structure has become an important question for planning and monitoring. This research describes these gap or patch-forming fire effects over a two-decade period for the Nantahala and Pisgah National Forest areas.

METHODS

Fire occurrence data

Only a small fraction of the prescribed and wildfires that have burned since the 1980s have geospatial boundaries available. Most large wildfires that occurred on Forest Service land since 2000 have operational fire perimeters available from the National Interagency Fire Center (NIFC) (https://data-nifc.opendata.arcgis.com/). The US Monitoring Trends in Burn Severity (MTBS) project also includes large fire perimeters back to 1985, but these were derived from burn area mapping using Landsat 5, 7 and 8 (https://www.mtbs.gov/). As most fires in the east burn with low intensity and occur shortly before canopy green-up in the spring, these perimeters can differ for the same fire. This is due to the inherent difficulties in mapping light or patchy leaf litter effects after canopy green-up. Where available, operational perimeters were used in this research to include lightly burned areas and to correspond with the burn units that are recognized by managers. Historical prescribed fire boundaries were most difficult to obtain consistently. Prescribed fire perimeters on Forest Service land were obtained from the US Forest Service Geospatial Clearinghouse fuels treatment dataset (https://data.fs.usda.gov/geodata/).

Many fire effects could not be mapped due to limited availability and quality of satellite imagery, whether limitations of a pre- or post-fire scene. We sought representativeness across the Pisgah and Nantahala Forests and temporally across seasons, fire weather and drought conditions. We identified 12 prescribed fires and 22 wildfires that burned between 1999 and 2019 (Figure 2). Several fires were reburns, particularly in Linville Gorge where one area burned four times between 2000 and 2017. In addition, a portion of the Joyce Kilmer Slickrock Wilderness burned twice—once in 1999 and again in 2016. All portions of the forest burned prior to 1999, but this was often as far back as the early 20th century, but scattered records suggest that other areas partly burned as late as the 1950s.

NDVI as a vegetation and fire severity indicator

Landscape forest monitoring commonly tracks forest conditions over time using a compositionally or structurally sensitive gridded measure. Most efforts use some type of vegetation-sensitive index that is constructed from wavelengths of reflected light. The Normalized Difference Vegetation Index (NDVI) is among the oldest such indices (Tucker 1979), and it has been widely used to track land cover change and forest canopy health and tree mortality (Khodaee, and others 2020; Spruce and others 2011; Yang and others 2018). NDVI normalizes the difference between the near infrared (NIR) and red bands as shown in formula 1.

Formula 1.

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$$

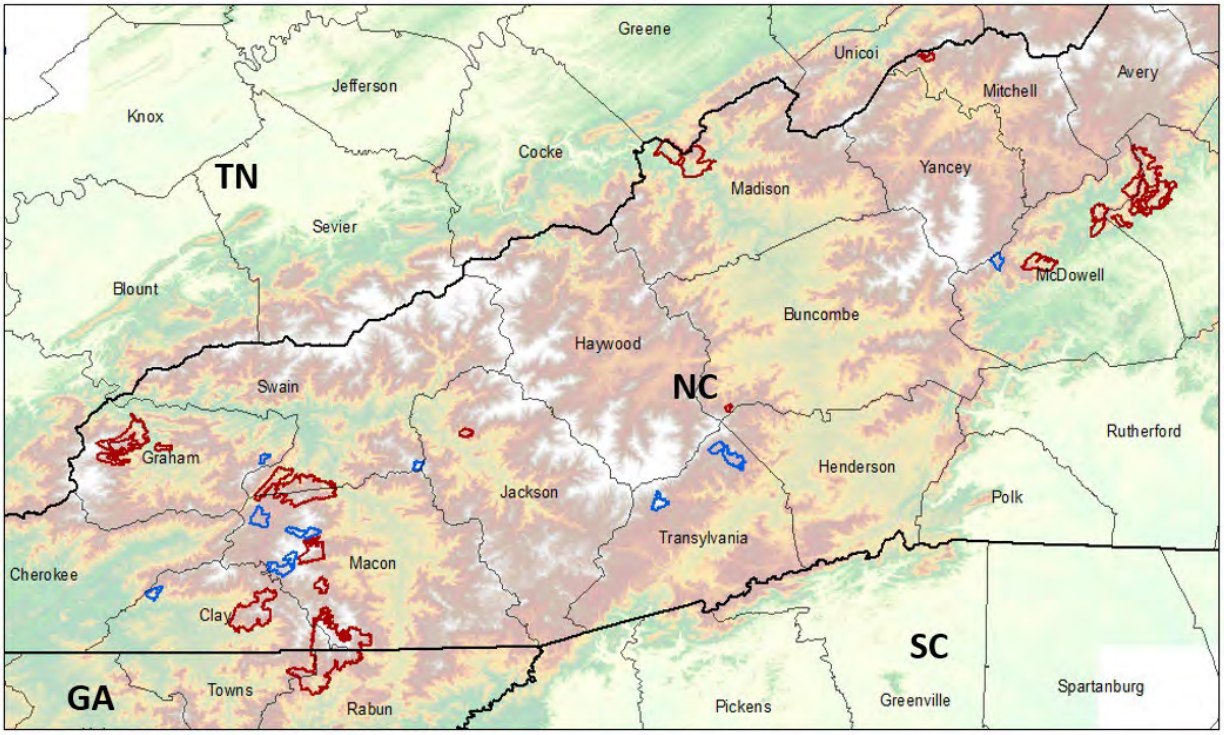

Figure 2: The location of the wildfires (red) and prescribed fires (blue) used in this analysis.

NDVI's use for monitoring fire-associated canopy mortality has been demonstrated for a range of vegetation types. In recent years, the Normalized Burn Ratio (NBR) has been widely adopted for use in satellite-based remote sensing efforts, and it is particularly useful in dry, open canopied coniferous forests (Eidenshink and others 2007; Chen and others 2011; Miller and Thode 2007; Warner and others 2017). Use of NBR has limitations compared to NDVI, including the lower grid resolution for recent fires and the less efficient capacity of the index to create multi-date mosaics which are often needed for eastern landscapes given frequent cloud cover in the east. NDVI is also especially powerful for tracking other forms of disturbance and patch-phase succession, so it is arguably among the most robust remote sensing tools for integrative landscape forest monitoring.

In this research, change in growing season NDVI is defined as a measure of canopy severity, and decline correlates with both canopy mortality or growing season stress across the grid cell. The ability of this gridded measure to resolve individual tree mortality depends on the size of the tree crown with respect to the grid resolution. Small individual tree gaps are often unresolvable even at the 10m resolution that's available from Sentinel-2 imagery, while gaps and patches involving multiple canopy tree losses are relatively easy to resolve at Landsat's 30m resolution. To capture change to the deciduous forest canopy, pre- and post-fire conditions are only compared for the growing season rather than the spring, fall or winter season when NDVI can only capture the conifer canopy or understory evergreen condition and when within-canopy shadows and topographic shadows are more problematic.

For each fire, NDVI change was analyzed using Google Earth Engine and the *HiForm.org* NDVI change script. When available, individual dates were used for the baseline and post-fire conditions, but in other cases to overcome clouds and hazy atmospheric conditions, full NDVI growing season mosaics were used using a maximum NDVI value compositing technique. The actual dates used for each fire are shown in *Appendix 1*. Change was calculated as the absolute difference between the baseline and post-fire NDVI as absolute change captures subtle drops in high-NDVI forests without exaggerating change in low NDVI shrub or woodlands as results from the percent change formulation that is sometimes used.

In this fire severity analysis, the targeted phenomenon to capture is canopy mortality. Aerial imagery is available roughly every two years since 2004 and this varies in resolution from 0.6 to 1m and most imagery was captured during the growing season. These high-resolution products are imperfect for image interpretation due to terrain and tree displacement that are more common than with satellite imagery. Differences in illumination and forest density also make it difficult to resolve individual crowns.

We used a combination of 30m-resolution Landsat-5 or 8 and 10m-resolution Sentinel 2 satellite imagery, deferring to the latter when it was available after 2016. With nine times the detail of Landsat, Sentinel-2 can resolve finer changes in tree canopy and gap structure. This finer resolution is more likely to resolve the mortality of individual trees and tree gaps that can occur with low to moderate severity wildfire (Figure 3).

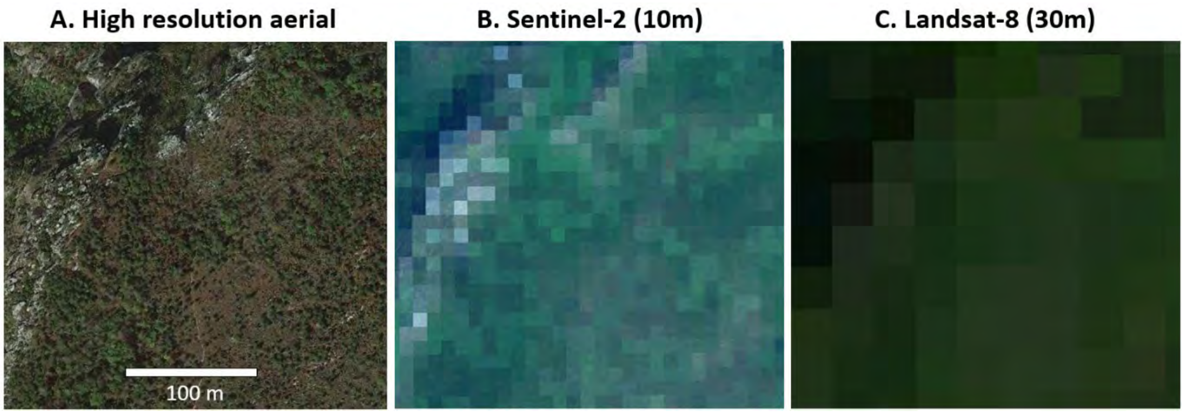

Figure 3: A comparison of grid-resolution a (a) 0.5m resolution aerial photo, (b) 10m Sentinel-2 and (c) 30m Landsat-8 in the Linville Gorge, Pisgah National Forest, NC.

Growing season-to-growing season canopy change was associated with fire severity by independently mapping canopy mortality using sub-meter imagery taken before and after the burn for selected areas. Ideally, tree mortality across the 20-year study period and two National Forests would be captured by 10 or 30m plots that are geo-located with respect to change imagery. As that is not possible retroactively, patch mortality polygons were drawn using high resolution aerial photographs from before to after three fires. These were the fall 2016 Rock Mountain wildfire using summer 2017 Georgia NAIP imagery and the 2007 Deweese Ridge prescribed fire using 2008 NAIP imagery. This technique was modeled after Lorber and others (2018) who used aerial imagery to hand draw high mortality for a large set of fires. In this research, I quantified change within lethal areas of these two fires to calibrate a high severity threshold for change from Sentinel-2 and Landsat-5, respectively. For both fires, this dNDVI value was -0.21, and that dNDVI threshold was used to define likely canopy mortality.

Multi-year delayed mortality is a known phenomenon after drought-associated fire in the Southern Appalachians, particularly on xeric sites (Carpenter and others, 2021). This project's reliance on growing season conditions after spring or fall fires means that only mortality that occurred from a few months to a half year after fire could be captured by this analysis. Even high-resolution satellite remote sensing can have difficulty resolving delayed mortality in the Southern Appalachian ecosystem due to rapid resprouting of trees and shrubs in the years after the burn. Field observations suggest that the best predictor for delayed mortality are areas of moderate to high severity where duff consumption is high and where fire can scar trees. No formal effort was undertaken to resolve this delayed mortality that occurred after the first growing season after fire for this analysis, although it was occasionally observed with 10m imagery as was general successional recovery.

While no systematic landscape-wide field validation of tree mortality was conducted for this regional effort, high fire severity was compared with analogous burn severity products generated by the Forest Service's Monitoring Trends in Burn Severity project when available for a subset of large wildfires, multi-year NDVI behavior from weekly 240m MODIS severity using the *ForWarn* system (http://forwarn.forestthreats.org), sequential views from meter or sub-meter NAIP aerial photographs, oblique aerial photos of select fall 2016 fires taken in July 2017 by the US Forest Service Forest Health Protection from light aircraft, and casual field observations for many of the fires that burned since 2015 to document mortality.

Point and patch analyses

The landscape scale objective of this analysis was to understand the underlying association of high canopy severity with coarse potential vegetation types and site moisture. Analysis of these associations within and among fires was achieved by extracting values from about 100,000 random points with a 30m minimum spacing using *ArcMap* 10.7.1 software. Raster values extracted during this step included fire name, season, fire type (wild or prescribed), potential vegetation type, TRMI and other topographic values. The extracted raster values were assembled into a matrix for data exploration and graphing. After eliminating edge values and non-target cover types, the matrix consisted of about 98,300 useful point extractions. These data provide statistical insights into the percent high, moderate and low severity for each wild and prescribed fire.

This extraction technique meant that these declines in post-fire growing season NDVI included a range of large patches and small tree clumps. To quantify the effects of these fires on large patch formation that are particularly important for some successional and habitat concerns, burn areas were converted to a 0-1 raster based on the high severity threshold, then severe values were converted to polygons to estimate patch area.

Ancillary datasets: site moisture and potential vegetation type

We characterized the fixed landform attributes of the landscape using a topographic relative moisture index (TRMI) derived from a 10m digital elevation model. This quantification of site moisture consisted of a three-part equally weighted relative index that integrated solar radiation, topographic position (relative to a 2km neighborhood circular mean) and drainage (a function of slope and flow accumulation). Each component was rescaled from 1 (wet) to 100 (dry), then averaged together and assigned to one of three categories—xeric, moderate and mesic using the mean and standard deviation of the greater region's TRMI values (Figure 4).

The vegetation type map used for this analysis was the same ecozone layer that was used for the vegetation analysis in the National Forest's current planning effort (Figure 5). The map shows general potential vegetation derived from plots and field observations that are modeled using elevation and topography (Simon 2005). Potential vegetation types do not show current conditions that result from severe disturbance, agricultural clearing, urban development, or logging. In montane areas such as western North Carolina, these patterns are largely reflective of topography, but the type is generalized to be considerably coarser than the 10m grid used in the site moisture index. Given that high fire severity often varies at very fine scales, that is at the 10m resolution of the TRMI, not just the broad forest type polygon, the integrated use of these two maps reveals heterogeneity of fire effects within potential vegetation types.

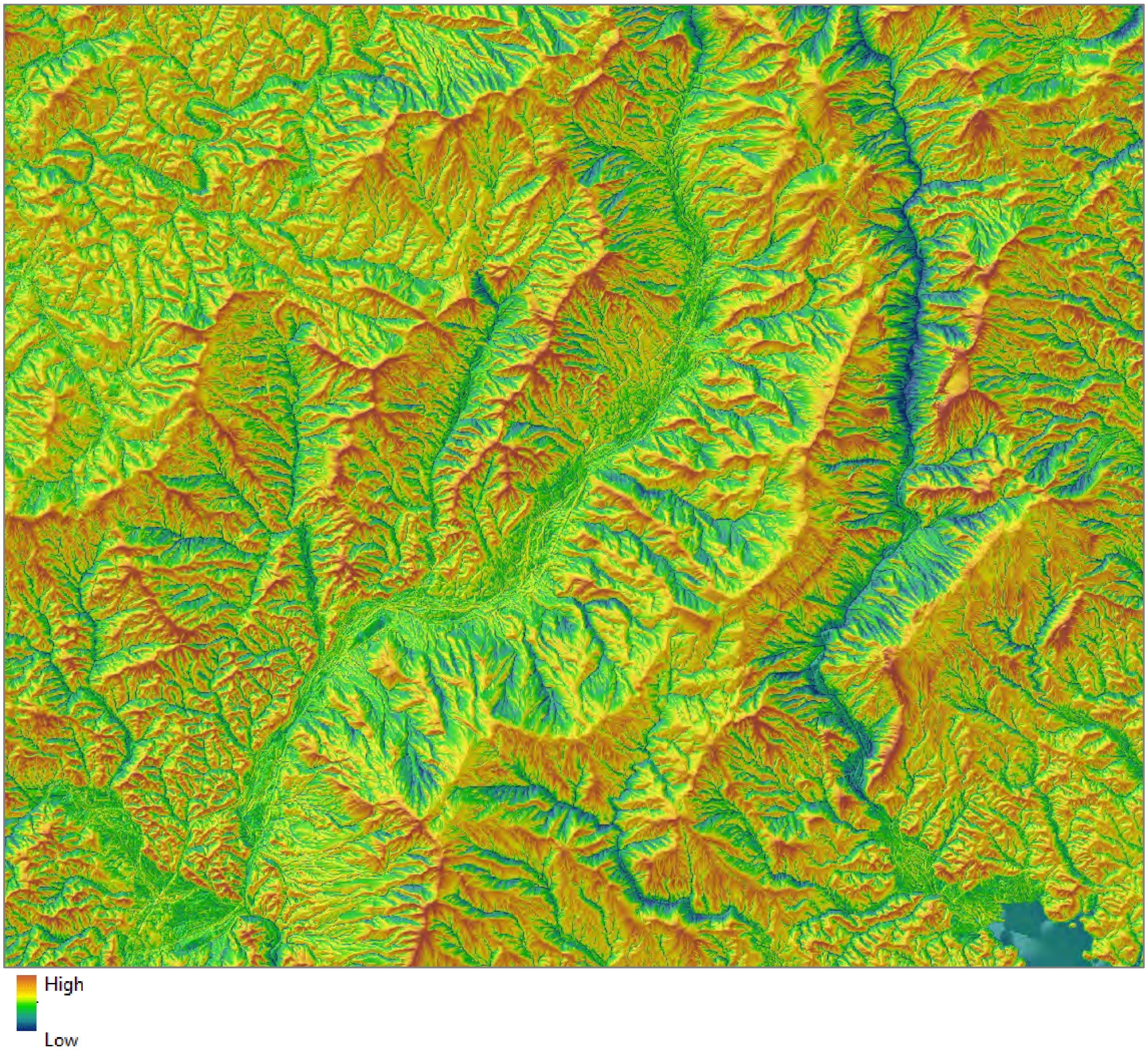

Figure 4: The 10m grid resolution Topographic Relative Moisture Index (TRMI) for a portion of the Grandfather Ranger District, showing Linville Gorge at right and the north fork of the Catawba valley at center. Lake James is at lower right. The mapped area shown is approximately 19km from west to east.

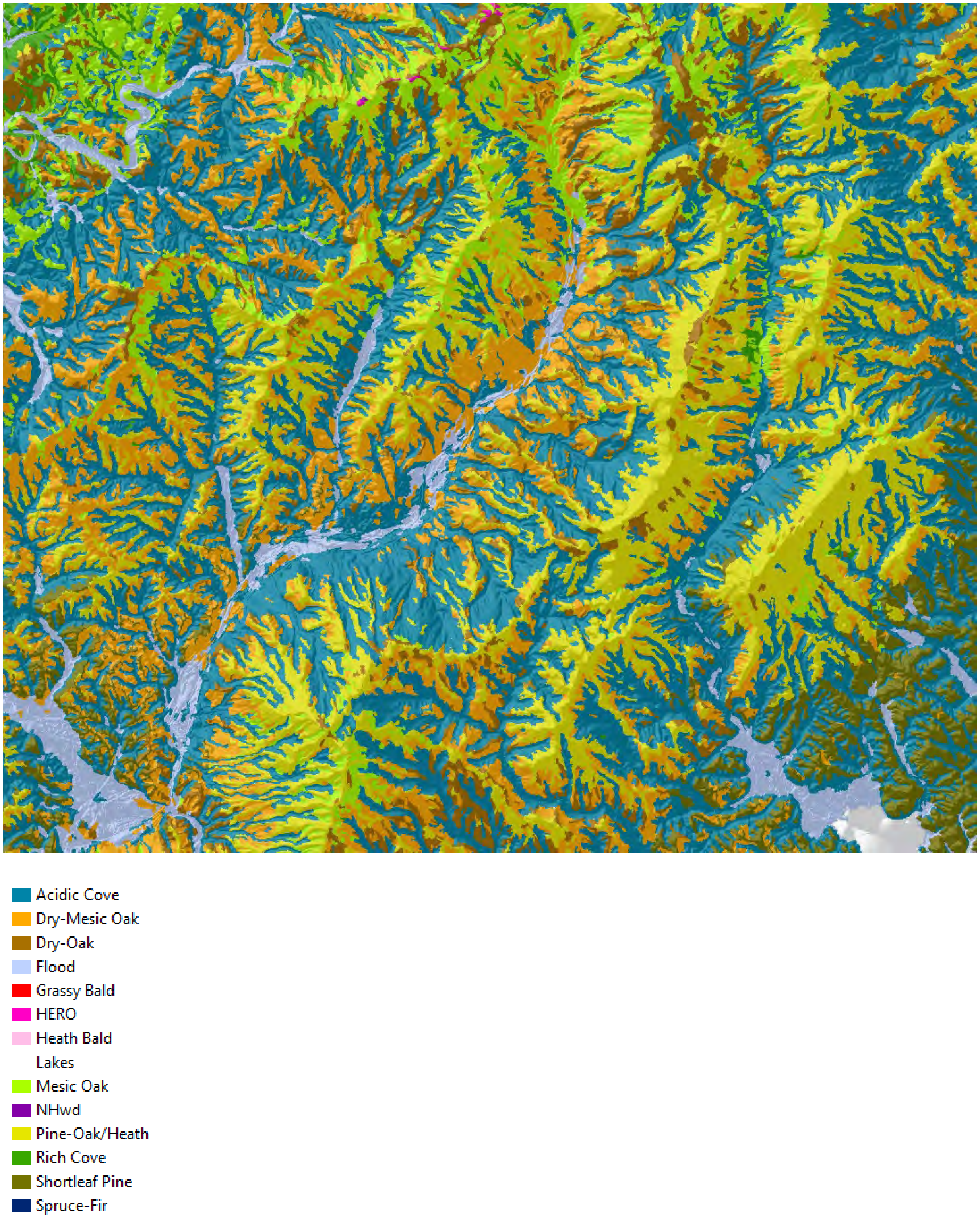

Figure 5: Ecozones for the same area shown in figure 4 above for a portion of the Grandfather Ranger District.

RESULTS

Twelve prescribed fires and 22 wildfires were selected for this analysis to represent the environmental diversity of the Nantahala and Pisgah forest region. Sampled fires come from eleven counties and four seasons that burned over two decades (Table 1).

Table 1: Western North Carolina prescribed fires and wildfires used in this analysis.

Fire name	Cause	Ignition	Acres Burned	National Forest	NC County
Prescribed fire					
2019 Appletree Rx	Rx fire	2019-Apr-23	2095	Nantahala NF	Macon
2016 Split White Oak Rdg. Rx	Rx fire	2016-Mar-7	838	Nantahala NF	Macon
2016 Fire Gap Rx	Rx fire	2016-Mar-8	1751	Nantahala NF	Macon
2010 Lost Bear East Rx	Rx fire	2010-Apr-5	1070	Pisgah NF	McDowell
2008 Pilot Mtn Rx	Rx fire	2008-Mar-22	1291	Pisgah NF	Transylvania
2008 Alarka Laurel Rx	Rx fire	2008-Dec-11	558	Nantahala NF	Swain
2007 Leatherwood Rx	Rx fire	2007-Mar-29	961	Nantahala NF	Clay
2007 Laurel Brook Rx	Rx fire	2007-Feb-28	2061	Pisgah NF	Transylvania
2011 Pink Beds Rx	Rx fire	2011-Mar-24	1017	Pisgah NF	Transylvania
2007 Highlands-Dirty John Rx	Rx fire	2007-Mar-9	850	Nantahala NF	Macon
2007 Deweese Ridge Rx	Rx fire	2007-Mar-14	844	Nantahala NF	Macon
2009 Cook Branch Rx	Rx fire	2009-Apr-18	442	Nantahala NF	Graham
Wildfire					
1999 Avey Creek Wf	Arson	1999-Nov-15	2099	Nantahala NF	Graham
1999 Goldie Deadon Wf	Arson	1999-Nov-15	1717	Nantahala NF	Graham
2000 Brushy Ridge Wf	Campfire	2000-Oct-28	12405	Pisgah NF	Burke
2001 Larman Wf	Arson	2001-Nov-12	3072	Pisgah NF	Madison
2007 Dobson Knob Wf	Lightning	2007-Jun-8	816	Pisgah NF	McDowell
2007 Linville-Shortoff Wf*	Lightning	2007-Jun-8	6466	Pisgah NF	Burke
2008 Sunrise Wf	Misc./Unknown	2008-Apr-18	1906	Pisgah NF	McDowell
2015 Bald Knob Wf	Lightning	2015-Jul-17	1268	Pisgah NF	McDowell
2015 Blue Gravel Wf*	Lightning	2015-Apr-14	521	Pisgah NF	Burke
2015 Poplar Wf	Arson	2015-Mar-31	768	Pisgah NF	Mitchell
2016 Boteler Wf	Lightning	2016-Oct-25	8627	Nantahala NF	Clay
2016 Camp Branch Wf	Arson	2016-Nov-22	3234	Nantahala NF	Macon
2016 Clear Creek Wf	Arson	2016-Nov-20	3493	Pisgah NF	McDowell
2016 Dicks Creek Wf	Misc./Unknown	2016-Oct-23	833	Nantahala NF	Jackson
2016 Highway 151 Wf	Other	2016-Nov-24	245	Pisgah NF	Buncombe
2016 Knob Wf	Arson	2016-Nov-2	1133	Nantahala NF	Macon
2016 Maple Springs Wf*	Arson	2016-Nov-4	8438	Nantahala NF	Graham
2016 Rock Mtn Wf	Arson	2016-Nov-9	24725	Nantahala NF	Macon
2016 Silver Mine Wf	Arson	2016-Apr-21	5510	Pisgah NF	Madison
2016 Tellico Wf	Arson	2016-Nov-3	13877	Nantahala NF	Swain-Macon
2017 Dobson Knob Wf	Misc./Unknown	2017-Apr-10	1720	Pisgah NF	McDowell
2017 White Creek Wf*	Lightning	2017-Mar-21	4166	Pisgah NF	Burke

*All or partially reburned within the prior 20 years

Fire severity varied considerably among fire types with wildfire being roughly eight times more likely to lead to a severe growing season NDVI decline than prescribed fire (Figure 6). Only stable and increased NDVI was higher for prescribed fire.

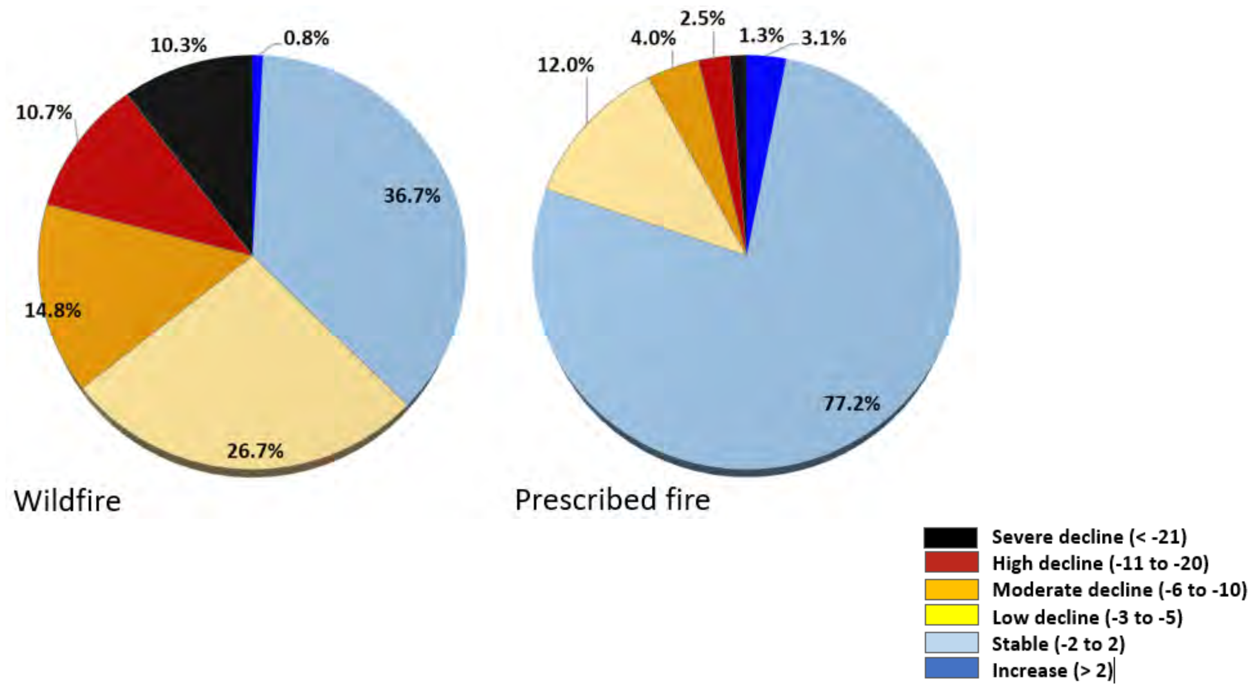

Figure 6: Fraction of wildfire and prescribed fire burning at different severities using the dNDVI thresholds shown in the legend at lower right.

The topographic footprints of wild and prescribed fire are not identical, and this could explain part of the observed variation in Figure 6. The two fire type's sampled density along elevational gradients is shown by thick black lines in Figure 7. Wildfires are more often at warmer and lower elevations than are prescribed fires. For a given elevation band, however, prescribed fires routinely burned with lower severity than wildfires. Elevations between 1,500-3,000' were particularly likely to burn with higher severity by wildfire than sites between 4000-5000', and this reflects the peculiar high severity of escarpment wildfires on the Grandfather Ranger District.

In addition to these elevational differences, severe fire was more likely to occur on drier slopes, particularly when wild (Figure 8; Table 2). Particularly strong was the TRMI component topographic position that showed more discrimination in severe fire than obtained from the solar radiation or drainage components or from TRMI overall.

As wildfire and prescribed fire may also differ in terms of the dryness of the sites that burned, Table 3 shows just how severe decline alone was observed across three TRMI site moisture classes compared to how often it would occur if by chance alone. Severe effects from prescribed fire are much less likely to occur on moderate sites and severe effects are more often restricted to just the driest sections of prescribed fire units.

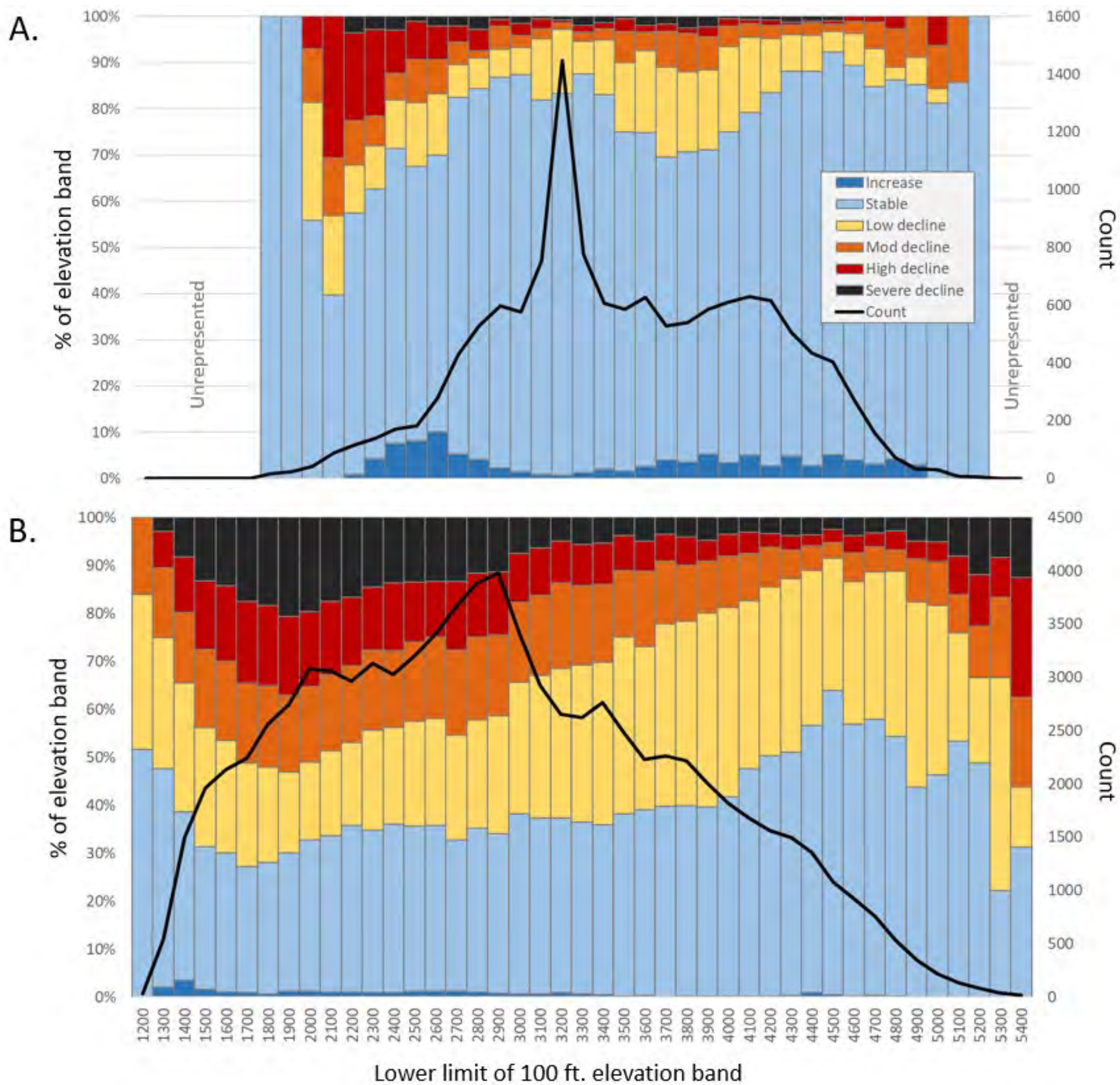

Figure 7: Differences in fire severity by elevation bands for (A) prescribed fires and (B) wildfires. The thick black lines shows the density of the sampled areas by elevation band.

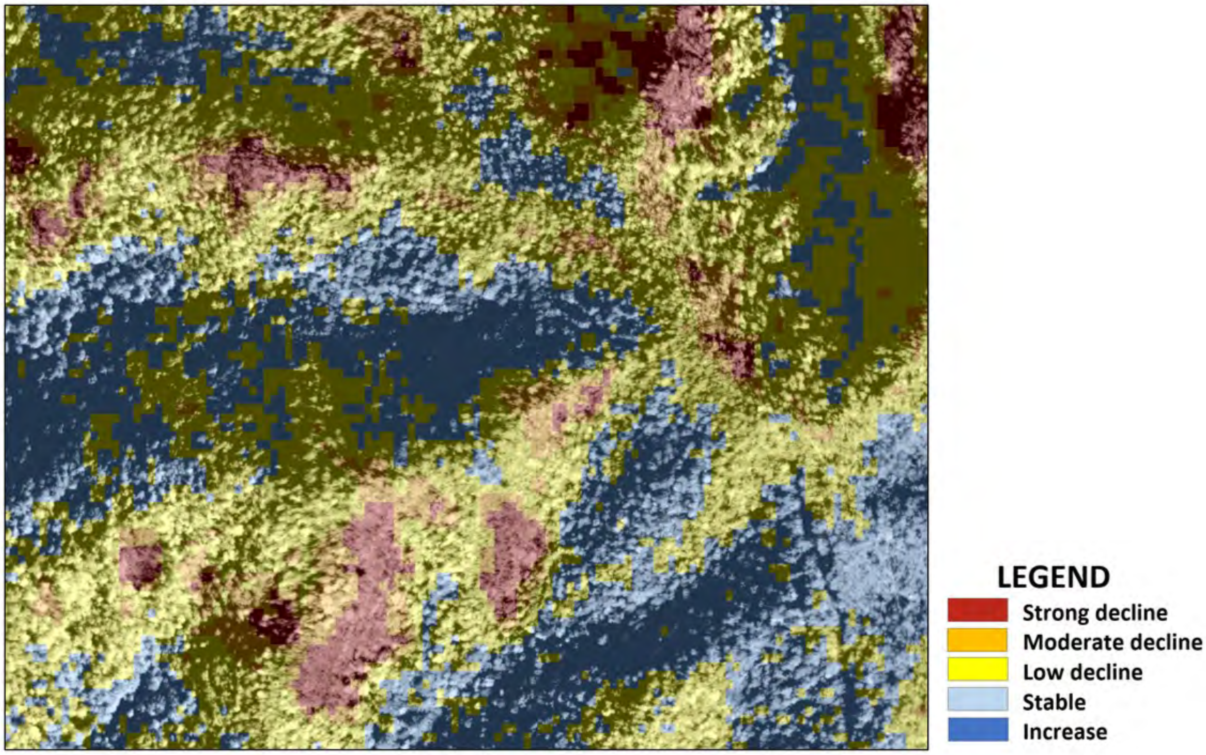

Figure 8: Change in NDVI (dNDVI) west of the Wesser Bald Fire Tower after the 2016 Tellico fire aligns well with topography. In contrast to the moderate to strong decline on most ridges, the larger and taller tree crowns of coves are relatively stable.

Table 2: Fire severity by constituent topographic variables and overall site moisture (TRMI) for selected wild and prescribed fires of the Pisgah and Nantahala Forests, 1999-2019.

	Increase	Stable	Low decline	Moderate decline	High decline	Severe decline	Count
TRMI-Overall Mesic							
Rx Fire	3.5%	80.9%	12.9%	2.4%	0.3%	0.1%	1,796
Wildfire	0.8%	48.0%	28.4%	12.2%	6.4%	4.2%	13,840
TRMI-Overall Moderate							
Rx Fire	3.3%	79.1%	11.6%	3.7%	1.7%	0.5%	8,604
Wildfire	0.8%	38.6%	26.7%	13.8%	10.2%	9.8%	49,726
TRMI-Overall Xeric							
Rx Fire	2.3%	69.5%	12.3%	5.9%	5.9%	4.1%	3,027
Wildfire	0.7%	24.7%	25.8%	18.8%	14.6%	15.3%	21,153
TRMI-Solar radiation Mesic							
Rx Fire	3.2%	79.4%	12.3%	4.1%	0.8%	0.2%	3,271
Wildfire	0.8%	40.6%	28.2%	14.3%	8.6%	7.4%	22,988
TRMI-Solar radiation Moderate							
Rx Fire	4.2%	80.2%	11.1%	2.6%	1.5%	0.4%	2,874
Wildfire	0.9%	41.5%	26.6%	13.2%	8.9%	8.9%	18,765

TRMI-Solar radiation Xeric							
Rx Fire	2.6%	75.0%	12.1%	4.6%	3.6%	2.1%	7,282
Wildfire	0.8%	32.5%	26.0%	15.8%	12.6%	12.4%	42,966
TRMI-Drainage Mesic							
Rx Fire	2.7%	81.0%	12.5%	1.9%	1.5%	0.4%	1,270
Wildfire	0.9%	48.8%	24.9%	11.4%	7.7%	6.3%	7,417
TRMI-Drainage Moderate							
Rx Fire	3.0%	78.0%	12.4%	3.9%	1.8%	1.0%	5,025
Wildfire	0.7%	39.3%	26.6%	13.3%	9.9%	10.2%	29,423
TRMI-Drainage Xeric							
Rx Fire	3.2%	76.0%	11.5%	4.5%	3.1%	1.7%	7,132
Wildfire	0.8%	33.2%	27.1%	16.3%	11.7%	10.9%	47,879
TRMI-Topographic position Mesic							
Rx Fire	4.5%	79.1%	11.6%	3.3%	1.2%	0.3%	5,566
Wildfire	0.9%	46.8%	27.0%	11.6%	7.8%	5.9%	34,986
TRMI-Topographic position Moderate							
Rx Fire	2.2%	76.8%	12.1%	4.3%	3.1%	1.5%	7,136
Wildfire	0.7%	31.6%	27.5%	16.3%	12.0%	11.9%	40,269
TRMI-Topographic position Xeric							
Rx Fire	1.4%	67.4%	12.8%	6.6%	5.0%	6.8%	725
Wildfire	0.8%	20.8%	22.4%	20.5%	16.2%	19.4%	9,464

Table 3: Severe growing season NDVI decline relative to site moisture and expectations based on site and fire type differences.

	Mesic	Moderate	Xeric	Total
Prescribed fire				
Expected	13.3%	64.1%	22.6%	100.0%
Observed	0.6%	27.0%	72.4%	100.0%
Wildfire				
Expected	17.1%	58.6%	24.3%	100.0%
Observed	6.6%	56.1%	37.3%	100.0%

Fire severity varied among vegetation types. The pine-oak heath type was particularly notable as a severe decline was observed a quarter of the time (Table 4). This likelihood of decline was roughly twice that of the dry oak and dry-mesic oak types and three times that observed for the acid cove type. Much of this difference relates to the pine-heath type's occurrence on dry upper slope sites that regularly burned severely. It is unclear from these data if this tendency for severe fire depends more on the type's vegetation or fuel attributes or the inherent tendency of these sites for a particular fire behavior. The pine-oak heath type's association with high severity did not extend as strongly to prescribed fire that shows a severe decline only 3% of the time.

Dry oak and dry-mesic oak forests were more likely to experience severe fire than were mesic oak forests, and as these types were modeled using topographical gradients, that is expected. High elevation red oak burned more similarly to mesic oak forests than to dry oak or dry-mesic oak types, and this is consistent with the elevation gradient effects shown on Figure 7.

Acidic cove types showed considerably more high severity than rich coves, and this may relate to site or compositional differences. Acidic coves often have an ericaceous shrub understory that can cause spotty pockets of high severity. Other vegetation types were not well represented by the prescribed fires or wildfires used in this analysis.

Table 4: Fire severity by potential vegetation type for selected wild and prescribed fires of the Pisgah and Nantahala Forests, 1999-2019.

	Increase	Stable	Low decline	Mod decline	High decline	Severe decline	Count
Acidic Cove	**1.7%**	**48.2%**	**22.9%**	**12.0%**	**8.6%**	**6.6%**	**21,558**
Rx Fire	3.9%	80.4%	12.5%	2.8%	0.4%	0.1%	3,285
Wildfire	1.3%	42.4%	24.8%	13.7%	10.0%	7.7%	18,273
Dry-Mesic Oak	**0.5%**	**34.0%**	**25.0%**	**16.8%**	**12.0%**	**11.8%**	**8,607**
Rx Fire	0.7%	84.6%	8.2%	2.8%	2.8%	1.0%	1,041
Wildfire	0.4%	27.0%	27.3%	18.7%	13.2%	13.3%	7,566
Dry-Oak	**1.2%**	**39.0%**	**23.7%**	**14.0%**	**10.4%**	**11.7%**	**4,849**
Rx Fire	2.7%	62.2%	14.9%	4.4%	6.6%	9.2%	866
Wildfire	0.9%	33.9%	25.6%	16.0%	11.2%	12.3%	3,983
Floodplain	**1.2%**	**45.2%**	**41.7%**	**11.9%**	**0.0%**	**0.0%**	**84**
Rx Fire	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	1
Wildfire	1.2%	45.8%	41.0%	12.0%	0.0%	0.0%	83
High Elev. Red Oak	**1.2%**	**56.4%**	**28.2%**	**7.1%**	**3.5%**	**3.6%**	**4,984**
Rx Fire	4.7%	85.3%	6.1%	2.9%	0.9%	0.1%	1,180
Wildfire	0.1%	47.4%	35.0%	8.4%	4.3%	4.7%	3,804
Mesic Oak	**0.9%**	**44.2%**	**31.7%**	**13.8%**	**6.1%**	**3.3%**	**16,476**
Rx Fire	2.9%	65.9%	22.5%	6.8%	1.2%	0.8%	1,798
Wildfire	0.6%	41.5%	32.9%	14.7%	6.7%	3.6%	14,678
Northern Hardwood	**1.4%**	**66.5%**	**24.2%**	**4.9%**	**1.8%**	**1.2%**	**2,507**
Rx Fire	3.2%	84.0%	9.9%	2.8%	0.1%	0.0%	880
Wildfire	0.4%	57.1%	32.0%	6.0%	2.6%	1.9%	1,627
Pine-Oak Heath	**1.0%**	**22.1%**	**16.2%**	**18.1%**	**19.5%**	**23.1%**	**19,380**
Rx Fire	1.0%	71.0%	10.0%	6.3%	8.6%	3.1%	1,663
Wildfire	1.0%	17.5%	16.7%	19.3%	20.5%	25.0%	17,717
linvillRich Cove	**1.0%**	**55.3%**	**29.6%**	**9.6%**	**3.4%**	**1.3%**	**16,909**
Rx Fire	3.6%	80.9%	9.3%	3.7%	2.1%	0.5%	2,619
Wildfire	0.5%	50.6%	33.3%	10.6%	3.6%	1.4%	14,290
Shortleaf Pine	**1.1%**	**23.2%**	**20.4%**	**20.0%**	**18.4%**	**16.9%**	**2,442**
Rx Fire	0.0%	68.8%	18.8%	6.3%	6.3%	0.0%	16
Wildfire	1.2%	22.9%	20.4%	20.1%	18.5%	17.0%	2,426
Spruce-Fir	**2.0%**	**62.4%**	**32.9%**	**1.7%**	**1.1%**	**0.0%**	**356**
Rx Fire	9.0%	85.9%	5.1%	0.0%	0.0%	0.0%	78
Wildfire	0.0%	55.8%	40.6%	2.2%	1.4%	0.0%	278
Grand Total	**1.1%**	**42.2%**	**24.7%**	**13.3%**	**9.6%**	**9.0%**	**98,152**

Wildfires resulted in larger high severity patches than did prescribed fires (Figure 9). Several fires on the Grandfather Ranger District were especially severe, leading to irregular, interconnected patches that exceeded 25 acres. Wildfires also created smaller patches and gaps, and these smaller successional features were more typical of prescribed fires, although high severity constituted a relatively minor fraction of most burns. Of the 121,150 acres of wild and prescribed fire included in this analysis, 8,950 wildfire acres resulted in patches greater than 0.5 acres and only 150 acres resulted. Although this research was not a complete census and early successional habitat results from other disturbances such as wind and logging, the majority of fire-associated gaps on the Forest have resulted from wildfire. However, the scheduled reburning of prescribed fire units may eventually lead to sustained early successional habitat on susceptible xeric sites and vegetation types and if not, fire events of greater intensity may be required (Arthur and others 1998; Schwartz and others 2016). Similarly, areas that are particularly sensitive to reburning wildfires such as the Linville Gorge Wilderness area, may see combinations of early successional habitat expansion from severe and moderately severe reburns (Hagen and others 2015).

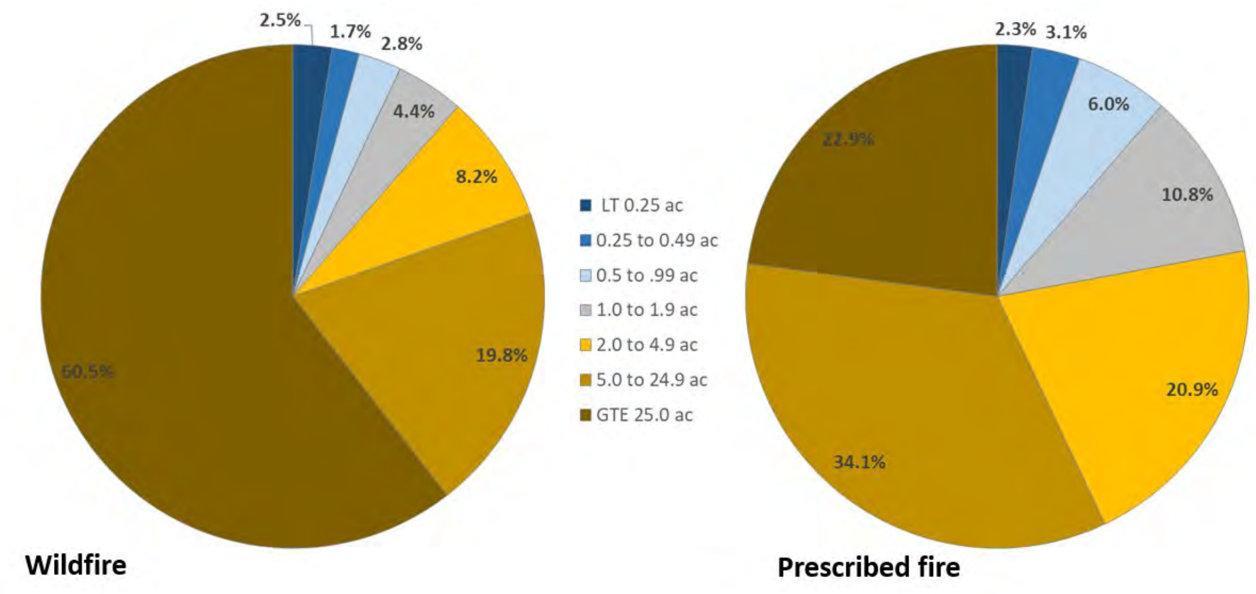

Figure 9: High severity patch/gap area for from wild and prescribed fire.

CONCLUSIONS

Gradients of fire and vegetation dynamics

Topographic-vegetational gradients drive the chance of severe fire, whether wild or prescribed. These results are consistent with our most detailed early reports of fire's effects from over a century ago and more recent observations of wildfire effects in the region (Ayres and Ashe 1905; Wimberly and Reilly 2007). Understanding that vegetation dynamics have consistently varied along such environmental gradients is especially helpful when addressing ecological resilience or ecological memory.

Gradient analysis of vegetation was popularized as an approach in the region during the mid-20th century to understand clear repeatable patterns of forest composition and structure (Whitaker 1956). At that time, researchers under-valued the importance of disturbance for reinforcing or even causing the patterns that they observed. This research underscores the well-established association between vegetation and topography in this region.

As in other montane areas where fire effects have been addressed with a landscape perspective (*e.g.,* Harris and Taylor 2017), this research shows that the topographic gradients reinforce pre-existing forest patterns, even after a century without fire, but that event-specific nuances like fire weather, fuels, spread direction and time of year, are also important for determining outcomes. More fire-adapted species and vegetation types (Varner and others 2021) have been more likely to burn severely than mesic slopes or coves. However, this does not mean that there have been no finer scale structural or compositional consequences after a century of fire exclusion that this research does not capture (*e.g.,* Carpenter and others 2021). In addition, long-term change from fire exclusion, non-native plants, insects and diseases, climate change and other social-ecological factors can include both substantive novelty and a less dramatic shift in the likelihood of a given severity outcome. More broadly however, site and vegetational inertia appear to dominate the dynamics of the area's modern fire regime.

Some researchers refer to such heterogenous landscape fire effects and regimes in montane systems as being of "mixed severity" (*e.g.,* Arthur and others 2021). From this research, fire effects reflect both temporal chance factors and recurrent spatial patterns from topography. In both aspects, Southern Appalachian fires are usually of mixed severity, but fire's behavior and effects are far from random as they can be in more topographically and vegetatively uniform environments.

When wildfires burned more frequently in the past, pine-oak heath forests may have been more likely to burn with lower severity than shown by some of the recent wildfires included in this research, but high severity fire was unquestionably an important part of the natural dynamic (Barden and Woods 1976, Waldrop and Brose 1999, Williams and Johnson 1990, Williams 1998). Depending on site and chance weather factors, even-aged cohorts of table and pitch pine may have been self-replacing and in other times and places, recurrent fires may have led to an open canopied woodland. The existence of the latter is suggested by uneven-aged, but pulsed pine establishment and multi-scarred pines that may have formed by combinations of fire and beetle mortality. With the vegetation type's historically frequent fire regime inferred from tree ring research, the recent fire severity of these sites may also reflect the anomalous accumulation of fuels and successional growth of flammable ericaceous understory (Lafon and others 2017). Even-aged pine cohorts are common after severe wildfires of the region, particularly for those of the Blue Ridge Escarpment on the Grandfather Ranger District (Figure 3, Figure 10).

More than any other vegetation type or site moisture condition, rich coves exhibit the most predictable fire effects, and effects were nearly always minor as measured by dNDVI. As hotspots of biomass and rich biodiversity, the disturbance regimes of these topographic niches appear to be more dominated by localized wind and tree fall gaps from downbursts, even though litter fires readily spread across these areas during the droughty 2016 fire season. High fuel moisture, mesic fuel types, lower diurnal temperatures and reduced wind under larger and taller tree canopies are among the specific factors that can explain reduced fire behavior here. Under some cool season prescribed fire conditions, coves can act as fire breaks, but in as much as litter carries fire during drought, these areas should not be thought of as fire refugia. Because of this conditional largely seasonal behavior of landscape fire spread, the frequent broad-scale fires that are thought to have burned prior to fire exclusion were either from widespread ignitions or they were indicative of drought. From a paleo-and historical perspective, the former (*i.e.,* ignitions) likely varied with shifting cultural factors, including human population density and distribution, while drought frequency varied across decades to centuries (Figure 11). Such dynamic temporal fire frequency and severity may have provided local opportunities for cohort establishment and further contributed to the vegetational and pyrodiversity of this montane landscape. Note in figure 11 that fire exclusion during the mid-20th century corresponded with less frequent drought, and this suggests that suppression success during that era may have been facilitated by decades of moderate fire weather, not just technology and prevention as more often claimed.

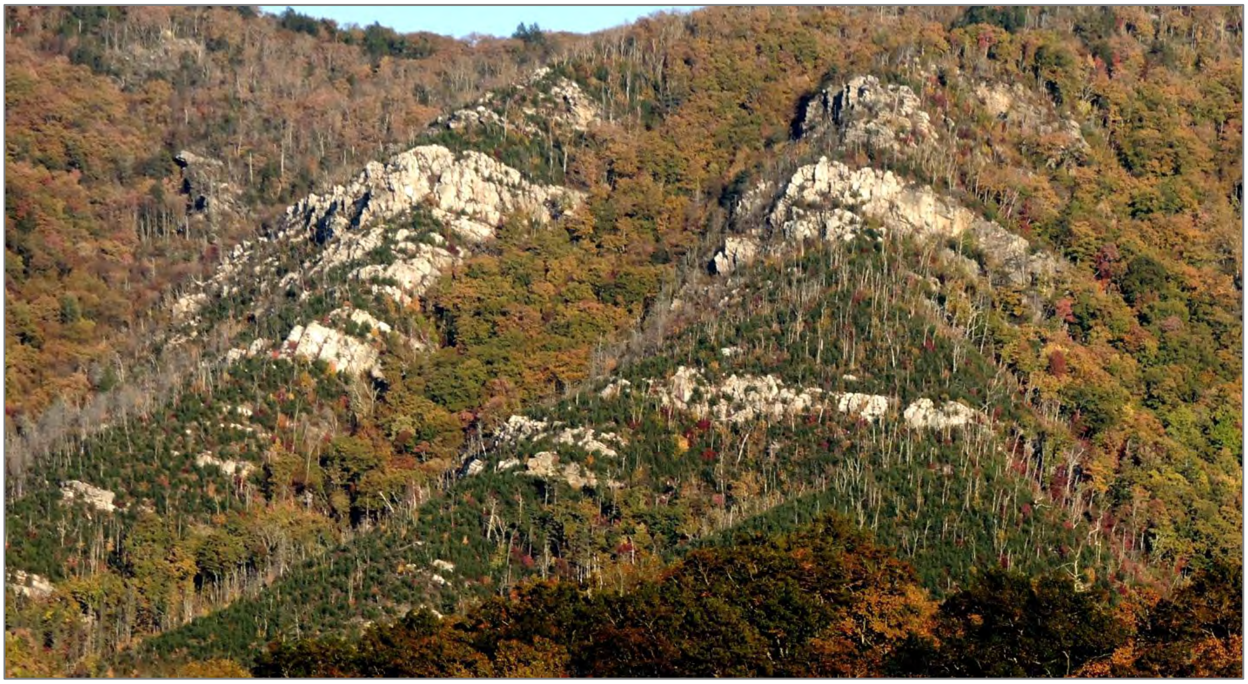

Figure 10: Age structure six years after the summer 2015 Bald Knob fire on the Grandfather Ranger District shows even-aged pitch and table mountain pine in the high severity patches that are represented by standing dead trees. Note the persistent hardwood forests in the inter-ridge drainages that burned less severely (see Appendix 1 for a map of this fire).

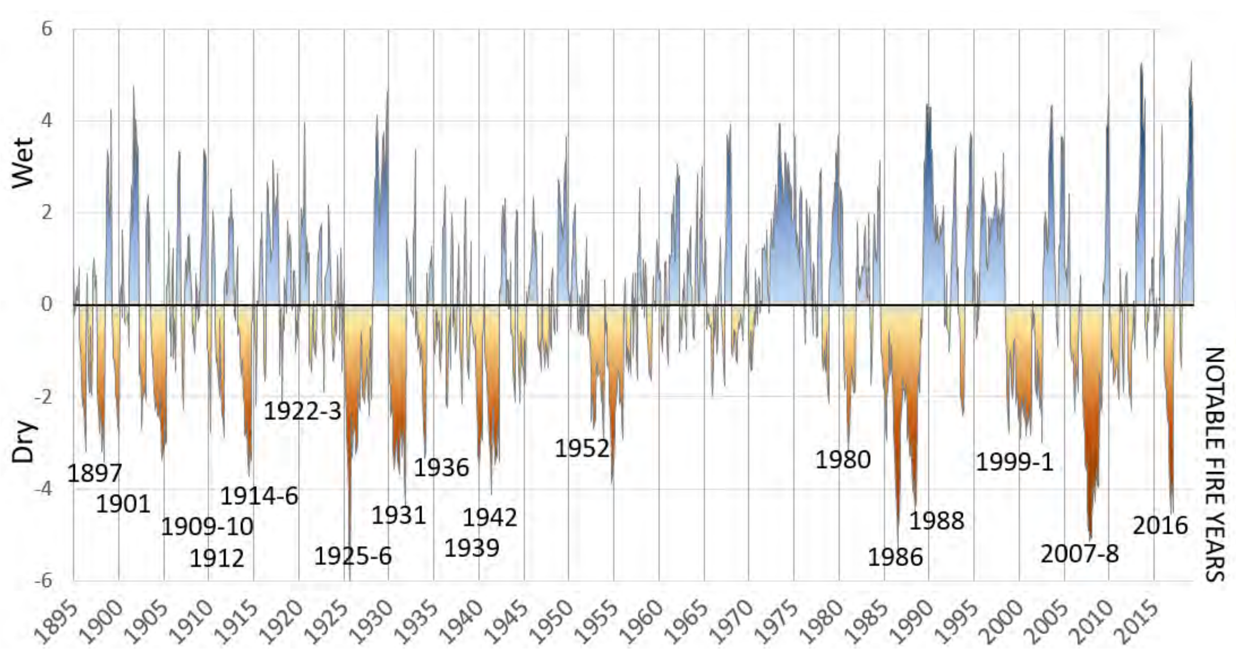

Figure 11: During the early 20th century, notable Southern Appalachian fire years correspond with both dry and moderate drought conditions. As wildfires began to return in the 1980s, they were more often only associated with extreme drought. Large fire years were inferred from regional newspaper accounts and official fire reports. Drought variability is from NOAAs Palmer Drought Severity Index for Climate Division NC1, TN1 and GA2.

Ecological changes that follow the restoration of fire after extensive fire exclusion may lead to divergent successional trajectories among vegetation types. For example, the fire-adapted species that dominate the pine-oak heath, dry oak and dry mesic oak vegetation types where forest mesophication has largely occurred may face altered competition or suffer disproportionately from fire's return (Lafon and others 2017; Arthur and others 2021, Carpenter and others 2021). Management restrictions on the seasonal timing or extent of fires could lead to less historical fire frequency or burn conditions.

Applications for planning

Successful forest planning involves anticipating the effects of management and the less predictable occurrence and effects of natural disturbances. Wildfire effects routinely vary due to nuances of weather, phenology or burn season, dynamic seasonal or event fuels, ignition location, and suppression response decisions. In addition, some variables that influence outcomes are poorly mapped across the Southern Appalachians, such as aspects of vegetation, fuels and ignitions. Whether uncertainties result from insufficient knowledge or stochastic factors, planning can frame outcomes in terms of likelihoods or risk probabilities (Bates and others 2021; Carriger and others 2021). That is, while the future occurrence and outcome of fire cannot be known with certainty, with the right use of landscape datasets, planners can know the relative likelihoods of desirable or undesirable outcomes happening for areas of concern.

This research quantifies a phenomenon that fire managers have long observed: that the chance of high severity fire and patch formation is not random. Results show that severe fire outcomes are somewhat predictable, but they vary among fire types, topography and potential vegetation type. From these insights, forest planners gain insights into where high severity fire patches are more or less likely to occur in the future, with implications for how and where fire-associated forest structural restoration efforts are likely to be self-sustaining over the long-term.

When statistical patterns from these fires are extrapolated from these selected fires to the broader landscape, these data provide a model of severe fire likelihoods *if* fire occurs. We know, however that the chance of fire occurring across the Southern Appalachians likely varies according to ignitions, fire spread and suppression difficulty, but as large wildfires are just now emerging in some parts of the region such as the Nantahala District during 2016, it is difficult to accurately predict future wildfire occurrence. Human ignitions are common, and the region's growing wildland urban intermix provides more opportunity for accidental ignitions and access for suppression response. If 2016's hot-droughty fall fire season provides a useful analogue for future wildfire occurrence with climate change, co-occurring large and mid-sized fires are to be expected, and coinciding wildfire outbreaks can tax suppression efforts and reduce its effectiveness. Many of the region's largest fires during 2016 occurred in wilderness areas where rugged topography and suppression constraints provide stable constraints, so large fires seem likely to return there with comparable drought, ignition, and suppression conditions. Importantly, these more remote forest tracts lie adjacent to the growing wildland urban interface, and as smoke from long-unburned fuels can spread across the region and into nearby urban areas (Zhao and others, 2019), wildfires in these more remote areas share concerns of those closer to communities in terms of both spread risks and public health.

Climate models indicate that more severe fire weather is in store for the southeastern US, particularly in the summer and fall (Liu and others 2013). In the Southern Appalachians, this will continue the pattern of drought and notable wildfire seasons that has been evolving since the mid-20th century (Figure 11). However, with more heat and more or less tropical storm activity in the fall, severe fire weather may develop with a more rapid onset or cessation than in the past or, alternatively, periodic multi-year droughts that have occurred throughout the last century and a quarter could become common.

With growing numbers of wildfires available for learning in the region, those that occur during extreme drought can become analogs or models for what may occur under future drought conditions. Similarly, observations of long-term change from repeated prescribed fires can lend insight into how outcomes compare to those of wildfires that burn during different seasons and weather. The decades-long archival record from remote sensing can be particularly useful for satisfying some aspects of these critical monitoring, planning and implementation needs. Having diversity and representativeness of multiple fires is key to meaningfully address landscape questions. By capturing the range of fire diversity we gain breadth of understanding and deep insight into how pyrodiversity has fostered the development and resilience of Southern Appalachian forests.

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Appendix 1: Wildfire and prescribed fire effects from remote sensing

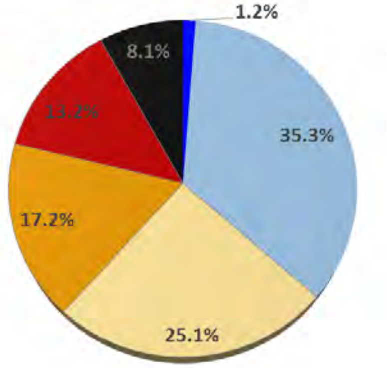
The following maps show change in NDVI from the growing season before to after the wild or prescribed fire occurred. Clear early summer scenes were used when available, however most baseline and post-fire values used are mosaics constructed from the highest NDVI observed during the period to as much as possible overcome the common problems of clouds, cloud shadows, atmospheric effects, and illumination. Atmospherically-adjusted surface reflectance values were used when available on Earth Engine and the hiform.org process. This was routine for Landsat 5 and Landsat 8 imagery and for Sentinel 2 since 2018, however 2016-2017 Sentinel 2 imagery relied on unadjusted top-of-atmosphere products. The standard surface reflectance corrections in both Landsat and Sentinel 2 products sometimes introduce errors in shadowed areas due to overcorrection—that is, a false high NDVI results from the correction process that is perpetuated by the maximum value process used for those overcorrected cells. To overcome this, the dates used for some maps was refined to exclude these spurious values.

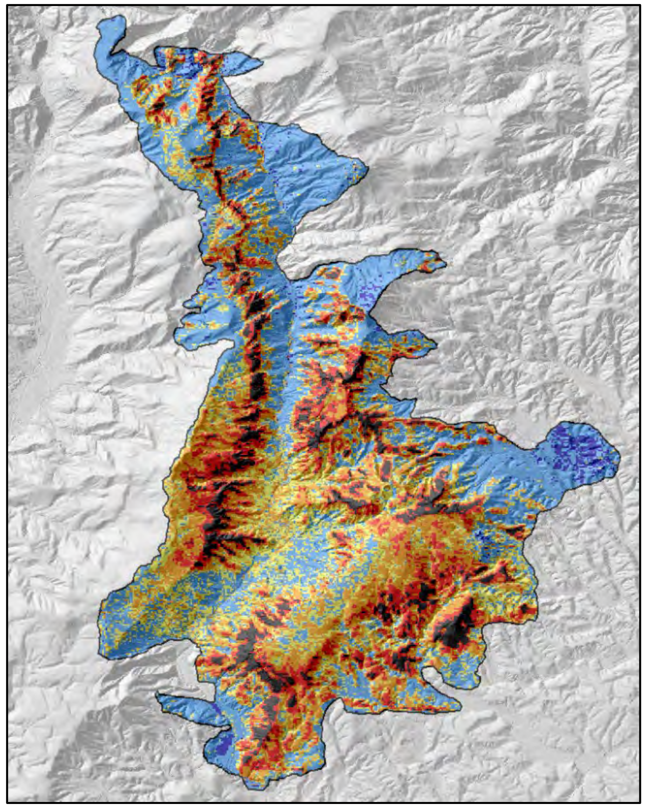
LEGEND

Severe decline (< -21)
High decline (-11 to -20)
Moderate decline (-6 to -10)
Low decline (-3 to -5)
Stable (-2 to 2)
Increase (> 2)

Brushy Ridge

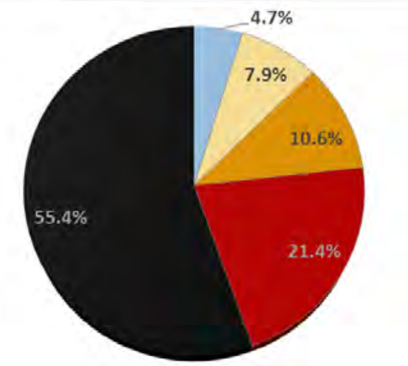
Fire type: Wildfire
Location: Pisgah National Forest
County: Burke
Ignition date: 28 Oct 2000
Cause: Accidental (campfire)
Source: Landsat 5 (30m)
Baseline: 2000-06-02
Post-fire: 2001-06-05
Area (acres): 12,405

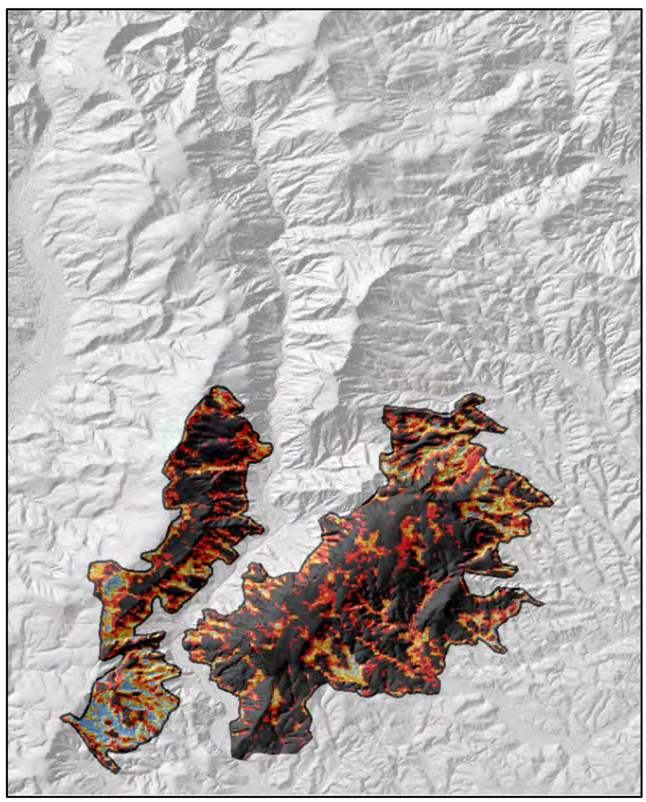




Shortoff (Linville Complex)

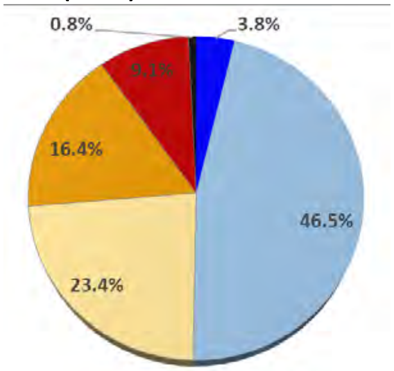
Fire type: Wildfire
Location: Pisgah National Forest
County: Burke
Ignition date: 8 Jun 2007
Cause: Lightning
Source: Landsat 5 (30m)
Baseline: 2006-05-15 to 09-21
Post-fire: 2007-08-09
Area (acres): 6,500

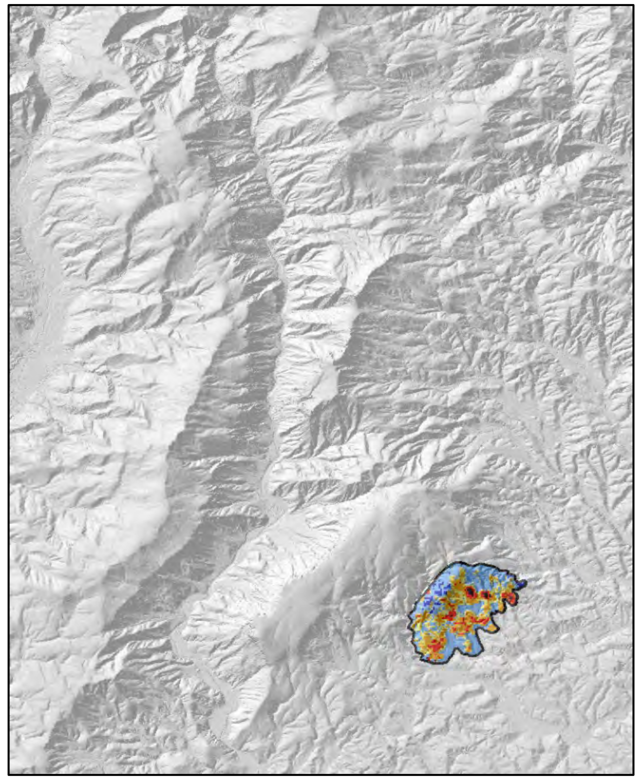




Blue Gravel

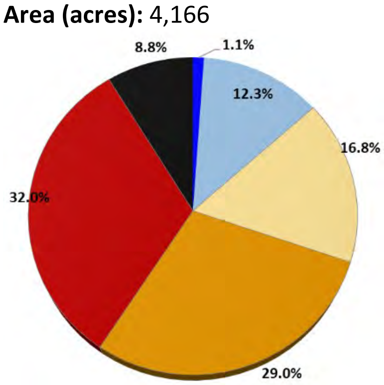
Fire type: Wildfire
Location: Pisgah National Forest
County: Burke
Ignition date: 14 Apr 2015
Cause: Lightning
Source: Landsat 8 (30m)
Baseline: 2014-05-15 to 09-21
Post-fire: 2015-05-15 to 09-21
Area (acres): 521

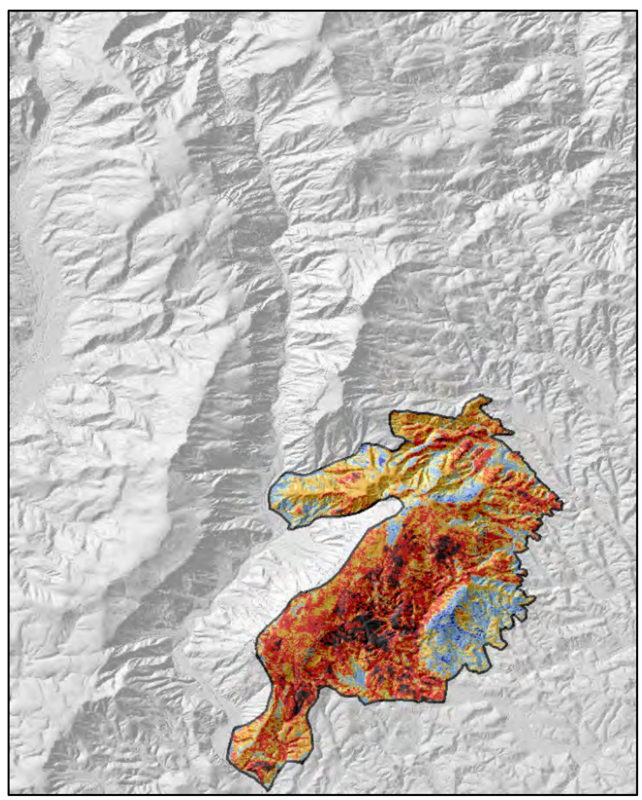




White Creek

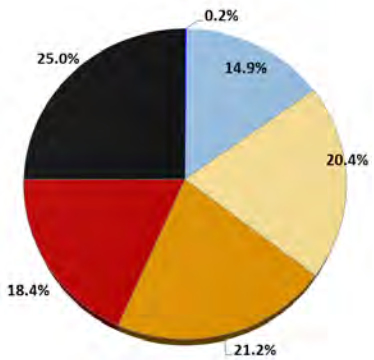
Fire type: Wildfire
Location: Pisgah National Forest
County: Burke
Ignition date: 21 Mar 2017
Cause: Lightning
Source: Sentinel 2 (10m)
Baseline: 2016-05-15 to 09-21
Post-fire: 2017-05-15 to 09-21
Area (acres): 4,166

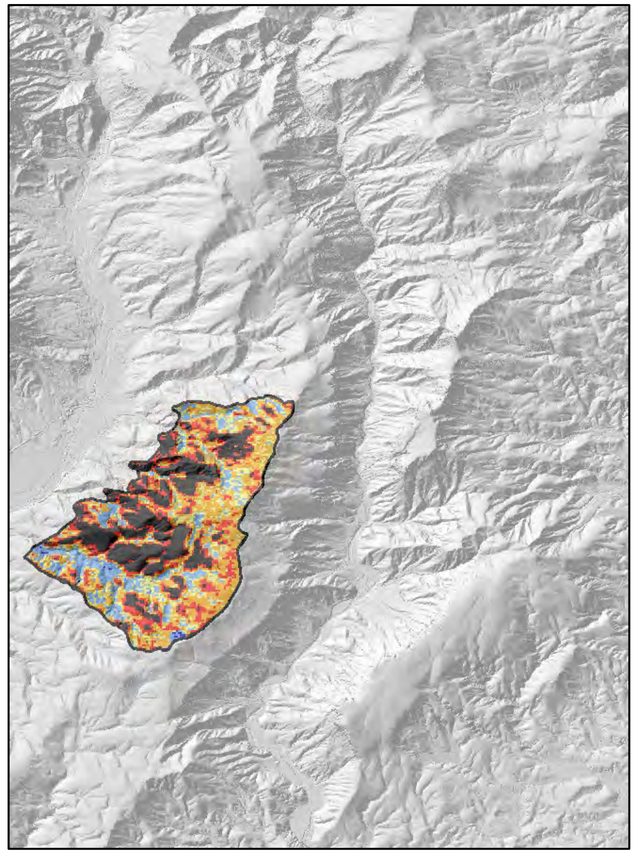




Sunrise

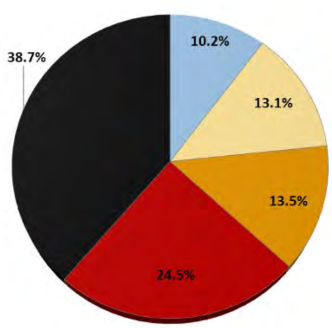
Fire type: Wildfire
Location: Pisgah National Forest
County: McDowell
Ignition date: 18 Apr 2008
Cause: Misc.
Source: Landsat 5 (30m)
Baseline: 2007-06-01 to 09-21
Post-fire: 2008-06-21
Area (acres): 1,906

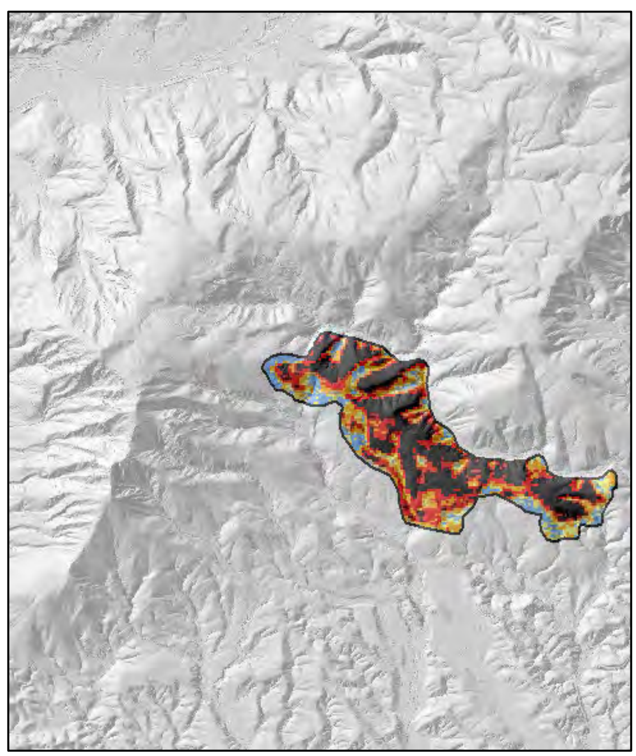




Dobson Knob

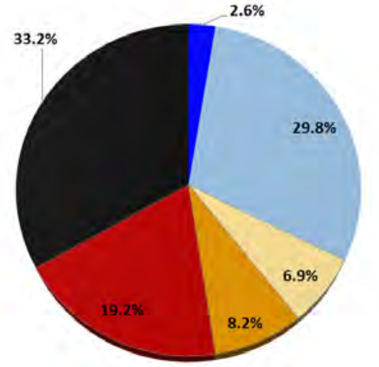
Fire type: Wildfire
Location: Pisgah National Forest
County: McDowell
Ignition date: 8 Jun 2007
Cause: Lightning
Source: Landsat 5 (30m)
Baseline: 2006-06-01 to 09-21
Post-fire: 2007-06-10 to 09-21
Area (acres): 820

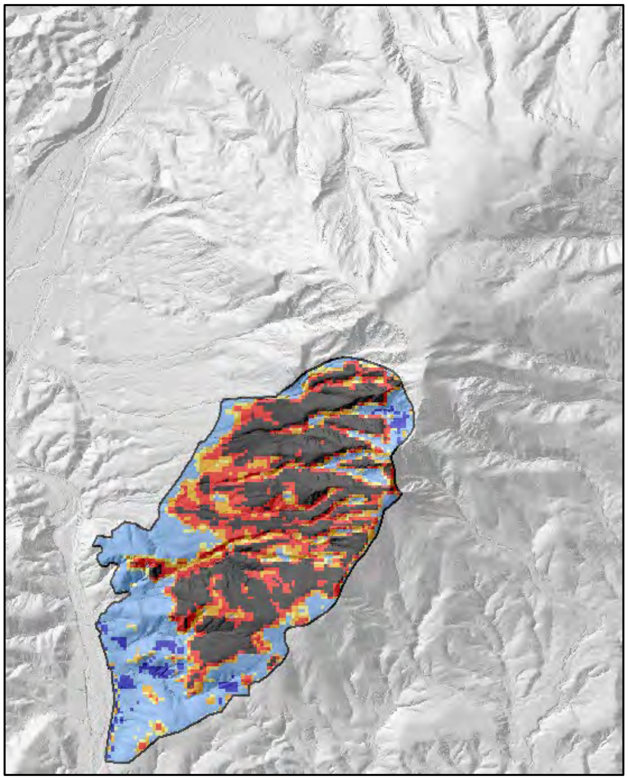




Bald Knob

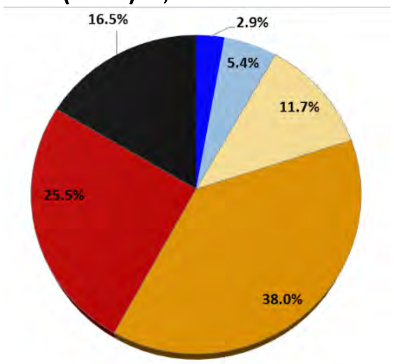
Fire type: Wildfire (fire use)
Location: Pisgah National Forest
County: McDowell
Ignition date: 17 Jul 2015
Cause: Lightning
Source: Landsat 8 (30m)
Baseline: 2015-06-19
Post-fire: 2016-06-21
Area (acres): 1,268

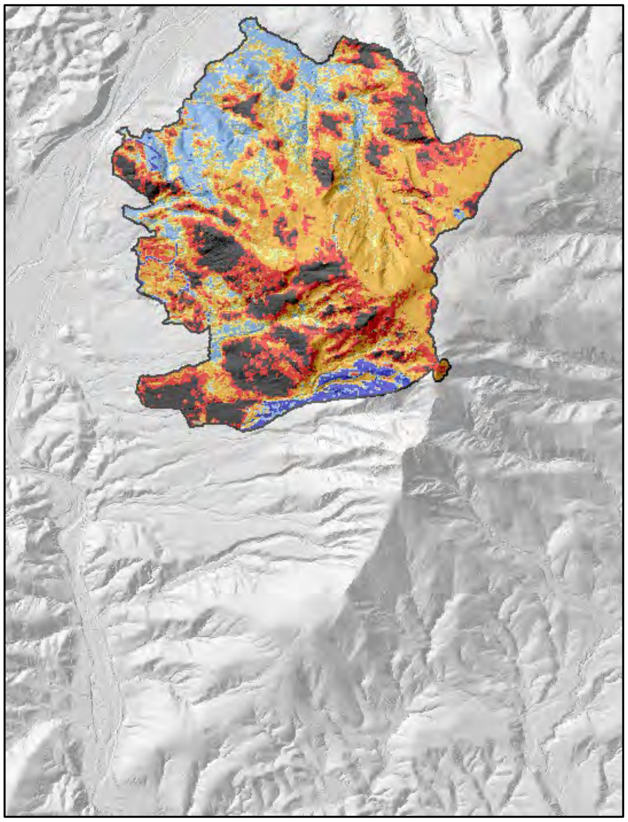




Dobson Knob

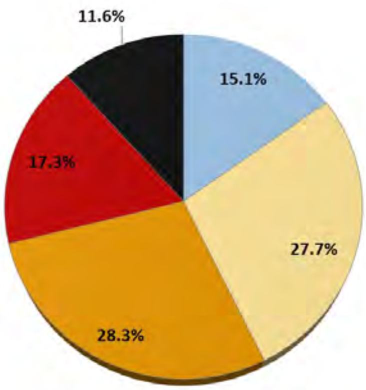
Fire type: Wildfire
Location: Pisgah National Forest
County: McDowell
Ignition date: 10 Apr 2017
Cause:
Source: Sentinel 2 (10m)
Baseline: 2016-05-15 to 09-21
Post-fire: 2016-05-15 to 09-21
Area (acres): 1,720

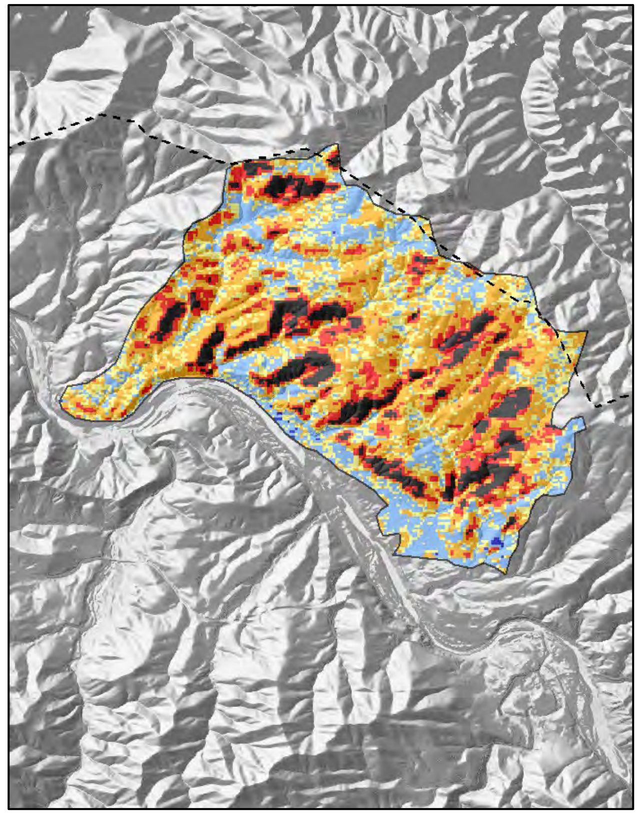




Larman

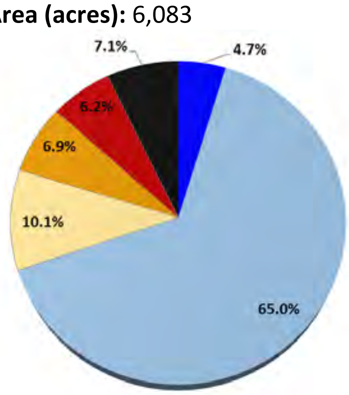
Fire type: Wildfire
Location: Nantahala National Forest
County: Madison
Ignition date: 12 Nov 2001
Cause: Arson
Source: Landsat 5 (30m)
Baseline: 2001-05-15 to 09-21
Post-fire: 2002-05-15 to 09-21
Area (acres): 3,072

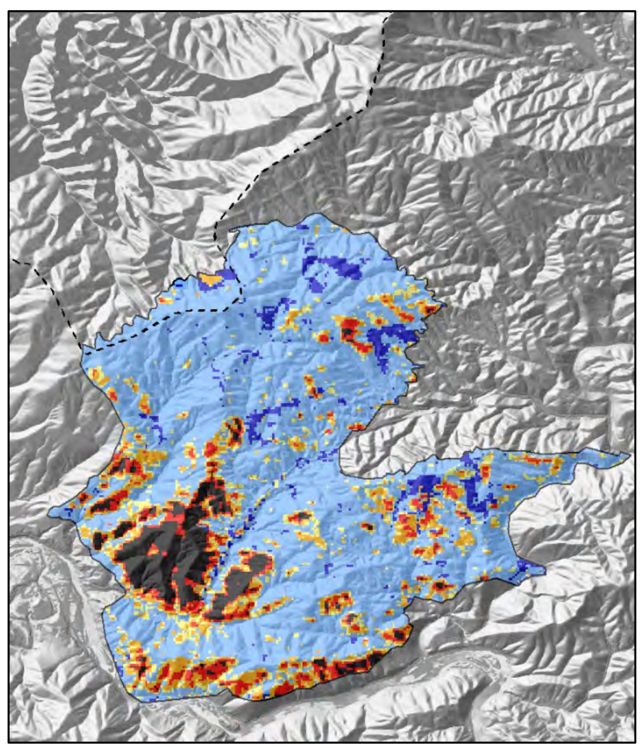




Silver Mine

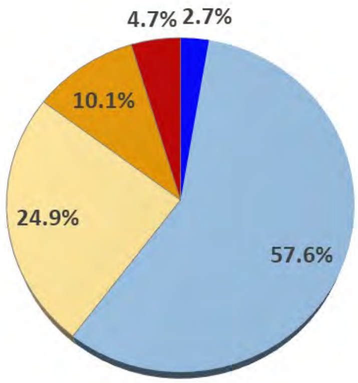
Fire type: Wildfire
Location: Pisgah National Forest
County: Madison
Ignition date: 21 Apr 2016
Cause: Arson
Source: Landsat 8 (30m)
Baseline: 2014-05-15 to 09-21
Post-fire: 2016-05-15 to 09-21
Area (acres): 6,083

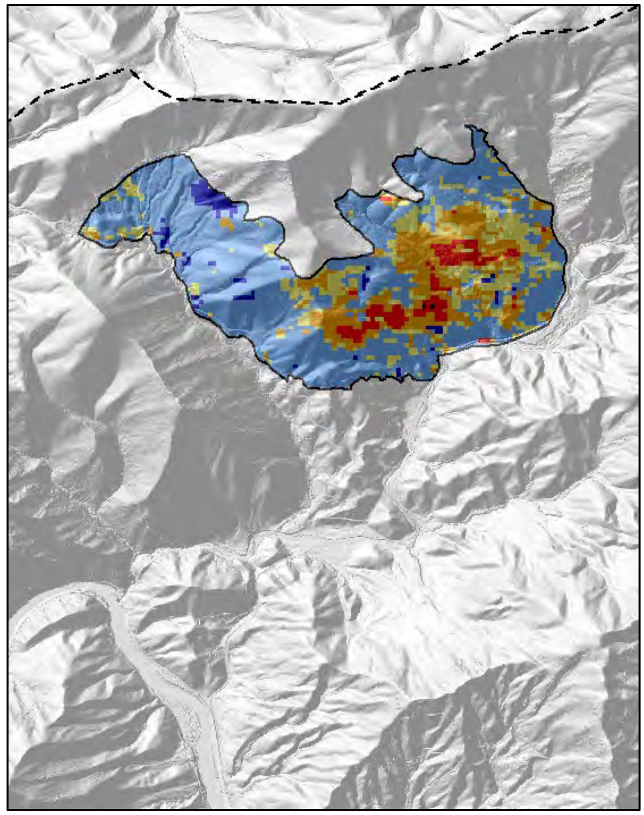




Poplar

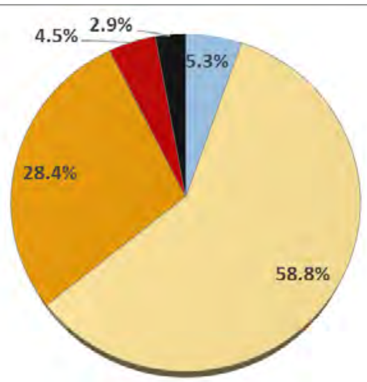
Fire type: Wildfire
Location: Pisgah National Forest
County: Mitchell
Ignition date: 31 Mar 2015
Cause: Arson
Source: Landsat 8 (30m)
Baseline: 2014-05-15 to 09-21
Post-fire: 2016-05-15 to 09-21
Area (acres): 768

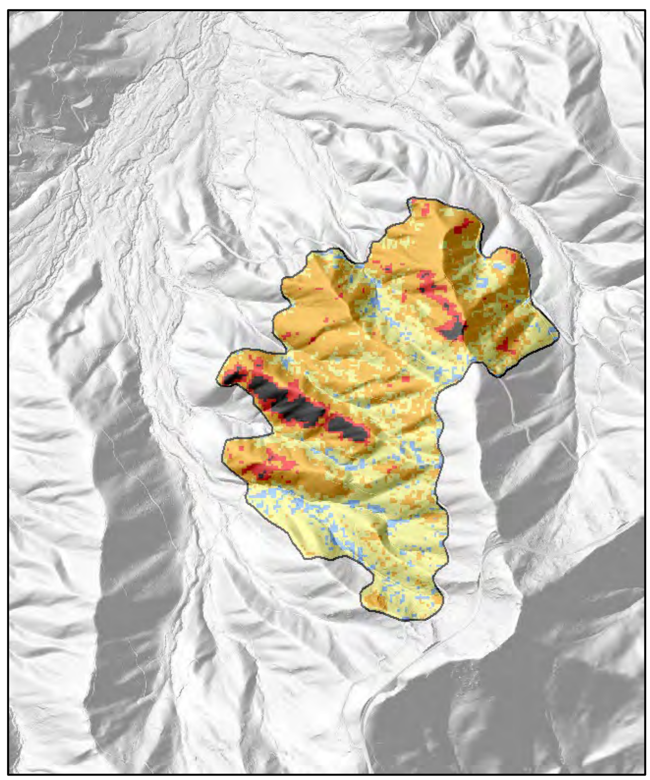




Highway 151

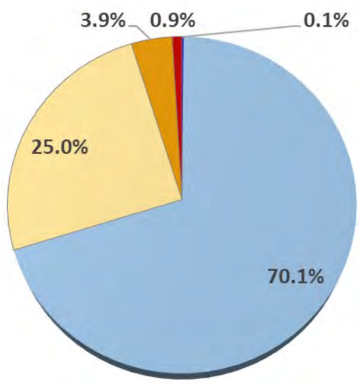
Fire type: Wildfire
Location: Pisgah National Forest
County: Buncombe
Ignition date: 24 Nov 2016
Cause: Accidental
Source: Sentinel 2 (10m)
Baseline: 2016-05-15 to 09-21
Post-fire: 2017-05-15 to 09-21
Area (acres): 245

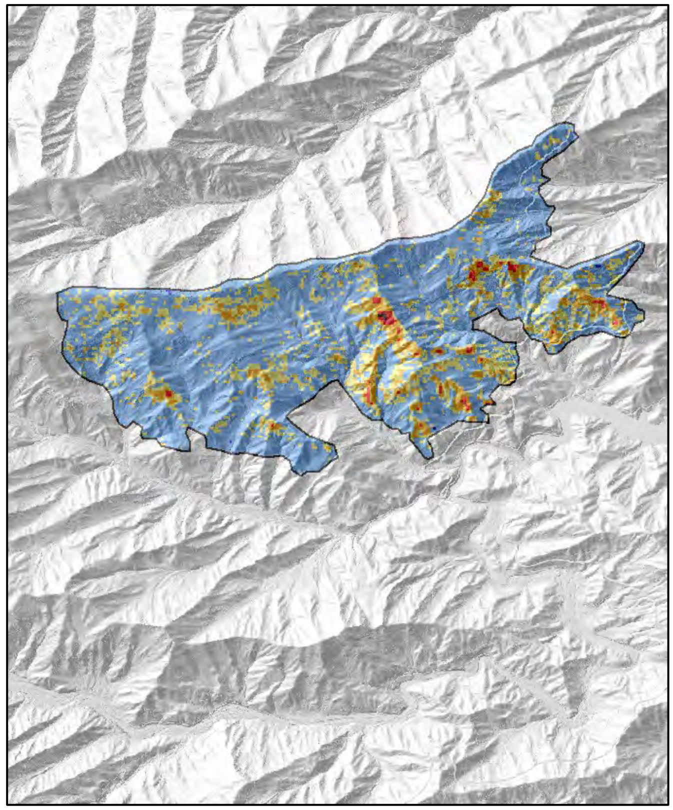




Avey Creek

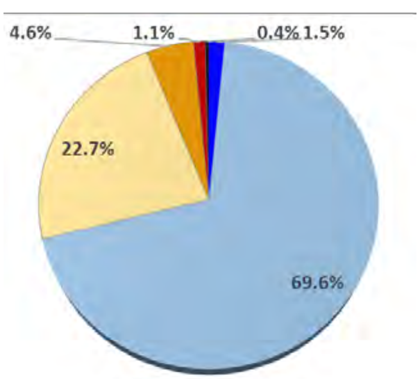
Fire type: Wildfire
Location: Nantahala National Forest
County: Graham
Ignition date: 15 Nov 1999
Cause: Arson
Source: Landsat 5 (30m)
Baseline: 1999-06-01 to 09-03
Post-fire: 2000-06-01 to 09-03
Area (acres): 2,099

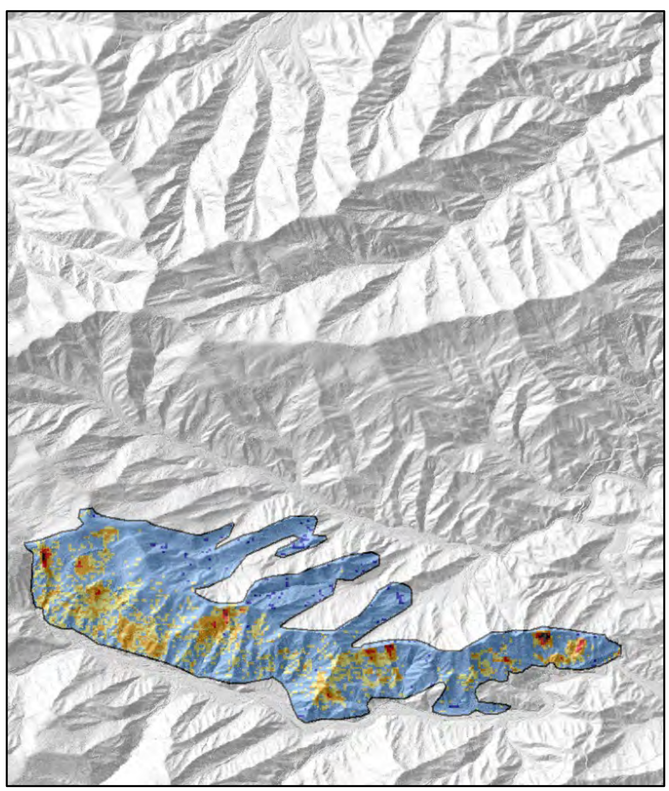




Goldie Deadon

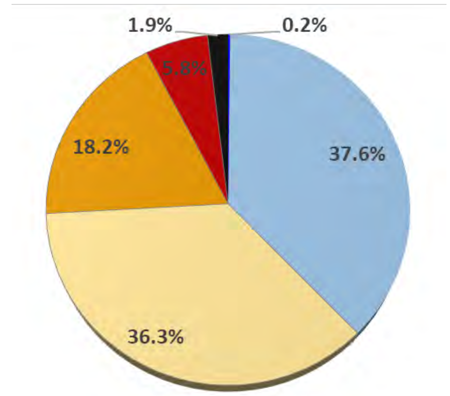
Fire type: Wildfire
Location: Nantahala National Forest
County: Graham
Ignition date: 15 Nov 1999
Cause: Arson
Source: Landsat 5 (30m)
Baseline: 1999-06-01 to 09-03
Post-fire: 2000-06-01 to 09-03
Area (acres): 1,717

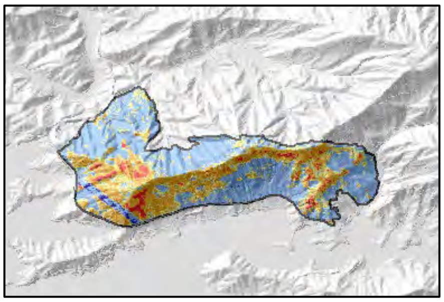


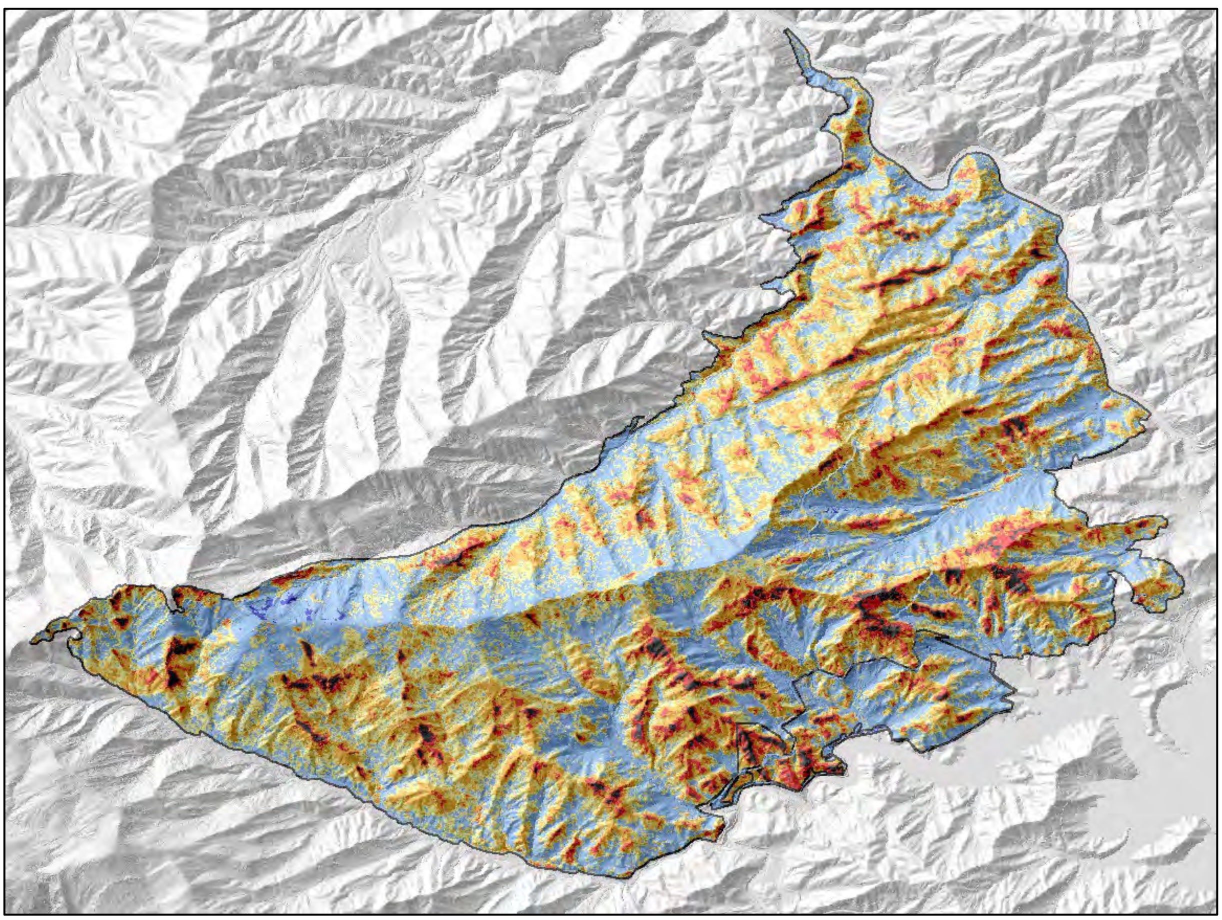


Maple Springs/Old Roughy

Fire type: Wildfire
Location: Nantahala National Forest
County: Graham
Ignition date: 4 Nov 2016
Cause: Arson
Source: Sentinel 2 (10m)
Baseline: 2016-05-15 to 09-21
Post-fire: 2017-05-15 to 09-21
Area (acres): 7,700

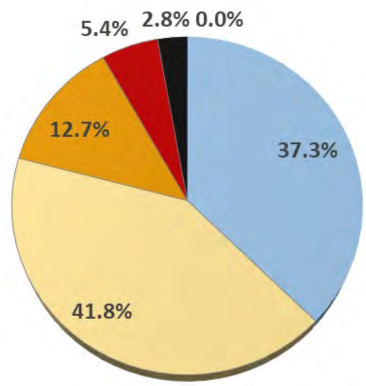


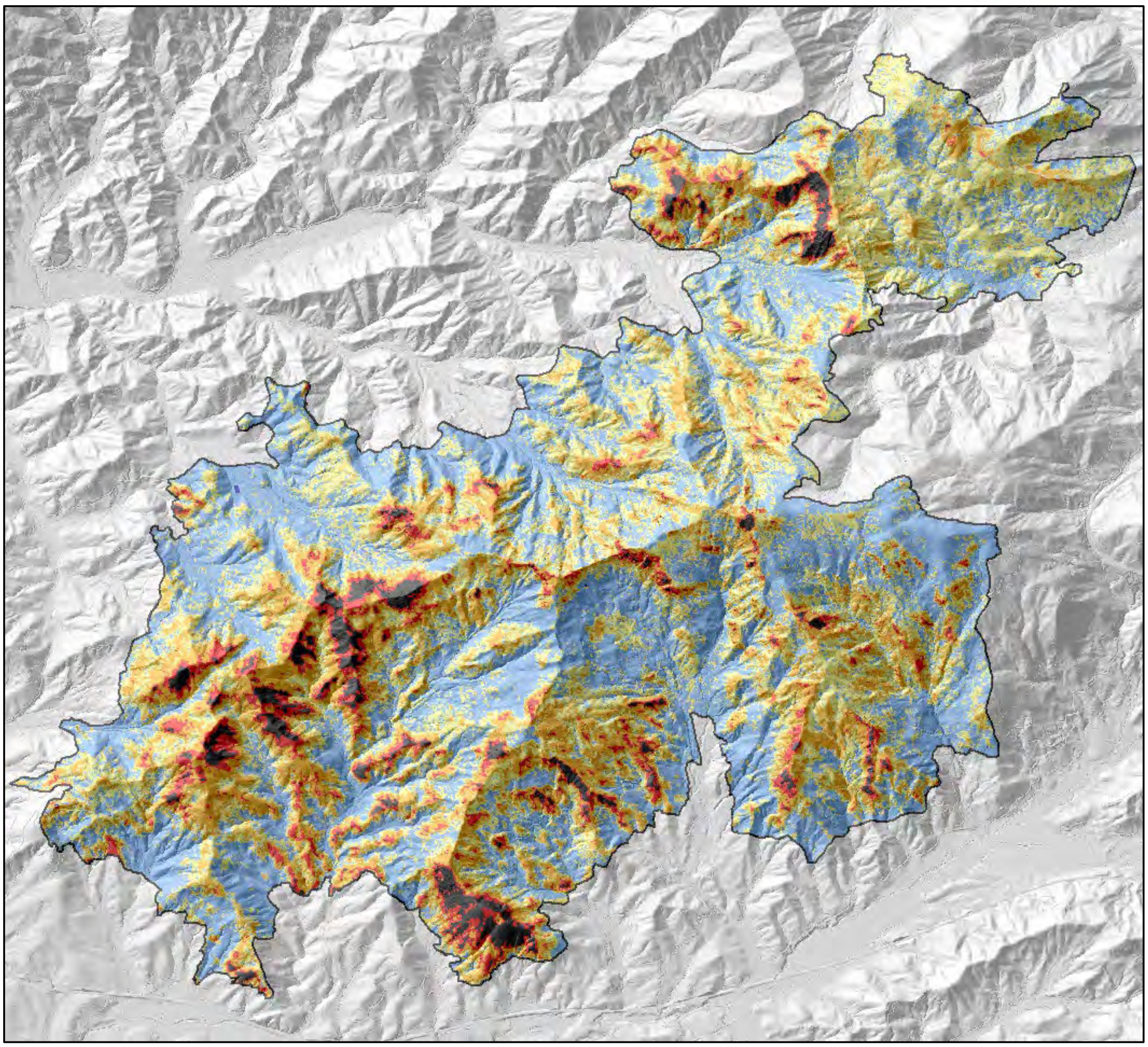




Boteler

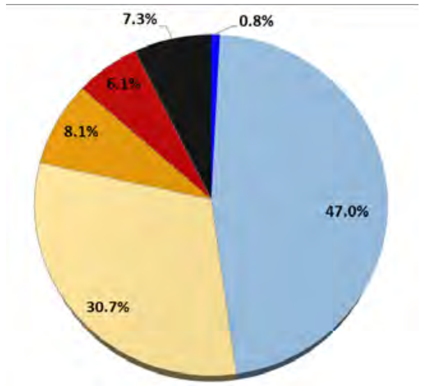
Fire type: Wildfire
Location: Nantahala National Forest
County: Clay
Ignition date: 25 Oct 2016
Cause: Lightning
Source: Sentinel 2 (10m)
Baseline: 2016-05-15 to 09-21
Post-fire: 2017-05-15 to 09-21
Area (acres): 8,627

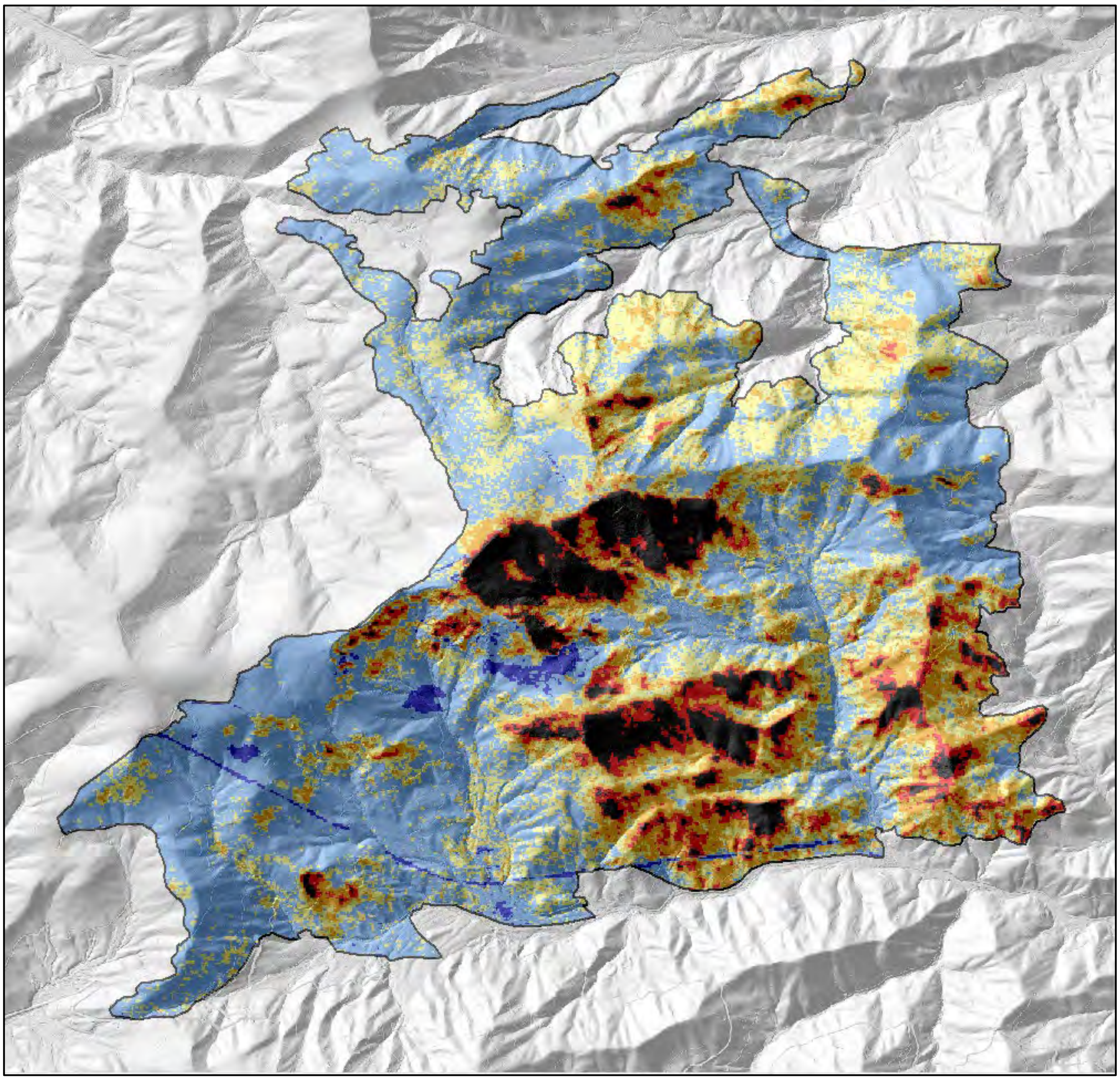




Camp Branch

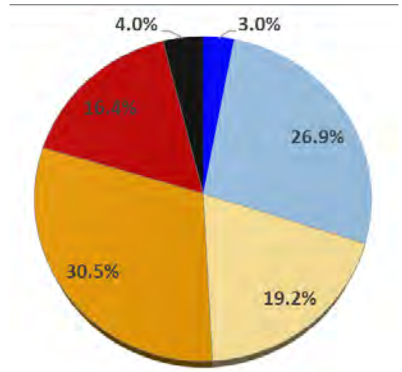
Fire type: Wildfire
Location: Nantahala National Forest
County: Macon
Ignition date: 22 Nov 2016
Cause: Arson
Source: Sentinel 2 (10m)
Baseline: 2016-05-15 to 09-21
Post-fire: 2017-05-15 to 09-21
Area (acres): 3,234

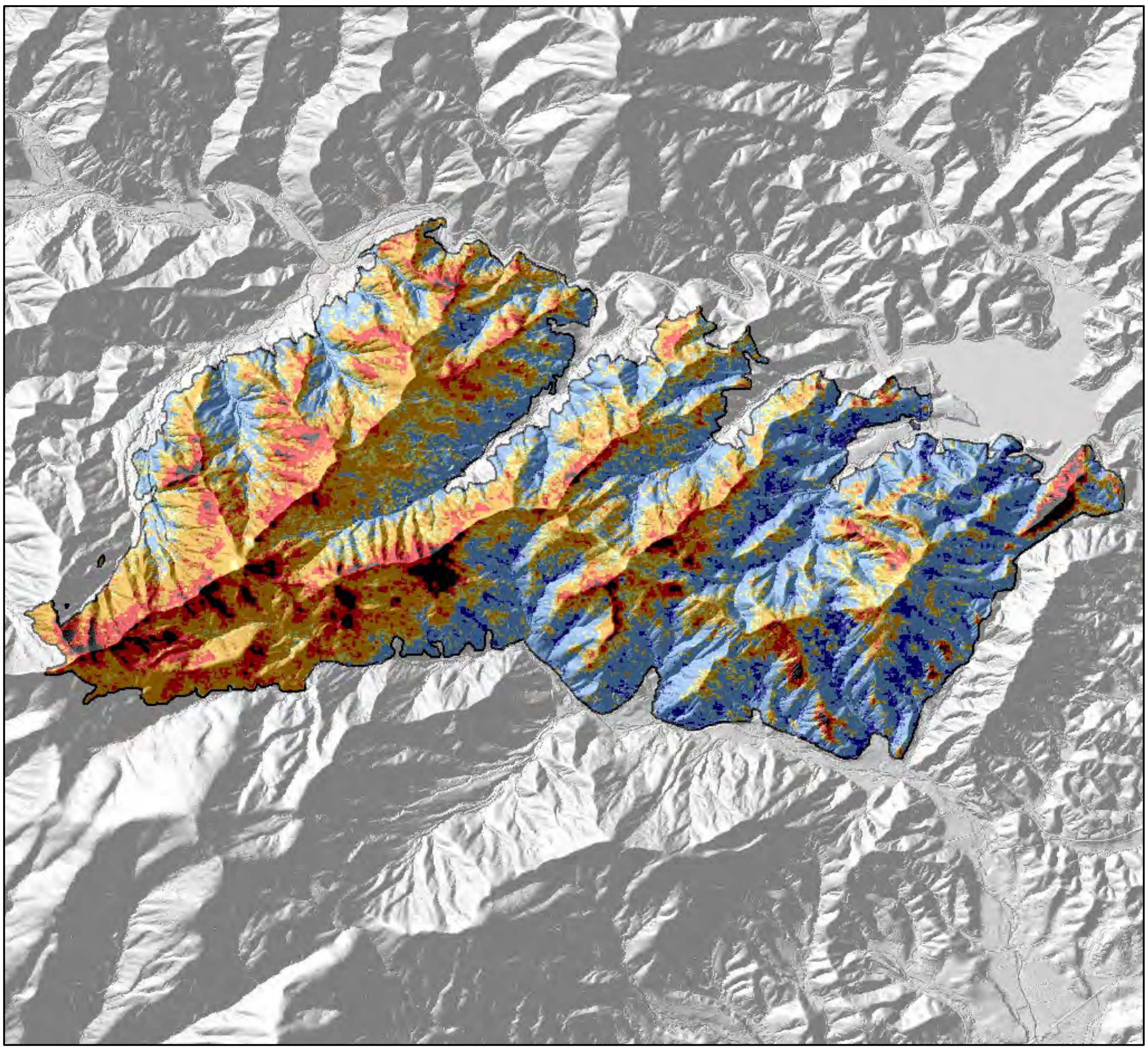




Clear Creek

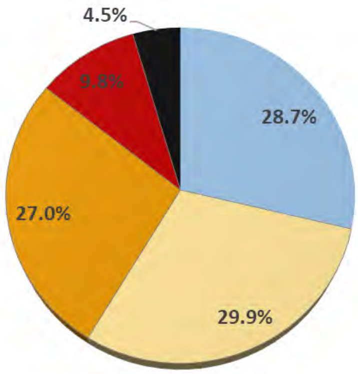
Fire type: Wildfire
Location: Nantahala National Forest
County: McDowell
Ignition date: 20 Nov 2016
Cause: Arson
Source: Sentinel 2 (10m)
Baseline: 2016-05-15 to 09-21
Post-fire: 2017-05-15 to 09-21
Area (acres): 3,493

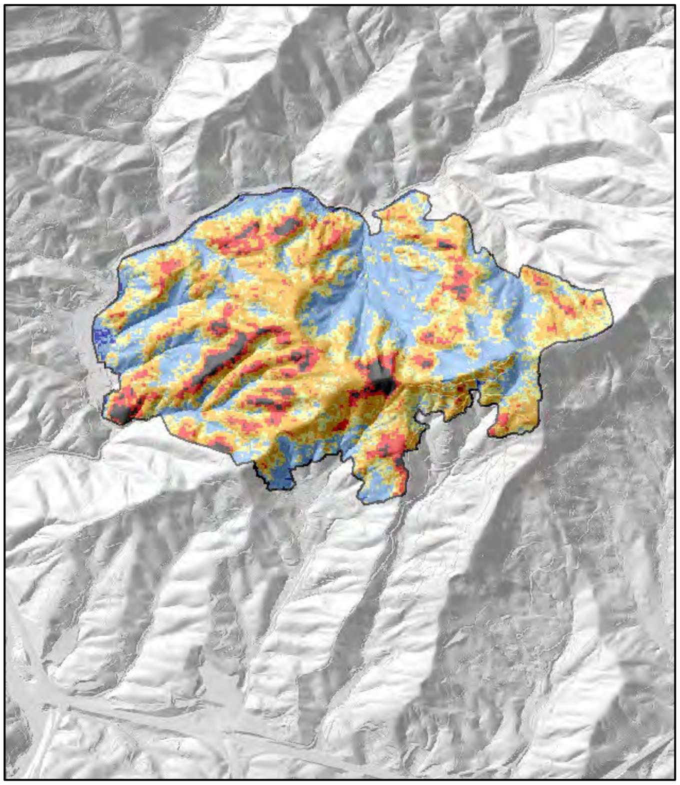




Dick's Creek

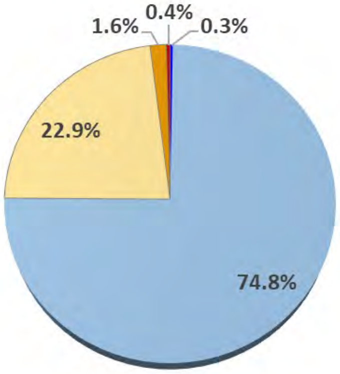
Fire type: Wildfire
Location: Nantahala National Forest
County: Jackson
Ignition date: 23 Oct 2016
Cause: Misc.
Source: Sentinel 2 (10m)
Baseline: 2016-05-15 to 09-21
Post-fire: 2017-05-15 to 09-21
Area (acres): 833

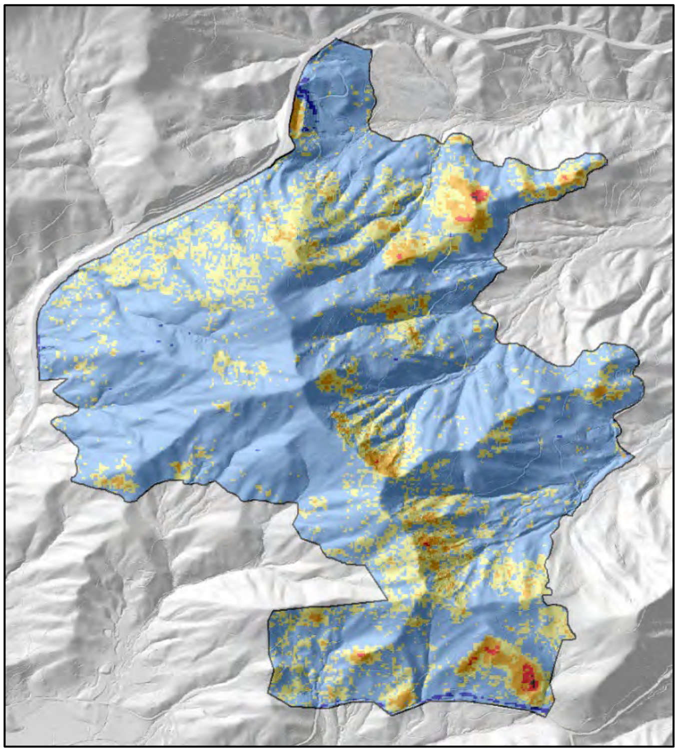




Knob

Fire type: Wildfire
Location: Nantahala National Forest
County: Macon
Ignition date: 2 Nov 2016
Cause: Arson
Source: Sentinel 2 (10m)
Baseline: 2016-05-15 to 09-21
Post-fire: 2017-05-15 to 09-21
Area (acres): 1,133

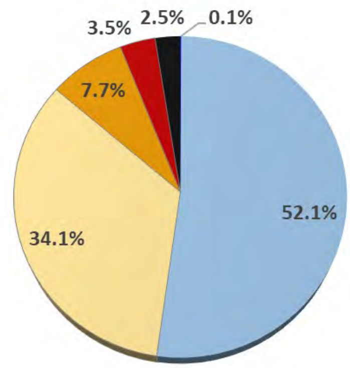


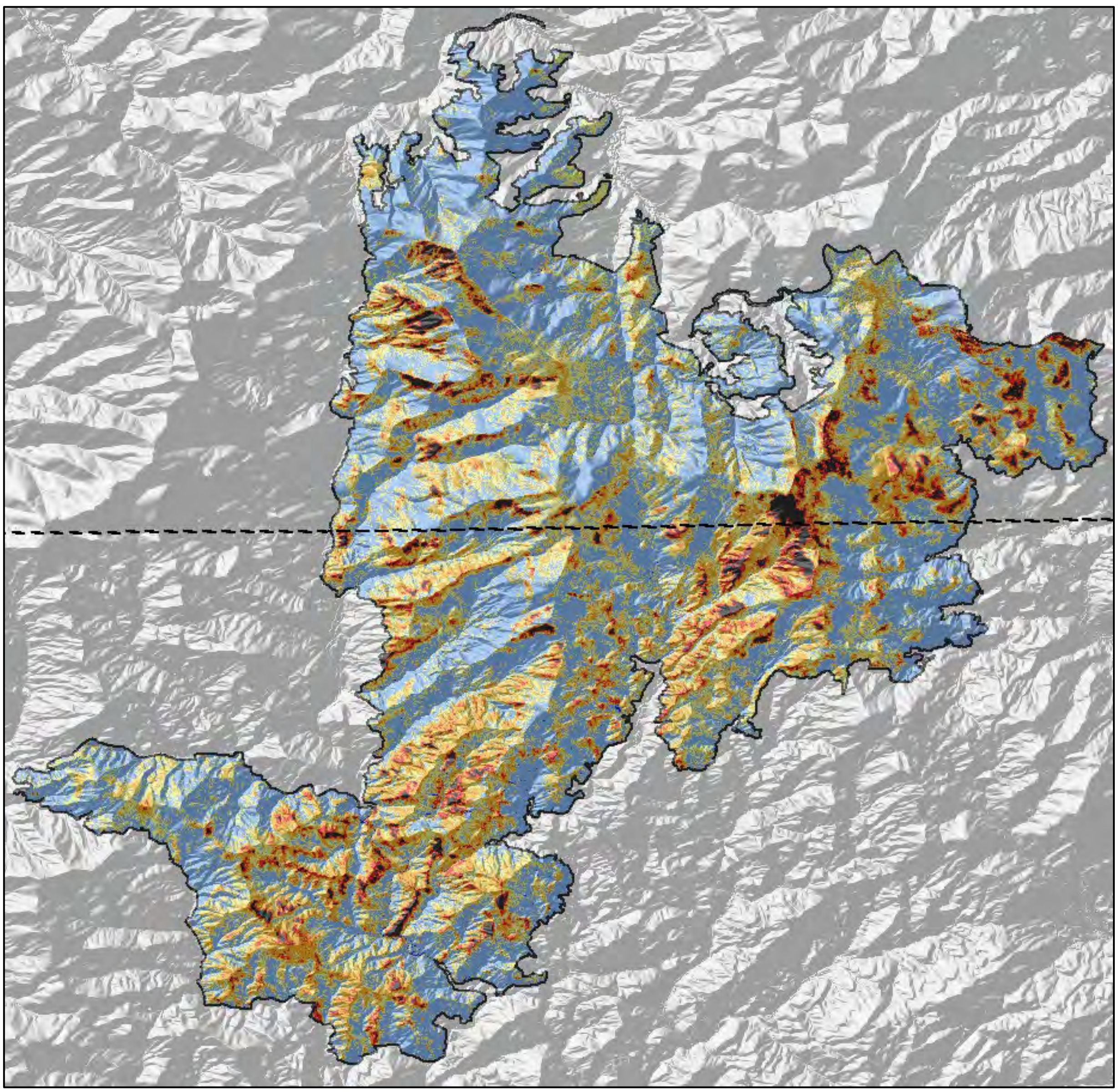


Rock Mountain

Fire type: Wildfire
Location: Nantahala National Forest
County: Macon
Ignition date: 9 Nov 2016 (in GA)
Cause: Arson
Source: Sentinel 2 (10m)
Baseline: 2016-05-15 to 09-21
Post-fire: 2017-05-15 to 09-21
Area (acres): 11,600 (NC only)

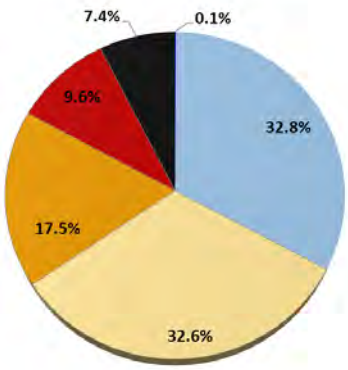
NC fraction only

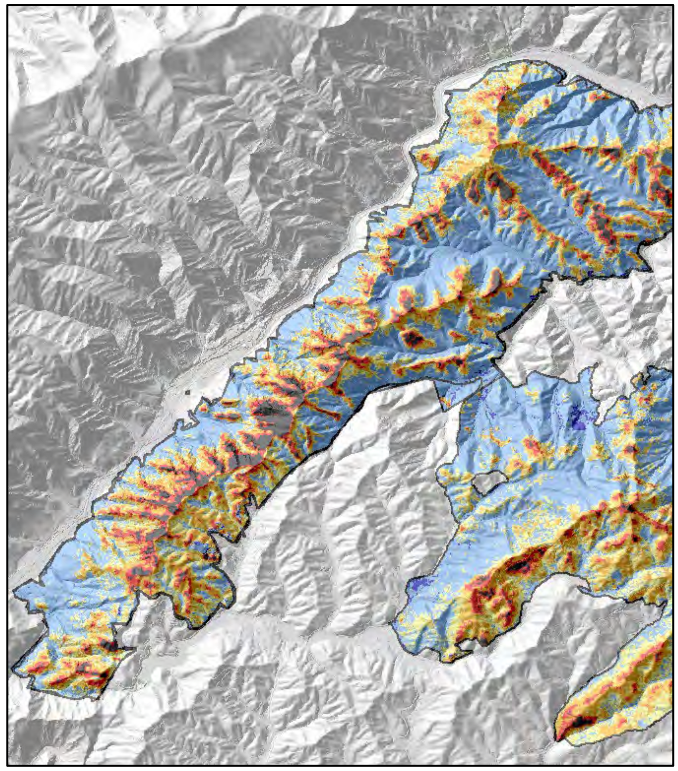


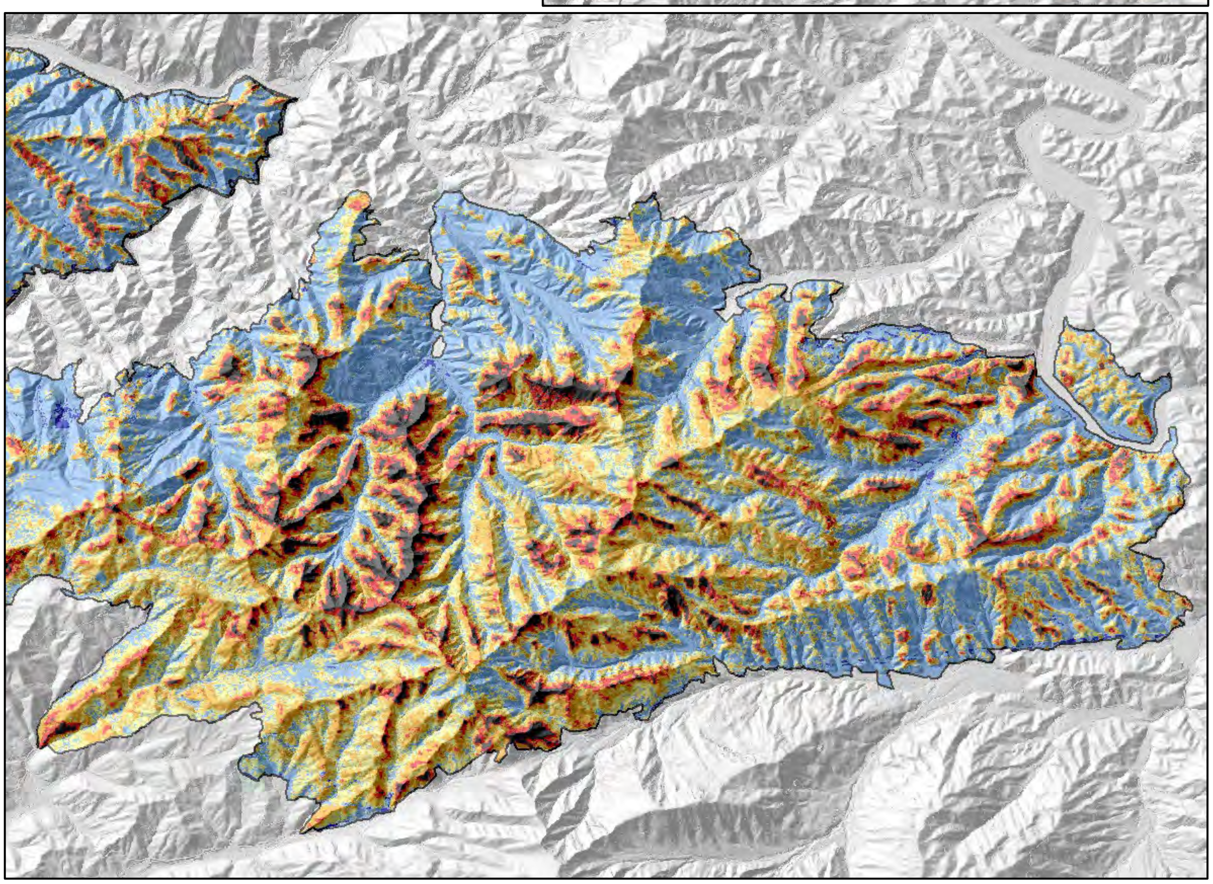


Tellico-Ferebee

Fire type: Wildfire
Location: Nantahala National Forest
County: Swain
Ignition date: 3 Nov 2016
Cause: Arson
Source: Sentinel 2 (10m)
Baseline: 2016-05-15 to 09-21
Post-fire: 2017-05-15 to 09-21
Area (acres): 14,172

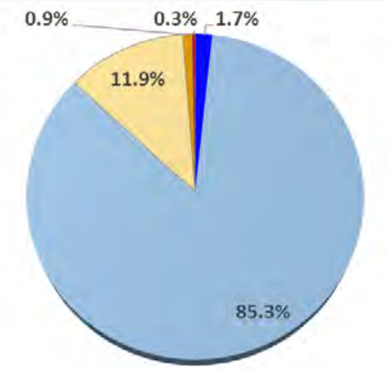


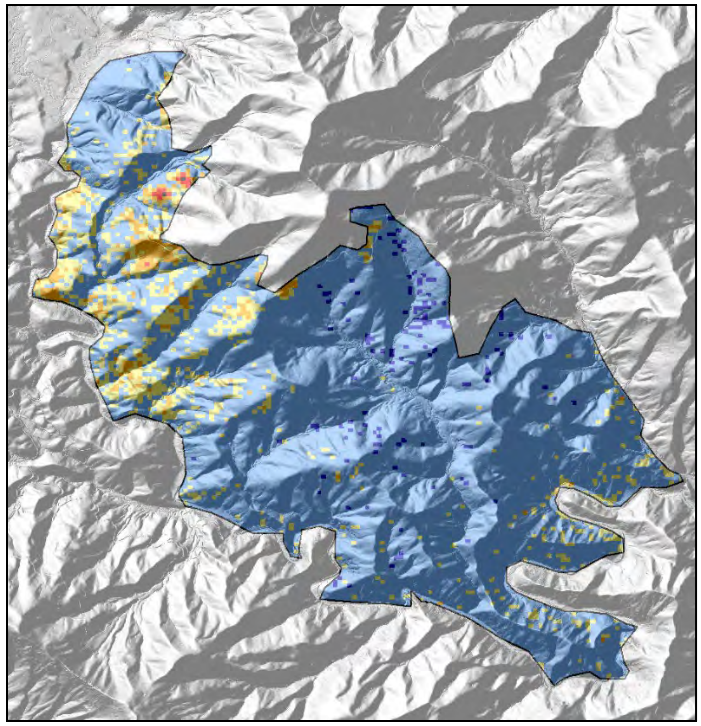




Laurel Brook

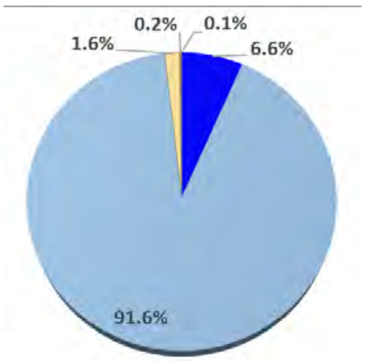
Fire type: Prescribed Fire
Location: Pisgah National Forest
County: Transylvania
Ignition date: 28 Feb 2007
Source: Landsat 5 (30m)
Baseline: 2005-07-01 to 09-09
Post-fire: 2007-07-01 to 09-21
Area (acres): 2,100

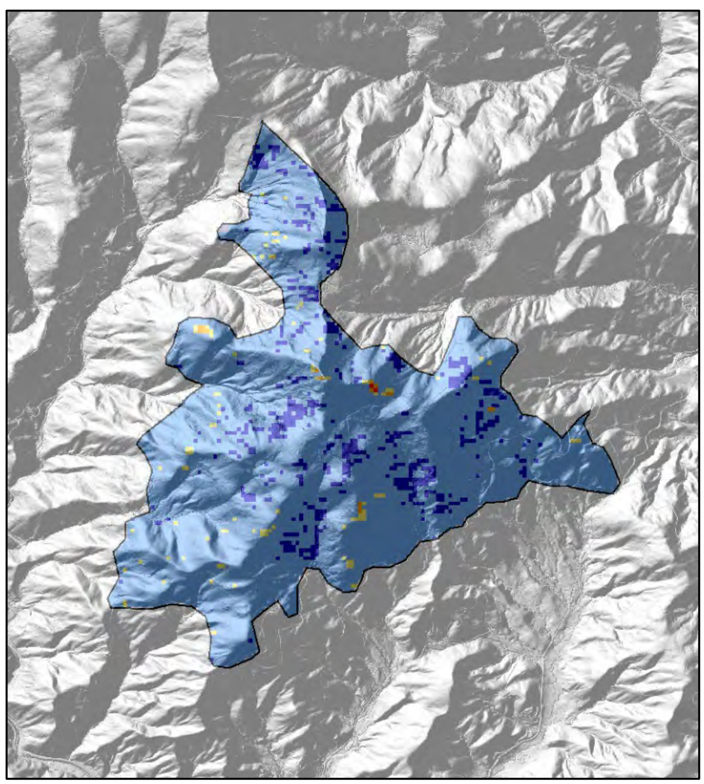




Pilot Mountain

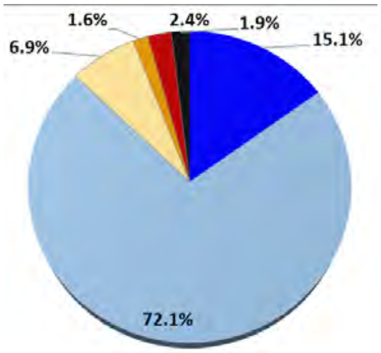
Fire type: Prescribed Fire
Location: Pisgah National Forest
County: Transylvania
Ignition date: 22 Mar 2008
Source: Landsat 5 (30m)
Baseline: 2007-08-01 to 09-21
Post-fire: 2008-08-02
Area (acres): 1,291

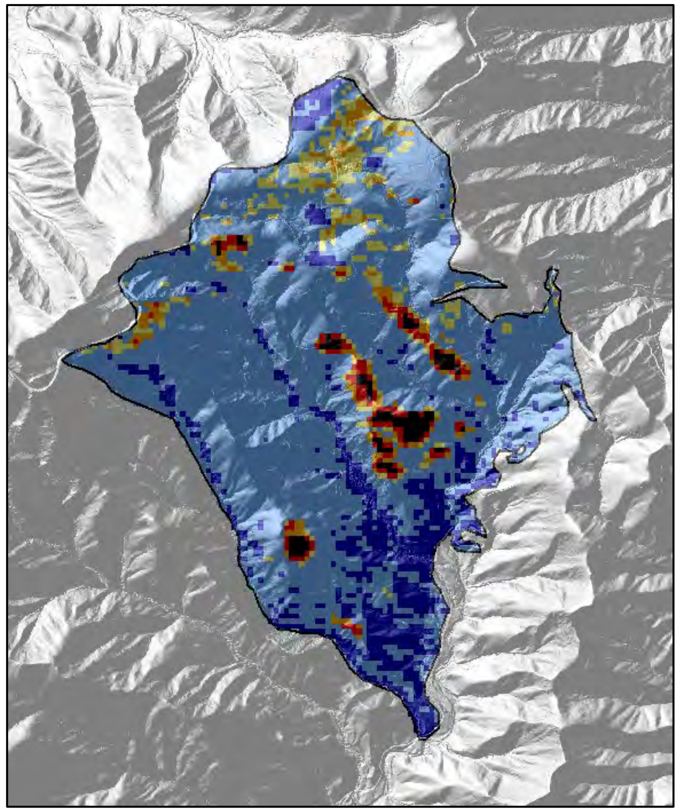




Lost Bear East

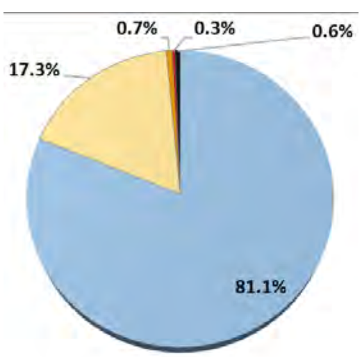
Fire type: Prescribed Fire
Location: Pisgah National Forest
County: McDowell
Ignition date: 5 Apr 2010
Source: Landsat 5 (30m)
Baseline: 2008-06-01 to 07-31
Post-fire: 2010-06-01 to 07-31
Area (acres): 1,070

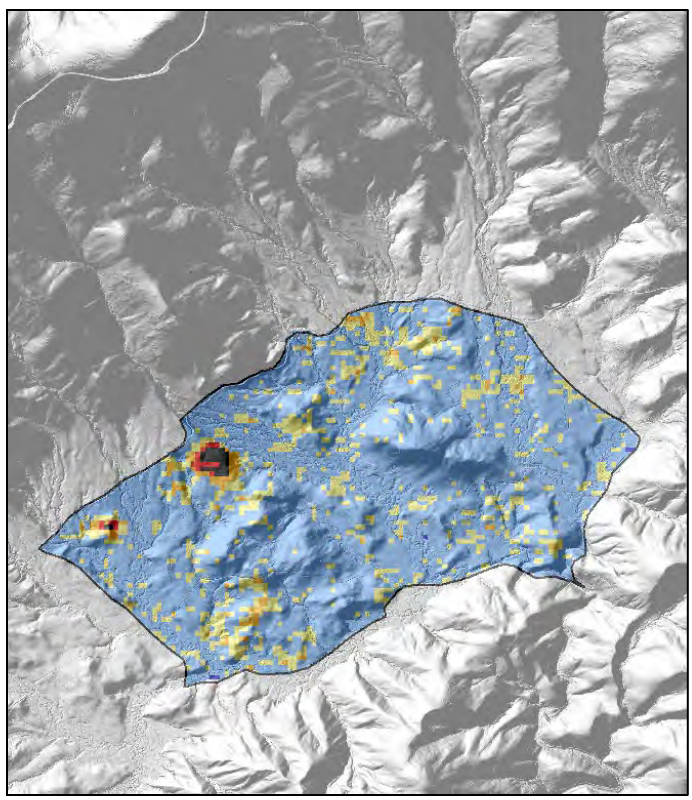




Pink Beds

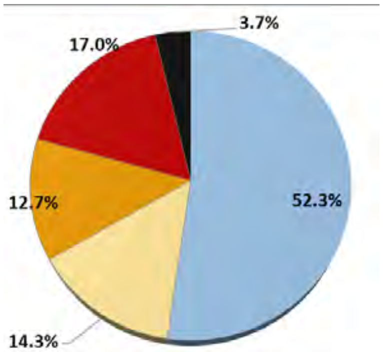
Fire type: Prescribed Fire
Location: Pisgah National Forest
County: Transylvania
Ignition date: 24 Mar 2011
Source: Landsat 5 (30m)
Baseline: 2010-06-21
Post-fire: 2011-06-24
Area (acres): 1,017

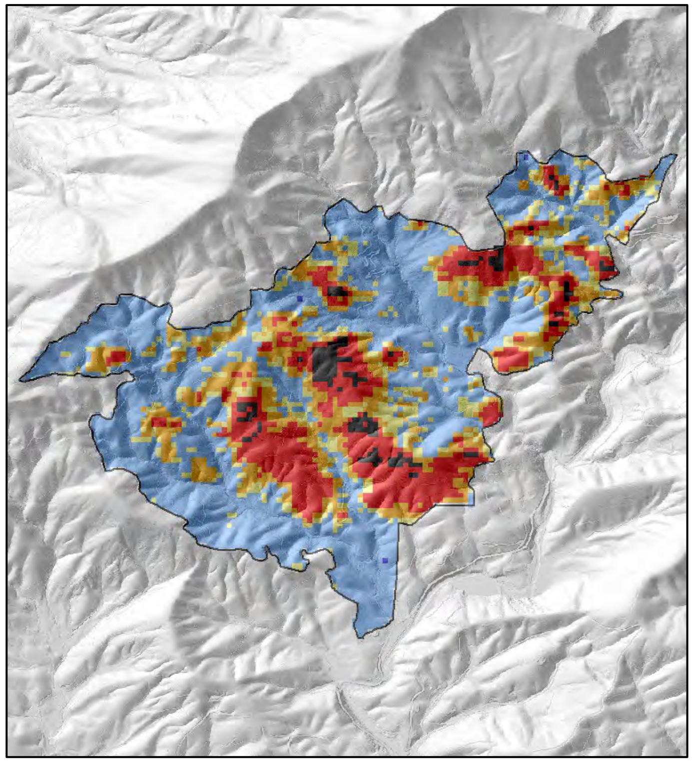




Leatherwood

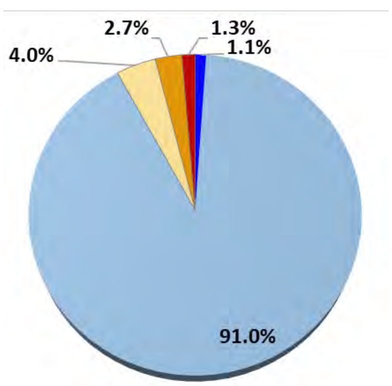
Fire type: Prescribed Fire
Location: Nantahala National Forest
County: Swain
Ignition date: 29 Mar 2007
Source: Landsat 5 (30m)
Baseline: 2006-05-15 to 09-21
Post-fire: 2007-05-15 to 09-21
Area (acres): 961

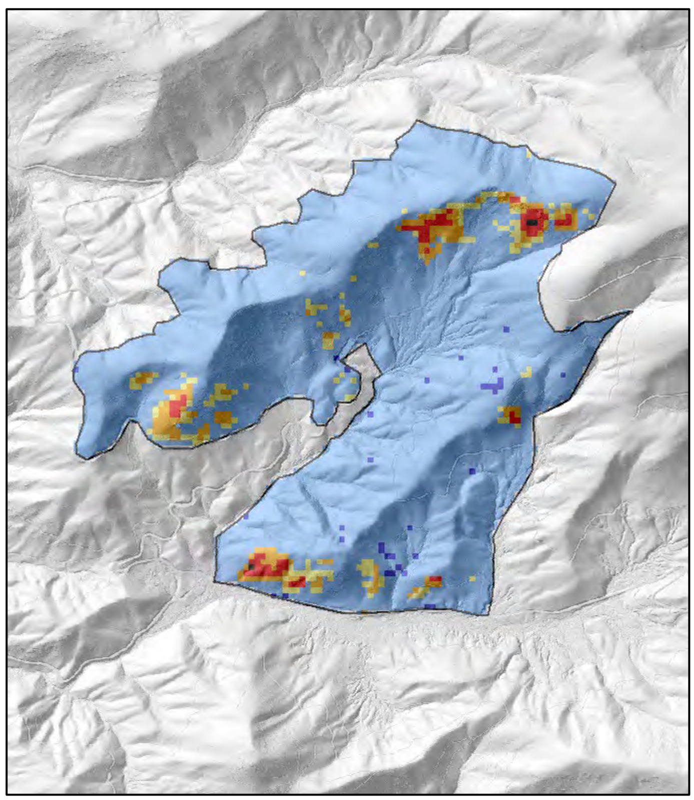




Highlands

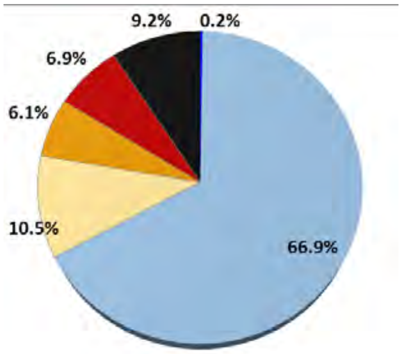
Fire type: Prescribed Fire
Location: Nantahala National Forest
County: Macon
Ignition date: 9 Mar 2007
Source: Landsat 5 (30m)
Baseline: 2006-05-15 to 09-21
Post-fire: 2007-05-15 to 09-21
Area (acres): 850

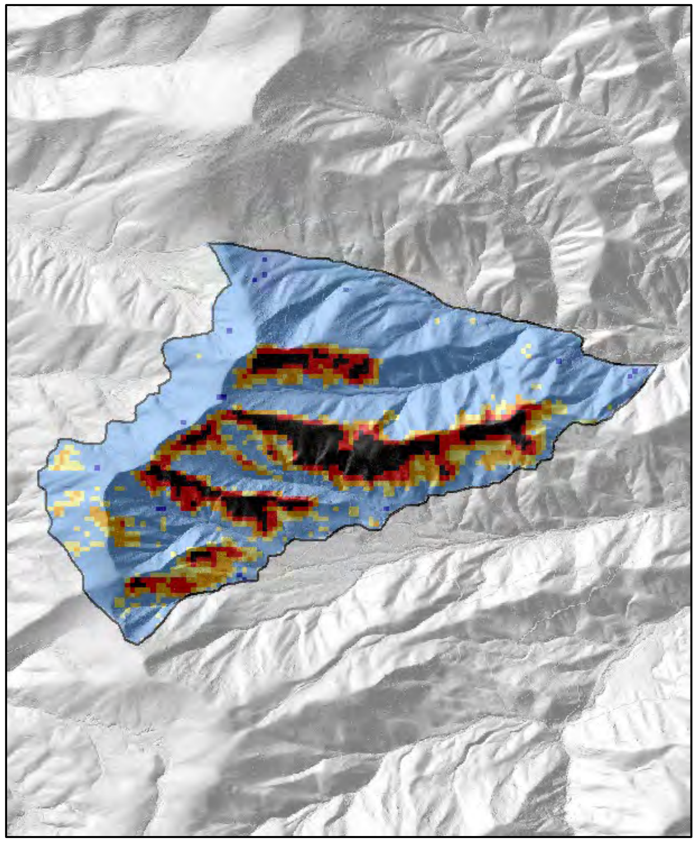




Deweese Ridge

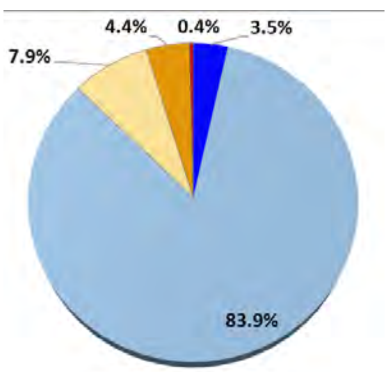
Fire type: Prescribed Fire
Location: Nantahala National Forest
County: Macon
Ignition date: 14 Mar 2007
Source: Landsat 5 (30m)
Baseline: 2006-05-15 to 09-21
Post-fire: 2007-05-15 to 09-21
Area (acres): 844

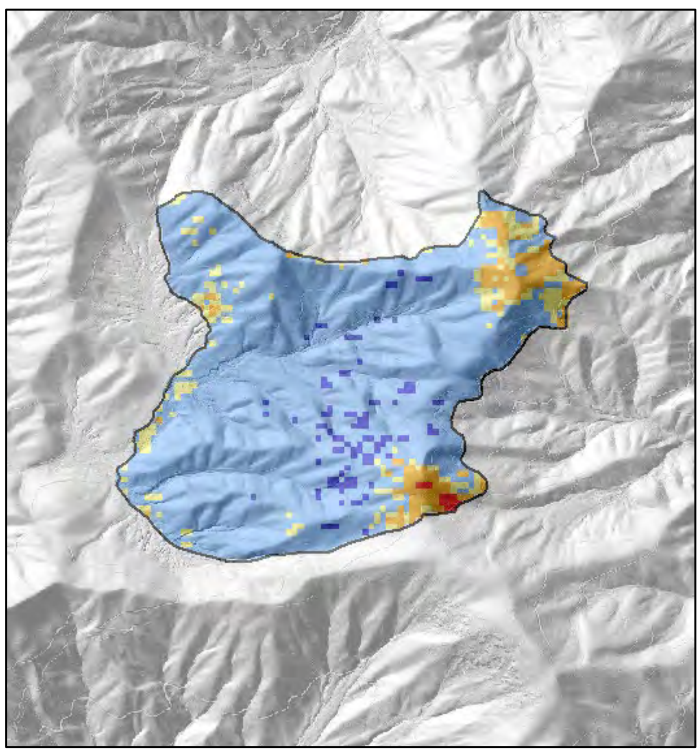




Alarka Laurel

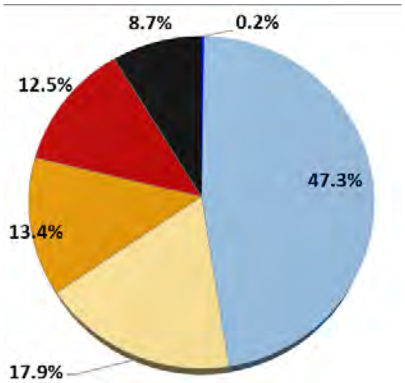
Fire type: Prescribed Fire
Location: Nantahala National Forest
County: Swain
Ignition date: 11 Dec 2008
Source: Landsat 5 (30m)
Baseline: 2008-06-30 to 07-18
Post-fire: 2009-06-01 to 06-30
Area (acres): 558

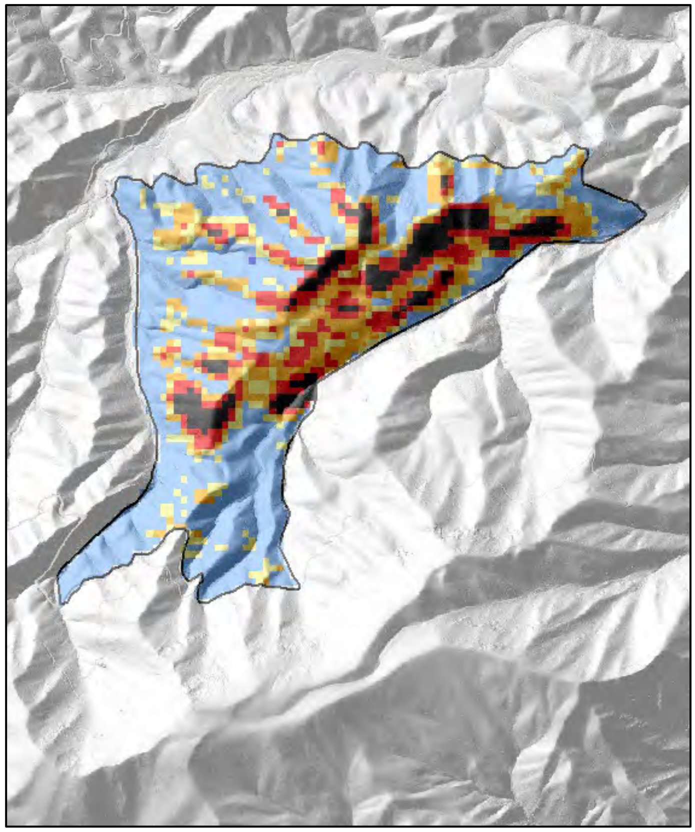




Cook Branch

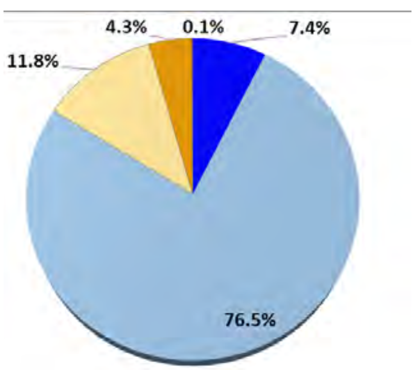
Fire type: Prescribed Fire
Location: Nantahala National Forest
County: Graham
Ignition date: 18 Apr 2009
Source: Landsat 5 (30m)
Baseline: 2008-06-30 to 07-31
Post-fire: 2009-06-09
Area (acres): 442

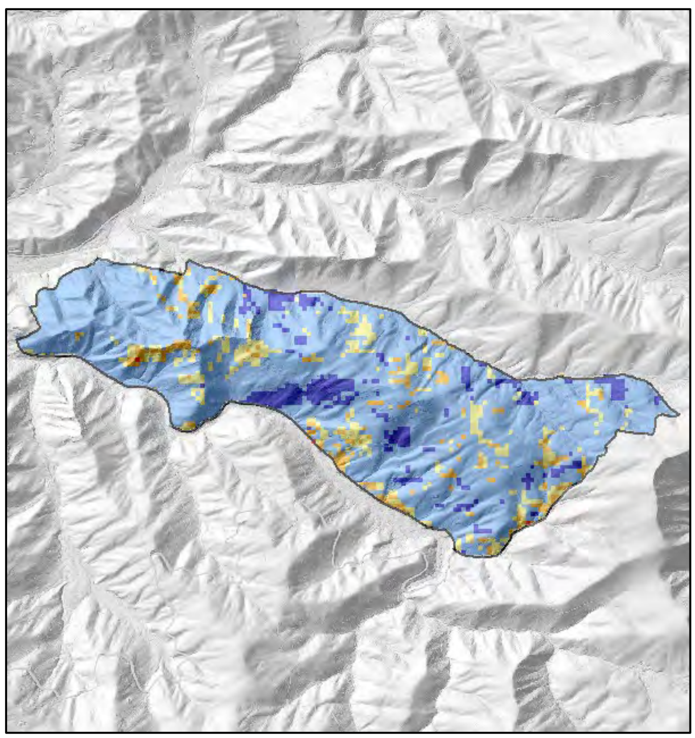




Split White Oak Ridge

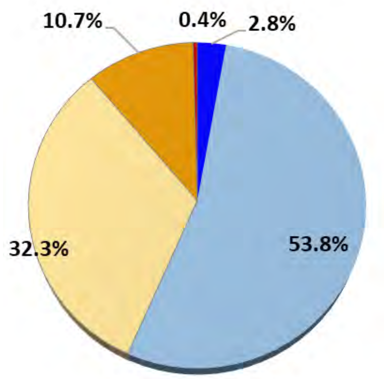
Fire type: Prescribed Fire
Location: Nantahala National Forest
County: Macon
Ignition date: 7 Mar 2016
Source: Sentinel 2 (10m)
Baseline: 2015-05-15 to 09-21
Post-fire: 2016-05-15 to 09-21
Area (acres): 838

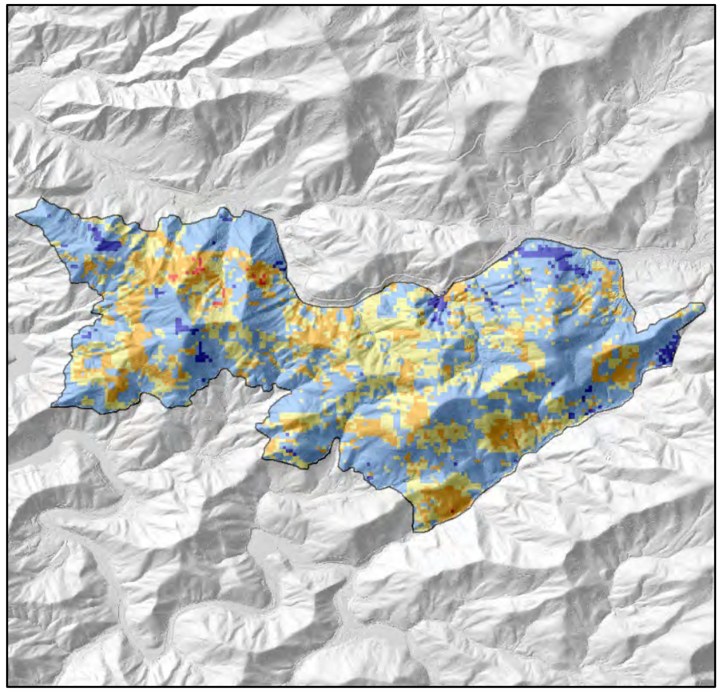




Fire Gap

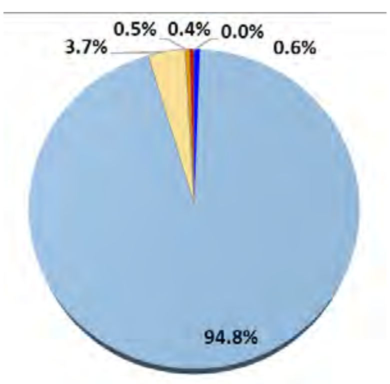
Fire type: Prescribed Fire
Location: Nantahala National Forest
County: Macon
Ignition date: 8 Mar 2016
Source: Sentinel 2 (10m)
Baseline: 2015-05-15 to 09-21
Post-fire: 2016-05-15 to 09-21
Area (acres): 1,751





Appletree

Fire type: Prescribed Fire
Location: Nantahala National Forest
County: Macon
Ignition date: 23 Apr 2019
Source: Sentinel 2 (10m)
Baseline: 2018-07-01 to 07-31
Post-fire: 2019-07-24
Area (acres): 2,095



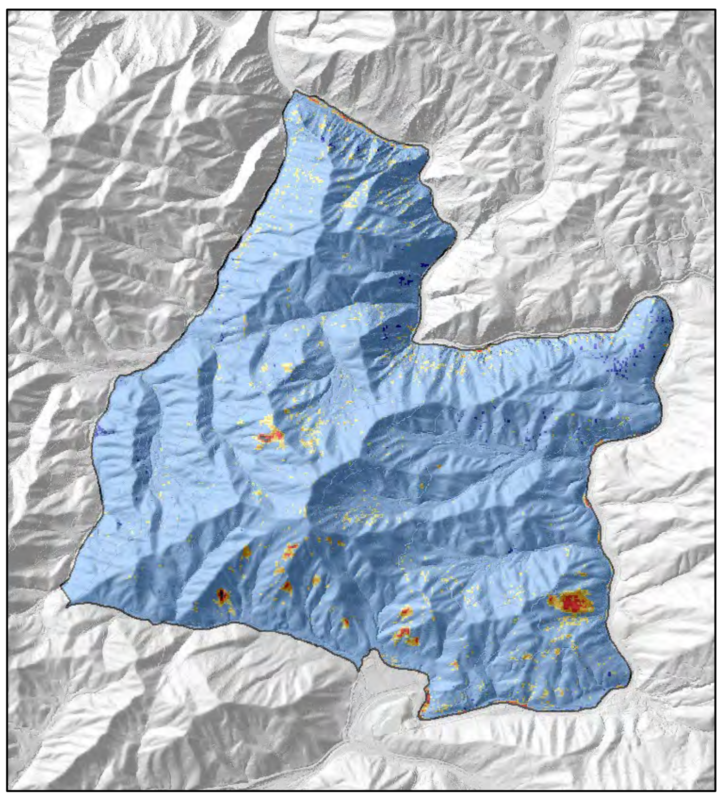


Table A2a: Likelihoods of dNDVI severity by prescribed fire and wildfire.

	Increase	Stable	Low Decline	Mod Decline	High Decline	Severe Decline	Grand Total
Rx Fire	**3.1%**	**77.2%**	**12.0%**	**4.0%**	**2.5%**	**1.3%**	**100.0%**
Rx_AlarkaLaurel_2008	3.5%	83.9%	7.9%	4.4%	0.4%	0.0%	100.0%
Rx_Appletree_2019	0.6%	94.8%	3.7%	0.5%	0.4%	0.0%	100.0%
Rx_CookBranch_2009	0.2%	47.3%	17.9%	13.4%	12.5%	8.7%	100.0%
Rx_DeweeseRidge_2007	0.2%	66.9%	10.5%	6.1%	6.9%	9.2%	100.0%
Rx_FireGap_2016	2.8%	53.8%	32.3%	10.7%	0.4%	0.0%	100.0%
Rx_Highlands_2007	1.1%	91.0%	4.0%	2.7%	1.3%	0.0%	100.0%
Rx_LaurelBrook_2007	1.7%	85.3%	11.9%	0.9%	0.3%	0.0%	100.0%
Rx_Leatherwood_2007	0.0%	52.3%	14.3%	12.7%	17.0%	3.7%	100.0%
Rx_LostBearEast_2010	15.1%	72.1%	6.9%	1.6%	2.4%	1.9%	100.0%
Rx_PilotMtn_2008	6.6%	91.6%	1.6%	0.2%	0.1%	0.0%	100.0%
Rx_PinkBeds_2011	0.0%	81.1%	17.3%	0.7%	0.3%	0.6%	100.0%
Rx_SplitWhiteOakRidge_2016	7.4%	76.5%	11.8%	4.3%	0.1%	0.0%	100.0%
Wildfire	**0.8%**	**36.7%**	**26.7%**	**14.8%**	**10.7%**	**10.3%**	**100.0%**
Wf_AveyCreek_1999	0.1%	70.1%	25.0%	3.9%	0.9%	0.0%	100.0%
Wf_BaldKnob_2015	2.6%	29.8%	6.9%	8.2%	19.2%	33.2%	100.0%
Wf_BlueGravel_2015	3.8%	46.5%	23.4%	16.4%	9.1%	0.8%	100.0%
Wf_Boteler_2016	0.0%	37.3%	41.8%	12.7%	5.4%	2.8%	100.0%
Wf_BrushyRidge_2000	1.2%	35.3%	25.1%	17.2%	13.2%	8.1%	100.0%
Wf_CampBranch_2016	0.8%	47.0%	30.7%	8.1%	6.1%	7.3%	100.0%
Wf_ClearCreek_2016	3.0%	26.9%	19.2%	30.5%	16.4%	4.0%	100.0%
Wf_DicksCreek_2016	0.0%	28.7%	29.9%	27.0%	9.8%	4.5%	100.0%
Wf_DobsonKnob_2007	0.0%	10.2%	13.1%	13.5%	24.5%	38.7%	100.0%
Wf_DobsonKnob_2017	2.9%	5.4%	11.7%	38.0%	25.5%	16.5%	100.0%
Wf_GoldieDeadon_1999	1.5%	69.6%	22.7%	4.6%	1.1%	0.4%	100.0%
Wf_Highway151_2016	0.0%	5.3%	58.8%	28.4%	4.5%	2.9%	100.0%
Wf_Knob_2016	0.3%	74.8%	22.9%	1.6%	0.4%	0.0%	100.0%
Wf_Larman_2001	0.0%	15.1%	27.7%	28.3%	17.3%	11.6%	100.0%
Wf_LinvilleComplex_2007	0.0%	4.7%	7.9%	10.6%	21.4%	55.4%	100.0%
Wf_MapleSprings_2016	0.2%	37.6%	36.3%	18.2%	5.8%	1.9%	100.0%
Wf_Poplar_2015	2.7%	57.6%	24.9%	10.1%	4.7%	0.0%	100.0%
Wf_RockMtn_2016	0.1%	52.1%	34.1%	7.7%	3.5%	2.5%	100.0%
Wf_SilverMine_2016	4.7%	65.0%	10.1%	6.9%	6.2%	7.1%	100.0%
Wf_Sunrise_2008	0.2%	14.9%	20.4%	21.2%	18.4%	25.0%	100.0%
Wf_Tellico_2016	0.1%	32.8%	32.6%	17.5%	9.6%	7.4%	100.0%
Wf_WhiteCreek_2017	1.1%	12.3%	16.8%	29.0%	32.0%	8.8%	100.0%
All fires combined	**1.1%**	**42.2%**	**24.7%**	**13.3%**	**9.6%**	**9.0%**	**100.0%**

Table A2b: Relative likelihood of severe fire across site moisture categories comparing the site moistures available for the fire with those observed to have a severe growing season decline.

		Mesic	Moderate	Xeric	Count	% Severe
Prescribed fire	**Available:**	**13.3%**	**64.1%**	**22.6%**	**13,427**	
	Observed:	**0.6%**	**27.0%**	**72.4%**	**173**	**1.3%**
Rx_AlarkaLaurel_2008	Available:	7.7%	66.7%	25.6%	546	
	Observed:	None	None	None	0	0.0%
Rx_Appletree_2019	Available:	21.4%	59.0%	19.6%	2,072	
	Observed:	0.0%	100.0%	0.0%	1	0.0%
Rx_CookBranch_2009	Available:	25.6%	55.1%	19.3%	425	
	Observed:	2.7%	48.6%	48.6%	37	8.7%
Rx_DeweeseRidge_2007	Available:	17.7%	55.7%	26.6%	835	
	Observed:	0.0%	16.7%	83.3%	77	9.2%
Rx_FireGap_2016	Available:	15.9%	59.8%	24.3%	1,711	
	Observed:	None	None	None	0	0.0%
Rx_Highlands_2007	Available:	4.3%	71.8%	23.9%	829	
	Observed:	None	None	None	0	0.0%
Rx_LaurelBrook_2007	Available:	11.6%	65.7%	22.7%	1,974	
	Observed:	None	None	None	0	0.0%
Rx_Leatherwood_2007	Available:	10.5%	60.6%	28.9%	920	
	Observed:	0.0%	17.6%	82.4%	34	3.7%
Rx_LostBearEast_2010	Available:	8.2%	63.2%	28.6%	950	
	Observed:	0.0%	16.7%	83.3%	18	1.9%
Rx_PilotMtn_2008	Available:	5.5%	65.4%	29.1%	1,263	
	Observed:	None	None	None	0	0.0%
Rx_PinkBeds_2011	Available:	0.0%	100.0%	0.0%	1,061	
	Observed:	9.8%	88.5%	1.7%	6	0.6%
Rx_SplitWhiteOakRidge_2016	Available:	19.7%	58.3%	22.0%	841	
	Observed:	None	None	None	0	0.0%
Wildfire	**Available:**	**17.1%**	**58.6%**	**24.3%**	**84,719**	
	Observed:	**6.6%**	**56.1%**	**37.3%**	**8,691**	**10.3%**
Wf_AveyCreek_1999	Available:	4.9%	53.5%	41.6%	2,127	
	Observed:	None	None	None	0	0.0%
Wf_BaldKnob_2015	Available:	12.9%	70.6%	16.5%	1,240	
	Observed:	13.8%	74.0%	12.1%	412	33.2%
Wf_BlueGravel_2015	Available:	6.0%	67.1%	26.8%	529	
	Observed:	0.0%	100.0%	0.0%	4	0.8%
Wf_Boteler_2016	Available:	15.2%	58.5%	26.2%	8,370	
	Observed:	4.1%	28.9%	67.0%	235	2.8%
Wf_BrushyRidge_2000	Available:	20.9%	58.4%	20.7%	11,851	
	Observed:	6.7%	48.4%	44.9%	955	8.1%
Wf_CampBranch_2016	Available:	11.7%	59.8%	28.5%	3,105	
	Observed:	0.0%	35.5%	64.5%	227	7.3%
Wf_ClearCreek_2016	Available:	23.3%	51.7%	25.0%	1,691	
	Observed:	2.4%	38.1%	59.5%	67	4.0%
Wf_DicksCreek_2016	Available:	27.5%	51.5%	21.0%	418	
	Observed:	4.0%	56.0%	40.0%	19	4.5%

Wf_DobsonKnob_2007	Available:	16.2%	58.1%	25.7%	801	
	Observed:	13.5%	60.5%	26.0%	310	38.7%
Wf_DobsonKnob_2017	Available:	15.5%	72.3%	12.2%	1,226	
	Observed:	7.5%	72.0%	20.5%	202	16.5%
Wf_GoldieDeadon_1999	Available:	4.6%	53.2%	42.2%	1,678	
	Observed:	0.0%	16.7%	83.3%	6	0.4%
Wf_Highway151_2016	Available:	25.5%	66.7%	7.8%	243	
	Observed:	0.0%	57.1%	42.9%	7	2.9%
Wf_Knob_2016	Available:	19.5%	56.7%	23.8%	1,101	
	Observed:	None	None	None	0	0.0%
Wf_Larman_2001	Available:	8.8%	57.5%	33.8%	2,703	
	Expected:	13.1%	56.7%	30.2%	314	11.6%
Wf_LinvilleComplex_2007	Available:	13.1%	61.2%	25.6%	6,381	
	Observed:	6.8%	60.8%	32.4%	3,534	55.4%
Wf_MapleSprings_2016	Available:	20.4%	52.3%	27.3%	8,187	
	Observed:	3.2%	25.0%	71.8%	154	1.9%
Wf_Poplar_2015	Available:	4.7%	72.0%	23.3%	595	
	Observed:	None	None	None	0	0.0%
Wf_RockMtn_2016	Available:	12.4%	69.1%	18.4%	11,280	
	Observed:	1.4%	36.4%	62.2%	284	2.5%
Wf_SilverMine_2016	Available:	14.0%	53.2%	32.7%	5,331	
	Observed:	2.1%	42.1%	55.8%	380	7.1%
Wf_Sunrise_2008	Available:	15.7%	73.9%	10.4%	1,961	
	Observed:	3.9%	77.1%	19.0%	490	25.0%
Wf_Tellico_2016	Available:	26.4%	51.2%	22.4%	9,663	
	Observed:	7.3%	45.7%	47.0%	719	7.4%
Wf_WhiteCreek_2017	Available:	13.0%	62.0%	25.0%	4,238	
	Observed:	7.6%	67.2%	25.3%	372	8.8%

Table A3: A comparison of high severity areas from patch analysis and point extraction analyses.

Fire Name	% severe in patch analysis	% severe in patch analysis >0.5acres	% severe from point analysis
Prescribed fire	**1.2**	**0.0**	1.3
2008 Pilot Mtn Rx	0.0	0.0	0.0
2016 Fire Gap Rx	0.0	0.0	0.0
2016 Split White Oak Rx	0.0	0.0	0.0
2008 Alarka Laurel Rx	0.0	0.0	0.0
2007 Deweese Ridge Rx	8.6	8.6	9.2
2007 Highlands Rx	0.1	0.0	0.0
2007 Laurel Brook Rx	0.0	0.0	0.0
2007 Leatherwood Rx	3.0	2.6	3.7
2009 Cook Branch Rx	8.1	7.6	8.7
2010 Lost Bear East Rx	1.8	1.8	1.9
2011 Pink Beds Rx	0.5	0.5	0.6
2019 Appletree Rx	0.0	0.0	0.0

Wildfire	**8.7**	**8.3**	**10.3**
1999 Avey Creek	0.0	0.0	0.0
1999 Goldie Deaden	0.2	0.1	0.4
2000 Brushy Ridge	7.4	7.1	8.1
2001 Larman	10.6	10.4	11.6
2007 Dobson Knob	38.8	38.3	38.7
2007 Linville Shortoff	56.0	55.7	55.4
2008 Sunrise	25.7	25.2	25.0
2015 Bald Knob	33.3	33.1	33.2
2015 Blue Gravel	0.8	0.6	0.8
2015 Poplar	0.0	0.0	0.0
2016 Boteler	3.0	2.8	2.8
2016 Camp Branch	6.7	6.4	7.3
2016 Clear Creek	2.6	2.1	4.0
2016 Dick's Creek	3.4	2.6	4.5
2016 Hwy 151	3.5	3.4	2.9
2016 Knob	0.0	0.0	0.0
2016 Maple Springs	1.9	1.6	1.9
2016 Rock Mountain	2.3	2.1	2.5
2016 Silver Mine	6.5	6.3	7.1
2016 Tellico	6.8	6.2	7.4
2017 Dobson Knob	14.8	13.8	16.5
2017 White Creek	7.2	5.9	8.8

Appendix 2: Excepts from early state reports of Southern Appalachian forest fires

When momentum grew for establishing national forests in the Southern Appalachians near the turn of the 20th century, federal and state foresters recorded conditions across the region in a series of reports. These reports have been most often used to demonstrate the historical importance of fire just before suppression occurred, but as shown in the tables below, the authors describe a remarkably complex fire regime at that time that includes variable severity from topography and land cover.

The first of these reports with local detail was from the state in 1895. A decade later, Ayres and Ashe published a more detailed report of the condition of the region's forest. This latter volume provides the most detailed and description of forest conditions from that era that exists. While there is undoubtedly observational bias in the portions of the watersheds the team visited and perceptional bias about fire that we expect from professionals from that era, these descriptions paint an unparalleled portrait of fire regimes prior to much industrial logging and organized fire suppression.

These descriptions may not represent the fire regimes of prior decades any more than they document the fire regimes of when the Cherokee managed fire. What we do glean is insights into the causes and variability of the common signs of fire and fire effects across a broad scope of the region's forests at that time. From these descriptions, the topographic effects of fire are repeated described: coves and north faces tend to have less to no fire or when they do, minimal effects of consequence. Dry southern slopes were prone to burn repeatedly with the greatest effects on tree mortality and contributed to failed or brushy regeneration.

There is also sign that fire varied in complex ways with relation to settlement. For some areas, Ayres and Ashe reported abundant regeneration near valley settlements as the fragmentation of those landscapes contributing to less pervasive fire there. These forests were "protected by clearings". There are also suggestions that isolation from settlements reduced fire. There may be a middle zone in this historical landscape where human fires ran frequently, with more interior and often higher elevation areas burning less. As fires were often used for resource benefit, such as for hunting, travel and chestnut harvesting, these sites at the margins of settlement may have been hotspots of frequent fire along an earlier wildland-urban gradient. Fire's association with intensively settled or trafficked areas is suggested by fragmentary evidence (Figure A1-1).

Figure A1-1. A section of a woodcut drawn from an 1871 sketch upstream of Hot Springs, North Carolina along the French Broad Valley where the 2016 Silver Mine fire burned after decades of fire exclusion. Note the snags on the hillside that were likely caused by a wildfire along the frequently traveled Drover's Road which some years later became a rail line. The original field sketch, still in existence, also shows these snags.

Bryant, W.C. (ed.) 1872. *Preserving a picturesque America, or the land we live in*. New York: Appleton and Co.

Remarkable as well in these reports, there is little indication of an industrial forestry association with fire at that time. That became a much greater concern in subsequent decades, particularly as the spruce forests of Mount Mitchell and the Balsam Mountains were logged, then burned where the severity was routinely catastrophic (Silver 2003). A linkage between untreated slash and severe fire was well established by experience in the northeast and upper Midwest in prior decades. The untreated slash fuels were often blamed, but with greater accessibility and logging railroads, there were also more ignitions, especially in these high elevation forests that had been relatively isolated prior to their logging.

Table A2a: W.W Ashe. 1895: *Forest fires: their destructive work, causes, and prevention*. North Carolina Geological Survey. Bulletin No. 7. Raleigh.

County	**Fire status report**
Alexander	Only a few forest fires, and these of the kind that may be called leaf-fires, were reported from this county has having occurred during 1894.
Buncombe	Burning the woods has nearly ceased in this county, but is still to some extent practiced in the mountain districts, where cattle are grazed in the woods.
Burke	There were 7,000 to 8,000 acres of timbered lands reported as burnt over in the South mountains alone, killing a large amount of pine timber and burning much fencing. Fires also occurred along the Blue Ridge and along the line of the Western North Carolina railroad, but did no great damage. All forest fires after the first of March kill much of the young forest growth . Fires were said to have originated from burning brush, o'possum hunters, and more frequently from incendiarism: those along the railroad from locomotives, and some were set by chestnut gatherers. One correspondent thinks that burning the dead herbage and undergrowth does good by killing insects; but sometimes it also kills yellow pines and growing timber. The benefit that may be done in the way of killing insects is doubtless insignificant as compared with the damage resulting from these forest fires in the way of killing out the young tree growth.
Caldwell	One correspondent states that he knew of nine large fires; one in March in Lenoir township, one in march in Globe township, one in march in Patterson township, one in April in Yadkin Valley township, one in November in Patterson township, and another there in December; one in December in Yadkin Valley township, one in Lower Creek township and one in Kings Creek township. There were from 10,000 to 15,000 acres burned over with a loss of about $5,000. Another correspondent mentions seven fires in his section of Caldwell county during the year 1894. One of these was in June in Globe township, and in August and again in November in the same township. In November, in the central part of the county, near Lenoir, two fires occurred, one in Yadkin Valley township and another in Yadkin Valley and Patterson township in December. There were about 40,000 acres burned over with a damage to timber of about $6,000. Young poplars and chestnuts suffer most from these fires, but white pines are very much injured, oaks are scarred and often injured for lumber, as is also the case with chestnuts and hickories. These fires, this correspondent thinks, will cause the gradual disappearance of the chestnut. The trees are scorched by the fires and decay sets in on the burnt side. Firs are set in the woods to make the grass grow for cattle and to burn the leaves so hogs can get mast. Wherever the stock law has been introduced the number of fires has been much lessened.
Graham (Swain, Cherokee)	Burning the woods has been practiced in this and in Cherokee county ever since they were settled, and before that time the Indians practiced it. The trees in many places, especially the chestnuts have been scorched on one side and then hollowed out from the effects of the fires. Much other timber and young growth is injured. Many of the mountains in Graham and Swain counties were burned over by the Indians during the past year. It is safe to say that one-fourth of the mountain lands these three counties, Graham, Swain and Cherokee, was burnt over during the past year.
Henderson	One report states that a large part of the forest lands, at least one-third, was burned over during the winter of 1893-'94, between November and May, with a heavy loss of timber. The same report states that at least two-thirds of the standing timber has been damaged by fires which occur regularly each season, and which are purposely stated to better the pasturage. Some fires, however, are accidental.
Jackson	The outside mountain lands, are yearly burned over to supply grazing. At least a third of the area of these lands was estimated to have been burned during the past year. Great damage is done to the poplar and chestnut timber; indeed it is difficult to find in these wild lands a tree of these kinds that is not defective at the base from this cause.
Macon	Like so many of the other mountain counties, yearly has a large part of the "wild lands" burned over. And although the fires are chiefly leaf-fires they have caused great damage to the timber. Between 10,000 and 20,000 acres were estimated to have been burned over during the past year. The loss from the fencing destroyed was placed at more than $20,000.
Madison	Although there were several fires at various places in the county there was only a single destructive one reported which burned over about fifty acres. Burning the woods is practiced in many sections of the county to keep the woods open and better the grazing.
Mitchell (Yancey, Wautaga)	Thousands of acres, mostly on southern slopes were reported as burned over during the past year in this county. One correspondent says that although the damage to standing timber from a single fire appears to be small the continued burning, year after year, results in serious damage, killing much of the timber and seriously injuring the rest, so that its value as been lessened one-half by the mere repletion of the leaf-fires. On many south mountain slopes many of the larger trees have been destroyed and only a brushy growth occupies their place. The practice of burning the woods for improving pasturage is a common one in parts of the county. Many of the statements made about the practice of firing and the resultant damage to the woodland of Mitchell county will apply as well to parts of the adjoining counties of Yancey and Watauga.

Table A2b: Descriptions of wildfire and its effects in the Southern Appalachians from 1905. Ayres, H.B., W.W. Ashe. 1905. *The Southern Appalachian Forests*. *Department of the Interior United States Geological Survey Professional Paper* No. 37. Washington: Government Printing Office.	
NEW RIVER BASIN	All the forest is inferior in condition, being either culled, fire scarred, or full of old and defective trees, while a dense undergrowth usually covers the. steep slopes.
Big Laurel Creek District (Ashe Co., NC)	Fires have done but slight damage, except on the upper slopes and on the spur extending south from Pond Mountain.
Horse Creek Basin (Ashe Co. NC)	Recently there has been very little fire, the woodland being protected by clearings.
Helton Creek District (Grayson Co. VA)	Only a few of the higher ridges have been seriously burned; the numerous clearings are a great protection against fire.
Wilson Creek Basin (Grayson Co. VA)	On the ridges about the headwaters fires are frequent, but the damage is less notable in this basin than in any other.
Fox Creek Basin (Grayson Co. VA)	Frequent light fires have overrun the ridges, seriously injuring the forest.
Guffeys Creek Basin (Grayson Co. VA)	Fires have been frequent on the ridges and south slopes, seriously injuring the forest.
Middle Fox Creek Basin (Grayson Co. VA)	Fires have been frequent on the mountain ridges and southern slopes and the forests have been much injured. Saplings are abundant only on north slopes and near clearings, where they are somewhat protected from fire. There is much brush, but sprouts and seedlings are few.
Dell District (Grayson Co. VA)	The forests of this tract are so isolated by clearings that fires are not prevalent except on Iron Mountain.
Knob Fork District (Grayson Co. VA)	On the south slope of Iron Mountain slight fires have been frequent almost annual. Elsewhere the wood lots are protected by clearings. Light undergrowth, especially on the south slope of Iron Mountain where subdued by fire.
Elk Creek District (Grayson Co. VA)	The south slope of Iron Mountain has been much burned by slight and often repeated tires reduced, in fact, to scrub growth^ and yields only about 8 cords of wood per acre. On the remainder of the tract fires have done much less damage, as the wood lots are protected by clearings.
Peach Bottom Creek District (Grayson Co. VA)	The woodlands on Point Lookout and Buck Mountain have been much burned in the general effort to make pasture land. Elsewhere the woodlands are protected by the surrounding clearings, and fires are not common.
Bridle Creek District (Grayson Co. VA)	The forest is so broken by clearings that fires could be prevented with ease. The prevalent custom of burning woodlands seems to be dying out.
Little Fox Creek Basin (Grayson Co. VA)	Formerly prevalent; fires in recent years have done very little harm.
Piney and Potato Creek Districts (Grayson Co. VA)	The forest is broken by numerous clearings, and fires can easily be prevented.
Grassy Creek Basin (Grayson Co. VA)	Fires are rare, being prevented by clearings.
Jefferson District	The woodland is so much broken by clearings that fires are not prevalent.
Boone District (Watauga Co. NC)	Fires are less prevalent here than in most of the mountain region, being checked by numerous clearings. About Three Top and Snake mountains and along the Blue Ridge there have been several severe fires.
Beverly District (Wythe Co. VA)	Frequent fires overrun the whole tract. The drier portions along the ridges have been severely burned and most of the timber killed.
Speedwell District (Wythe Co. VA)	On the ridges, fires have been frequent and severe; about 1,600 acres have been severely burned, and light fires have overrun most of the remainder.

Kinser Creek District (Smyth and Wythe Co. VA)	Fires have been unusually severe in this district. Practically all of the timber on 9 square miles on the crests of the mountain and the spurs has been killed, except some scattered black pine [Pinus rigida]. Fires have run lightly over all of the remaining forest, except that portion north of Horns Branch which is isolated by clearings. Most of the coves have a good stand of [second growth] saplings, but the ridges are deficient in young trees, owing to fire.
Cripple Creek District (Smyth Co. VA)	Fires have been frequent and severe, and have killed about half of the forest. Much of the log timber has been destroyed and new growth has been prevented.
Brush Creek Basin (Alleghany Co. NC)	Humas and litter nearly all consumed by the frequent fires. Burns are common but not severe, except on the south slope of Bullhead.
S. FORK Holston River Basin	The steep slopes west of Damascus and east of Como Gap are in a very inferior forest condition, owing largely to the long-continued prevalence of fires, which have not only prevented a vigorous growth, but have even driven out the most valuable species.
Cressy Creek District (Smyth Co. VA)	Fires have been repeated and the forest is greatly reduced. In recent years, however, the fires seem to have been less severe….On the ridges, where most frequently burned, much black pine [*Pinus rigida*] is coining in.
Dickey Creek District (Smyth Co. VA)	Fires have been frequent, and along the spurs and ridges of the divides have greatly injured the forest.
Rye Valley District Smyth Co. VA)	Fires have been frequent and severe, much timber has been killed or injured, and much of the forest has been reduced to brush. Seedlings start freely, but are soon killed by the fires.
Como Creek Basin (Smyth Co. VA)	The summits of the ridges have been severely burned. The slopes have been occasionally overrun by light fires.
Holston District (Washington and Smyth Co. VA)	Light fires have run over most of this tract, but severe fires killing the log timber have been exceptional. The forest is very poor because of these fires…the abundant brush and the frequent fires prevent a dense stand of seedlings.
N side of Holston Mountain (Washington Co. VA and Sullivan Co. TN)	Fires have been frequent and the forest has been greatly reduced. But little log timber has been killed, though the young growth has been greatly injured. Reproduction is very free, except as hindered by fire.
Shady Valley District (Washington Co. VA, Johnson Co. TN)	Only the ridges have been severely burned, and on them little of the logging timber has been killed; but the fires have been sufficiently severe -and frequent to prevent the best growth of timber.
Laurel Bloomery District (Johnson Co. TN)	The ridges have been repeatedly and, in many cases, severely burned. Nearly all of the woodland is subject to fire, and the stand of timber and young growth is in very inferior condition on that account. On the foothills protected by clearings are some excellent stands of [second growth] saplings, but as a rule the young growth is very deficient because of the fires.
White Top Creek District (Washington and Smyth Co. VA)	Fires have been frequent, especially on the ridges of Iron Mountain, where the timber has been much reduced. The northern slopes of Balsam and White Top mountains have been almost free from fire.
Valley Creek District (Johnson County, TN)	Fires are not prevalent except on the slope of Pond Mountain and on Chestnut Ridge, where light fires creep through the woods nearly every year.
WATAUGA RIVER BASIN	Fires are preventing a good growth on large portions, although they are seldom so severe as to kill much timber. Vigorous sprouts, seedlings, and saplings abound on old cuttings and burns, and prevention of fire and some judicious thinning would soon develop a forest that would justify transportation companies in building railroads to haul its products to market.
N End of Buffalo Mtn. (Washington and Carter Co. TN)	Fires are usual each winter or spring. The south slopes have been seriously injured. Abundant [second growth] saplings are found on north slopes, but on south slopes the stand of young timber of valuable species is deficient, owing to fire and grazing.

	Sprouts and seedlings spring up quickly on north slopes after cutting and burning, but on south slopes are usually soon killed by fire.
Little and Stone Mtn Districts (Carter and Unicoi Co. TN)	The customary fires have reduced the forests of the driest portion of the southern slopes to a few scattered pines and brush…. Were it not for fire, reproduction would be free both by sprouts and seed. Oak and white pine seedlings are most abundant.
Gap Creel Mtn. (Carter Co. TN)	Humus light owing to frequent fires. Fires have been frequent, and the stand is greatly reduced. The southern ridges especially are very scantily wooded. [Second growth] saplings are deficient in number and quality, due to the frequent fires.
Little Doe River and Ripshin Creek Districts (Carter Co. TN)	There have been very few severe fires except on the slopes of Tiger Creek Valley, where timber trees on a few acres have been killed. Light fires have run over the ridges from time to time without much damage to the large trees, but have seriously reduced the supply of saplings and seedlings
White Rock Mtn. (west side) Carter Co. TN)	Fires have been frequent and severe; timber is very inferior because of them. There are very few saplings, because of frequent fires. Reproduction is low on account of fires.
Laurel Fork District (Carter Co. TN)	This tract is being logged …only the ridges and steeper slopes have been repeatedly burned.
Pond Mtn District (Carter Co. TN)	The ridges have been scorched, but the damage on this tract is less than in adjacent areas.
Iron Mtn District (Carter Co. TN)	Fires are very frequent, and the forest is of inferior quality because of them. [Second growth] saplings are inferior because of frequent fires. There are not half enough for a good stand.
Stony Creek District (Carter Co. TN)	Fires have been frequent and about one-half the tract has been burned over every year. Along the foothills, where protected from fire by the clearings, [second growth] saplings are abundant, but higher on the mountain sides vigorous growth is prevented by the frequent fires and the remaining old trees.
Little Doe River Basin (Johnson Co. TN)	Fires overrun the ridges almost every year, and about 5 square miles have been so severely burned as to kill most of the log timber. Light fires run almost annually over nearly all the remaining portion.
Roane Creek District (Johnson Co. TN)	Fires are frequent, especially on the ridges on the southern slopes, where the forests have been seriously injured.
Forge Creek District (Johnson Co. TN)	Except along the crest of Forge Mountain there have been few fires beyond those used in clearing the land.
Fish Spring District (Johnson Co. TN)	Fires have been frequent on the mountain ridges and the forest is much depleted, and a large part of the young growth has been destroyed.
Buck Mtn District (Carter and Watauga Co. TN)	Fires have been frequent and the forest is much depleted.
Hattie District (Watauga Co. NC)	There have been 'very few fires, except along the crest of Stone Mountain, where the forest is much depleted.
Key Station District (Johnson Co. TN)	Fires have been frequent on Stone Mountain, where the forest is in poor condition because of them. The predominance of white pine there is due, no doubt, largely to the prevalence of fire, as the thick bark of this species protects the trunk from injury while other species are killed. Fires also prepare favorable seed beds for the white-pine seeds. The remainder of the valley is largely cleared and the woodlands near the cleared land are thus protected.
S Trib Basins of Watauga River (Watauga Co. NC)	Light fires are common, but severe fires are rare. Most of those set are intended to improve pasturage, to aid in gathering chestnuts, or for some reason of similar importance.
Western Tributary basins of Doe River	Fires, though frequent, have not killed much timber except near the crest of the mountain. Usually this tract is too damp for severe fires.

above Roan Mtn Station (Carter Co. TN)	
Elk Creek District (Mitchell and Watauga Co. NC)	Though fires are frequent they have not killed much timber, but the forest has been greatly reduced.
Cove Creek District (Watauga Co. NC)	The numerous clearings afford good protection from fires for most of the tract. The mountain sides are liable to be burned and bear evidence of some recent severe burning' on about 1,500 acres.
Elizabethton District (Carter and Unicoi Co. TN)	Well protected [from fire] by clearings.
NOLICHUCKY RIVER BASIN	In forest condition there is also great variety , dependent largely upon the prevalence of fire. Fires are freely set during autumn, winter, and spring, and great injury to timber, forest seedlings, and soil results. A large proportion of the timber trees are defective and much of the woodland area is imperfectly stocked.
Cherokee and Buffalo Mtn Districts (Washington and Unicoi Co. TN)	[Humus and litter] light; consumed by repeated fires. The stand of [second growth] saplings is deficient, owing to prevalence of fire. Undergrowth: Light; too thoroughly burned and grazed.
Limestone Cove District (Unicoi Co. TN)	Light fires are frequent in winter and spring. Saplings are abundant, except on the driest ridges and south slopes, where most severely burned and closely pastured.
Erwin District (Unicoi Co. TN)	Nearly 6,000 acres have been severely burned. Fires are very frequent. [Second growth] saplings are abundant near the farm lands, where fire is less common, but on the mountains there is not more than half a stand.
North Bald Creek Basin (Mitchell Co. NC)	Occasionally fires have run over the higher ridges, but the damage has been less than usual, very few large trees having been killed; the forest, however, is not in as good condition as it would be if the fires had been prevented.
Jacks Creek District (Mitchell Co. NC)	Fires are not prevalent, though small burns are common. The clearings limit them to small areas.
Caney River District (Yancey Co. NC)	In general the fires have been light, but frequent. Owing to them the ridges are very lightly timbered, except by pine.
Spive Creek District (Unicoi Co. TN)	Fires have been frequent and severe, especially on the ridges forming the northern boundary of this tract, where the forest is reduced to scattered pines and an undergrowth of oak sprouts and huckleberry brush. On the divide between Spive and Granny creeks white pine would soon occupy the land were it not for the annual fires. Elsewhere the hard-wood growth is checked by fires and grazing.
Rocky Fork District (Unicoi Co. TN)	Occasionally light fires occur, but little damage has been done to mature timber. On the ridges and southern exposures they keep the forest in very poor condition.
South Indian Creek District (Unicoi Co. TN)	The ridges and south slopes are frequently burned, and these portions are in poor condition. In the north coves the damage has been slight.
Embreville District TN	Repeated fires have destroyed the accumulated litter, except in a few of the deepest hollows. This forest has been badly burned and the greater part of the hard woods are stool shoots, and the same is true of much of the black pine.
Indian Creek District (Unicoi Co. TN)	Repeated fires have robbed the soil of much of the accumulated humus, except in damp hollows and on north slopes. There is considerable undergrowth in most of the forests; in some places rhododendron and Kalmia; in burned woods it is chiefly sourwoods, huckleberry, and sprouts from the stumps of fire-killed trees.
South Toe River Basin (Mitchell and Yancey Co. NC)	A great part of the forest land on Sevenmile Ridge has been badly burned and the soil covering removed.

Hollow Poplar and Pigeon Roost Creek Basins (Mitchell Co. NC)	On the lower hills and on the dry southern slopes [leaf mold] is often very scant, especially where it has been reduced by fire or by excessive pasturage, which has broken the forest cover.
Caney River Basin above Burnsville (Yancey Co. NC)	A few small areas in the spruce forest have been badly burned.
Doebag Branch District (Yancey Co. NC)	Where the woods are burned at irregular intervals there is often a dense undergrowth of stool sprouts from small trees and shrubs killed by the fires.
FRENCH BROAD RIVER BASIN ABOVE SKYLAND	Fires, grazing, and culling have greatly reduced the original quality of the forest. Bordering the farms are many fine stands of sapling second growth, but the remote mountains are full of defective trees and brush.
Puncheon Fork District (Madison Co. NC)	Fires are frequent, but not severe.
Little Creek District (Madison Co. NC)	Fires have been light, but frequent, consuming humus and retarding undergrowth.
Foster Creek and Roaring Fork Districts (Madison Co. NC)	Fires have been frequent, though usually not severe. The larger trees have been only slightly injured, but many seedlings and small saplings have been killed.
Shelton Laurel Creek District (Madison Co. NC)	Fires are very frequent, especially on the ridges in the northern part, where large amounts of timber have been killed and the forest is reduced to scattered survivors and sprouts of oak, chestnut, and maple. [Second growth is] very deficient, except on small areas near clearings. Elsewhere fires have been too severe.
Spillcorn Creek District (Madison Co. NC)	Fires are frequent along the ridges, where saplings and brush are frequently killed and the forest is kept in inferior condition. The lower slopes, however, have not been severely damaged by fire.
Spring Creek Basin Below Bluff (Madison Co. NC)	Fires are frequent and severe; almost the entire tract is overrun each year; many of the timber trees have been killed and the forest is reduced to scattered survivors with an underbrush of sprouts and shrubs, except in some of the hollows, in which there is a fair stand of timber trees.
Spring Creek Basin above Bluff (Madison Co. NC)	Th.e western ridges have been frequently burned and the forest on them has been considerably reduced. Elsewhere the fires are held in check by the clearings.
Big Pine Creek District (Madison Co. NC)	Fires are frequent, but the forest is much protected by clearings and the fires could easily be prevented.
Pawpaw and Little Pine Creek Districts (Madison Co. NC)	Limited. The large area of cleared land forms a protection against fires.
Sandymush Creek District (Madison and Buncombe Co. NC)	Limited; the woodlands are protected by the clearings.
Wolf Creek Basin	[Actively being logged.] Much of the woodland in which there is any pine has been burned and the timber to some extent damaged.
Paint Creek Basin (Madison Co. NC)	No area severely burned…. On the lower hills and dry south slopes [leaf mold] is often altogether absent, on account of the brush fires and pasturage…. The woods are generally open, though in some places there are rhododendron thickets and underbrush sprouts, which have followed fires.
S Fork of Hominy Creek Basin (Buncombe Co. NC)	There is very good soil cover in nearly all of the coves, but many of the steep slopes have been badly burned.

Shut-in Creek Basin (Madison Co. NC)	2 square miles severely burned. In the lower part of the basin, where the woodland is closely pastured and frequently burned, humus is scanty. Where the steep quartzite ridges occur, fires destroy nearly all of the leaves each winter. The woodland in the lower part of the basin, which is largely in wood lots connected with the farms, is seldom burned; the dry pine forests of the quartzite ridges suffer much from severe and frequent conflagrations, which have destroyed nearly all of the young growth, or reduced it to stool shoots, and injured the commercial value of the mature pine. But little damage has been done to the forest at the head of the stream.
Meadow and Roaring Fork Basins (Madison Co. NC)	3 square miles severely burned.The soil is often bare where pines are abundant and their dry leaves have been burned. Where this is the case it is apt to be on a south slope and at a comparatively low elevation. Fires are of exceptional occurrence in the hard woods. They are most frequent on the southern spurs of Round, Max Patch, Hogback, and Spring Creek mountains. In the pine woods they are of nearly annual occurrence, damage much standing timber, and destroy or kill back to stool shoots much young growth of fire-tender species.
Paint Creek Basin (Cocke Co. TN)	3 square miles severely burned. The forest is formed of oaks and chestnut associated with black pine. The stand is generally poor, and a great deal of the hardwood is stump sprouts or is defective from ancient fires. Second growth is very abundant in the burned woods and consists largely of oak sprouts and black-pine and white-pine seedlings.
Gulf Fork Basin (Cocke County, TN)	A large area severely burned. Much of the best white-pine land has been badly burned, and many trees that would have otherwise been sound have butt rot, or hollows caused by fire. The dry and sandy black-pine lands are also burned at frequent intervals, and the young growth is suppressed or reduced to stool shoots, so that these woods have a stand seldom more than one-half normal.
PIGEON RIVER BASIN	All species reproduce excellently under proper light conditions and, under exclusion of fire and a judicious system of lumbering, there would be no difficulty in perpetuating this forest and increasing the proportion of valuable species in its composition.
East, West and Little East Forks of Pigeon River Basins	Very little lumbering has been done in this area… These forests have been very little damaged by fire….
Pigeon River Valley Between Canton and Ferguson	No mention of fire.
Cataluchee Creek District.	2 square miles burned. [Humus and litter is] light in the lower portion of the valley, where it is much burned. Abundant elsewhere. Many fires set to make pasture, by which a large amount of log timber has been killed.
Big Creek Basin	1.36 square miles severely burned. Active logging. Fires have recently invaded the mountain slope, being set freely to improve grazing, and have killed much timber, reducing large areas to brush land. The timber that remains is in remote coves or on steep mountain sides. [Reproduction is] scant; fires are too frequent and brush comes in too freely.
Mountain Creek Basin	No mention of fire.
Hurricane Creek Basin	No mention of fire.
Crabtree Creek Basin	
Hemphill Creek Basin (Haywood County, NC)	No area severely burned.
Ground hog and Cold Spring Creek Basins (Haywood County, NC)	Very little severely burned. Fires pass through the brush on dry southern slopes at frequent intervals, so that on these slopes there is little or no litter. Most of the southern slopes are burned over each fall, but the tires rarely pass beyond the leaves, destroying the young growth and occasionally injuring mature trees.

East Fork of Pigeon River Basin (Haywood Co. NC)	1 square mile severely burned. A great many of the southern slopes, however, have been badly burned or are suffering from excessive pasturage, and the humus has been greatly reduced. The entire basin of Pisgah Creek has been badly burned and is lightly timbered [after being logged].
Jonathan Creek Basin above Delwood (Haywood Co. NC)	1 square mile severely burned. …wherever the undergrowth has been burned or the pasturage excessive, as at present, there is scant humus.
West Fork of Pigeon River Basin above Vavinia (Haywood Co. NC)	1 square mile severely burned. Some of the timbers show the effects of ancient fires and there are a few areas which have recently been badly burned.
Pigeon River Basin between Lavinia and Clyde (Haywood Co. NC)	Slight area burned. The leaf mold is generally thin. In many places the mountain slopes have been badly burned by repeated ground fires…
Fines Creek Basin (Haywood Co. NC)	Little area severely burned. Except on some of the burned land in the mountains and on some of the steepest and driest south slopes, leaf mold has generally accumulated to a considerable depth.
NORTHWESTERN SLOPE OF SMOKY MOUNTAINS (TN)	With the exception of a few "balds" or grassy areas on the higher summits and the alluvial lands of the lower coves and creek valleys, the forest of this great mountain side is practically unbroken. Fire, grazing, and culling have reduced this forest considerably. Imperfect trees and inferior species are abundant, while some of the burns and cattle ranges are deficient in stand.
North Slope White Rock Mountain (Cocke County, TN)	3.48 square miles burned. Much [humus and litter] has been burned away by recent fires.
Briar Cove District (Sevier Co. TN)	3 square miles burned. Most of the ridges have been burned over, and much of the timber on them has been killed and replaced by brush.
Alum Cave Creek District (Sevier Co. TN)	1 square mile burned. There are some scalds on ridges. About 500 acres are severely burned. Lighter fires have reduced the timber on the drier portions, yet the spruce is sparse and scrubby.
Little River Basin above Eli M'Carter's (Sevier Co. TN)	A few small fires have occurred. The burns have been restocked with brush rather than with timber trees.
Jakes Creek Basin (Sevier Co. TN)	1 square mile burned. Fires have run over most of the ridges, on which about half the trees are dead. The coves have escaped severe fire.
Little River Basin below Eli M'Carter's (Sevier Co. TN)	Light [humus and litter]; mostly consumed by fire. At least half of this tract is burned over annually. Most of the underbrush has been killed, except laurel[rhododendron], which is abundant along the streams…. Fires have been too frequent, and very little young stock is coming up, especially on the ridges.
Middle and West Prongs of Little River Basins (Sevier and Blount Co. TN)	2 square miles burned. Scant [humus and litter]; mostly consumed by fire. Nearly all the ridges have been burned over every year, killing much of the underbrush, injuring many timber trees, and deadening large areas. Free [reproduction] on cuttings that have not been burned. The burns are pastured, and seedlings are kept down. The pines come in most freely on such land.
Laurel Creek Basin (Blount Co. TN)	0.32 square miles severely burned. Many fires have been set along the road, and much of the forest near it has been killed. The remote portions are but slightly injured.
Cades Cove District (Blount Co. TN)	0.24 square miles burned. Usually light [humus and litter] owing to repeated fires and much grazing…. The large proportion of the timber has been burned in clearing. Fires are set whenever they will run, and the forest shows the effect of this practice. The brush is subdued; the timber is frequently scorched at the butt, often killed….

	Abundant saplings promise better timber than the original forest. These must have started at a time when fires were less prevalent than now.
Abram Creek District (Blount Co. TN)	Light [humus and litter] nearly all consumed by the numerous fires. Fires are very frequent. Many trees have been injured or killed, but no large areas are entirely deadened. [Reproduction is] very scant, owing to the numerous fires and the close grazing.
Chilhoweee Mountain (Blount Co. TN)	Fires are very frequent, killing sprouts and consuming humus and litter. [Reproduction is] scant. Many seedlings start up, but they are usually killed by fire and grazing. Under these conditions pine reproduces better than other species.
Tennessee Gap (Blount and Monroe Co. TN)	Abundant [humus and litter] in a few coves that have escaped fire, but scant elsewhere… Surface fires are very frequent. But little humus or litter is left.
LITTLE TENNESSEE RIVER BASIN	Repeated forest fires, started with a view to improve the pasturage, have destroyed much timber on dry south slopes, and by continued suppression of the young growth have greatly reduced the density. Reproduction, however, is good, and if the open woods were protected there would soon be a fine young growth beneath the old trees.
Cat Creek Basin (Macon Co. NC)	No severely burned area…. Leaf mold is thin on the south slopes and on the lower hills. There is an excellent ground cover, however, on most of the north slopes and in the coves.
Watauga Creek Basin (Macon Co. NC)	No severely burned area.
Cowee Creek Basin (Macon County, NC)	No severely burned area…. There is very little leaf mold, as the prevailing slopes are southerly and dry, and have, in addition, in many places been badly burned by ground fires.
Bradley Creek Basin (Macon Co. NC)	No area [severely?] burned. There is a deep accumulation of leaf mold on the north slopes and in the hollows, but much less on the south slopes, which have been badly burned…. In a few places there are thickets of shrubs and brush, which have followed fires.
Lakey Creek Basin (Macon County, NC)	Slight area severely burned…. In some places the woods are brushy where they have been burned.
Alarka Creek Basin (Macon Co. NC)	No area severely burned…. South slopes have been badly burned, however, and there is very scant humus.
Grassy Camp and Norton Creek Basins (Jackson Co. NC)	On the steeper slopes the accumulated leaf mold is scant because of repeated fires. There is more or less humus in all the deep hollows, and in hemlock forests where fires seldom or never occur… The upper slopes of Shortoff Mountain, Yellow Mountain, and all the higher surrounding ridges are badly burned. Frequent fires consume the brush and litter in nearly all of the hard-wood forests, which are thin and open on this account…. In localities where there have been no fires in several years there are masses of vigorous stool shoots, chiefly of chestnut, scarlet oak, and sourwood, but in most places there is very little second growth.
Savanna Creek Basin (Jackson Co. NC)	No area burned.
Cullowee River Basin (Jackson Co. NC)	No area burned. Young timber is generally scant in the forest, except where breaks have been made in the cover, either by lumbering or by fires. Many of the living trees show traces of injury by ancient fires.
E Fork Tuckasegee River Basin (Jackson Co. NC)	A great portion of the south-side land, lying on Wolf and Tennessee creeks, has been very badly burned and the humus destroyed or very much reduced. Elsewhere, except on badly burned land, there is much more humus.
Cullasagee River Basin from Franklin to the	Some steep south slopes are frequently badly burned and most of the undergrowth and young seedlings killed or reduced to stool shoots. In culled woods that are not

mount of Buck Creek (Macon Co. TN)	frequently burned nor too severely pastured there are many vigorous young trees and saplings [of second growth]..
Yellow Creek Basin (Graham Co. NC)	2 square miles severely burned. The woods are generally open, except where there are occasionally thickets of Kalmia or other shrubs, or where badly or frequently burned thickets of sprouts spring up from the stools of young trees…. [Reproduction] is scanty … on the dry and frequently burned south side of Yellow Creek Mountain…. Fires and cattle suppress much of the second growth on south slopes.
Wine Spring Creek Basin (Macon County NC)	No area severely burned. Occasional ground fires on crests and steep slopes have replaced many seedlings of fire-tender species by stool shoots. Fires, however, are not common, and the burned area is not large.
Jarrett Creek Basin (Macon Co. NC)	A little area severely burned…. [Humus and litter] is often thin on steep south slopes, particularly in the upper part of the basin, or where there have been fires. There is much badly burned land on the steep southern slopes, especially near the head of the creek. The leaves, dried grass, and brush are purposely burned about every two years to keep the woods open and improve the grazing. It is thought also that burning the dead leaves tends to prevent the cattle disease known throughout the Southern Appalachians as milk sickness, which is probably caused by the cattle eating some poisonous plant.
Chogee Creek Basin (Macon County, NC)	No area severely burned…..There have been no fires in recent years, except along the tops of the ridges or on dry slopes.
Burningtown Creek Basin (Macon County, NC)	A small area severely burned…. Standing timber has been much damaged by repeated ground fires, which have produced butt hollows, and by keeping the growth open have caused short and knotty boles. The south slopes and crests, and the lower hills are frequently burned….The forests are generally open below.
Tellico Creek Basin (Macon Co. NC)	No area severely burned….. On the lower hills and on south slopes, where the density is low and the forest has been badly burned, the ground in places is almost devoid of humus…. The hill country and the south sides of the mountains have been badly burned, and in consequence the forests are thin, the growth short-bodied, and many of the trees defective. In many places there is considerable undergrowth of sourwood and huckleberries, which rapidly sprout when the old trees are killed by fire.
White Oak Creek Basin (Macon Co. NC)	Very little severely burned….. South slopes have been badly burned by repeated ground fires but the forests of the hollows and north slopes have suffered little, if at all. There is already a vigorous crop of young seedlings and stump sprouts on the lands which have been cut over, and it will do well unless destroyed by fire
Caney Fork Basin (Jackson Co. NC)	1 square mile burned…. Many of the south slopes have been veiy badly burned and the humus has been mostly destroyed. In nearly all of the hollows, however, it has been undisturbed.
Buck Creek Basin (Macon Co. NC)	No area severely burned. On the steep upper slopes, especially on the southern faces of Yellow and Hamburg mountains and their southern spurs, there is very little leaf mold, as the slopes are steep and have washed badly, and ground fires are frequent and severe. There is an excellent accumulation of humus, however, in the deep hollows opening to the north on the lower part of the stream….. Nearly all of the south slopes have been badly burned, and much of the mature timber has defective butts. A great part of the young growth has been reduced to stool shoots, there being often half a dozen sprouts from the same stump, the result of repeated fires.
Wayah Creek Basin (Macon Co. NC)	No area severely burned. At different times nearly the entire watershed has been badly burned, and southern slopes suffer from regularly repeated ground fires
Soco Creek Basin (Jackson Co. NC)	1 square mile severely burned….. In the mountains the leaf mold is good, except on steep south slopes or poor dry soils. … [Most] of the basin, except the lower and the extreme eastern part, is owned by the Eastern band of Cherokee Indians…

Oconalufty River Basin above Forks (Swain Co. NC)	3 square miles severely burned. There is a deep accumulation of leaf mold in the deep hollows at the heads of the streams where there has been no fire, but on all the drier land, especially that at a low elevation and on south slopes, it is deficient. The large areas of open forest, where there is no young growth, would readily restock naturally if afforded protection. This condition chiefly prevails on the lands of the Cherokee Indians.
Oconalufty River Basin below Forks (Swain Co. NC)	No mention of fire…. The Eastern band of the Cherokee Indians owns a large portion of the mountain land.
Twentymile Creek Basin (Swain Co. NC)	1 square mile severely burned. In the deep hollows and on north slopes there is an accumulation of leaf mold. In some places it is very deep. On the lower hills near the mouth of the stream and on many of the dry southern slopes, especially such as have been burned, it is often very scant…. There is considerable undergrowth on some slopes, especially where there have been ancient fires, and many shoots have sprung up from the stools of young fire-killed trees…. Groves of young trees, some apparently seedlings and others evidently stool sprouts, are frequent in woods that have been burned.
Eagle Creek Basin (Swain Co. NC)	2 square miles severely burned. The prevailing forest floor is a deep leaf mold. It is often absent or scant on south slopes or where fires are prevalent…. Second growth is scant, except in a few places where there have been fires.
Hazel Creek Basin (Swain Co. NC)	3 square miles severely burned. In the lower part of the basin, and where the woodland is closely pastured and frequently burned, and on many south slopes above, leaf mold is scant.
Forney Creek Basin (Swain Co. NC)	3 square miles severely burned. …Leaf mold is generally deep, except on dry southern slopes, or where it has been destroyed by fires….
Noland Creek Basin (Swain Co. NC)	2 square miles burned.
Brush Creek Basin (Swain Co. NC)	A great part of the forest, especially that on the steep slopes near the mouth of the creek in which there is pine, has been badly burned and the soil covering destroyed….There is very little undergrowth, with the exception of a few Kalrnia thickets and brush which have followed fires. Reproduction is generally thorough, though much young growth is suppressed by frequently occurring fires.
Big Creek Basin (Macon Co. NC)	No area severely burned. Repeated fires have robbed the soil of accumulated litter and brush, except in damp hollows or on steep north slopes. ….The greater part of the forest has been severely injured by repeated ground fires, which have destroyed the humus, and greatly reduced the forest cover by repeatedly suppressing the young growth and so increasing the dryness of an already poor and shallow soil. In spite of the destruction of the mold, many of the species reproduce abundantly by seed, especially the scarlet oak, chestnut, white oak, and sourwood, and where it occurs, the black pine. The reproduction from stools of young-growth oak, chestnut and sourwood, after being top killed by fires, is free and vigorous; that of the pine is less vigorous and is confined to small trees…. Kalmia forms most of the undergrowth in the oak woods, but in most places there is very little of it. It is often killed by fires, but sprouts vigorously from the old stools.
Tennessee River between Bushnell and the State line	5 square miles burned. On the north side of the Yellow Creek Mountains an excellent forest condition prevails, with deep humus and undisturbed litter. The south slopes on the opposite side of the river have been frequently burned, and leaf mold is scant. …South slopes are sometimes brushy with Kalmia and young tree growth, which has followed fires; north slopes with laurel [i.e., rhododendron].
Tuckasegee River (S side) between Webster and Bushnell	Leaf mold has accumulated to a considerable depth in nearly all of the hollows, but many of the mountain slopes have been badly burned and the ground cover destroyed.

(Jackson and Swain Co. NC)	
Deep Creek Basin (Swain Co. NC)	No mention of fire.
Panther Creek Basin (Graham Co. NC)	Repeated fires have reduced [humus and litter]…. Ground fires have been very frequent. [Second growth is] deficient, owing to the prevalence of fires during many years past. The best stand of saplings is on wood lots where protected from fire.
Stekoah Creek District (Graham Co. NC)	[Humus and litter are] usually scant because of much burning. …Light surface fires have been frequent. The customary fires have prevented the growth of saplings.
Little and Big Snowbird Creek Basins (Graham Co. NC)	The southward slopes have been much burned. Humus has been consumed and seedlings killed. The northern slopes have escaped frequent fires….here are many saplings 8 to 10 inches in diameter, but most of those that have started later have been, subdued by fire.
West Buffalo Creek Basin (Graham Co. NC)	The southern slopes are usually burned over every year.
Santeetla Creek District (Graham Co. NC)	Fires are common whenever it is dry enough for them. The undergrowth and pasturage are much reduced by fire.
Little Santeetla Creek District (Graham Co. NC)	Very common. The pasture has been much reduced by them, especially by those of late spring and early summer….Very scant [undergrowth from] too much fire and grazing.
Atoa Creek Basin (Graham Co. NC)	Fires are repeatedly set in the spring. The brush is; reduced and the trees are frequently scarred.
Long Creek District (Graham Co. NC)	Fires have been very common
Buffalo and Cochran Creek Basins (Graham Co. NC)	Nearly all of the tract is frequently burned over. …Saplings are quite abundant on the isolated wood lots, but on the mountains, especially on the ridges where fires have been prevalent for many years, there are but few.
Mountain Creek Basin (Graham Co. NC)	Annual fires are the rule, and the forest shows the effect in injured trees and scant underbrush….Dense stands of [second growth] saplings are found on wood lots where protected from fire by clearings. On the mountains saplings are not abundant.
Sweetwater Creek Basin (Graham Co. NC)	Frequent fires.
Tallulah Valley (Graham Co. NC)	Frequent fire. The humus and undergrowth are much reduced.
HIWASSEE RIVER BASIN	Here [compared to the southern slope of the Blue Ridge], fires have been more prevalent and have kept decaying vegetation thoroughly consumed. They have killed less timber, but have done no less damage by preventing new growth.
Valley River Basin above Andrews (Cherokee Co. NC)	Repeated tires have reduced the undergrowth and the humus, and even seriously injured the pasturage, especially on southward slopes…. Old burns are slowly covered by persimmon, oak, hickory, etc.
Valley River Basin Below Andrews (Cherokee Co. NC)	Fires have been prevalent for many years. Free [reproduction] where not repeatedly burned. Old fields are soon recovered with persimmon and oak.
Peachtree Creek District (Cherokee Co. NC)	Scant [humus and litter] owing to fires and grazing…. Many fires have seriously injured the greater portion of the forest. The western hills are reduced almost to brush land.
Fires Creek District (Clay Co. NC)	Scant [humus and litter] owing to customary fires and grazing….Fires have been so frequent that the undergrowth and the pasture are greatly reduced. Some large areas were seen where there was absolutely no vegetation under the trees.

Tusquitee Creek Basin (Clay County, NC)	Repeated fires have greatly reduced the forest or prevented its best development. The people claim that fires have greatly injured the mountain pasturage…. [Undergrowth is] very scant, because the forest is frequently burned over and closely grazed.
Shooting Creek District (Clay County, NC)	Fires are frequent and show their effect in the depletion of the forest.
Bell Creek District (Union County, GA)	Scant [humus and litter] owing to repeated fires…. Repeated light fires have greatly depleted the forest.
Hightower Creek District (Towns County, GA)	Frequent light tires have reduced the undergrowth and the pasturage, at the same time injuring many of the timber trees and preventing the growth of young stock…. [Undergrowth] reduced by fire and grazing. Very little brush, except on damp areas.
Swallow Creek Basin (Towns County, GA)	This tract is much less subject to fires than others of the region, because the exposure is toward the north, and the upper portion of the basin is isolated.
TALLULAH-CHATTOOGA RIVER BASIN	In condition also the forest is inferior to that of the plateau. The injuries by fire are greater…. The greater portion is in the condition of a natural forest, with many old, crooked, fire scarred and otherwise defective trees and inferior species, and with subordinate saplings, crooked and retarded. Because of prevalent fires the stand is imperfect, many spaces being covered with mere brush where a stand of good timber is possible. Along the line of the old railroad grade from Walhalla to Rabun Gap, much burning was done at the time of grading; this area is now covered with a dense stand of saplings, principally oak and hickory…. The effect of the no-fence law is plainly noticeable south of Chattooga River, where the forest is more severely injured by fires, which are there fiercer because of more combustible material.
Dicks Creek Basin (Rabun County, GA)	Repeated light fires have run everywhere, killing many of the timber trees, scarring many others, and reducing the undergrowth to strips or clumps in the ravines.
Moccasin Creek Basin (Rabun Co. GA)	Fires are common, but their effect is not as noticeable here as in the valley of Dicks Creek.
Wild Cat Creek Basin (Rabun Co. GA)	[Fires are] common. The ridges are burned over nearly every year. Many trees are injured, and the seedlings are prevented from developing…. [Second growth is] abundant, except on ridges, where much exposed to fire, drought, and grazing.
Soque River District (Habersham Co. GA)	Scant [humus and litter]. The soil is almost invariably light colored, and the litter is consumed by the frequent fires. Fires are very frequent, and the whole tract is burned over as often as sufficient material accumulates to support the fire…. Fires and grazing on most of the tract have prevented the underbrush from accumulating. There are some narrow strips of laurel [rhododendron] along the streams, but elsewhere the woods are almost free from brush and seedlings.
Tallulah River Basin below Timpson Creek (Rabun Co. GA)	Very light [humus and litter] owing to the frequent fires…. The land is burned over as often as material accumulates to support a fire usually every year. Many trees are injured and the brush is subdued, while young growth is decimated or entirely prevented…. Though many seedlings start very few are able to form trees, as they are either killed by fire or eaten off by cattle. The natural supply of brush, which would otherwise be abundant in this pine forest, is kept very thin by fires and grazing.
Tiger Creek Basin (Rabun County, GA)	Most of the area is burned over ever}7 year, and timber and pasturage are thus injured and young growth is prevented.
Persimmon Creek District (Rabun Co. GA)	Fires are very frequent and the forest shows their effect in injured butts and deficient young growth…. Deficient [second growth] owing to the custom of burning the woods frequently. There is very little brush and seedlings are few. Seedlings start abundantly, but some reach only 1 foot above the ground before they are killed by fire.
Popcorn Creek Basin (Rabun Co. GA)	Not as abundant as in most of the adjoining valleys.
Plum Orchard Creek Basin (Rabun Co. GA)	Frequent, though not as severe and damaging as farther south.

Timpson Creek Basin (Rabun Co. GA)	Scant [humus]. The numerous fires and close grazing do not permit it to accumulate…. Fires prevail in dry periods wherever there is material enough to feed them. The forests are considerably depleted by them.
Tallulah River Basin above Plum Orchard and Persimmon Creeks (Rabun and Towns Counties, GA and Macon County, NC)	Fires have been less prevalent in this region than in that adjoining, owing principally to the sparse population. The development of the mines by introducing more people will undoubtedly make fires more prevalent.
TOXAWAY RIVER BASIN	The forests of this region are variable; they have been seriously injured by fires, and as a result have some large openings on the ridges…. Improvement in forest condition, may be rather more difficult here than elsewhere, owing to the abundance of brush and the liability to fire.
SALUDA AND FIRST AND SECOND BROAD RIVER BASINS	Even with such protection as the frequently burned forests afford, the humus is washed from the woods, and, being light, is carried far down the stream to still waters before it finds a lodging place…. In condition these forests are inferior. There is very little log timber. Many of the trees are fire scarred; many, though old, are small because fire and erosion of humus have retarded growth.
CATAWBA RIVER BASIN	Nearly all south and east slopes, especially at a low elevation, have been damaged by fires to some extent.
Wilson Creek Basin (Burke Co. NC)	3 square miles burned of 63 wooded. There is evidence that this forest was at one time far more extensive, but that successive fires have destroyed it…. Only in the hollows has the ground cover been undisturbed, for nearly all of the slopes have been burned at one time or another. On some of the steep southern slopes humus is almost wanting.
Linville River Basin below falls (Burke Co. NC)	2 square miles burned of 32 wooded. Both slopes of the basin have often been severely burned and the fires have destroyed the previous scant ground cover…. In a few places there is a dense undergrowth, but the fires keep the woods open except for a year's growth of stool sprouts from the fire killed shrubs and trees. There is no second growth, except the young trees which have appeared on fire scalds. A great many of these have already been injured by fires; this is the case also with nearly all of the old timber. Reproduction is poor on all the slopes. It is better in the hollows where the ravages of the fires are not so great.
John River Basin above Forks (Caldwell Co. NC)	6 square miles burned of 78 wooded. As the prevailing aspect is southerly and the slopes are dry, fires are frequent. The ground cover is proportionately scant. Many of the hollows face the south and fire passes through them…. In the lower part [of the basin] and on the dryer slopes there is more oak, and chestnut is more largely replaced by various yellow pines. Many of the trees are fire scarred, and on all the coniferous slopes there are pines which have been killed by fires.
N Fork Catawba River (McDowell Co. NC)	8 square miles burned of 107 wooded. The slopes of Linville Mountain and much of the upper part of the Blue Ridge are often severely burned and there is very little humus on these slopes…. Where the woods are burned at irregular intervals there is often a dense undergrowth of stool sprouts from small trees and shrubs killed by the fire.
Irish, Table Rock, and Upper Creek Basins (Burke Co. NC)	8 square miles severely burned of 227 wooded. Kalmia forms many thickets on rocky land, and there is a considerable amount of brush which has followed fires…. Young trees are generally not abundant, evidently on account of the fires which destroy the seedlings.
Headwaters of Catawba River above	8 square miles severely burned of 37 wooded. The upper slopes of the mountains are periodically and severely burned…. There is no second growth of value, as the repeated fires injure stool shoots before they become large enough to be of any use.

Old Fort (McDowell Co. NC)	While there is not very much Kalmia or rhododendron, there is, in nearly all the badly burned woods, a considerable undergrowth of sprouts from fire-killed trees and deciduous shrubs.
Brush, Clear, and Crib Creek Basins (McDowell Co. NC)	2 square miles burned of 55 wooded. Active logging. Fires are not infrequent and humus is scant over the entire burned area…. There is a considerable amount of second-growth poles and saplings at various places in the forest where old tires have run. This is especially the case in the pine woods at low elevation.
YADKIN RIVER BASIN	…the poverty of the naturally infertile south slopes is augmented by repeated fires which destroy the litter and facilitate the removal of the finer particles of the soil by the heavy rains.
ROARING RIVER BASIN	Frequent fires on the dry ridges exposed southward have greatly injured the forest by preventing reproduction. But little marketable timber has been killed, however.
North and Middle Forks of the Reddie River Basins (Wilkes Co. NC)	Light [litter and humus] mostly consumed by the frequent fires. … Frequent [fire]; the damage is not striking, but the forest is in very inferior condition on this account.
Mulberry Creek Basin (Wilkes Co. NC)	Light [litter and humus] mostly consumed by the frequent fires. Although frequent, very few large trees are killed; the forest is very inferior on this account.
South Fork of the Reddie River Basin (Wilkes Co. NC)	Light [litter and humus] except in north coves where fire is infrequent…. The ridges have been repeatedly burned, and, although little log timber has been killed by fire, the forests are in poor condition because of so much burning. Were it not for fire reproduction would be abundant, but, as it is, the stand is not half what it should be.

<u>Attachment 08</u>

Landscape Conservation Forecasting: Great Smoky Mountains National Park

Landscape Conservation Forecasting

Great Smoky Mountains National Park

Happy Valley Ridge Wildfire, September 2016. *(photo by Greg Salansky)*

By

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September, 2017

Front cover photo: *Happy Valley Ridge Wildfire, September 2016, by Greg Salansky.*

Despite control efforts which limited its size, this fire burned for nearly a month during 2016 through an outstanding remnant of low elevation pine woodland. The effects of this fire will provide important clues about the ecology and restoration of this important ecological system.

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Executive Summary

Preface

In the autumn of 2016 the Southeastern United States experienced an extraordinary number of wildfires, including a tragic fire event the likes of which had not occurred for at least a century in the deciduous hardwood forests of the Southern Appalachians. The Chimney Tops 2 fire that originated in Great Smoky Mountains National Park shocked the nation and devastated local communities, as is the case with many natural disasters. While we rebuild our communities and mourn our losses, we must also study the ecological implications of this fire and learn more about the role of fire in our forests. We hope that the information contained within this report and the associated maps and models will contribute to our understanding of fire and how to use fire constructively as a management tool.

Introduction

Stretching over 500,000 acres in the heart of the Southern Blue Ridge, the Great Smoky Mountains National Park (GRSM) is widely considered among the most important natural areas in the eastern United States. However, GRSM is experiencing significant effects from long-time fire suppression/exclusion. Numerous studies and peer-reviewed papers have documented losses in ecosystem function and diversity resulting from the exclusion of fire.

Developing a vision for management actions to address the losses due to fire exclusion requires a carefully considered approach. Landscape Conservation Forecasting (LCF) is a management decision-making support tool that has been successfully used by public agencies in numerous landscapes across the United States. Examples include the adjacent Cherokee National Forest as well as the Great Basin National Park in Nevada. Benefits of using LCF include:

- Uses the best available science to develop reference conditions that describe a Natural Range of Variability (NRV) for each ecological system modeled
- Uses remote sensing to assess the health of existing ecological systems
- Employs predictive ecological models to demonstrate how those ecosystems will change over time
- Utilizes computer simulations to assess how alternative management actions can influence those changes
- Customizes management actions based on agency mandates or local constraints
- Provides a cost/benefit analysis for management actions

In 2015, the National Park Service and The Nature Conservancy entered into an agree-ment to collaborate on Landscape Conservation Forecasting, with a primary focus on the fire-maintained forests of GRSM. The LCF project proceeded in two stages. Stage one processed and optimized existing park vegetation data, ecological zone data and LiDAR data for use in LCF. Stage two included four workshops in 2016 that engaged park staff and others to develop state-and-transition models for historical vegetation, complete the ecological departure analysis, and compare potential future management scenarios.

Objectives for Great Smoky Mountains National Park Landscape Conservation Forecasting

- Engage NPS Resource Management staff and regional experts to conduct highly credible research that contributes to the establishment of meaningful landscape-scale objectives, effective prioritization, and shared ownership of future fire management direction.
- Synthesize research findings, remote sensing, and spatial data to inform a more complete understanding of past, current, and desired future conditions for fire-maintained forests.
- Use state-and-transition modeling to develop pre-settlement reference conditions for structure and composition of fire-maintained forests in GRSM.
- Complete an ecological departure analysis to highlight the greatest priorities for management action, and provide insight into fuels treatment objectives and effectiveness.
- Produce a final set of management scenarios for a 20-40 year time horizon to serve as a planning guide for future fire management plans, 5-year fuels treatment plans, and prescribed burn plans.

Process and Methodologies

LCF has built upon and modified methodologies developed under the national interagency LANDFIRE program -- including mapping, models, and metrics -- to assess a landscape's ecological condition. The essence of LCF is a measure of ecological departure. Ecological departure is an integrated, landscape-level estimate of the ecological condition of terrestrial and riparian ecological systems. Ecological departure incorporates species composition, vegetation structure, and disturbance regimes to estimate an ecological system's departure from its natural range of variability (NRV). NRV is the percentage of each vegetation succession class that would be expected under a natural disturbance regime. Ecological departure is measured using a scale of 0 to 100 where higher numbers indicate higher departure from NRV.

The LCF project completed the following tasks that were reviewed and revised at the workshops with GRSM's natural resource managers:

- Datasets. Reviewed and processed existing datasets, including historic and existing vegetation mapping, Ecological Zone mapping, disturbance history, and fire history.
- Potential Natural Vegetation. Worked with Steve Simon (Ecological Mapping and Fire Ecology, Inc.) to develop a map of GRSM's potential natural vegetation (the dominant vegetation types expected in the physical environment under a natural disturbance regime). The final "hybrid" map included the best elements from the existing Park vegetation map (1:15,000 scale) (2003), Simon's 10 meter resolution Ecological Zone maps, and a collaboratively developed cross-walk / rule set that defined ecological systems.
- Existing Vegetation. The current/existing ecological systems were largely identified from the 173 dominant vegetation types defined in the 2003 Park map following the same logic and groupings used to identify potential natural vegetation types. Ecological Zone maps were also used to approximate a small number of ecological systems and to help identify 'highly departed vegetation' classes.

- Vegetation Succession Classes. LiDAR remote sensing data for GRSM was processed at 3 meter resolution and used along with disturbance data and a set of decision rules to interpret and map current ecological systems' succession classes.
- Ecological Models. Reviewed and refined state-and-transition ecological models for nine ecological systems, using reference condition models initially developed for the Cherokee National Forest and the Nantahala-Pisgah National Forests based upon the LANDFIRE methodology. Special attention was directed towards refining the models for seven oak and pine-dominated systems, several of which are highly fire-dependent.
- Current Ecological Departure. For each ecological system, compared current vegetation class distributions with the potential natural vegetation and calculated each system's ecological departure from its NRV. Each ecological system was assessed an ecological departure score (0% to 100% departure from NRV).
- Forecast Ecological Departure. Forecasted the future condition of each ecological system over the next 20 - 40 years without active management, based on computer simulations using ST-Sim software incorporating the predictive ecological models.
- Landscape Restoration Objectives. At the May 2016 workshop, GRSM's natural resources managers confirmed a set of overall landscape restoration objectives for GRSM, as follows:

Landscape Restoration Objectives

- Restore fire as a key ecological process in oak and pine ecosystems where practical and most needed.
- Restore more open canopy conditions in dry oak and pine ecosystems to more closely approximate reference conditions/NRV.
- Restore early and mid-succession vegetation in dry oak and pine ecosystems to more closely approximate reference conditions/NRV.
- Manage fire appropriately to protect life and human & cultural resources within and adjoining GRSM.

- Focal Ecological Systems. Five fire-maintained ecological systems were selected for active management using prescribed fire, based upon their high departure from NRV and likelihood of continued future departure. The five focal systems for active management included: Dry Oak forest; Dry-Mesic Oak Forest; Low Elevation Pine Forest; Low Elevation Pine-Oak Heath; and Montane Pine-Oak Heath.
- Management Models. Reference condition models were modified to incorporate prescribed burning as a management action, as well as reflect current levels of fire exclusion in GRSM. With assistance from TNC's LANDFIRE program, expert assistance was secured to develop ST-Sim models that incorporated three prescribed fire "passes" in simulated non-spatial burn units, designed to achieve positive ecological outcomes.
- Management Scenarios. At and between workshops, prescribed fire management strategies were explored to achieve the objectives for these focal systems. Predictive ST-

Sim computer models were used to simulate conditions under alternative future management scenarios. All scenarios assume current levels of fire exclusion will continue in GRSM. The likely future condition of the five focal systems was assessed after 20 and 40 years under four primary scenarios: No Action, Maximum Management, Current Management, and Preferred Management.

- Return on Investment. Return on investment was calculated to compare ecological benefits to management costs.
- Limitations of LCF. LCF is a landscape-scale planning tool, and thus has some inherent limitations in its applications. The LCF maps, models and metrics for GRSM primarily focused on ecosystem structure and disturbances, and were not able to assess the desired *composition* of a given vegetation succession class for a given ecological system. LCF also does not assess the desired size of forest openings or other stand-level treatments.

Key Findings

The primary findings of the landscape conservation forecasting are summarized as follows:

The Landscape's Current Condition

- **The 515,000 acres of Park vegetation support a diversity of Southern Appalachian ecological systems**, ranging from lower elevation pine woodland to large cove forests to higher elevation spruce-fir forests. Eleven major ecological system types in GRSM were identified from the vegetation data, including seven oak and pine systems.
- **Three xeric oak and pine systems constituting 21% of GRSM show high ecological departure** – Dry Oak Forest, Low Elevation Pine Forest and Low Elevation Pine-Oak Heath.
- **Three other oak and pine systems – constituting another 21% of GRSM – are moderately departed from NRV** – Dry-Mesic Oak Forest, High Elevation Red Oak Forest, and Montane Pine-Oak Heath.
- **Three systems that are more mesic show low departure**, including the Cove Forest (itself almost one-fourth of GRSM), Northern Hardwood Forest and Mesic Oak Forest.
- **The primary reason for ecological departure across the landscape is due to overly closed canopy structure in the oak and pine systems**, as compared to more open structure under natural conditions. Across all systems, LIDAR data showed over 80% of GRSM's vegetation structure was closed canopy.
- **There is also a substantial shortfall of early succession and mid succession classes** in the forest as compared to natural conditions.
- **A century of fire suppression and exclusion in GRSM has been a primary cause** of these altered conditions.

<u>The Landscape's Future Condition – Without Management</u>

- **After 20 years, five oak and pine systems remain substantially departed from NRV (~50% or higher), and there is little improvement over the following 20 years.** Somewhat counter-intuitively, these systems do show some slight improvement over their current condition with No Action. A modest increase in early succession and open canopy occurs due to varied disturbances (insects, weather, and some fire) in the models, and over time, some early succession moves to mid succession.
    - Note: this "improvement" only represents improvement to structural classes; it does not account for continued detrimental changes that would likely occur to forest composition during these time periods.
- **Without prescribed fire, five fire-maintained ecosystems comprising almost 40% of GRSM will remain substantially departed from NRV.**

<u>Future Condition – With Prescribed Fire</u>

- **Maximum Management levels of prescribed fire (24,000 acres/year) essentially restore the oak and pine systems to low ecological departure.** The large amount of prescribed fire in these simulations approximates the natural fire regime and serves to open up the canopy and create early/mid succession classes that are much closer to NRV.
- **Current Management levels of prescribed fire (1,500 acres/year) achieve modest improvement in ecological departure scores.** After 40 years, the current level of prescribed fire achieves the greatest improvement in low elevation pine and low elevation pine-oak heath as compared to the No Action scenario. *Note: GRSM's ecological departure scores are based fundamentally on forest <u>structure</u>; current levels of prescribed fire are expected to improve vegetation <u>composition</u> for the managed systems, but this improvement is not accounted for in GRSM's ecological departure scores.*
- **Preferred Management levels of prescribed fire (5,000 acres/year) achieve continued, meaningful improvement over 20 and 40 years (see following table).**

Departure from Natural Range of Variability		
Ecological System	**No Action Ecological Departure 40 Yrs**	**Proposed Restore & Maintain (5K/Yr) Ecological Departure 40 Yrs**
Dry Oak Forest	**51**	**42**
Dry Mesic Oak Forest	**45**	**38**
Low Elevation Pine	**64**	**49**
Low Elev Pine-Oak Heath	**51**	**29**
Montane Pine-Oak Heath	**45**	**36**

- **GRSM's current and proposed allocation of prescribed fire among the ecological systems is reflective of their sizes and fire regimes and is achieving desirable results**.
- **Return on Investment (ROI) analysis also confirmed the allocations of prescribed fire among the systems.** There were very small differences in ROI across the five focal systems when their respective size in acres was taken into account.
- **The average annual cost of the Preferred Management prescribed fire is approximately $250,000 per year,** as compared to approximately $75,000 per year currently.
- **Reducing fire suppression/exclusion in GRSM would also improve ecological departure – recognizing, however, the many difficulties of implementing this strategy.** Current fire management practice allows approximately 7.5% of "natural" fire to occur; increasing this level to 15% would improve average ecological departure scores by 4 points over 40 years.

Preface

In the autumn of 2016 the Southeastern United States experienced an extraordinary number of wildfires, including a tragic fire event the likes of which had not occurred for at least a century in the deciduous hardwood forests of the Southern Appalachians. The Chimney Tops 2 fire that originated in Great Smoky Mountains National Park shocked the nation and devastated local communities, as is the case with many natural disasters. While we rebuild our communities and mourn our losses, we must also study the ecological implications of this fire and learn more about the role of fire in our forests. We hope that the information contained within this report and the associated maps and models will contribute to our understanding of fire and how to use fire constructively as a management tool.

Introduction

Stretching over 500,000 acres in the heart of the Southern Blue Ridge, the Great Smoky Mountains National Park (GRSM) represents a major North American refuge for temperate zone flora and fauna. GRSM is home to over 1,600 species of flowering plants, including 100 native tree species and over 100 native shrub species, as well as many rare or endemic plants and animals. It is widely considered among the most important natural areas in the eastern U.S. and is a designated World Heritage Site. However, GRSM is experiencing significant negative impacts from disruption of natural disturbances regimes – most notably the long-term exclusion of fire. Numerous studies and peer-reviewed papers have documented losses in ecosystem function and diversity resulting from the exclusion of fire (Flatley and others 2015, Harrod and others 2000, Harrod and others 1998, Turrill and others 1995, Harmon and others 1983, Dimmick and others 1980).

Determining the appropriate role of fire on any modern landscape is not a simple task. While fire exclusion has social and ecological costs, determining the need for management actions requires a carefully considered approach. Landscape Conservation Forecasting (LCF) is a management decision-making support tool that has been successfully used by public agencies in numerous landscapes across the United States (Low et al. 2010). Examples include the adjacent Cherokee National Forest (Medlock et al. 2012) as well as the Great Basin National Park in Nevada (Provencher et al. 2013). Benefits of using LCF include:

- Uses the best available science to develop and use reference conditions that describe a Natural Range of Variability (NRV) for each natural community (or *ecological system*) modeled
- Uses remote-sensing to assess the health of existing ecological systems
- Employs predictive ecological models to demonstrate how those ecosystems will change over time
- Utilizes computer simulations to assess how alternative management actions can influence those changes

- Measures success by calculating an ecosystem's departure from its NRV, on a scale of 1 to 100, with and without various management actions
- Uses local or expert derived knowledge
- Customizes management actions based on agency mandates or local constraints
- Provides a cost benefit analysis for management actions

In 2015, the National Park Service (NPS) and The Nature Conservancy (TNC) entered into an agreement to collaborate on landscape conservation forecasting for each of GRSM's ecological systems, with a focus on the fire-maintained forests of GRSM. The LCF project proceeded in two stages. Stage one processed and optimized existing park vegetation data, ecological zone data and LiDAR data for use in LCF. Stage two included four workshops in 2016 that engaged park staff and others to develop state-and-transition models for historical vegetation, complete the ecological departure analysis, and compare potential future management scenarios.

Project Area

Great Smoky Mountains National Park (GRSM) straddles the border between North Carolina and Tennessee (Figure 1). It encompasses over 500,000 acres, making it one of the largest protected areas in the eastern United States. The main park entrances are located along U.S. Highway 441 (Newfound Gap Road) at the towns of Gatlinburg, Tennessee, and Cherokee, North Carolina. It is the most visited national park in the United States.

The Great Smoky Mountains (also known as the Smokies) are a portion of the Appalachian Mountain range, among the oldest mountain ranges in the world. The Smokies are among the tallest mountains in the Appalachian chain. Within GRSM, elevations range from about 875' to 6,643', with sixteen peaks rising more than 5,000 feet. Mount Le Conte rises to 6,593' from a base of 1,292', making it the tallest (but not the highest), mountain in the Eastern United States. The GRSM's highest summit, Clingmans Dome, is the third tallest peak east of the Mississippi River (NPS 2016).

This range in altitude mimics the climate and habitat changes a person would experience driving north or south across the eastern United States. Plants and animals common in the southern United States thrive in the lowlands of the GRSM while species common in the northern states find suitable habitat at the higher elevations. The north-south orientation of the Appalachian chain allowed the Smokies to become a refuge for many species of plants and animals that were displaced from their northern homes by glaciers in the last ice age around 10,000 years ago.

In terms of weather, GRSM's abundant rainfall and high summertime humidity provide excellent growing conditions. In the Smokies, the average annual rainfall varies from approximately 55 inches in the valleys to over 85 inches on some peaks. The relative humidity in GRSM during the growing season is about twice that of the Rocky Mountain region.

Environmental conditions range from xeric (dry) ridgetops and rock outcroppings to very mesic (moist) coves and mountaintops that are often enveloped in low-lying clouds. Forest composition varies continually with differing combinations of elevation and exposure. Major forest community types include oak-hickory forest, hemlock forest, pine-oak forest, cove-hardwood forest, northern hardwood forest and spruce-fir forest (White and others 2004). Almost 95% of GRSM is forested, and about 20% of that area is old-growth forest.

GRSM is one of the most biodiverse parks in the National Park system. Biological diversity, or 'biodiversity', means the number and variety of different types of animals, plants, fungi, and other organisms in a location or habitat. No other area of equal size in a temperate climate can match GRSM's amazing diversity. Some 100 species of native trees find homes in GRSM, more than in any other North American national park. Over 1,500 additional flowering plant species have been identified in GRSM. GRSM is also the center of diversity for salamanders and is home to more than 200 species of birds, 68 species of mammals, 67 native fish species, 39 species of reptiles, and 43 species of amphibians. Mollusks, millipedes, and mushrooms reach record diversity there. All told, over 19,000 species have been documented within GRSM and scientists believe an additional 80,000-100,000 species may live there (NPS 2016).

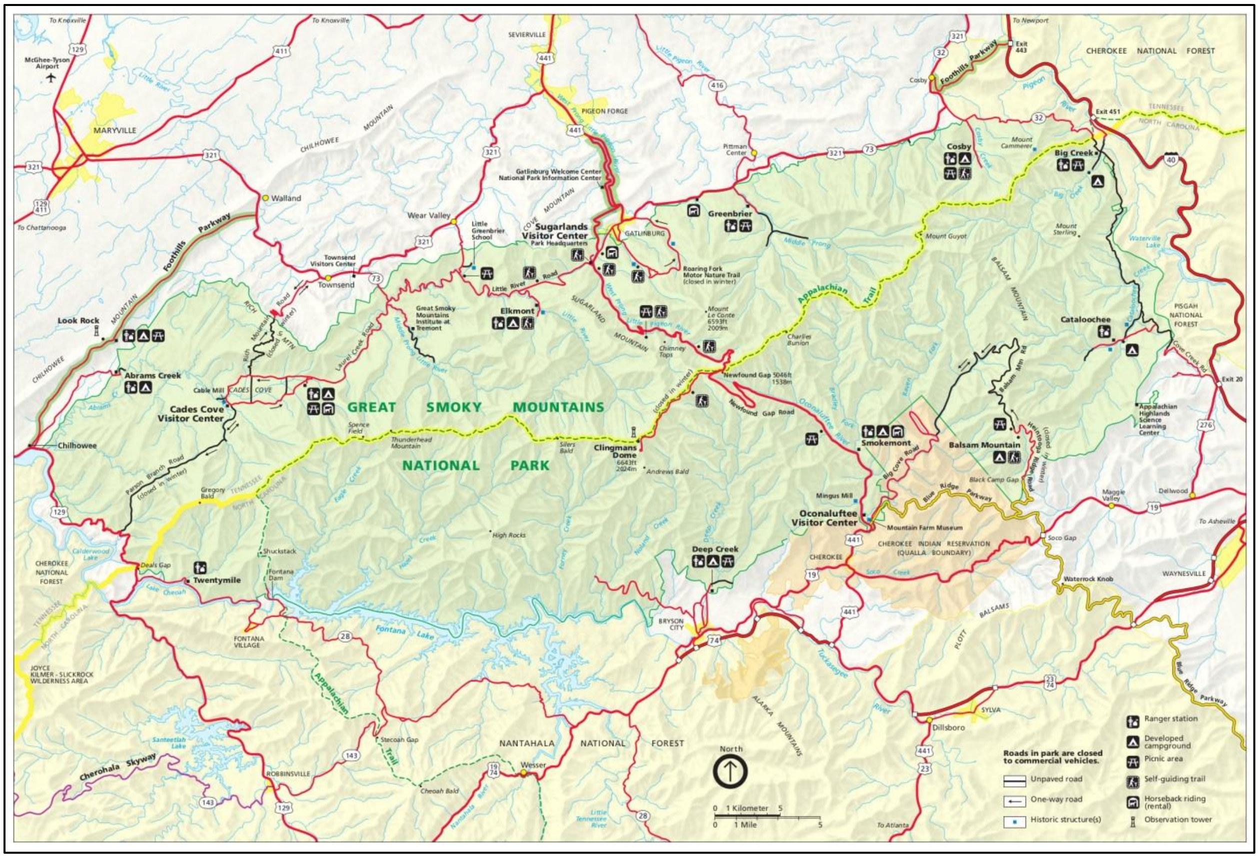

Figure 1. Great Smoky Mountains National Park.

Humans and the Landscape

The interaction between humans and the Great Smoky Mountains landscape has had a major impact on the vegetation and wildlife of the area for the past 10,000 years. The nature of these interactions and their effects on the natural landscape and biota have been studied by numerous authors, and no understanding of past or present vegetation can be complete without acknowledging humans as principal agents of disturbance and change.

The first humans to inhabit the area were very likely Paleo-Indians who arrived over 10,000 years ago. These people are known to have lived in small, multi-family bands that were a migratory, hunting and gathering society. The earliest physical evidence of human use of the Smokies landscape dates to the later Archaic Period, approximately 8000 years ago (Bass 1977). Societies during the Archaic Period were still mostly comprised of small, migratory groups that relied on hunting and gathering subsistence methods, though by the Late Archaic around 4000 years ago, humans had started to develop agricultural systems.

These trends toward plant domestication and larger, more complex and sedentary societies continued into the Woodland and Mississippian Periods, which began around 3000 and 1000 years ago, respectively. These larger societies were found in the river valleys and foothills surrounding GRSM - at sites along the Little Tennessee River, and in places like modern-day Sevierville, Townsend, and Bryson City. Though these populations were centered in locations outside the modern-day Park, the GRSM landscape was continually utilized for hunting, collection of plant resources, and travel. Paleoecological evidence suggests that long-term, widespread use of fire by Woodland and Mississippian people had substantial impacts to the Southern Appalachian landscape, favoring forests dominated by fire-adapted species like oak, chestnut, and pine (Delcourt and Delcourt 1998). After the 16th century, Native American culture began to be heavily influenced by the European presence in North America, and resulted in the Cherokee culture that dominated the area when the first European settlers arrived.

The GRSM area was permanently settled in the late 1700s/early 1800s by pioneers of European descent. In the 1880s, the invention of the band saw and the logging railroad led to a boom in the lumber industry. As forests throughout the Southeastern United States were harvested, lumber companies pushed deeper into the mountain areas of the Appalachian highlands, including GRSM. The GRSM area was heavily logged in the early 1900s. Between 1910 and 1920, corporate lumbermen built railroads into the most remote watersheds and removed more than 60 percent of the old-growth forest (Brown 2000).

Extensive and intensive human-related disturbances in the pre-Park era were carefully chronicled in a 1985 Park research report by Charlotte Pyle (Pyle 1985). Pyle reported that logging occurred to some degree on approximately 70% of GRSM. Mechanized corporate logging occurred on 40% of GRSM, often followed by intensive fires. Diffuse disturbance occurred on 29% of GRSM (large tracts with patches of intensive logging; smaller forest stands with small logging operations, livestock grazing and frequent, non-intensive fires; and disturbed tracts where some big trees remained). Concentrated human settlement occurred on an additional 9% of GRSM. Conversely, 20% of GRSM was found to have little or no record of major disturbance from logging or settlement (Pyle 1988).

As a response to societal concerns about the rapidly vanishing wilderness, GRSM was chartered by the United States Congress in 1934. The mission of the National Park Service is "...to promote and regulate the use of ...national parks... to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations" (National Park Service Organic Act, 16 U.S.C.1.**).**

The human relationship to this landscape endures today in the conservation and protection of GRSM. The NPS Foundation Document for the GRSM (2016) (see excerpt below) serves as a guide for planning and decision-making to “protect resources and values that are integral to park purpose and identity.” The purpose statement and the values listed in the Foundation Document reflect the GRSM enabling legislation and the legislative history that accompanied the GRSM development.

Great Smoky Mountain National Park Foundation Document (2016) Purpose Statement :

Great Smoky Mountains National Park preserves a vast expanse of the southern Appalachian Mountains ecosystem including it scenic beauty, extraordinary diversity of natural resources, and rich human history, and provides opportunities for the enjoyment and inspiration of present and future generations.

https://www.nps.gov/grsm/learn/management/upload/GRSM_FD_SP.pdf

Fire in Great Smoky Mountains National Park

For thousands of years, wildland fires have been a common and repeated natural event in the Southern Appalachian region, including the area that is now called the Great Smoky Mountains (Underwood 2013, Flatley and others 2013, Laforest 2012, Fesenmyer and Christensen 2010, Delcourt and Delcourt 1998, Harmon 1982). The countless interactions between these frequent fires and weather, topography, and vegetation have played a critical role in the development of several of the widespread natural communities that are found in the Great Smoky Mountains.

Pine woodlands, oak forests, and chestnut forests (prior to the introduction of chestnut blight) were all expanded and maintained on the landscape by various regimes of recurring fire that resulted from both human ignitions and lightning (Flatley and others 2015, Delcourt and Delcourt 1998). Natural communities that are rare in the Southern Appalachian landscape, such as meadows and heath balds, were also very likely created or maintained by fire (Langdon 2005). Numerous other species - from grasses to birds to reptiles to insects - were able to thrive in the unique habitats that resulted from burning, thus increasing the genetic, species, and landscape diversity found throughout the region.

A primary goal of the National Park Service is to preserve native plants and animals inGRSM, as well as the natural processes which perpetuate them. Fire history and ecology research have clearly established wildland fire as one of the natural processes upon which many plants and animals depend. However, when the Great Smoky Mountains National Park was established in 1934, fire was seen as only a destructive force by park managers, and a policy of fire exclusion was instituted. This policy sought to prevent all wildland fires, and used people and tools to suppress any wildland fires that were started, whether by humans or lightning. This disruption of the thousands-year-old disturbance regime had many unforeseen impacts to GRSM ecology, and some of those impacts are still being discovered today - over 80 years after fire exclusion policies were originally put in place.

Historical Role of Fire

Studies of soil and pond charcoal provide direct evidence that wildland fires have occurred on the Southern Appalachian landscape for nearly 10,000 years (Underwood 2013, Fesenmyer and Christensen 2010, Delcourt and Delcourt 1998). Additionally, these paleoecology studies have used fossil pollen and species identification of charcoal fragments to show that prehistoric fires were associated with expanding forests of pine, oak, and chestnut. Though no direct evidence of ignition source exists for these ancient fires, Delcourt and Delcourt (2004) have developed a compelling body of work suggesting that: 1) use of fire by Native American populations was pervasive in the Southern Appalachian region, particularly during the Woodland and Mississippian cultural Periods, and 2) this pervasive use of fire was associated with "profound" impacts to vegetation composition and structure.

In addition to the prehistoric fire history developed from paleoecology, dendrochronology offers a higher-resolution picture of fire history over the past several centuries. Dendrochronology is the study of growth rings and fire scars from trees, and such research can provide data as to the specific year, season, associated climate, and specific fire frequency for a given site. Several dendrochronology studies have been completed within GRSM, with the focus on the pine and oak-dominated western end. These studies have demonstrated that for numerous sites in GRSM's western end, fire was occurring quite frequently for the 100-200 years prior to GRSM establishment (Flatley and others 2013, Laforest 2012, Harmon 1982). When the results from these studies are viewed collectively, we have strong evidence that fires burned, on average, every 5-15 years through lower-elevation pine and oak forests in GRSM. Other studies and observations suggest that more remote or higher-elevation pine and oak sites may have burned less frequently (Brose and Waldrop 2006, Armbrister 2002, Harmon 1982).

These frequent fires acted in conjunction with climatic and soil factors to favor the widespread development and maintenance of disturbance-dependent woodlands and forests across the lower and middle elevations of GRSM. The specific roles that fire played in the GRSM landscape and within these natural communities include:

- Maintenance of structural heterogeneity (stand, watershed, and landscape scales)

- ❖ Selection of fire-adapted and sun-loving plant species
- ❖ Creation/maintenance of wildlife habitat
- ❖ Enhancement of biodiversity (genetic, species, community)
- ❖ Building resilience (by maintaining healthy populations of fire and drought tolerant species).

Consistent with the pattern of fine-scale vegetation diversity across the Southern Appalachian Mountains, numerous natural communities developed within the footprints of repeated fires. These natural communities included a wide array of woodlands and open forests dominated principally by a variety of yellow pines, oaks, and American chestnut. The sunny, open conditions resulting from frequent fire acted to favor regeneration of these species and to increase the cover and diversity of sun-loving grasses and forbs relative to the more shade-tolerant trees and shrubs that dominate the forest understory today (Harrod et al 2000). The structure and food resources (foliage, nectar, seeds, etc.) associated with these herb-dominated woodlands, in turn, provided the foundation for a rich ecological web that was essentially dependent on the occurrence of frequent fire.

Ecological Impacts of Fire Exclusion

The establishment of Great Smoky Mountains National Park in 1934 heralded a dramatic shift in the role of fire in the southern appalachian mountains. Concerns about damage to forest resources, impacts to scenic values, and protection of life and property led to policies of complete fire exclusion from the landscape. The prevention of wildland fires became a core goal, and when fires were started (by lightning or humans), GRSM managers acted to suppress the fire as quickly as possible. This focus on prevention, detection, and suppression resulted in a dramatic change to the fire regime that had acted on the GRSM landscape for thousands of years. The resultant decrease in fire frequency in the 20^{th} century was recorded by the same dendrochronology studies that showed how fires were occurring frequently for centuries prior to park establishment (Flatley and others 2015, Laforest 2012, Harmon 1982).

This long-term exclusion of fire from GRSM forests has been a major factor driving changes to forest structure, function, and composition, particularly among forest types dominated by yellow pines (shortleaf, pitch, table mountain, and Virginia) and oaks. The ecological impacts of fire exclusion from GRSM include:

- ❖ Native pine and oak species have been greatly diminished, while fire sensitive trees and shrubs have proliferated. This has rendered many areas more vulnerable to wildfires, and changed vegetation to species poorly adapted to drought and a changing climate

- ❖ Wildland fuels - particularly duff, woody debris, and evergreen shrubs – have accumulated substantially, leading to a higher risk of more severe wildfires

- ❖ Sun-loving grasses and forbs, which are the foundation of biodiversity in dry forest communities, have been shaded out and reduced across the landscape

- ❖ Table mountain pine, which needs fire to release its seeds, has declined dramatically
- ❖ Unique 200-400 year old Shortleaf pine forests are threatened by forest pests and lack of regeneration.
- ❖ The federally endangered red-cockaded woodpecker, which depends upon fire- maintained mature pine forests for its habitat, was extirpated from GRSM in the 1980s
- ❖ Loss of habitat for a unique set of plants, insects, and wildlife that are not found in other parts of GRSM.

All of these changes are the direct result of long-term suppression and exclusion of fire, and they have been documented by GRSM scientists and managers over the past 40 years. These are only the most obvious impacts of fire exclusion in the most fire-prone portion of the GRSM landscape. In the longer term, the continued lack of fire will result in widespread declines in plant and animal diversity, increased difficulty in controlling unwanted wildfires, and will lead to dominance by species that are poorly adapted to drought, fire, and changing climatic conditions. These changes over such a substantial portion of the GRSM land base are believed to pose a serious threat to GRSM's ability to achieve its goals for protection of life and property and preservation of a diverse, resilient, and naturally functioning ecosystem.

Current Fire Management

The Fire Management Plan (FMP) of 1996 was developed as a response to direction in the GRSM General Management Plan, Resource Management Plan, and National Park Service policy to take action in order to prevent and reverse these negative impacts. The 2015 FMP provides the most current update to NPS policy and park direction for the management of fire, and includes the following goals:

GRSM Fire Management Goals

- ➢ Protect human life, communities, and resources from the adverse effects of wildfire without compromising safety
- ➢ Maintain and restore fire adapted ecosystems using appropriate tools and techniques in a manner that will provide sustainable, ecological and social benefits
- ➢ Integrate knowledge generated through fire and natural resource research into fire management priorities, decisions and actions
- ➢ Integrate fire as a natural process into GRSM's ecosystem to the fullest extent possible
- ➢ Communicate and coordinate with interagency organizations and other stakeholders to pursue common goals, programs and projects

- Build and promote organizational effectiveness by building program capacity, leadership, and effective management practices.

The protection of human life, property and resources from the adverse effects of wildfires remains the most important goal for fire management at GRSM. While the complete exclusion of fire was the policy until 1996, wildfires have still occurred. Over 900 wildfires have been recorded in GRSM between 1942 and 2016. There have been an average of approximately 13 wildfires per year in that time span, and over 70,000 total acres have burned. The vast majority (70%) of wildfires has been 10-acres or less in size, and nearly half (46%) have been 1-acre or less. Fires greater than 1000-acres have been very rare (1% of total), and the largest wildfire in GRSM history was the 17,140-acre (10,964 in Park) Chimney Tops 2 wildfire of November 2016.

Aside from re-emphasizing the primary objective of wildfire protection, the 1996 FMP recognized the importance of using fire to reverse the decades of fuel buildup and ecosystem decline. One of the tools identified as appropriate to achieve these objectives was the management of selected natural (lightning-caused) wildfires for resource benefits. Lightning ignitions have been recorded in GRSM since at least 1942, with over 144 total occurrences, or an average of 2 per year. Prior to 1996, the average size of these fires was 16 acres, and after 1996, the average size was 72 acres – the largest being the Chilly Spring Knob Fire of 2006 (913 acres). The total number of acres burned by managed lightning fires since 1996 is 2,949.

The other tools that were identified in the 1996 FMP were manual thinning of fuels and prescribed burning. Since 1996, manual thinning of fuels has occurred along the GRSM Wildland-Urban-Interface at several locations in Sevier and Blount Counties in Tennessee. These fuel reduction efforts have been accompanied by both pile-burning and broadcast-prescribed burning, with the primary goal to remove large numbers of evergreen shrub stems and heavy fuel accumulations from the GRSM boundary with private residences.

In areas of GRSM that could benefit from fire, the Park Service has conducted prescribed burns. Prescribed fire is a planned fire (also sometimes called a “controlled burn” or “prescribed burn”) and is used to meet management objectives. A prescription is a set of conditions that considers the safety of the public and fire staff, weather, and probability of meeting the burn objectives. Such fires have pre-determined boundaries and are ignited only under very specific conditions. Limiting conditions include weather, fuel moisture, soil moisture, availability of trained fire-fighting personnel, and air quality conditions.

GRSM has conducted 106 prescribed burns since 1996 for a total of nearly 20,000 acres, or an average of about 1000 acres per year. Some focal areas for the prescribed burns have included Cades Cove, Tabcat Creek, the landscape just west of Cades Cove known as “North of Abrams”, and the forests around Cataloochee Valley. Scientific monitoring is conducted before and after the burns to make sure the fires achieve the desired results. This monitoring has shown that prescribed burns can successfully reduce fuels and restore fire-adapted species (Jenkins et al 2011), though multiple burns may be required to effectively achieve long-term objectives. The important work of fuels reduction and fire restoration will continue. In 2016, Great Smoky Mountains National Park produced a *Foundation Document* that reemphasized the important role of fire and prescribed burning in effectively managing GRSM resources into the future (see excerpt below).

Great Smoky Mountain National Park Foundation Document (2016)
Fire Management Excerpts :

*In "**Threats to Ancient Mountain Ecosystems:**"*

> *"Alteration of the natural fire regime is creating uncharacteristically dense forests or converting them to mixed mesophytic community types."*

*In "**Trends of Biodiversity – Wondrous Variety of Life:**"*

> *"While the number of known species is increasing, overall biodiversity is decreasing due to the lack of natural disturbance (namely natural fire regimes)."*

*In "**Threats to Biodiversity:**"*

> *"Climate change may reduce the range and distribution of some vegetation communities and amplify invasive species, diseases and pests, and possibly fire."*

*In "**Opportunities for Biodiversity:**"*

> *"Prescribed and natural fire will continue to restore fire-adapted ecosystems including both open meadow and forest areas where fuel loads are high and increasing. Increased funding through federal or private sources is needed to expand this effort."*

Finally, in the ***Wilderness Character Narrative***, the need for responsible fire management is summarized in the context of the "Natural" qualities of GRSM's wilderness:

"Restoration of some semblance of natural fire regimes would help to maintain the ecological integrity of fire-adapted habitats and associated wildlife species, while enhancing the diversity of vegetation in the wilderness."

https://www.nps.gov/grsm/learn/management/upload/GRSM_FD_SP.pdf

Objectives

The Great Smoky Mountains National Park's large landscape, with its legacy of decades of fire suppression, along with the promising more recent use of prescribed fire, now provide opportunities to improve the ecological condition of the fire-maintained ecosystems. The Landscape Conservation Forecasting project aimed to help make this happen.

The specific objectives for GRSM Landscape Conservation Forecasting project were as follows:

- Engage NPS Resource Management staff and regional experts to conduct highly credible research that contributes to the establishment of meaningful landscape-scale objectives, effective prioritization, and shared ownership of future fire management direction.
- Synthesize past and current research findings, remote sensing, and spatial data to inform a more complete understanding of past, current, and desired future conditions for fire-maintained forests.
- Use state-and-transition modeling to develop pre-settlement reference conditions for structure and composition of fire maintained forests in GRSM.
- Complete an ecological departure analysis that will highlight the greatest priorities for management action, and provide insight into fuels treatment objectives and effectiveness.
- Produce a final set of management scenarios for a 20-50 year time horizon to serve as a planning guide for future fire management plans, 5-year fuels treatment plans, and prescribed burn plans.

Process and Methods

Landscape Conservation Forecasting (LCF) has built upon and modified methodologies developed under the national interagency LANDFIRE program (Rollins 2009, LANDFIRE 2016) -- including mapping, models, and metrics -- to assess a landscape's ecological condition. The LCF process used for GRSM consisted of six primary components or steps, as follows:

1. Develop maps of potential vegetation types, called ecological systems, and current vegetation succession classes (s-classes) within ecological systems.
2. Refine computerized predictive state-and-transition ecological models for the ecological systems by updating previously developed models, or developing new models as needed.
3. Determine current condition of all ecological systems (a broad-scale measure of their "health"), using the ecological departure metric. Ecological departure is measured by comparing the current condition of vegetation with the Natural Range of Variability (NRV), which represents the reference condition for the ecological systems.
4. Use computerized ecological models to forecast anticipated future condition of ecological systems with no management action.
5. Use the computerized ecological models to forecast anticipated future condition of ecological systems under alternative management strategies and scenarios.
6. Use return-on-investment analysis to assess which strategies for which ecological systems yield the most advantageous results.

A schematic diagram that displays the relationship of these components to each other is presented below (Figure 2):

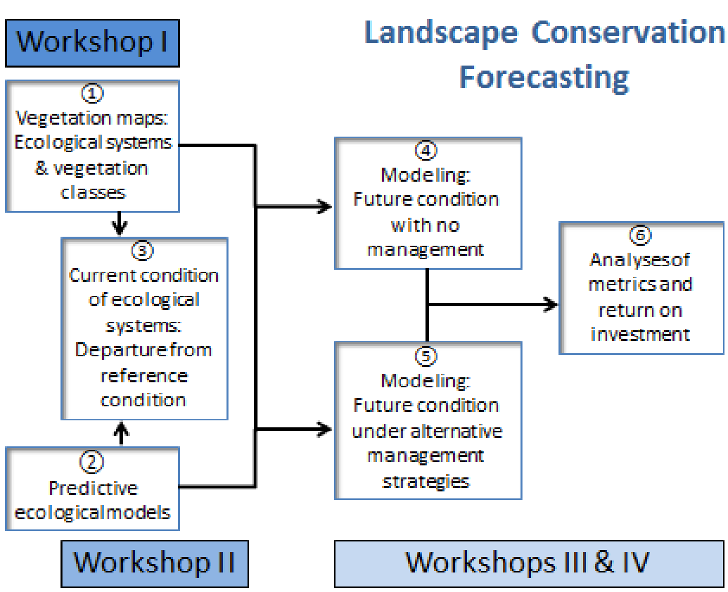

Figure 2. LCF Process Diagram.

The LCF project at GRSM proceeded in two stages. Stage one processed and optimized existing park vegetation data, ecological zone data and LiDAR data for use in LCF. Stage two included four workshops in 2016 that engaged park staff and others to develop state-and-transition models for historical vegetation, complete the ecological departure analysis, and compare potential future management scenarios.

Detailed descriptions of methods used in each of the project's component steps are presented in the following subsections.

Vegetation Data

The fundamental elements of LCF's ecological departure analysis include: 1) mapping the distribution of ecological systems as potential natural vegetation – i.e., the dominant vegetation types expected in the physical environment under a natural disturbance regime; 2) mapping current vegetation succession classes of each ecological system; and 3) for each ecological system, comparing the current structural class distribution with the expected "natural" distribution and calculating each system's departure from its NRV. NRV is the percentage of each vegetation succession class that would be expected under a natural disturbance regime.

Steve Simon (Ecological Mapping and Fire Ecology, Inc.) was engaged to develop a map of GRSM potential natural vegetation and integrate this map with current vegetation data. Existing datasets were reviewed and processed, including current and historic vegetation mapping, ecological zone mapping, disturbance history, and fire history. A set of crosswalks and decision rules were applied as needed to conform with the LANDFIRE-based vegetation data classification methods used by LCF.

Spatially referenced data is necessary for determining composition and structure parameters and for evaluating LCF results at a given project area. The following vegetation data were spatially defined in a Geographic Information System (GIS) for GRSM. These data were grouped within NatureServe's Ecological Systems classification approach (Comer et al. 2003) which is deployed by LANDFIRE and LCF:

1. Potential Natural Vegetation, defined as either -
    a. Biophysical Settings (BpS): 'the vegetation that may have been dominant on the landscape prior to Euro-American settlement based on both the current biophysical environment and an approximation of the historical disturbance regime' (LANDFIRE 2016), or
    b. Ecological Zones: 'units of land that delineate the environment that can support a specific plant community or plant community group under historical disturbance regimes that may or may not represent current vegetation composition' (Simon 2011).

2. Current/Existing Vegetation, as determined by existing vegetation mapping geospatial data, generally created through interpretation of aerial photography or remotely-sensed data.
3. Succession Classes, identified primarily by –
    a. canopy height, and
    b. canopy gaps and/or dNBR (pre- and post-fire Landsat imagery radiance and reflectance values), and
    c. canopy cover (tree and evergreen shrub)

The following sub-sections providing details on the mapping of potential natural vegetation, current vegetation and succession classes are extracted from Simon's report.

Potential Natural Vegetation

Three primary data sources were available for developing a map of potential natural vegetation suitable for NRV measurements at GRSM:

1) An existing vegetation map produced in 2003 (1:15,000 scale) that included 173 dominant vegetation types and two companion documents that, in combination, provided a rough cross-walk between the dominant vegetation types and ecological systems:
    a. Final Report May 2003: 'Vegetation classification of Great Smoky Mountains National Park': Unpublished report submitted to BRDNPS Vegetation Mapping Program. NatureServe: Durham, NC. (White, R.D., K.D. Patterson, A. Weakley, C.J. Ulrey, and J.Drake. 2003)
    b. Draft Report May 2004: Vegetation Classification System Outline for Mapping Great Smoky Mountain National Park (Center for Remote Sensing and Mapping Science (CRMS) Department of Geography, the University of Georgia & NatureServe-Durham Office.
2) A preliminary grouping of the 173 dominant vegetation types by reference and current condition, Great Smoky Mountains Park Ecological Systems, and LANDFIRE Ecological Systems (GRSM staff - Rob Klein), and
3) An Ecological Zone map (10 meter resolution) produced in 2011 that included 21 Zones and 12 Ecological Systems and a companion document that described these types (Ecological Zones in the Southern Blue Ridge 3rd Approximation, S.Simon, 2011: Unpublished report submitted to the National Forests in North Carolina).

GIS map representations of these data were produced for ecological systems from both intersected and independent data coverages; these GIS map data were then evaluated at both broad and local landscape levels. Some relatively minor map unit errors in both mapped data sources were evident. For example, for the Cades Cove and Mount Guyot USGS quads, data reflected different photo interpreter's judgment of existing vegetation classes. However, these errors were very localized.

Based upon these observations, a "hybrid" map of potential natural vegetation was produced that included the best elements from the existing vegetation and ecological zone maps, along with a collaborative effort at developing a crosswalk / rule set that defined ecological systems. The final ecological system “rules” are included in Appendix 1.

The hybrid map included some minor adjustments of polygons based upon an analysis of over 300 field reference plots that were used in both the existing vegetation and ecological zone map development. Approximately 620 acres, primarily at higher elevations, were adjusted to better reflect ecological systems where reference plots were not in agreement with existing vegetation map units.

The hybrid map was created to allow flexibility for different types of ecosystem evaluation, i.e., types were split as much as the data would allow but could be easily aggregated. For example, Spruce and Fir types were identified separately, but combined for the LCF ecological system analysis. On the other hand, some ecological systems were split into elevation or moisture-temperature gradients to reflect major types that were evident in the field and for which differences existed in disturbance regimes. For example, the oak types were split into four systems - Dry Oak Forest, Dry-Mesic Oak Forest, Mesic Oak Forest, and High Elevation Red Oak Forest based on differences in composition and fire regime. A total of eleven ecological systems were identified in the final map (Table 1).

Other highlights of the final hybrid map of potential natural vegetation include:

- Low Elevation Pine-Oak ecological system split into: (1) Low Elevation Pine-Oak Heath at elevations < 2,300’ and within the Pine-Oak Heath Ecological Zone, and (2) Low Elevation Pine = other Pine-Oak existing vegetation < 2,300’ (all Yellow Pine-Oak > 2,300 = Montane Pine-Oak Heath),
- Identified Northern Hardwood, Hemlock-Northern Hardwood, and Beech Gaps but aggregated these into the Northern Hardwood ecological system,
- Identified Hemlock and Hemlock-White Pine but these aggregated to Acidic Cove,
- Identified Acidic Cove and Rich Cove but aggregated these types to the Cove Forest ecological system, and
- Split White Pine-Oak into either Dry Oak or the ecological zone model prediction.

Approximately 90% of the final hybrid map area was derived by grouping existing vegetation map units into logical ecological systems; approximately 10% of the area was derived from ecological zone models.

Table 1: Ecological systems identified by the hybrid map. Original LANDFIRE-based system names were shortened for naming GRSM systems for LCF

LANDFIRE Ecological System Name	System Name for GRSM LCF	Acres
Central and Southern Appalachian Spruce-Fir Forest	Spruce-Fir Forest	40,830

Southern Appalachian Northern Hardwood Forest	Northern Hardwood Forest	67,830
Southern and Central Appalachian Cove Forest	Cove Forest	123,900
Central Interior and Appalachian Riparian and Floodplain Systems	Montane Alluvial	7,920
Central and Southern Appalachian Montane Oak	High Elevation Red Oak Forest	22,410
Central and Southern Appalachian Northern Red Oak-Chestnut Oak	Mesic Oak Forest	60,560
Southern Appalachian Oak Forest – dry type Southern Appalachian Oak Forest – dry-mesic type	Dry Oak Forest Dry-Mesic Oak Forest	80,370 65,850
Southern Appalachian Montane Pine Forest and Woodland - high elevation type Southern Appalachian Montane Pine Forest and Woodland - low elevation type	Montane Pine-Oak Heath Low Elevation Pine-Oak Heath	18,760 8,760
Southern Appalachian Low-Elevation Pine Forest	Low Elevation Pine Forest	17,870
Not included in LCF evaluation (developed areas, roads, balds, water, fields, etc.)		29,130
TOTAL		544,190

Current (Existing) Vegetation

Ecological departure analysis requires that both the potential and existing vegetation are defined as ecological systems map units. The GRSM existing vegetation map produced in 2003 clearly defined vegetation composition at that time; this map was used to define current vegetation types. The significant but highly localized forest disturbances that have occurred since the 2003 map was produced have been documented and were included in the evaluation of vegetation succession classes for the LCF analysis.

For approximately 90% of GRSM, the current/existing ecological systems were identified from the 173 dominant vegetation types defined in the 2003 map following the same logic and groupings used to identify potential natural vegetation types.

The other 10% of the area (52,260 acres) included the following more generalized “types” that could not be accurately placed within an ecological system using the dominant vegetation type classification:

- Southern Appalachian Early Successional Hardwoods (19,710 ac.),
- Southern Appalachian Mixed Hardwood Forest (Acidic) (23,355 ac.),
- High Elevation Xeric Woodlands (885 ac.),
- Eastern White Pine and Mixed Eastern White Pine-Dry Oak (7,027 ac),
- Eastern White Pine-Mesic Oak Forest (548 ac.), and

- Chestnut Oak/Hardwoods with White Pine (735 ac).

Ecological zone maps were used to approximate where these types fit within ecological systems (Table 2).

Table 2: Ecological systems used in the LCF identified by ecological zone in the hybrid model

LANDFIRE Ecological System Name	System Name for GRSM LCF	Acres
Central and Southern Appalachian Spruce-Fir Forest	Spruce-Fir Forest	1,470
Southern Appalachian Northern Hardwood Forest	Northern Hardwood Forest	2,640
Southern and Central Appalachian Cove Forest	Cove Forest	25,990
Central Interior and Appalachian Riparian and Floodplain Systems	Montane Alluvial	1,010
Central and Southern Appalachian Montane Oak	High Elevation Red Oak Forest	2,210
Central and Southern Appalachian Northern Red Oak-Chestnut Oak	Mesic Oak Forest	8,870
Southern Appalachian Oak Forest Southern Appalachian Oak Forest	Dry Oak Forest Dry-Mesic Oak Forest	680 5,150
Southern Appalachian Montane Pine Forest and Woodland - high elevation type	Montane Pine-Oak Heath	3,210
Southern Appalachian Low-Elevation Pine Forest	Low Elevation Pine Forest	900
Not included in LCF evaluation (developed areas, roads, balds, water, fields, etc.)		140
TOTAL		52,260

Ecological zone maps were also used in combination with GRSM existing vegetation map to identify "highly departed vegetation" (i.e., uncharacteristic) classes. LANDFIRE describes a vegetation class that is outside the historic range of variability in vegetation composition and structure as "uncharacteristic" – either uncharacteristic native vegetation or uncharacteristic exotic vegetation. For example, cheatgrass (an exotic annual grass) that occurs in sagebrush ecological systems in the Western U.S. is often used to characterize an 'uncharacteristic exotic' LANDFIRE condition. The extent and severity of this type of uncharacteristic condition does not occur in ecological systems within GRSM. However, uncharacteristic classes can also include native vegetation when the vegetation structure or composition would not have been expected to occur on the ecological system during the reference condition period. Within GRSM, only 5,475 acres were found to be of this uncharacteristic type, which were labeled as "highly departed vegetation"; they include stands where tulip poplar is dominant in Oak ecological systems or where white pine or oak is dominant in Low Elevation Pine or Pine-Oak Heath ecological systems.

Succession Classes (s-classes)

Seral Stages

Forest seral stages are most easily categorized by stand age. Stand age is used in the 5-box LANDFIRE ecological models (see following section) to define early, mid, and late succession classes. Stand age, however, is not available spatially for GRSM and consequently a combination of factors was needed to estimate seral stages for the GRSM ecological systems.

At the time of GRSM establishment in 1934, over half of the total area of GRSM had been cut over by large corporately owned logging companies, and pioneers had settled and farmed in some areas for 100 years (Pyle, 1985). Most of the logging occurred between 1910 and 1930 (Brown, 2001) which would suggest an average current age of 86 to 106 years for over half of GRSM, i.e., at or near late seral condition for most ecological systems. Pyle (1985) also identified and mapped over 110,000 acres as “undisturbed” at the time of park establishment. This would suggest that much of these areas are likely in late seral “old growth” condition because there has been no extensive logging or widespread natural stand-replacing disturbance since park establishment.

Although disturbance history data would indicate that most forests in GRSM are late successional, natural disturbances (e.g., wind and fire) have occurred since park establishment that have caused localized stand replacement and more widespread canopy gaps. These disturbances have either reset succession to early seral stages or maintained mid-successional conditions, but not all of these disturbances have been documented or mapped. In order to estimate where these conditions might occur, tree canopy height and canopy gap size were considered to be suitable surrogates or indicators of stand age and therefore seral condition. LiDAR (Light Detection and Ranging) data were available across GRSM and were used to spatially measure canopy height. The LiDAR data were processed at 3 meter resolution.

Early succession vegetation was defined as forests where canopy height is less than 20’ in canopy gaps greater than 1/20 of an acre in size, regardless of ecological system. A similar method was applied and field reviewed on the adjacent Nantahala-Pisgah National Forests and proved reasonably accurate (Josh Kelly, personal communication). In addition, early succession was evaluated from 12 documented disturbance events (wildfire, prescribed fire, and a tornado), three of which occurred after the 2009 acquisition of LiDAR data. The relationship between LiDAR early succession estimates and dNBR (the difference in pre- and post-disturbance vegetation radiance and reflectance values) were evaluated to estimate early succession in the largest of these disturbance events, the 2011 tornado concentrated in the Calderwood USGS quad. A dNBR score of > 270 was considered indicative of significant canopy mortality and found to correlate well with LiDAR early succession estimates for disturbance events documented from 1986 to 2009 (pre LiDAR acquisition).

Determining mid-succession forest was also accomplished using canopy height (although with somewhat less confidence for this hard-to-determine seral stage, which GRSM staff have found to be much less prevalent in the GRSM current vegetation structure). Height growth rates for different species on different sites were considered and the following “rules” established to identify mid-successional classes:

- canopy height > 20' but < 60' in Low Elevation Pine, Dry-Mesic Oak, Mesic Oak, Cove Forest, Northern Hardwood Forest, Spruce-Fir, and Alluvial Forest ecological systems, and
- canopy height > 20' but < 30' in Montane Oak, Low Elevation Pine-Oak Heath, Montane Pine-Oak Heath, and Dry Oak ecological systems.

All other areas within GRSM, except those excluded from the LCF analysis (developed areas, roads, balds, water, and fields*)* were considered late-succession vegetation. Areas mapped as "undisturbed" by Pyle (1985) were separately identified as "old growth," which could be used as a potential "Late 2" seral stage in the ecological models.

Canopy Cover

In addition to seral stages, canopy cover is the other key component of identifying vegetation s-classes in the LANDFIRE methodology. LANDFIRE models typically include both Open and Closed canopy cover for the Mid and Late seral stages. Early succession is typically classified as Open canopy structure.

Due to the high degree of competition and shading that can result in areas of GRSM that have dense evergreen shrub cover, shrub cover was included as a factor in the determination of canopy cover. The LiDAR data were used to estimate both canopy cover and evergreen shrub cover. The following rules were used to define open and closed canopy classes within different succession classes in the ecological models:

- mid-succession open canopy class =
  - canopy cover < 60% and shrub cover < 75% (all ecological systems)
- mid-succession closed canopy class =
  - canopy cover ≥ 60% or shrub cover > 75% (all ecological systems)
- late-succession open canopy class =
  - canopy cover < 80% in the Cove Forest ecological system
  - canopy cover < 80% and shrub cover < 75% in the Mesic Oak ecological system
  - canopy cover < 60% and shrub cover < 75% in all other Oak ecological systems
  - canopy cover < 60% and shrub cover < 75% in all Pine-Oak ecological systems
  - canopy cover < 60% in Northern Hardwood, Spruce-Fir, and Alluvial Forest systems
  - dNBR > 270 within the 2011 tornado disturbance area
- late-succession closed canopy class =
  - canopy cover ≥ 80% in the Cove Forest ecological system
  - canopy cover ≥ 80% or < 80% and shrub cover > 75% in the Mesic Oak ecological system
  - canopy cover ≥ 60% or < 60% and shrub cover > 75% in all other Oak ecological systems
  - canopy cover ≥ 60% or < 60% and shrub cover > 75% in all Pine-Oak ecological systems
  - canopy cover ≥ 60% in Northern Hardwood, Spruce-Fir, and Alluvial systems

Ecological Models

Landscape Conservation Forecasting uses state-and-transition models to estimate vegetation succession class distributions for reference conditions and to simulate future management scenarios. A state-and-transition model is a discrete non-spatial, box-and-arrow representation of the continuous variation in vegetation composition and structure of an ecological system (Bestelmeyer et al. 2004). The LANDFIRE program worked with hundreds of experts to develop state-and-transition model descriptions for every terrestrial ecological system in the United States. These descriptive models are accompanied by quantitative models that can be viewed and manipulated in ST-Sim State-and-Transition Simulation Model (hereafter ST-Sim), computer-based simulation software developed with LANDFIRE support by Apex Resource Management Solutions. ST-Sim is a successor program to the Vegetation Dynamics Development Tool (VDDT) used in earlier LCF applications. LANDFIRE used the computer models to estimate reference conditions (also referred to as "Natural Range of Variability" or NRV) for each ecological system, which are then used to help evaluate ecosystem health through the ecological departure metric (Low et al. 2010; LANDFIRE 2016).

At their core, LANDFIRE models have the reference condition represented by some variation around succession classes labeled by five "boxes" (Figure 3). Each box represents a distinct developmental stage of forest growth, usually from early succession herbaceous vegetation to increasing woody species dominance where the dominant woody vegetation might be shrubs or trees. Two classes (boxes) typically represent mid-succession seral stages, and two classes (boxes) represent late-succession stages. Each Class is also considered to be either Open or Closed canopy. Therefore the 5th box for a forest system might represent Late-succession (e.g., age 71+), Open-canopy condition (Figure 3).

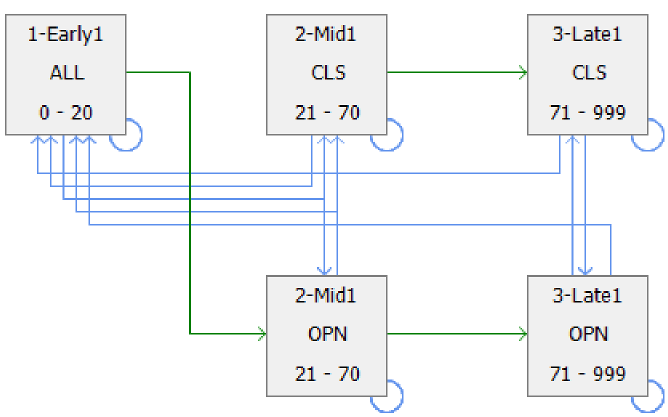

Figure 3. S-classes with age ranges and transition pathways for Dry Oak Forest model in ST-Sim. Green lines represent primary succession pathways. Blue lines represent transitions due to disturbances.

The models all incorporate the relevant natural disturbances that influence each ecological system. Disturbances for forest systems might include fire, insects, disease, wind, and weather events. These disturbances may be further sub-divided – fire typically includes surface fire, mixed fire and replacement fire. Each disturbance has an average return interval under natural conditions (e.g. 100 year return interval for replacement fire); these return intervals for disturbances are converted into probabilities for a given year in the ST-Sim software (i.e., a 100 year return interval equals a .01 probability that replacement fire will occur in any given year). The replacement fire would typically convert a mid-succession or late-succession class back to an early succession state in the ST-Sim software.

In addition to modeling reference conditions, the predictive models allow for addition of management actions to allow managers to simulate future conditions under alternative management strategies and scenarios (Low et al. 2010; TNC 2009).

Models and Descriptions

State-and-transition models were reviewed and refined for nine ecological systems within GRSM. These systems included: Dry Oak Forest, Dry-Mesic Oak Forest, Mesic Oak Forest, High Elevation Red Oak Forest, Low Elevation Pine Forest, Low Elevation Pine-Oak Heath, Montane Pine-Oak Heath, Cove Forest, and Northern Hardwood Forest.

Most of these models had a long “lineage” going back to original LANDFIRE models, and many were subsequently refined for LCF application in the Cherokee National Forest Landscape Restoration Initiative (Medlock 2012). Additional refinements were made for the Nantahala-Pisgah National Forest by Gary Kauffman, USFS Botanist, and Kori Blankenship with the TNC-LANDFIRE program. These latter models were used as the starting point for refinements and modifications for LCF models at GRSM. An entirely new model was developed for one system, the Low Elevation Pine-Oak Heath, building off the model parameters for similar systems.

Special attention was directed towards refining the models for the seven oak and pine-dominated systems, several of which are highly fire-dependent. In particular, the fire return intervals (FRI) for all three types of fire (surface, mixed and replacement) were compared across all of the oak and pine systems, and refinements made by GRSM resources staff based upon their experience in GRSM, knowledge of the systems, and available scientific literature. The fire return intervals for the reference condition models of the oak and pine systems are displayed in Table 3 below. The shortest FRI is 8 years for surface fire in Early and Mid-Open classes of Low Elevation Pine. The longest FRI is 333 years for replacement fire for Mid-Open and Late-Open classes in Mesic Oak. A discussion of the fire regime and development of model parameters is included in the descriptions of ecological systems (Appendix 2).

Other relatively minor adjustments and refinements were made to the Kaufmann model parameters in the process of comparing age ranges for the succession classes, other disturbances (e.g., insects, weather) and alternative succession (i.e., conversion Open to Closed condition in absence of fire) across systems. These changes are documented in the ST-Sim model database descriptions.

Kaufmann’s revised LANDFIRE models for Cove Forest and Northern Hardwood Forest at the Nantahala-Pisgah National Forest were used to assess conditions for these two systems at GRSM. The FRIs in the models for these two mesic systems were very long, with replacement fire occurring every 1000 years for Cove Forest and every 667 years for Northern Hardwood, as well as infrequent Surface and Mixed fire. These two systems account for approximately 38% of the vegetation in GRSM, but represent a very small fraction of the fire across all systems within GRSM in the reference condition models (see Appendix 6).

The LANDFIRE-based models for two other ecological systems – Montane Alluvial and Spruce-Fir Forest – were not reflective of these systems within GRSM. Trying to refine or rebuild these models had issues going beyond the project team's expertise and the scope of the project; accordingly, these models were not used for the LCF project.

Table 3. Fire return intervals, by s-class, for GRSM 9 modeled ecological systems. The shaded bars for each system display the average FRI for all 5 s-classes.

	Type of Fire		
	Surface	Mixed	Replacement
Dry Mesic Oak	**28**	**127**	**224**
Early	29	50	83
Mid-Closed	29	83	200
Mid-Open	20	200	303
Late-Closed	32	100	200
Late-Open	22	200	333
Dry Oak	**17**	**73**	**136**
Early	15	22	67
Mid-Closed	18	56	100
Mid-Open	12	100	200
Late-Closed	20	77	111
Late-Open	13	111	200
High Elevation Red Oak	**33**	**102**	**163**
Early	25	50	67
Mid-Closed	37	91	100
Mid-Open	25	125	200
Late-Closed	40	100	200
Late-Open	28	143	250
Low Elevation Pine	**10**	**74**	**145**
Early	8	20	100
Mid-Closed	10	50	100
Mid-Open	8	100	200
Late-Closed	11	77	125
Late-Open	9	125	200
Low Elev Pine-Oak Heath	**14**	**55**	**115**
Early	12	15	50
Mid-Closed	15	34	75
Mid-Open	12	75	149
Late-Closed	17	50	100
Late-Open	13	100	200
Mesic Oak	**37**	**175**	**243**
Early	33	67	100
Mid-Closed	37	143	200
Mid-Open	33	250	333
Late-Closed	40	167	250
Late-Open	37	250	333
Montane Pine-Oak Heath	**22**	**60**	**97**
Early	20	25	50
Mid-Closed	22	50	75
Mid-Open	20	75	125
Late-Closed	25	67	83
Late-Open	22	83	149

	Surface	Mixed	Replacement
Cove Forest	**100**	**500**	**1000**
Early	100	500	1000
Mid-Closed	100	500	1000
Mid-Open	100	500	1000
Late-Closed	100	500	1000
Late-Open	100	500	1000
Northern Hardwood	**333**	**667**	**667**
Early	333	500	667
Mid-Closed	333	667	667
Mid-Open	333	500	667
Late-Closed	333	667	667
Late-Open	333	1000	667

"Back tests" were conducted on the models of two representative fire-dependent systems – Dry Oak Forest and Low Elevation Pine Forest – to help confirm the validity of the fire-return intervals and other key variables in the models. These tests were designed to roughly mimic the major human-caused disturbances in GRSM over the last century and see if the models would generate results that approximate actual current conditions. Using ST-Sim, the back tests populated the reference condition s-classes as the Initial Conditions for these two systems as of 1910. It then simulated heavy logging (50% clearcut) over a 20 year period, and recorded the s-class outcomes after those simulations as new Initial Conditions as of 1930. It then simulated 85 years of 98% fire suppression and recorded the s-class outcomes after those simulations. The final simulated 2015 results for both systems very closely tracked actual current conditions with only about 10% overall variance (Appendix 3).

The project team considered and tested both 5-box and 7-box models for GRSM's ecological systems. 7-box models had been developed for several ecological systems in the Cherokee National Forest in order to account specifically for old-growth forest, which was determined to need special attention in regard to National Forest management decisions. "Late 2" classes were added for both Open and Closed old-growth condition, thereby creating 7-box models. This approach was continued for the Nantahala-Pisgah models.

However, after reviewing simulations for both 5-box and 7-box models at GRSM, it was determined that the 5-box models provided sufficient, simpler and clearer information. This was the case for several reasons: (1) GRSM manages for overall natural conditions and does not need to focus special attention on managing for old growth forest, unlike the National Forests which manage for multiple use including timber harvest; (2) GRSM has abundant old growth forest – approximately 20% – due to an absence of logging since GRSM park establishment; (3) much of GRSM's current late-succession forest that is not *now* old growth will soon *become* old growth due to natural aging of the forest, which was heavily logged about a century ago; and (4) the disturbance parameters for the old-growth classes in the 7-box models were identical to the late-succession classes in the 5-box models, thereby providing no distinction in the combined late-class outcomes in simulations.

Descriptions of all ecological systems are provided in Appendix 2. Model parameter values for the age ranges of classes (deterministic transitions) are provided in Appendix 4. Model parameter values for all disturbances (probabilistic transitions) are provided in Appendix 5. The ST-Sim model databases, including outcomes of all simulations, are available online at https://tnc.app.box.com/s/489f7i45kmbjkskgc0tsd4wrcq2c4a9t/1/8487753965. They will also be made available on the NPS Date Store.

Natural Range of Variability

The vegetation composition and structure prior to European settlement was considered to be each ecological system's reference condition or natural range of variability (NRV). ST-Sim model runs were conducted to re-simulate NRV, using 10 simulations over a 1,000 year time horizon. The mean natural range of variability for each ecological system is listed below in Table 4.

The project team considered and tested using a *range* for the frequency of each disturbance regime (as was included in the Nantahala-Pisgah models) to estimate NRV (Blankenship 2015). For example, instead of a surface fire return interval of 17 years for the Dry Oak system, the *range* may be 5-20 years. This approach calculates a *range* of NRV for each s-class, in addition to a *mean* score. [While the mean NRV provides a useful benchmark, land managers and researchers are often interested in knowing the range of variability around the mean.] However, this methodology requires determining not only an *average* return interval for each disturbance in the models, but also a *minimum* and a *maximum* return interval for each disturbance. The GRSM LCF project team did not feel there was sufficient science information to establish these minimum and maximum return intervals with confidence, and therefore used the traditional LANDFIRE methodology with stochastic variance in ST-Sim for determining mean-based NRV.

Table 4. The natural range of variability for the GRSM nine modeled systems.

Ecological System	Vegetation S-Class				
	Early	Mid-Closed	Mid-Open	Late-Closed	Late-Open
Dry Oak Forest	17%	9%	21%	24%	29%
Dry-Mesic Oak Forest	9%	9%	18%	32%	31%
Mesic Oak Forest	6%	17%	14%	46%	17%
High Elevation Red Oak Forest	14%	14%	12%	37%	23%
Low Elevation Pine Woodland	13%	10%	30%	12%	35%
Low Elevation Pine-Oak Heath	21%	13%	30%	15%	21%
Montane Pine-Oak Heath	25%	16%	25%	15%	19%
Cove Forest	4%	24%	4%	57%	11%
Northern Hardwood Forest	6%	22%	1%	59%	12%

Assessment of Ecological Condition - Metrics

Ecological Departure

The ecological departure methodology was used to assess the overall ecological condition of each of the modeled systems. Ecological departure is a broad-scale measure of ecosystem “health” – an integrated, landscape-level estimate of the ecological condition of terrestrial and riparian ecological systems. Ecological departure estimates an ecological system’s *departure* from its NRV. The level of departure, or dis-similarity, from NRV for each ecological system was calculated by comparing the current vegetation succession-class distribution with the expected “natural” distribution (see Dry Oak example in Table 5).

Ecological departure (Low et al. 2010) – currently known in LANDFIRE as Vegetation Departure or VDEP (LANDFIRE 2016) – is scored on a scale of 0% to 100% departure from reference conditions: Zero percent represents NRV while 100% represents total departure from NRV [i.e., the higher the number, the greater the departure]. Originally In LANDFIRE, a coarser-scale metric known as Fire Regime Condition Class (FRCC) was used by federal agencies to group ecological departure scores into three classes (FRCC Guidebook 2010): FRCC 1 represents ecological systems with low (<34%) departure, which is color coded green; FRCC 2 indicates ecological systems with moderate (34 to 66%) departure, which is color coded yellow; and FRCC 3 indicates ecological systems with high (>66) departure, which is color coded red. The new VDEP-based metric in LANDFIRE is called Vegetation Condition Class (VCC) rather than FRCC. VCC now provides a six-category classification system in addition to the original three class-FRCC system. The LCF scorecard at GRSM therefore uses six color shades (two red shades for >66, orange for >50, yellow for > 33, and two green shades for <33). An example of ecological departure scoring is shown in Table 5.

Table 5. Calculation of Ecological Departure for Dry Oak at GRSM

Dry Oak Forest				
Vegetation Class	**NRV** Mean	**Current %**	Current Acres	Delta vs Mean NRV
Early	17%	2%	1,600	-15%
Mid-Closed	9%	0%	0	-9%
Mid-Open	21%	0%	100	-21%
Late-Closed	24%	90%	72,300	66%
Late-Open	29%	8%	6,200	-21%
Highly Departed Composition	0%	0%	100	0%
Totals	100%	100%	80,300	0
Ecological Departure		**66**		

Ecological Departure = 100% $- \sum_{i=1}^{n} \min\{Current_i, NRV_i\}$

Other Metrics Considered

Ecological departure can be caused by two factors: departure from the expected natural seral stage structure and/or departure from the expected natural canopy structure. For LCF at GRSM, a new *Open Canopy Departure* metric was used as a working metric by the project team to quickly assess the departure from historical open canopy conditions. This metric proved to be a useful analysis tool since much of the ecological departure of the fire-dependent systems was often accounted for by the forest's overly closed canopy conditions due to long-time fire suppression. The calculation was derived by adding the total percentage of Mid-Closed and Late-Closed classes, and then subtracting the combined NRV percentages for these two classes. In the Dry Oak example, as shown in Table 6 below, total current Closed canopy is 90% as compared to NRV closed canopy of only 33%; the difference is 57%. As with the Ecological Departure metric, a score of 0 would represent no departure from historic open conditions, whereas higher scores would indicate more overly closed forest conditions. For the Dry Oak system, Open Canopy Departure was 57% as compared to the 66% overall Ecological Departure, meaning that much of the ecological departure was attributable to departure in canopy structure (versus changes in seral stage).

Table 6. Calculation of Open Canopy Departure for Dry Oak at GRSM

Dry Oak Forest				
Vegetation Class	**NRV** Mean	**Current %**	Current Acres	Delta Mean
Early	17%	2%	1,600	-15%
Mid-Closed	9%	0%	0	-9%
Mid-Open	21%	0%	100	-21%
Late-Closed	24%	90%	72,300	66%
Late-Open	29%	8%	6,200	-21%
Highly Departed Composition	0%	0%	100	0%
Totals	100%	100%	80,300	0
Total Closed	33%	90%	72,300	57%
Ecological Departure		**66**		
Open Canopy Departure		**57**		

The project team also tested and temporarily deployed a new metric to assess departure from the *range* of NRV as was calculated in the Nantahala-Pisgah models, but discarded this metric when it decided that the ranges for the disturbance return intervals could not be scientifically established at GRSM (see Natural Range of Variability section above).

Management Objectives

At the May 2016 workshop, after reviewing the initial ecological departure scores for current condition, GRSM natural resources managers developed a set of overall landscape restoration objectives for GRSM, as follows:

- Restore fire as a key ecological process in oak and pine ecosystems where practical and most needed.
- Restore more open canopy conditions in dry oak and pine ecosystems to more closely approximate reference conditions/NRV.
- Restore early and mid-succession vegetation in dry oak and pine ecosystems to more closely approximate reference conditions/NRV.
- Manage fire and fuels appropriately to protect life and human & cultural resources in and adjoining the park.

Five fire-maintained ecological systems were selected for active management using prescribed fire, based upon their high departure from NRV and likelihood of continued future departure. The five focal systems for active management included: Dry Oak Forest; Dry-Mesic Oak Forest; Low Elevation Pine Forest; Low Elevation Pine-Oak Heath; and Montane Pine-Oak Heath.

Assessment of Future Ecological Condition – Alternative Management Scenarios

Predictive state-and-transition computer models are a valuable tool for assessing future condition because they can simulate management actions. A fundamental purpose of LCF is to identify specific, cost-effective vegetation management strategies to maintain, enhance or restore the desired more natural conditions. The assessment of current ecological condition is merely a precursor to this ultimate endpoint.

Fire in the Management Models

Reference condition models for the five focal systems were modified to incorporate prescribed burning as a management action, as well as reflect current levels of fire exclusion in GRSM. These models are considered to be <u>management</u> models. In order to conduct simulations of future management scenarios (in contrast to the historical NRV simulations described previously), it was necessary to determine the amount of fire that would occur in the management models. Two types of fire were built into the management models – the *suppressed reference condition fire* and the *prescribed fire that is added* as a management action. [Note: Reference condition fire was based on the modeled fire return intervals as shown previously in Table 3.]

Fire Suppression/Exclusion

Two factors were considered in accounting for fire activity in GRSM models: the amount and type of total fire activity in the GRSM over its recent history, and the virtual certainty of substantially continued fire suppression/exclusion as an overarching management activity (see Introduction) in the foreseeable future.

Fire history data for GRSM was analyzed for the period from 1920 to 2012 and compared to the amount of "natural" fire that was predicted in the NRV simulations for the models (Appendix 6). During the decades from the 1930s to the 1990s, GRSM's fire management policy was essentially complete fire suppression – i.e., "out by 10am" the following morning after a fire was reported. Data show approximately 98% fire suppression over these decades as compared to the amount of fire that occurs during reference conditions in the models. In 1996, Park management changed from its previous policy of near-total suppression to provide for the addition of some prescribed fire, as well as some limited "wildland fire use." From 2000 to 2012 data show that wildfire equaled approximately 7.5% of the predicted reference condition fire in the models, which converts to approximately 92.5% suppression on average. Prescribed fire equaled an additional 5.5% of the predicted reference condition fire.

It is relatively straightforward to model fire suppression in ST-Sim, using transition multipliers. A transition multiplier is a number that multiplies a base disturbance rate in the ST-Sim models: e.g., for a given year, a transition multiplier of 1.0 creates no change in a disturbance rate, whereas a multiplier of 0 is a complete suppression of the disturbance rate, and a multiplier of 0.50 halves the disturbance rate. For GRSM, a transition multiplier of .075 (1.00 - .925) was applied for all three types of fire to reflect the rate of fire suppression/ exclusion as compared to fire during reference conditions, based on the analysis described above.

Prescribed Fire

Adding prescribed fire to ecological models is typically a relatively straightforward modeling task that has been applied during many LCF applications. The ecological effects of the prescribed fire are determined for each s-class in which it might occur. Then the management action is added as a new Transition type in the ST-Sim models (e.g., RxFire). The modeler then determines the number of acres and years they wish to simulate prescribed burning for a given ecological system or set of systems, and conducts a simulation computer run (TNC 2009).

However, this modeling task was more complex for GRSM. Prescribed burning in GRSM is not a one-off event to achieve the desired outcomes. Rather, fire managers typically define a burn unit and apply prescribed fire within that unit in a number of "passes" over a number of years. This approach is necessary to achieve the desired ecological effects; trying to achieve the effects with a one-time burn has been found to produce results which are undesirable over large spatial scales. Accordingly, with assistance from TNC's LANDFIRE program, expert assistance was secured from the developers of ST-Sim to develop models that incorporated three prescribed fire “passes” in simulated non-spatial burn units, designed to achieve the desired ecological outcomes. Each pass was modeled to occur within 10 years after the previous pass.

Collectively, the three passes of prescribed fire were considered to be *restoration burning*. The ecological effects were programmed to occur upon the completion of the 3rd pass. Based upon knowledge of previous control burns in GRSM, the effects were deemed to be different for Closed versus Open canopy classes of the fire-maintained systems, with the bigger impacts occurring in the Closed canopy classes, as follows:

- In Closed canopy
  - 20% converts to Early succession
  - 60% converts to Open canopy
  - 20% remains Closed canopy (i.e., no change in class)
- In Open canopy
  - 10% converts to Early succession
  - 90% remains Open canopy (i.e., no change in class)

For the second 20-year period in the models (i.e., years 21-40), the allocation of prescribed fire was modified to include *maintenance* burning in addition to the restoration burning used exclusively in the first 20 years. Maintenance burning was programmed to occur in forest patches that were in Open condition as a result of previous prescribed burns or otherwise. Maintenance burning is intended to retain the Open canopy structure, versus converting Closed canopy to Open. The effects of the maintenance fire are the same as described for Open canopy above (i.e., 90% remains Open and 10% converts to Early succession). In the management scenario modeling, fifty percent of the prescribed burning during years 21-40 was allocated to maintenance burning and fifty percent to restoration burning.

Allocation of Prescribed Fire Across Systems

The ecological systems within GRSM are frequently arrayed in a mosaic pattern, and prescribed burns are not directed towards one single ecosystem, but rather to multiple ecological systems within a functional burn unit. Therefore it was necessary to determine how the controlled burning in the non-spatial ST-Sim models would be allocated among the five focal systems, along with other ecological systems in GRSM that receive burning as a result of the functional design of burn units on the ground.

The models deployed an allocation ratio based largely upon the recent allocation of prescribed fire among the ecological systems during controlled burns, based upon an assessment by GRSM staff. This allocation is shown in Table 7 below. Thus if 1000 acres of prescribed burning were to occur in a given year across GRSM, 300 acres (30%) would be allocated to Dry Oak Forest, and so on. The 25% of prescribed burning allocated to Cove Forest and all other systems represents the less fire-prone portions of functional burn units. These areas are not the focal point for fire restoration and they often do not burn under controlled-burning conditions, and so were not accounted for in the ST-Sim models.

Table 7. Allocation of Prescribed Fire Across Ecological Systems

Ecological System	% of Rx Fire
Dry Oak Forest	30%
Dry Mesic Oak Forest	15%
Low Elevation Pine Woodland	12%
Low Elevation Pine-Oak Heath	10%
Montane Pine-Oak Heath	8%
Cove Forest/All Others	25%
Total	100%

Management Scenarios

At and between workshops, prescribed fire management strategies were explored to achieve the objectives for the focal systems. ST-Sim computer models were used to simulate conditions under alternative future management scenarios. All scenarios assume current levels of wildfire exclusion will continue in GRSM. The likely future condition of the five focal systems was assessed after 20 and 40 years under four primary scenarios:

1. No Action – i.e., no prescribed fire.
2. Maximum Management – use of prescribed fire to restore ecological departure to the lowest possible level, regardless of budget or practicality.
3. Current Management – prescribed fire at current levels -- approximately 1,500 acres/year average parkwide.
4. Preferred Management – prescribed fire at proposed levels – 5,000 acres/year average parkwide.

Computer Simulations and Reporting Variables

ST-Sim computer simulations were used to test the scenarios for each of the focal ecological systems over a 20-year and 40-year time horizon. Five replicates were run for each scenario to capture some degree of stochastic variability in fire activity and other natural disturbances. The mean of the five replicates was used for reporting.

The primary reporting variables for simulations were: (1) ecological departure score, (2) total acres treated with prescribed fire, and (3) total cost. Results were tallied in an Excel-based Model Runs Workbook.

Reducing Levels of Fire Suppression/Exclusion

ST-Sim computer simulations were also used to test the effect of reducing the degree of fire suppression/exclusion in GRSM, which as reported previously was set at a rate of 92.5% suppression of reference condition fire in the models. Rates of 85% exclusion and 77.5% exclusion were tested (i.e., allowing additional increments of 7.5% of natural wildland fire to occur in GRSM), using the No Action scenario as the baseline. The reporting variable for this exercise was the ecological departure score.

Return on Investment (ROI) Analysis

The final step in the LCF process was the calculation of benefits (magnitude of ecological improvement) as compared to the costs of management. Two ROI metrics were used to determine which of the five focal systems received the greatest ecological benefits per dollar invested, independent of their size (absolute) and reflecting their varying acreage (systemwide). The two ROI metrics calculated were:

(1) Absolute ROI. The change of ecological departure between the NO ACTION scenario and an ALTERNATIVE MANAGEMENT scenario for a given ecological system in year 20 or year 40, divided by total cost of the scenario over the period of years. Correction factors were used to bring all measures to a common order of magnitude.

(2) Systemwide ROI. The change of ecological departure between the NO ACTION scenario and an ALTERNATIVE MANAGEMENT scenario for a given ecological system in year 20 or year 40, *multiplied by total area of the ecological system*, divided by total cost of the scenario over the period of years. Correction factors were used to bring all measures to a common order of magnitude.

If ROI values differ substantially, they are sometimes a useful tool for land managers to decide where to allocate scarce management resources among many possible choices on lands that they administer. Of course, managers also select final strategies or treatment areas based upon a variety of additional factors, such as availability of financial resources, policy constraints, and other societal objectives.

LCF Benefits and Limitations

By developing a decision support tool to assess alternative management strategies, LCF provides many benefits to natural resource managers. Among the key benefits are the answers that LCF provides to the following questions:

- What is the current condition of each ecological system in the landscape
- What systems are likely to change in condition, and how much
- Which management treatments, and how much, will improve altered ecosystems
- What degree of improvement can be feasibly achieved
- Where to place treatments on the landscape, by ecological system
- Which management treatments produce the most cost effective results

The models used to help develop the answers to these questions are relatively simple, transparent and easily adaptable, thereby providing a solid framework for adaptive ecosystem management.

Some additional LCF benefits include:

- Scorecards of current & future condition
- Scientific documentation for Fire Planning and National Environmental Policy Act (NEPA) documents
- Help attract funding for implementation
- Help build collaborative learning and consensus among resource managers and stakeholders

Landscape Conservation Forecasting has some limitations in its applications. Some constraints were overcome by adaptations for the Great Smoky Mountain National Park project, such as revising LANDFIRE ecological models based upon local expertise and substituting higher resolution local vegetation data for national LANDFIRE data. The following general constraints and challenges were inherent in the LCF methods used at GRSM.

- Maps and Data. The assessment of current condition is only as good as the vegetation data that supports it. High-resolution and well-interpreted geospatial data is best for understanding current conditions and was used at GRSM; nevertheless a number of crosswalks, assumptions and rules were required to interpret that data and apply it for LCF.
- Models. "All models are wrong, but some are useful," said prominent statistician George Box. A well-developed predictive model can provide a reasonable approximation of reality. LANDFIRE was designed to use relatively simple, peer-reviewed, consistent, and repeatable scientific methods in developing ecological models. However, many standard LANDFIRE models do not accurately reflect local conditions, and therefore require local, expert-based modifications, as was done with all models for GRSM.

Incorporating management actions into models also requires expert-based judgments on their ecological effects and probability of success.

- Metrics. While ecological departure is a powerful, unified metric of overall ecological "health" – generally incorporating vegetation structure, composition, and all relevant ecological processes – it does not fully account for all impairments to ecosystems or all improvements in ecological health from potential management actions. Ecological departure typically is based upon the NRV for the reference conditions of an ecosystem. NRV reflects many elements of what is typically desired for a given ecosystem, such as the amount of early succession habitat and the degree of open canopy structure. However, its application at GRSM generally does not capture the desired vegetation *composition* within a given succession class, other than the designation of "highly altered vegetation" found within some ecological systems.
- Perceived Precision. The 0-100 ecological departure scores and other related metrics may suggest a high level of precision to some readers (e.g. a departure score of 53), whereas the scores should be more appropriately viewed as approximations that reflect ranges of outcomes. A small percentage difference in scores (e.g. 52 vs. 55) is not meaningful, given the inherent imprecision of the underlying models and/or data.
- Climate Change. LCF has addressed climate change effects in a few projects, but it is complex and challenging to do so and with a high confidence level in the models. LCF climate change forecasting in the northern Sierra Nevada found that effects were not occurring at a significant level until 40 years out. Two important findings were that management actions taken to restore ecosystems closer to NRV helped to improve future condition in the face of climate change, and the sooner these restoration actions were taken, the better the long-term outcome.
- Non-Spatial. While LCF can be assessed with spatial models, spatial modeling is very complex, time-intensive and expensive. The more common non-spatial application of LCF using ST-Sim models does not address the *pattern* of vegetation and succession classes across the landscape. Addressing vegetation heterogeneity and fragmentation requires the addition of complex and more expensive spatial modeling tools and metrics.
- Stand-level Dynamics and Treatments. LCF is a landscape-scale planning tool. The non-spatial application of LCF does not address vegetation patch size, openings, or stand-level treatments. Qualitative management treatment guidelines cannot be simulated because quantitative rules are required by all simulation platforms.
- Vegetation Composition. The LCF maps, models and metrics for GRSM primarily focused on ecosystem *structure* and *disturbances*, and generally were not able to reflect or assess the desired *composition* of a given vegetation succession class for a given ecological system. However, the Ecological System Descriptions found in Appendix 2 provide an account of the dominant vegetation expected for each succession class in a given ecological system.
- Aquatics. LCF does not address aquatic ecosystems.

Findings

Current Ecological Condition

Ecological Systems

The 515,000 acres of Park vegetation supports a diversity of Southern Appalachian ecological systems, ranging from low-elevation pine woodland to large cove forests to higher elevation spruce-fir forests. Eleven major ecological system types in GRSM were identified from the vegetation data, including seven oak and pine systems. These systems and the acreage of each system (rounded) are as follows:

Ecological System	% of Acres	Acres
Dry Oak Forest	16%	80,300
Dry Mesic Oak Forest	13%	66,000
Mesic Oak Forest	12%	60,500
High Elevation Red Oak Forest	4%	22,300
Low Elevation Pine Forest	3%	17,800
Low Elevation Pine-Oak Heath	2%	8,800
Montane Pine-Oak Heath	4%	18,800
Cove Forest	24%	123,800
Northern Hardwood Forest	13%	67,800
Spruce-Fir Forest	8%	40,900
Montane Alluvial	2%	7,900
Total Acres		514,900

Cove Forest is the largest ecological system in GRSM; at approximately 124,000 acres it comprises almost one-fourth of the GRSM's total vegetation. Four oak systems collectively constitute approximately 229,000 acres, or 45% of GRSM's vegetation. Three pine-dominated systems equal approximately 45,000 acres, or almost 10% of the vegetation. Three other systems (Northern Hardwood Forest, Spruce-Fir Forest, and Montane Alluvial) make up the remainder of the vegetation. All of the ecological systems are described in Appendix 2.

Ecological Departure

The current condition of GRSM's varied ecological systems ranges from good (low ecological departure) to relatively poor (high ecological departure) – see Table 8. Three xeric oak and pine systems constituting 21% of GRSM show *high* ecological departure – Dry Oak Forest, Low Elevation Pine Forest and Low Elevation Pine-Oak Heath. Three other oak and pine systems – constituting another 21% of GRSM are *moderately* departed from NRV – Dry-Mesic Oak Forest, High Elevation Red Oak Forest and Montane Pine-Oak Heath. Three systems that are more mesic show *low* departure, including the Cove Forest, Northern Hardwood Forest and Mesic Oak Forest.

The primary reason for ecological departure across the landscape is due to overly closed canopy structure in the oak and pine systems, as compared to more open structure under reference conditions (Table 9). Across all systems, LIDAR data showed over 80% of GRSM vegetation was closed canopy. There is also a substantial shortfall of early succession and mid succession classes in the most-departed systems as compared to reference conditions. The large-scale logging operations prior to the Park's establishment, followed by a century of fire suppression and exclusion, have been the primary causes of the currently altered conditions, most notably in the drier oak and pine systems. In contrast, the more closed-canopy conditions within mesic systems − including Cove Forest, Northern Hardwood Forest and Mesic Oak Forest − which are much less influenced by fire, show low departure from reference conditions.

Table 8. Current Ecological Departure of GRSM's ecological systems. The measure of Ecological Departure is scored on a scale of 0% to 100% departure from NRV: 0% represents NRV while 100% represents total departure. Departure was not calculated for the two systems that were not modeled.

Ecological System	Acres	Current Ecological Departure
Dry Oak Forest	80,300	66
Dry-Mesic Oak Forest	66,000	57
Mesic Oak Forest	60,500	32
High Elevation Red Oak Forest	22,300	59
Low Elevation Pine Forest	17,800	66
Low Elevation Pine-Oak Heath	8,800	70
Montane Pine-Oak Heath	18,800	64
Cove Forest	123,800	30
Northern Hardwood Forest	67,800	25

Table 9. Acres, percentages and NRV for all S-classes, including totals for 7 oak and pine systems.

Dry Oak Forest							
Class	Early	Mid-Closed	Mid-Open	Late-Closed	Late-Open	Highly Departed	Total
Acres in Class	1,600	-	100	72,300	6,200	100	80,300
NRV %	17%	9%	21%	24%	29%	0%	100%
Current % in Class	2%	0%	0%	90%	8%	0%	100%
Ecological Departure							66
Dry-Mesic Oak Forest							
Class	Early	Mid-Closed	Mid-Open	Late-Closed	Late-Open	Highly Departed	Total
Acres in Class	500	4,500	500	56,300	1,500	2,700	66,000
NRV %	9%	9%	18%	32%	31%	0%	99%
Current % in Class	1%	7%	1%	85%	2%	4%	100%
Ecological Departure							57
Mesic Oak Forest							
Class	Early	Mid-Closed	Mid-Open	Late-Closed	Late-Open	Highly Departed	Total
Acres in Class	400	2,300	400	39,700	15,900	1,800	60,500
NRV %	6%	17%	14%	46%	17%	0%	100%
Current % in Class	1%	4%	1%	66%	26%	3%	100%
Ecological Departure							32
High Elevation Red Oak Forest							
Class	Early	Mid-Closed	Mid-Open	Late-Closed	Late-Open	Highly Departed	Total
Acres in Class	300	10	10	21,400	600	-	22,320
NRV %	14%	14%	12%	37%	23%	0%	100%
Current % in Class	1%	0%	0%	96%	3%	0%	100%
Ecological Departure							59
Low Elevation Pine Forest							
Class	Early	Mid-Closed	Mid-Open	Late-Closed	Late-Open	Highly Departed	Total
Acres in Class	500	2,200	700	12,900	900	600	17,800
NRV %	13%	10%	30%	12%	35%	0%	100%
Current % in Class	3%	12%	4%	72%	5%	3%	100%
Ecological Departure							66
Low Elevation Pine-Oak Heath							
Class	Early	Mid-Closed	Mid-Open	Late-Closed	Late-Open	Highly Departed	Total
Acres in Class	190	-	-	7,370	1,100	100	8,760
NRV %	21%	13%	30%	15%	21%	0%	100%
Current % in Class	2%	0%	0%	84%	13%	1%	100%
Ecological Departure							70
Montane Pine-Oak Heath							
Class	Early	Mid-Closed	Mid-Open	Late-Closed	Late-Open	Highly Departed	Total
Acres in Class	1,100	100	100	14,700	2,600	200	18,800
NRV %	25%	16%	25%	15%	19%	0%	100%
Current % in Class	6%	1%	1%	78%	14%	1%	100%
Ecological Departure							64
Cove Forest							
Class	Early	Mid-Closed	Mid-Open	Late-Closed	Late-Open	Highly Departed	Total
Acres in Class	900	1,500	200	84,500	36,700	-	123,800
NRV %	4%	24%	4%	57%	11%	0%	100%
Current % in Class	1%	1%	0%	68%	30%	0%	100%
Ecological Departure							30
Northern Hardwood Forest							
Class	Early	Mid-Closed	Mid-Open	Late-Closed	Late-Open	Highly Departed	Total
Acres in Class	1,200	7,000	700	56,900	2,000	-	67,800
NRV %	6%	22%	1%	59%	12%	0%	100%
Current % in Class	2%	10%	1%	84%	3%	0%	100%
Ecological Departure							25
All Oak & Pine Systems (7)							
Class	Early	Mid-Closed	Mid-Open	Late-Closed	Late-Open	Highly Departed	Total
Acres in Class	4,590	9,110	1,810	224,670	28,800	5,500	274,480
Simple Ave NRV %	15%	13%	21%	26%	25%	0%	100%
Current % in Class	2%	3%	1%	82%	10%	2%	100%

Future Condition Without Management

Using ST-Sim, the future condition of each modeled system was simulated after 20 years and 40 years, assuming no active management action to restore ecological condition. This essentially represents a "no action" scenario – other than the continuation of current levels of fire exclusion.

20 Year Forecast

After 20 years, five oak and pine systems remain substantially departed from NRV (~50% or higher): Dry Oak Forest (56% departure), Dry-Mesic Oak Forest (48% departure), Low Elevation Pine Forest (63% departure), Low Elevation Pine-Oak Heath (57% departure), and Montane Pine-Oak Heath (51% departure) – see Table 10. These five ecological systems are the most fire-dependent systems in GRSM. High Elevation Red Oak, which has a longer fire return interval, remains moderately departed but shows substantial improvement without management. The three more mesic systems that are currently low departure remain in low departure.

Table 10. Forecasted Ecological Departure summary after 20 Years

Ecological System	Acres	Current Ecological Departure	No Action Ecological Departure 20 Yrs
Dry Oak Forest	80,300	66	56
Dry-Mesic Oak Forest	66,000	57	48
Mesic Oak Forest	60,500	32	30
High Elevation Red Oak Forest	22,300	59	44
Low Elevation Pine Forest	17,800	66	63
Low Elevation Pine-Oak Heath	8,800	70	57
Montane Pine-Oak Heath	18,800	64	51
Cove Forest	123,800	30	22
Northern Hardwood Forest	67,800	25	14

Somewhat counter-intuitively, the fire-maintained systems do show some improvement over their current condition without management. Over the 20 years, a modest increase in early succession and open canopy occurs due to varied disturbances (insects, weather, and some fire) in the models, and over time, some early succession moves to mid succession. Departure analysis for each of the five focal systems is summarized in Tables 11-15 below:

Table 11. Forecasted Ecological Departure after 20 Years – Dry Oak Forest

Vegetation Class	NRV Mean	Current %	No Action - 20 Yrs
Early	17%	2%	6%
Mid-Closed	9%	0%	2%
Mid-Open	21%	0%	0%
Late-Closed	24%	90%	80%
Late-Open	29%	8%	12%
Highly Departed Composition	0%	0%	0%
Totals	100%	100%	100%
Total Early/Open			
Total Closed	33%	90%	82%
Ecological Departure		66	56
Open Canopy Departure		57	49

- 2nd largest system
- Modest improvement with No Action – a little more Early & Open
- Still highly Closed canopy after 20 years
- Still large shortfall in Early & Mid succession

Table 12. Forecasted Ecological Departure after 20 Years – Dry-Mesic Oak Forest

Vegetation Class	NRV Mean	Current %	No Action - 20 Yrs
Early	9%	1%	3%
Mid-Closed	9%	7%	5%
Mid-Open	18%	1%	2%
Late-Closed	32%	85%	76%
Late-Open	31%	2%	10%
Highly Departed Composition	0%	4%	4%
Totals	99%	100%	100%
Total Early/Open			
Total Closed	41%	92%	81%
Ecological Departure		57	48
Open Canopy Departure		51	40

- Same overall story as Dry Oak, but slightly better condition
- 4% highly departed vegetation -tulip poplar
- Modest improvement with No Action – more Open canopy
- Still highly Closed canopy after 20 years
- Still large shortfall in Early & Mid succession

Table 13. Forecasted Ecological Departure after 20 Years – Low Elevation Pine Forest

Vegetation Class	NRV Mean	Current %	No Action - 20 Yrs
Early	13%	3%	5%
Mid-Closed	10%	12%	16%
Mid-Open	30%	4%	2%
Late-Closed	12%	72%	66%
Late-Open	35%	5%	8%
Highly Departed Composition	0%	3%	3%
Totals	100%	100%	100%
Total Early/Open			
Total Closed	22%	85%	82%
Ecological Departure		66	63
Open Canopy Departure		63	60

- Highly departed system
- Virtually no improvement with No Action
- Still very Closed canopy
- Large shortfall in Early & Mid succession (but more in Mid classes than other systems)
- 3% highly departed vegetation- white pine

Table 14. Forecasted Ecological Departure after 20 Years – Low Elevation Pine-Oak Heath

Vegetation Class	NRV Mean	Current %	No Action - 20 Yrs
Early	21%	2%	9%
Mid-Closed	13%	0%	7%
Mid-Open	30%	0%	1%
Late-Closed	15%	84%	71%
Late-Open	21%	13%	11%
Highly Departed Composition		1%	1%
Totals	100%	100%	100%
Total Early/Open			
Total Closed	28%	84%	78%
Ecological Departure		70	57
Open Canopy Departure		56	50

- Some improvement with No Action – more Early & Mid succession
- But still large shortfall in Early & Mid
- Still overly Closed canopy
- 1% highly departed vegetation- oak species

Table 15. Forecasted Ecological Departure after 20 Years – Montane Pine-Oak Heath

Vegetation Class	NRV Mean	Current %	No Action - 20 Yrs
Early	25%	6%	10%
Mid-Closed	16%	1%	9%
Mid-Open	25%	1%	1%
Late-Closed	15%	78%	65%
Late-Open	19%	14%	13%
Highly Departed Composition	0%	1%	1%
Totals	100%	100%	99%
Total Early/Open			
Total Closed	31%	79%	74%
Ecological Departure		**64**	**51**
Open Canopy Departure		**48**	**43**

- Similar to LEPOH but slightly less departed
- Some improvement with No Action – more Early & Mid succession
- But still large shortfall in Early & Mid
- Still overly Closed canopy
- 1% highly departed vegetation- oak species

The four other modeled systems in GRSM, which are less fire dependent, also show improvement over their current condition without management. Over 20 years, varied disturbances (e.g., insects, weather, and some fire) and/or natural age succession in the models bring all of these systems closer to their NRV. The departure analysis for the other systems is summarized in Table 16.

Table 16. Forecasted Ecological Departure Summary over 20 Years for Other Modeled Systems

	Mesic Oak Forest			High Elevation Red Oak			Cove Forest			Northern Hardwood		
Vegetation Class	**NRV**	**Current %**	**No Action - 20 Yrs**	**NRV**	**Current %**	**No Action - 20 Yrs**	**NRV**	**Current %**	**No Action - 20 Yrs**	**NRV**	**Current %**	**No Action - 20 Yrs**
Early	6%	1%	2%	14%	1%	5%	4%	1%	4%	6%	2%	5%
Mid-Closed	17%	4%	2%	14%	0%	2%	24%	1%	5%	22%	10%	10%
Mid-Open	14%	1%	3%	12%	0%	0%	4%	0%	0%	1%	1%	1%
Late-Closed	46%	66%	57%	37%	96%	81%	57%	68%	76%	59%	84%	73%
Late-Open	17%	26%	33%	23%	3%	12%	11%	30%	14%	12%	3%	12%
Highly Departed Composition	0%	3%	3%									
Totals	100%	100%	100%	100%	100%	100%	100%	100%	99%	100%	100%	101%
Total Early/Open	37%	28%	38%	49%	4%	17%	19%	31%	18%	19%	6%	18%
Total Closed	63%	69%	59%	51%	96%	83%	81%	69%	81%	81%	94%	83%
Ecological Departure		**32**	**30**		**59**	**44**		**30**	**22**		**25**	**14**
Open Canopy Departure		**6**	**-4**		**45**	**32**		**-12**	**0**		**13**	**2**

40 Year Forecast

Without active management, there is little improvement in ecological departure forecasts over the second 20 years (Table 17). Without management (i.e., prescribed burning), all five fire-dependent ecosystems comprising almost 40% of GRSM will remain substantially departed from NRV after 40 years: Dry Oak Forest (51% departure), Dry-Mesic Oak Forest (45% departure), Low Elevation Pine Forest (64% departure), Low Elevation Pine-Oak Heath (51% departure), and Montane Pine-Oak Heath (45% departure)

Table 17. Forecasted Ecological Departure Summary after 40 Years

Ecological System	Acres	No Action Ecological Departure 20 Yrs	No Action Ecological Departure 40 Yrs
Dry Oak Forest	80,300	56	51
Dry-Mesic Oak Forest	66,000	48	45
Mesic Oak Forest	60,500	30	34
High Elevation Red Oak Forest	22,300	44	40
Low Elevation Pine Forest	17,800	63	64
Low Elevation Pine-Oak Heath	8,800	57	51
Montane Pine-Oak Heath	18,800	51	45
Cove Forest	123,800	22	16
Northern Hardwood Forest	67,800	14	12

Management Scenarios Forecasts

Using ST-Sim, the future condition of the five focal fire-maintained systems (Dry Oak Forest, Dry-Mesic Oak Forest, Low Elevation Pine Forest, Low Elevation Pine-Oak Heath, and Montane Pine-Oak Heath) was simulated after 20 years and 40 years under three different management scenarios to restore ecological condition. The three management scenarios deployed different levels of prescribed fire. The average annual amount of prescribed fire, parkwide, in the scenarios was:

MAXIMUM MANAGEMENT 24,000 acres

CURRENT MANAGEMENT 1,500 acres

PREFERRED MANAGEMENT 5,000 acres

A summary of the outcomes for all scenarios is shown in Appendix 7. Detailed outcomes for all scenarios for the five focal systems are shown in the Excel Model Runs Worksheets in Appendices 7-11.

Maximum Management

Maximum Management is typically run in LCF as a "bookend" scenario to determine how much ecological improvement is possible, regardless of cost or feasibility. At GRSM, Maximum Management restores the five oak and pine systems to low ecological departure (Table 18). After just 20 years, the large amount of prescribed fire in the Maximum Management simulations, which approximates the natural fire regime for these systems, serves to open up the canopy and create early succession and mid succession classes that are much closer to NRV.

Table 18. Forecasted Ecological Departure with Maximum Management as Compared to No Action – 20 & 40 Years

Ecological System	Acres	No Action Ecological Departure 20 Yrs	No Action Ecological Departure 40 Yrs	Max Mgmt Ecological Departure 20 Yrs	Max Mgmt Ecological Departure 40 Yrs
Dry Oak Forest	80,300	56	51	28	20
Dry-Mesic Oak Forest	66,000	48	45	32	21
Low Elevation Pine Forest	17,800	63	64	28	26
Low Elevation Pine-Oak Heath	8,800	57	51	34	21
Montane Pine-Oak Heath	18,800	51	45	32	17

Current Management

Current Management levels of prescribed fire (1,500 acres/year average parkwide) achieve modest improvement in ecological departure scores after 20 and 40 years, as compared to the No Action scenario (Table 19). After 40 years, the current level of prescribed fire achieves the greatest improvement in Low Elevation Pine Forest and Low Elevation Pine-Oak Heath as compared to No Action. Departure scores for all systems, except for Low Elevation Pine, fall below 50% after 40 years under current management.

It should be noted that ecological departure scores for GRSM are based fundamentally on forest structure; current levels of prescribed fire are expected to improve vegetation composition for the managed systems, but this improvement is not accounted for in GRSM's ecological departure scores.

Table 19. Forecasted Ecological Departure with Current Management as Compared to No Action – 20 & 40 Years

Ecological System	Acres	No Action Ecological Departure 20 Yrs	No Action Ecological Departure 40 Yrs	Current Mgmt (1500 Ac/Yr) Ecological Departure 20 Yrs	Current Mgmt Restore & Maintain (1500 Ac/Yr) 40 Yrs
Dry Oak Forest	80,300	56	51	54	48
Dry-Mesic Oak Forest	66,000	48	45	47	43
Low Elevation Pine Forest	17,800	63	64	60	58
Low Elevation Pine-Oak Heath	8,800	57	51	52	43
Montane Pine-Oak Heath	18,800	51	45	50	42

Preferred Management

The Preferred Management levels of prescribed fire (5,000 acres/year average parkwide) achieve continued, meaningful improvement in ecological departure for all five systems over 20 and 40 years (Table 20). As with the Current Management scenario, the greatest 40-year improvements as compared to No Action occur in in Low Elevation Pine Forest and Low Elevation Pine-Oak Heath (which actually falls into the low departure category after 40 years).

Table 20. Forecasted Ecological Departure with Preferred Management as Compared to No Action – 20 & 40 Years

Ecological System	Acres	No Action Ecological Departure 20 Yrs	No Action Ecological Departure 40 Yrs	Preferred Mgmt (5000 Ac/Yr) Ecological Departure 20 Yrs	Preferred Restore & Maintain (5000 Ac/Yr) Ecological Departure 40 Yrs
Dry Oak Forest	80,300	56	51	50	42
Dry-Mesic Oak Forest	66,000	48	45	45	38
Low Elevation Pine Forest	17,800	63	64	52	49
Low Elevation Pine-Oak Heath	8,800	57	51	43	29
Montane Pine-Oak Heath	18,800	51	45	46	36

Allocation of Fire in Management Scenarios

The management models assigned the amount of prescribed fire to each system based largely upon the ratio of prescribed fire among GRSM's ecological systems during actual controlled burns. The relative amount of modeled prescribed fire the management models matched up closely with the relative amount of modeled natural fire in the reference models

(Table 21). For example, Montane Pine-Oak Heath accounts for approximately 4% of the vegetated acres in GRSM but 8% of the total natural fire in the reference model simulations. Accordingly, it has an approximately 2 to 1 ratio of fire to system acres. The amount of prescribed fire in the management models almost exactly replicated this 2 to 1 ratio. The comparative ratios were very close for four of the five focal systems, with the only exception being Low Elevation Pine-Oak Heath. Low Elevation Pine-Oak Heath received the highest comparative ratio of prescribed fire in the management models, comprising about twice as much relative fire as the other four systems. Therefore, not surprisingly, as reported in the previous section, this system had the lowest of all departure scores (29) after 40 years.

Table 21. Percentages of Fire as Compared to Park Acres in Reference Models and Management Models for Focal Systems

Natural Fire in Reference Model Simulations

Ecological System	% ot Total Acres	% ot Total Fire	Ratio
Dry Oak	15%	38%	2.4
Dry-Mesic Oak	12%	16%	1.4
Low Elevation Pine	3%	11%	3.4
Low Elev Pine-Oak Heath	2%	5%	3.0
Montane Pine-Oak Heath	4%	8%	2.1

Prescribed Fire in Management Models

Ecological System	% of Park Acres	% of Rx Fire	Ratio
Dry Oak Forest	16%	30%	1.9
Dry Mesic Oak Forest	13%	15%	1.2
Low Elevation Pine	3%	12%	3.5
Low Elev Pine-Oak Heath	2%	10%	5.9
Montane Pine-Oak Heath	4%	8%	2.2

Alternative Levels of Fire Exclusion

The effect of reducing the degree of fire suppression/exclusion in GRSM was also tested using ST-Sim. Just as adding prescribed fire improves ecological departure, reducing fire suppression/ exclusion in GRSM would also improve ecological departure – recognizing, however, the many challenges, risks and difficulties of implementing this strategy, especially in the light of the recent deadly wildfires in and around GRSM. Current fire management practice allows approximately 7.5% of "natural" wildfire to occur (i.e., 92.5% suppression) ; increasing this level to 15% (i.e., 85% suppression) would improve average ecological departure scores for the five focal systems by an average of 4 points over 40 years (Table 22).

Table 22. Ecological Departure Scores with Alternative Level of Fire Suppression/Exclusion – No Action Scenario - 40 Years

Ecological Departure with Alternative Fire Suppression Levels				
"No Action" Scenarios				
Year	40			
		Fire Suppression		
Row Labels	**77.5%**	**85.0%**	**92.5%**	
DryMesicOak	39	41	45	
DryOak	43	46	51	
LowElevationPine	55	59	64	
LowElevPineOakHeath	43	48	52	
MontanePineOakHeath	38	42	45	

Management Budgets & Return-on-Investment

The final step in the LCF process was calculating the cost of proposed management actions and the benefits (magnitude of ecological improvement) as compared to costs of management. Two return-on-investment (ROI) metrics were used to determine which of the systems received the greatest ecological benefits per dollar invested.

Budgets

The *average* cost of implementing prescribed fire was estimated at $50 per acre by GRSM's fire management staff. Actual cost on the ground for a given prescribed burn will vary depending upon many circumstances, but it was felt that $50 per acre represented a reasonable average cost. These costs do *not* include the regularly scheduled time of Park staff.

Based upon the current level of prescribed burning (1,500 acres/year), the average annual cost is $75,000 per year. The proposed level of burning to achieve the desired ecological outcomes (5,000 acres/year) would cost approximately $250,000 per year. These are *average* estimated costs; actual costs will vary depending upon actual acres burned in a given year, as well as other variables.

Return-on-Investment

Two ROI metrics were used to determine which of the five focal systems received the greatest ecological benefits per dollar invested, independent of their size (absolute) and reflecting their varying acreage (systemwide). Overall, there were not dramatic differences in the results among the five focal systems that might influence management decisions.

The "absolute" return on investment (Table 23) was highest for the Low Elevation Pine-Oak Heath (8.8), followed by Low Elevation Pine (5.0) and Montane Pine-Oak Heath (4.5), as compared to the two larger oak systems. This is not a surprising outcome, as the three high ROI systems are all small in size and cost less to burn to achieve the desired results.

On the other hand the "systemwide" ROI, which takes the relative sizes of the systems into account, showed roughly equivalent results across all five ecological systems. With this metric the two larger oak systems actually achieved the highest scores.

Table 23. Absolute and Systemwide Return-on-Investment over 40 Years (ROI calculations are multiplied by constants)

	Total Acres	RxFire Acres / Year	Ecological Improvement vs No Action	Annual Cost	Absoute ROI 40 Years	Systemwide ROI 40 Years
Dry Oak	80,300	1,500	9	$ 75,000	1.2	2.4
Dry-Mesic Oak	66,000	750	7	$ 37,500	1.9	3.1
Low Elevation Pine	17,800	600	15	$ 30,000	5.0	2.2
Low Elevation Pine-Oak Heath	8,800	500	22	$ 25,000	8.8	1.9
Montane Pine-Oak Heath	18,800	400	9	$ 20,000	4.5	2.1

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Appendix 1. "Rules" for Vegetation Mapping at Great Smoky Mountains National Park.

Ecological System 'RULES' ***2nd Approximation Hybrid Ecological System Model***

GRSM Ecological Systems - - Ecological Zone	***Landfire Ecological System***	***"DOMINANT VE" Classes Reference Condition (original grouping unless indicated)***	***Approx. extent [1/] acres***	***Hybrid Model Comments***	***"DOMINANT VE" Classes Current Condition[2/]***
Southern Appalachian Low Elevation Pine-Oak Forest - - Shortleaf Pine-Oak	Southern Appalachian Low Elevation Pine Forest	PI, PIp, PIr, PIv, PI-OzH, PI/OmH, PI/OzH, PIp-OzH, PIp/OzH, PIv-OzH, PIv/OzH -- **Oak/Pine and Oak-Pine that intersect with Miller YPH?** OzH/PI, OzH-PI, OzH/PIp, OzH/PIv, OzH/PIr	*17,850 total*	all classes included < 2300' RULE -- all classes included < 2300' RULE includes ≈ 15 acres from reference plot analysis	PI, PIp, PIr, PIv, PI-OzH, PI/OmH, PI/OzH, PIp-OzH, PIp/OzH, PIv-OzH, PIv/OzH
Original Comments: This system contains much greater amounts of PINRIG than PINECH. Not sure PINECH types can be separated out, but would like to do that.					
Montane Pine-Oak-Heath - - Pine-Oak Heath	Southern Appalachian Montane Pine Forest and Woodland	Same as Low-Elev Pine RULE = > 2300'	*18,775 total*	includes ≈ 265 acres from reference plot analysis	Same as Low-Elev Pine
Low Elevation Pine-Oak Heath - - Pine-Oak Heath	not defined	Same as Low-Elev Pine	*8,775 total*	Same as Low-Elev Pine **and** Ecological Zone = Pine-Oak Heath includes ≈ 100 acres from reference plot analysis	Same as Low-Elev Pine
Low Elevation Dry to Xeric Oak - - Dry Oak	Southern Appalachian Oak Forest	OzH, OzHf, OzHfA < 2300' -- Och < 2300' -- OzH-PIs, OzH/PIs, OzHF/PIs **(that does not intersect with Miller WPH)** < 2300' -- **Oak/Pine and Oak-Pine that do not intersect with Miller YPH?** < 2300' OzH-PI, OzH/PIp, OzH/PIv, OzH/PIr, OzH/PI --	*79,144 total*	all units included regardless of Elevation Rule -- moved to Dry-Mesic Oak regardless of Elev. Rule -- all classes included < 2300' per RULE -- all classes included < 2300' per RULE -- PIs/OzH added (Rob-March 2016), was described as 'uncharacteristic' originally. At Feb 22nd mtg. it was decided that White Pine is not 'uncharacteristic' in oak types	OzH, OzHf, OzH/PI, OzH-PI, OcH, OzHfA, OzH/PIp, OzH/PIv, OzH/PIr
Original Comments: For all oak types that would have had chestnut as a dominant/codominant, we have decided to pretend chestnut never existed. This because is it functionally gone and has no known chance of returning at any appreciable scale.					

GRSM Ecological Systems - - Ecological Zone	***Landfire Ecological System***	***"DOMINANT VE" Classes Reference Condition (original grouping unless indicated)***	***Approx. extent acres***	***Hybrid Model Comments***	***"DOMINANT VE" Classes Current Condition***
Dry-Mesic Oak-Hickory - - Dry-Mesic Oak	Southern Appalachian Oak Forest	OmHA, OmHA-PI, OmHA/PI, OmHA/PIs **(That does not intersect with Miller WPH)** OmHA/T ---------- OmH ---------- **Should this group be its own Mixed Hardwood system?** HxA, HxBl, HxBl/R, HxAz, HxA/T ----------	*60,233 total* 15,283	 split from Dry-Mesic to Mesic Oak Hickory original group ---------- split by elevation (< 2300' to Dry-Mesic Oak) ---------- HxBI moved to CoveForest HxA, HxBI/R, HxAz, HxA/T: moved to 'use Ecological Zones to define' ---------- Och added (Rob-March 2016, all elevations) ---------- includes ≈ 130 acres from reference plot analysis	OmH, OmHA, OmHr, OmHR, OmHp/R, OmHL, OmH/T, OmHA/T, OmHA/PI, OmHA-PI
Mesic Oak-Hickory - - Montane Oak Cove&Slope	Montane Red Oak-Chestnut Oak	OmHr, OmHR, OmHL, OmH/T, OmHr/PIs OmH	*60,431 total* 20,996	 split by elevation (> 2300' to Mesic Oak) includes ≈ 87 acres from reference plot analysis	
Original comments: This one is tough! Should probably be divided according to landform. OmHA and associated variants have a different disturbance ecology than many of the "Om" types, but may not rise to the same regime as "Oz" types.					
Montane Oak - - High Elev. Red Oak		MOz/K, MOa/K ---------- MOz, MOa, MOr/Sb, MOr, MOr/R-K, MOr/G, MOr/K, MOr/R, MOr/T ---------- **At elevations > 2300'**: OzH, OzHf, OzHfA ---------- Och		not in GIS, but listed in Draft Report (May 2004) ---------- all classes included as the 'core' ---------- moved to Dry Oak (Rob-March 2016) ---------- moved to Dry-Mesic Oak (Rob-March 2016) ---------- includes ≈ 247 acres from reference plot analysis	MOz, MOz/K, MOa, MOa/K, MOr/Sb, MOr, MOr/R-K, MOr/G, MOr/K, MOr/R, MOr/T **At elevations > 2300':** OzH, OzHf, OzH/PI, OzH-PI,OcH, OzHfA, OzH/PIp, OzH/PIv, OzH/PIr
Original comments: Treatment of elevations based on higher frequency of fire at lower elevations.					
Southern Appalachian Spruce-Fir - - Spruce-Fir	Central & Southern Appalachian Spruce-Forests	Fir & Spruce-Fir = (F), (F)S, F, F/S, S(F), S-F, S-F/Sb, S/F, S/R, S/Sb: Spruce =S, S-NHx, S-NHxB, S-R, S-T, S-TR, S/NHx, S/NHxA, S/NHxB, S/T	*40,490 total*	added to original grouping: NHxS, NHxB/S, NHxE, T/S ---------- includes ≈ 13 acres from reference plot analysis	S/NHxB, S, S/NHx, S/T, S/R, S/F, S(F), F, S-NHxB, S/HNxA, S-T, S/Sb, F/S, S-F, S-F/Sb , S-NHx, (F), (F)S, S-R
Original comments: Park interest in capturing change in areal extent of Spruce and Spruce-Fir. Hypothesize that area is less today than in the ref. condition (Beyond just loss from BWA). Don't know how best to capture this spatially? Are changes due to BWA best captured by canopy ht. changes, or should we look for a better way to deal with this loss? The veg map uses (F) for former fir sites.					

GRSM Ecological Systems – Ecological Zone	***Landfire Ecological System***	***"DOMINANT VE" Classes Reference Condition (original grouping unless indicated)***	***Approx. extent acres***	***Hybrid Model Comments***	***"DOMINANT VE" Classes Current Condition***
Hemlock and Hemlock/White Pine Forest - - None	None	T/HxA, T/OmH, T/OmHA, OmHA-T, T/PIs, PIs-T, PIs/T, T/CHxA, T/HxL, T/CHx, T/CHxR, T/MAL, T, T/R, T/K ---------- MAL-T, MALc-T ---------- T/NHxA, T/NHx, T/NHxB, NHxA-T, T/NHxR, NHxR-T ---------- T/S ---------- HxA-T	*0 total*	 moved to Cove Forest ---------- moved to Alluvial Forest ---------- moved to Hemlock-Northern Hardwood ---------- moved to Spruce-Fir ---------- moved to 'use Ecological Zones to define'	T, T/R, T/CHxA, T/CHx, T/NHxA, T/HxA, T/PIs, PIs-T, MAL-T, NHxR-T, NHxA-T, HxA-T, T/NHx, T/OmH, PIs/T, T/OmHA, T/S, T/NHxR, T/NHxB, T/K , OmHA-T, MALc-T, T/HxBI, T/CHxR, T/HxL, T/MAL
Original comments: Significant Hemlock also exists in Acid Cove, Acidic NH, and Spruce. How to deal with loss of hemlock? "Treated" Hemlock is a Vegetation Management geodatabase.					

White Pine - Oak	None	PIs/OzH --- <u>OmHA/PIs -----------------------------------</u> PIs, PIs/OmHA, PIs/OzHf, PIs/OmH, OzH-PIs, OzHf/PIs, OzH/PIs	*0* *total*	moved to Dry Oak (Rob-March 2016) -- <u>All in DMoak because none = Miller WPH</u> moved to 'use Ecological Zones to define' **Note Original Rules for classes:** WP-Oak, = intersects with Miller WPH (2,700 acres) Uncharacteristic = not Miller as above (6,156 acres)	PIs, PIs/OzH, OzH-PIs, OzHf/PIs, OzH/PIs, OmHA/PIs, OmHr/PIs, PIs/OmHA, PIs/OzHf, PIs/OmH **(that intersects with Miller WPH)**
Cove Forests - - Rich Cove <u>Cove</u> Acidic <u>Cove</u> Oak/ Rhodo Rich & Acidic Cove	Southern and Central Appalachian Cove Forest	CHx, CHxR, CHxL, CHxO, CHxR/T, CHxR-T, HxF, HxF/T CHxA, CHxA-T, CHx-T, CHx/T, CHxA/T, CHxL/T, HxL, Hx, HxL/T, HxL-T -- not in original grouping --	*128,859* *total*	all classes included all **but** highlighted classes included -- added to the original group: HxBI T/HxA, T/OmH, T/OmHA, OmHA-T, T/PIs, PIs-T, PIs/T, T/CHxA, T/HxL, T/CHx, T/CHxR, T/MAL, T/HxF (T & T/R & T/K) may include Northern Hardwood - Hemlock on S-facing slopes at higher elevations. -- OmHp/R -- HxL, Hx, HxL-T, HxL/T = use Ecological Zones -- includes ≈ 254 acres from reference plot analysis	CHx, CHxR, CHxL, CHxO, CHxR/T, CHxR-T, CHxA, CHxA-T, CHx-T, CHx/T, CHxA/T, CHxL/T
Original Comments: Could inform the best placement of HxL (successional LIRTUL) with Miller or Simon model? Is there a way to capture the loss of hemlock in Acid Cove? For example, the veg map distinguishes acid cove with hemlock (CHxA-T, CHx-T). Could we simply call these types "uncharacteristic" in the current veg? (unless they are in a "treated" polygon).					
GRSM Ecological Systems - - Ecological Zone	***Landfire Ecological System***	***"DOMINANT VE" Classes Reference Condition (original grouping unless indicated)***	***Approx. extent acres***	***Hybrid Model Comments***	***"DOMINANT VE" Classes Current Condition***
Northern Hardwood - - Northern Hardwood Slope and Cove	Appalachian Northern Hardwood	<u>Nothern Hardwood</u>: NHx, NHxR, NHxB, NHxY, NHxR/T, NHxB/S, NHxBe, NHxE, NHxY-T -- <u>Hemlock Northern Hardwood</u>: NHx-T, NHx/T, NHxB/T, T/NHxAz --- <u>Beech Gaps</u>: NHxBe, NHxBe/Hb, NHxBE/G --- -- NHxA, NHxA/T, NHxBl/R, NHxAz, NHxAz/T	*67,329* *total*	all classes included --- all classes included --- Beech Gaps lumped with Northern Hardwood --- added to the original group: Hemlock-Northern Hardwood = T/NHxA, T/NHx, T/NHxB, NHxB-T, NHxA-T, T/NHxR, NHxR-T moved out of this System: approx. 250 acres in 13 polygons based upon Ecological Zone ref. plots -- defined by Ecological Zones	NHx, NHxR, NHxB, NHx-T, NHxY, NHxA/T, NHx/T, NHxBl/R, NHxR/T, NHxB/S, NHxAz, NHxBe, NHxB/T, NHxE NHxA (acidic)
Original Comments: Ditto the comment on hemlock loss in Acid Cove.					
Montane Alluvial Forest - - Alluvial Forest	Central Interior and Appalachian Riparian and Floodplain	MAL, MALc, MALt, MALj, MAL/T, HxJ	*7,850* *total*	added to the original group: MAL-T, MALc-T includes ≈ 3 acres from reference plot analysis	MAL, MALc, MALt, MALj, MAL/T
Balds		Hth		not included in LCF	Hth
Beech Gaps?				lumped with Northern Hardwood	

GRSM Ecological Systems - - Ecological Zone	*Landfire Ecological System*	*"DOMINANT VE" Classes Reference Condition (original grouping unless indicated)*	*Approx. extent acres*	*Hybrid Model Comments: Description of DOMINANTVE Classes*	*"DOMINANT VE" Classes Current Condition*
			52,260 total 10.1 % of LCF area		use the original Rules or new Rules
Use Ecological Zones to define: Variable Systems	Variable	Hx, HxL, HxL/T, HxL-T	19,710	Southern App. Early Successional Hardwoods	
		HxA-T, HxA, HxBl/R, HxAz, HxA/T, NHxA, NHxA/T, NHxBl/R	23,355	Southern App. Mixed Hardwood Forest, Acidic	
		NHxAz , NHxAz/T	885	High Elevation Xeric Woodlands	
		PIs, PIs/OzHf	7,027	Eastern White Pine and Mixed Eastern White Pine - Dry Oak	
		PIs/OmHA, PIs/OmH	548	Eastern White Pine Mesic Oak Forest	
		OzH-PIs[1/], OzHf/PIs, OzH/PIs [1/] not listed in 2004 Report but is a GIS mapunit	735	Chestnut Oak/Hardwoods with White Pine	
Uncharacteristic **ORIGINAL GROUPING**				Mixed Hardwoods (Hx) should maybe not be considered uncharacteristic? Though some of these sites may have been logged or dominated by chestnut, this does seem to be a distinct veg type?	PIs,PIs/OzH, OzH-PIs, OzHf/PIs, OzH/PIs, OmHA/PIs, OmHr/PIs, PIs/OmHA, PIs/OzHf PIs/OmH **(that does not intersect with Miller WPH)** HxL, HxL/T, HxL-T, Hx, HxF, HxF/T **(successional LIRTUL)** HxA, HxBl, HxBl/R, HxAz, HxA/T? **(former Chestnut forest?)** HxJ **(old homesites along streams - former Montane Alluvial?)** **"Untreated"** T, T/R, T/CHxA, T/CHx, T/NHxA, T/HxA, T/PIs, PIs-T, MAL-T, NHxR-T, NHxA-T, HxA-T, T/NHx, T/OmH, PIs/T, T/OmHA, T/S,

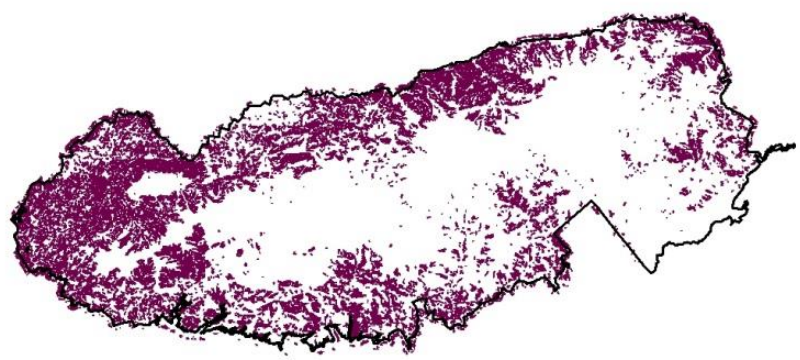
Appendix 2. Description of fire-maintained ecological systems in Great Smoky Mountains National Park.

Dry Oak Woodland

Dominant Species (Reference Condition): *Quercus montana, Q. coccinea, Q. velutina, Q. falcata, Carya glabra*

Dominant Species (Current Condition): *Quercus montana, Q. coccinea, Acer rubrum, Pinus strobus*

LCF Mapping Rules (Reference Condition): All occurrences of included vegetation map codes; all occurrences of veg map codes with codominant white pine; all occurrences of veg map codes with codominant yellow pine ***if*** they do not intersect with Miller "YPH"



Dry Oak Woodland

NVCS Classes and GRSM Veg Map Codes:

- 56% is 6271 – Chestnut oak forest (xeric ridge type); veg map codes OzH
- 36% is 7267 – Appalachian montane oak-hickory forest (Chestnut oak type); veg map code OzHf
- 3% is 7230 – Appalachian montane oak-hickory forest (Typic acidic type); veg map code OzHfA
- 3% is 7519 – Appalachian white pine – xeric oak forest; veg map codes PIs/OzHf, PIs-OzHf
- Concept also includes 7691 – Appalachian oak-hickory forest (low elevation xeric type)
    - ❖ 7691 was apparently not included in the 2004 veg map; not sure why, but this association would have probably been 10-20% of the Dry Oak type parkwide, with a distribution related to that of shortleaf pine. It is prominent in the Community Classification document.

S-Class Comparison:

- Landfire BPS 5713150 Southern Appalachian Oak Forest
  - Early 5%
  - Mid closed 25%
  - Mid open 35%
  - Late open 26%
  - Late closed 9%

- GRSM LCF Model - Reference Conditions:
  - Early 17%
  - Mid closed 9%
  - Mid open 21%
  - Late open 29%
  - Late closed 24%

- GRSM LCF Model - Current:
  - Early 2%
  - Mid closed 0%
  - Mid open 0%
  - Late open 8%
  - Late closed 90%

Physical Description (Geology, Soils, Topography):

Geology – Metasedimentary and sedimentary rocks of the Great Smoky, Snowbird, Walden Creek, and Chilhowee Groups

Mountains: Metasedimentary geology - Metasandstone, metasiltstone, metagraywacke, metaconglomerate, phyllite, slate, shale

Western Foothills (Beard Cane to Chilhowee): "diverse" Sedimentary/metasedimentary geology: sandstone, shale, slate, siltstone, quartzite (which is metamorphic), isolated dolomite

Soils - Dystrudepts of the Ditney-Unicoi and Soco-Stecoah series; Hapludults of the Junaluska-Tsali series. These soils are generally nutrient-poor, well-drained, rocky, and strongly acidic.

Topography – Ridgetops and convex middle to upper slopes. Slopes have primarily south and west aspects. Elevations range from 900' to 4000', though this is primarily a low elevation type. Most occurrences are below 3000'.

Vegetation Description:

Vegetation ranges from oak and oak-pine woodlands with shrub layers dominated by ericaceous species to stands with more open understories dominated by a diverse set of dry-site herbs and grasses. Chestnut oak and scarlet oak are the characteristic trees, with black oak, white oak, and southern red oak co-occurring or becoming dominant on lower elevation sites. Blackjack oak and post oak are infrequent and localized, but are strong indicators of low-elevation dry oak woodlands. Other associated tree species include shortleaf pine, Virginia pine, pitch pine, pignut hickory, red maple, and black gum. Under current conditions, red maple, black gum, and white pine may have high densities in all size classes except the largest tree classes.

Typical understory trees include sourwood, dogwood, sassafras, and black locust. The density of the shrub layer can be highly variable. Under reference conditions, shrubs have moderate to sparse cover, but shrubs like mountain laurel and bear huckleberry could become well-established and dense in stands where the fire-return interval exceeds the historical average. High cover of these shrubs is very common in contemporary, unburned stands. *Vaccinium pallidum, V. stamineum, V. arboreum*, and *V. hirsutum* are other common shrubs and are good indicators of low-elevation dry oak forests.

The herb layer is also variable, ranging from sparse-to-moderate coverage by waxy-leaved evergreen subshrubs like *Gaultheria procumbens, Epigaea repens*, and *Galax urceolata* to high coverage by a diverse set of herbs and grasses that includes *Schizachyrium scoparium, Danthonia sericea, Piptochaetium avenaceum, Dichanthelium commutatum, Eurybia surculosa, Coreopsis major*, *Sericocarpus asteroides*, and *Baptisia tinctoria*. The vine species *Smilax rotundifolia* and *Smilax glauca* are also common.

Fire Regime:

Comparison with Landfire:

LCF	**Landfire (BPS 5713150)**
Surface fire – 17 year MFI	Surface Fire – 16 year
Mixed Fire – 73 year MFI	Mixed Fire – 139 year
Replacement – 136 years MFI	Replacement – 602 year

Description:

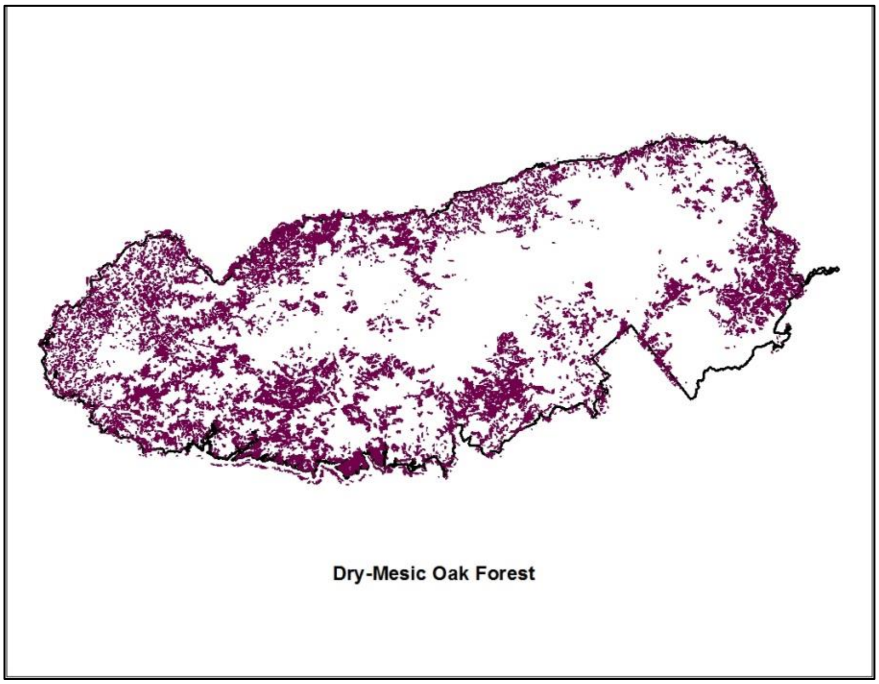
Frequent, low severity fires are the norm, with mean fire-free intervals (MFI) of 12-18 years, on average. This system is included in Landfire Fire Regime Group 1. Fires can occur virtually any time of year, but most commonly occur during the dormant season, between November and May. Fires in the winter months of December and January are rare. Mixed severity fires, where fires top-kill 25-75% of the dominant vegetation (Landfire definition), are much less common, occurring every 50-100 years. Replacement fires (>75% top-kill) are rare events that occur every 100-200 years in an average stand. Both mixed severity and replacement fires are most likely to occur during the growing season and they are typically associated with extreme droughts. High severity fires may also be associated with extreme wind events during any time of year.

Dry Mesic Oak Forest

Dominant Species (Reference Condition): *Quercus alba, Q. montana, Castanea dentata, Q. rubra, Carya glabra*

Dominant Species (Current Condition): *Quercus alba, Q. montana, Q. rubra, Carya glabra, Acer rubrum, Carya alba, Pinus strobus, Liriodendron tulipifera*

LCF Mapping Rules (Reference Conditions): All occurrences of included vegetation map codes, except for OmH, for which occurrences below 2300' elevation were mapped as Dry-Mesic Oak (above 2300' were mapped as mesic oak).



Dry-Mesic Oak Forest

NVCS Classes and GRSM Veg Map Codes:

- 47% is 7230 – Appalachian montane oak-hickory forest (Typic acidic type); veg map code OmHA
- 23% is 6192 – Appalachian montane oak-hickory forest (Red Oak Type); veg map code OmH < 2300'
- 14% is 7267/7230 – Appalachian montane oak-hickory forest (Typic acidic type); veg map code OcH. Appalachian montane oak-hickory forest (Chestnut oak type) ; veg map code OcH
- 8% is 6286 – Chestnut Oak Forest (Mesic Slope Heath Type); veg map code OmHp/R
- 4% is 7219 - Early Successional Appalachian Hardwood Forest; veg map code HxL
- Trace of 7100, 7944, 7519, 8558, 6271, 7517

S-Class Comparison:

- Landfire BPS 5713150 Southern Appalachian Oak Forest
  - Early 5%
  - Mid closed 25%
  - Mid open 35%
  - Late open 26%
  - Late closed 9%

- GRSM LCF Model - Reference Conditions:
  - Early 9%
  - Mid closed 9%
  - Mid open 18%
  - Late open 31%
  - Late closed 32%

- GRSM LCF Model - Current:
  - Early 1%
  - Mid closed 7%
  - Mid open 1%
  - Late open 2%
  - Late closed 85%

Physical Description (Geology, Soils, Topography):

Geology – Metasedimentary and sedimentary rocks of the Great Smoky, Snowbird, Walden Creek, and Chilhowee Groups

> Mountains: Metasedimentary geology - Metasandstone, metasiltstone, metagraywacke, metaconglomerate, phyllite, slate, shale
>
> Western Foothills (Beard Cane to Chilhowee): "diverse" Sedimentary/metasedimentary geology: sandstone, shale, slate, siltstone, quartzite (which is metamorphic), isolated dolomite

Soils - Dystrudepts of the Soco-Stecoah and Ditney-Unicoi series; Hapludults of the Junaluska-Tsali series. These soils are good to nutrient-poor, well-drained, rocky, and strongly acidic.

Topography – Protected ridgetops and saddles. South and west-facing low slopes and concave slopes. Upper north and east-facing slopes. Elevations range from 1200' to 4500'.

Vegetation Description:

Vegetation ranges from open oak-hickory forests to oak woodlands. The shrub layer can moderately dense and dominated by a single ericaceous species, but is most often sparse to moderate with several deciduous species and no clear dominant. White oak and chestnut oak are the characteristic species, though they often occur separately with other species such as northern red oak, black oak, mockernut hickory, and pignut hickory. White pine, red maple or tulip poplar may be much more important in current forests than they were in reference-condition forests. American chestnut was likely very important in reference-condition forests, though it is relegated to the shrub layer in current forests.

Typical understory trees include sourwood, dogwood, Fraser magnolia, and black gum. White pine and (now dead) hemlock saplings may occur at high densities. The density and composition of the shrub layer can be highly variable. Under reference conditions in typical sites, a wide variety of shrubs (including *Acer pensylvanicum, Rhododendron calendulaceum, Castanea dentata, and Pyrularia pubera*) can occur at moderate to sparse cover, but shrubs like great rhododendron or bear huckleberry can become well-established and dense in stands where the fire-return interval exceeds the historical average.

The herb layer can range from sparse with species such as *Galax urceolata, Chimaphila maculata, and Goodyera pubescens* to high coverage by a diverse set of herbs and ferns that includes *Amphicarpa bracteata, Desmodium nudiflorum, Polystichum acrosticoides, Maianthemum racemosum, Eurybia divaricata, Dennstaedtia punctilobula, and Dichanthelium spp.*

Fire Regime:

Comparison with Landfire:

LCF	**Landfire (BPS 5713150)**
Surface fire – 28 year MFI	Surface Fire – 16 year
Mixed Fire – 127 year MFI	Mixed Fire – 139 year
Replacement – 224 years MFI	Replacement – 602 year

Description:

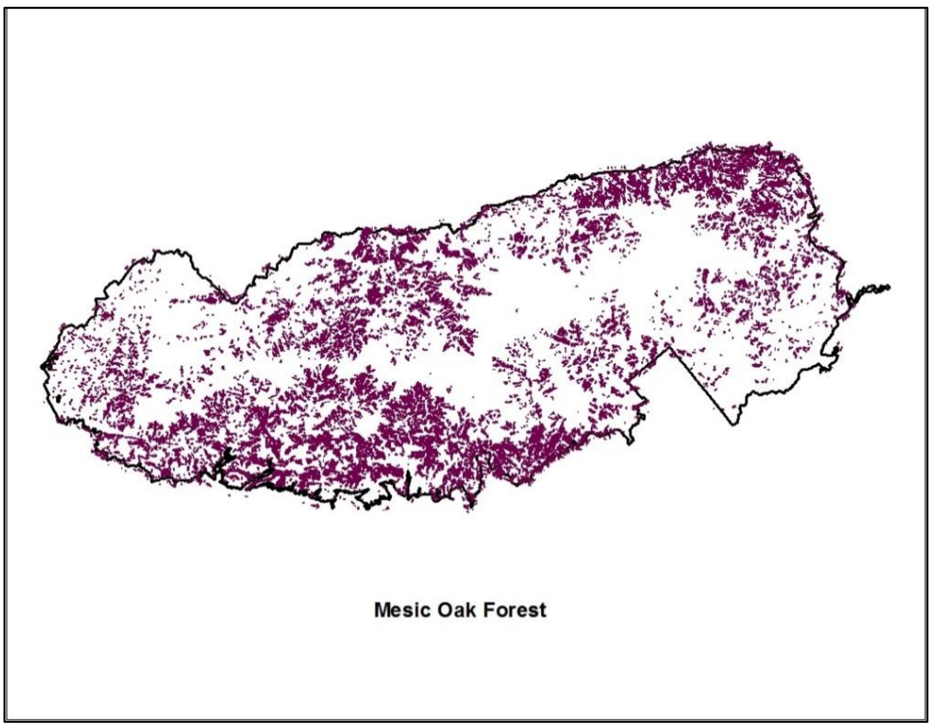
In the Dry-Mesic Oak system, low severity fires are the norm. Mean fire-free intervals (MFI) for surface fires can be long (20-32 years), but are still classified as Fire Regime Group 1 by Landfire. Surface fires occur more frequently in the open s-classes and less frequently in the closed s-classes due to subtle differences in fuel composition, site exposure, and hence fuel moisture/availability. These fires can occur virtually any time of year, but most commonly occur during the dormant season, between November and May. Fires in the winter months of December and January are rare. Mixed severity fires, where fires top-kill 25-75% of the dominant vegetation (Landfire definition), are much less common, occurring every 100-200 years. Replacement fires (>75% top-kill) are rare events that may occur every 200-400 years in an average stand. Both mixed severity and replacement fires are most likely to occur during the growing season and they are typically associated with extreme droughts. High severity fires may also be associated with extreme wind events during any time of year.

Mesic Oak Forest

Dominant Species (Reference Condition): *Quercus rubra, Q. alba, Catanea dentata, Carya alba, Acer rubrum, Liriodendron tulipifera, Q. montana*

Dominant Species (Current Condition): *Quercus rubra, Q. alba, Acer rubrum, Carya alba, Liriodendron tulipifera, Q. montana*

LCF Mapping Rules: All occurrences of OmH above 2300' elevation. All occurrences of OmHr, OmHL, OmH/T, or OmH/PIs. All current occurrences of HxA and NxA were included in this concept because these areas were historically believed to be dominated by Chestnut or oak that failed to regenerate following logging or fire.



NVCS Classes and GRSM Veg Map Codes:

- 75% is 6192 – Appalachian montane oak-hickory forest (Red Oak Type); veg map codes OmH > 2300', OmHr, OmHL, OmH/T, OmH/PIs
- 11% is 7692 – Appalachian montane oak-hickory forest (Rich Type); veg map code OmHr
- 10% is 8558 – Southern Appalachian Mixed Hardwood Forest; veg map code HxA, NxA
- 3% is 7219 – Early Successional Appalachian Hardwood Forest; veg map code HxL
- Trace of 7100, 7944, 7519, 6271, 7517, 7267

S-Class Comparison:

- Landfire BPS 5713150 Southern Appalachian Oak Forest
    - Early 5%
    - Mid closed 25%
    - Mid open 35%
    - Late open 26%
    - Late closed 9%

- GRSM LCF Model - Reference Conditions:
    - Early 6%
    - Mid closed 17%
    - Mid open 14%
    - Late open 17%
    - Late closed 46%

- GRSM LCF Model - Current:
    - Early 1%
    - Mid closed 4%
    - Mid open 1%
    - Late open 26%
    - Late closed 66%

Physical Description (Geology, Soils, Topography):

Geology – Metasedimentary and sedimentary rocks of the Great Smoky, Snowbird, Walden Creek, and Chilhowee Groups

> Mountains: Metasedimentary geology - Metasandstone, metasiltstone, metagraywacke, metaconglomerate, phyllite, slate, shale
>
> Western Foothills (Beard Cane to Chilhowee): "diverse" Sedimentary/metasedimentary geology: sandstone, shale, slate, siltstone, quartzite (which is metamorphic), isolated dolomite

Soils - Primarily Dystrudepts of the Soco-Stecoah and Ditney-Unicoi series; some occurrence on Hapludults of the Junaluska-Tsali series. These soils are good to nutrient-poor, well-drained, rocky, and circumneutral to strongly acidic.

Topography – Typically on protected slopes with northern, eastern, southeastern aspect. Some occurrences have been documented on western slopes. Typical elevations range from 2000' to 4500', though small examples of this system can occur at elevations down to 1000' in GRSM's western end.

Vegetation Description:

Vegetation is oak, oak-hickory, and oak-mixed hardwood closed forest. Well-developed subcanopies, shrub layers, and herb layers are typical, though open s-classes may approach open forest conditions. Red oak is the characteristic species of the mesic oak system, though white oak or chestnut oak may also dominate or share dominance. Red maple, tulip poplar, mockernut hickory, and/or pignut hickory may be locally important, and red maple may be codominant. Under current conditions, red maple is the most abundant species in the subcanopy, and (now dead) eastern hemlock may be abundant in the understory. American chestnut was likely very important in reference-condition forests, though it is relegated to the shrub layer in current forests.

Typical understory trees include sourwood, silverbell, and dogwood. Shrub coverage is moderate to high and includes the following species: *Gaylussacia ursina, Calycanthus floridus, Castanea dentata, Pyrularia pubera, and Acer pensylvanicum*. *Rhododendron maximum* can be present and may be abundant.

The herb layer is typically very diverse and can range from sparse to high cover, with species such as *Galax urceolata,Thelypteris noveboracensis, Eurybia divaricata*, several *Carex spp., Polygonatum biflorum, Houstonia purpurea,Lysimachia quadrifolia*, and *Dioscorea quaternata*. The richest, closed forests within this system may approach cove forest in species diversity and composition. These stands may include: *Cimicifuga racemosa, Adiantum pedatum, Dryopteris intermedia, Collinsonia Canadensis, Caulophyllum thalictroides, Amphicarpa bracteata, and Athyrium filix-femina,* among many others.

Fire Regime:

Comparison with Landfire:

LCF	**Landfire (BPS 5713150)**
Surface fire – 37 year MFI	Surface Fire – 16 year
Mixed Fire – 175 year MFI	Mixed Fire – 139 year
Replacement – 243 years MFI	Replacement – 602 year

Description:

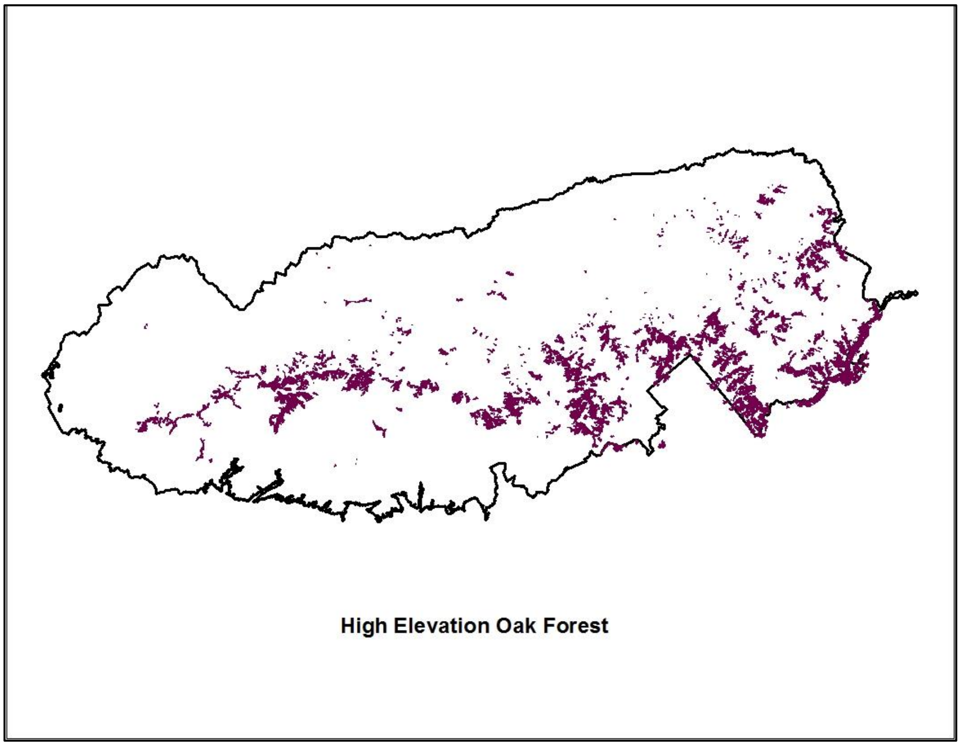
The fire regime of the Mesic Oak system represents the lowest frequency among the oak forest systems, with mean fire-free intervals (MFI) for surface fires between 33-40 years. This fire regime falls within the Landfire Fire Regime Group III. Low severity surface fires are the norm, and like the dry-mesic oak system, fires occur most frequently in the early and mid- s-classes due to subtle differences in fuel composition, site exposure, and hence fuel moisture/availability. These fires can occur virtually any time of year, but most commonly occur during the dormant season, between November and May. Fires in the winter months of December and January are rare. Mixed severity fires, where fires top-kill 25-75% of the dominant vegetation (Landfire definition), are much less common, occurring every 150-250 years. Replacement fires (>75% top-kill) are very rare events that may occur every 250-400 years in an average stand. Both mixed severity and replacement fires are most likely to occur during the growing season and they are typically associated with extreme droughts. High severity fires may also be associated with extreme wind events during any time of year.

High Elevation Oak Forest

Dominant Species (Reference Condition): *Castanea dentata, Quercus rubra, Quercus alba,*

Dominant Species (Current Condition): *Quercus rubra, Q. alba, Acer rubrum, Prunus serotina, Betula alleghaniensis*

LCF Mapping Rules: All occurrences of veg map codes listed below.



NVCS Classes and GRSM Veg Map Codes:

- 34% is 7300 – High-Elevation Red Oak Forest (Deciduous Shrub Type); veg map code MOr/Sb
- 31% is undifferentiated 7298, 7299, 7300 – High Elevation Red Oak Forest; veg map code MOr
- 21% is 7299 – High-Elevation Red Oak Forest (Evergreen Shrub Type); veg map code MOr/K, MOr/R, MOz
- 5% is 8558 – Southern Appalachian Mixed Hardwood Forest; veg map code HxA, NxA
- 5% is 7298 – High-Elevation Red Oak Forest (Tall Herb Type); veg map code MOr/G
- 4% is 7295 – Southern Blue Ridge High Elevation White Oak Forest; veg map code MOa
- Trace of 7230, 7517, 4973, 7219, 6192

S-Class Comparison:

- Landfire BPS 5713200 Central and Southern Appalachian Montane Oak Forest

(Note: This BPS is narrowly-defined as stunted talus-slope woodlands)

  - Early 2%
  - Mid closed 21%
  - Mid open 77%
  - Late open 0% *(not used)*
  - Late closed 0% *(not used)*

- GRSM LCF Model - Reference Conditions:
  - Early 14%
  - Mid closed 14%
  - Mid open 12%
  - Late open 38%
  - Late closed 22%

- GRSM LCF Model - Current:
  - Early 1%
  - Mid closed 0%
  - Mid open 0%
  - Late open 3%
  - Late closed 96%

Physical Description (Geology, Soils, Topography):

Geology – Predominantly found on metasedimentary rocks of the Great Smoky Group, with some occurrence on Snowbird Group geology, and on the small areas of Biotite augen gneiss found in the Balsam Mountains.

Soils - Primarily Dystrudepts of the Soco-Stecoah series; some occurrence on Dystrudepts of Cataska-Sylco, Hapludults of Evard-Cowee, and Humudepts of Breakneck-Pullback soils. These soils range from good to nutrient-poor, are well-drained, stony, and strongly acidic.

Topography – High ridges, mid- to upper slopes of all aspects, but primarily south and southeast-facing. This is a high-elevation system that occurs between 3500’ – 5000’.

Vegetation Description:

Vegetation includes high-elevation forests and woodlands strongly dominated by northern red oak, with a small percentage of stands dominated by white oak. The upper canopy oak trees may be stunted and gnarled by exposure to wind and ice. Other tree species include: yellow birch, red maple, and cherry. The subcanopy is typically open to poorly developed. American chestnut was very important in reference-condition forests, though it is relegated to the shrub layer in current forests.

There are four distinct associations within this system, and these associations are largely distinguished by differences in the structure of the understory. Most stands in this system have a very dense shrub layer, which may be dominated by evergreen or deciduous species. Stands with evergreen shrubs typically have a high cover of *Rhododendron maximum*, though *Kalmia latifolia* can be present. Stands dominated by white oak more often have a shrub layer dominated by *Kalmia*. These forests have low herbaceous cover and diversity, typically dominated by *Galax urceolata*.

Forests in this system that are dominated by deciduous shrubs may include the following species in the understory: *Ilex montana, Rhodendron calendulaceum, Castanea dentata, Rubus canadensis, Vaccinium erythrocarpum, or V. corymbosum*. These stands often have a high coverage of diverse herbs that is dominated by the ferns Dennstaedtia puntilobula and Thelypteris noveboracensis. The final montane oak association has a sparse, open shrub layer and an herb layer that is strongly dominated by Carex pensylvanica, which can appear a dense carpet. Other herbs may include: *Angelica triquinata, Eurybia chlorolepis, Cuscuta rostrate, Dryopteris intermedia, Prenanthes altissima,* and *Lilium superbum*, among others.

<u>**Fire Regime:**</u>

Comparison with Landfire:

LCF	**Landfire (BPS 5713200)**
Surface fire – 33 year MFI	Surface Fire – 13 year
Mixed Fire – 102 year MFI	Mixed Fire – none
Replacement – 163 years MFI	Replacement – none

Description:

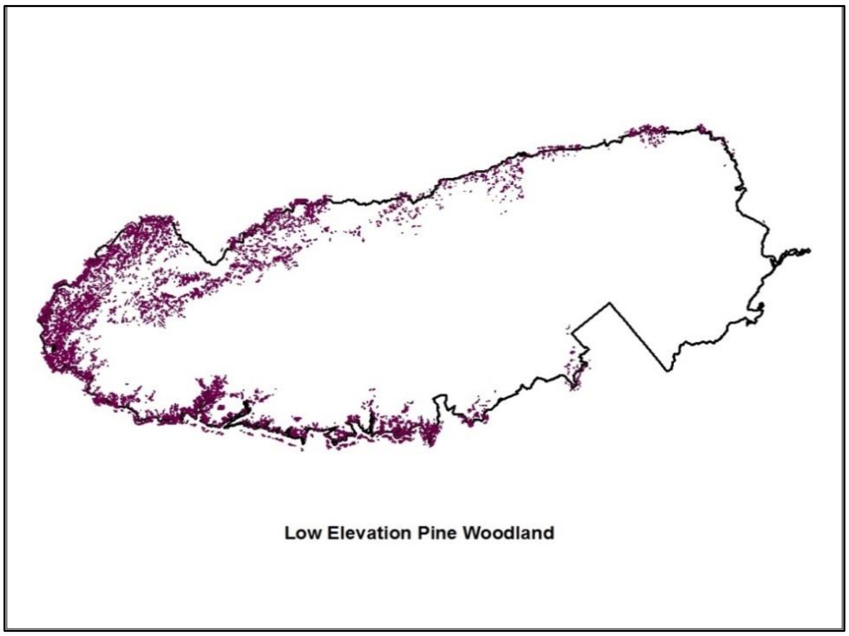
The fire regime of the High Elevation Oak Forest is not well understood. It is generally thought to be a frequent, low severity regime due to its woodland-like structure and the exposed nature of its high-elevation sites; however, due to the isolation of most stands and the higher moisture levels that are present at higher elevations, it is likely a much longer mean fire-free interval than lower-elevation dry oak stands. This project maintained this system in the Landfire Fire Regime Group I, but used a relatively long MFI of 25-40 years (average 33 years). Due to the high moisture conditions at high elevations in GRSM, fires likely occurred most frequently in the early and open s-classes, and this is reflected in the modelled fire regime. Low severity fires are the norm, however mixed severity (MFI 100 years) and replacement fires (160 years) likely occurred more frequently than in lower-elevation mesic oak forests due to topographic features such as exposure and slope. Fires can occur virtually any time of year, but most commonly occur during the dormant season, between November and May. Fires in the winter months of December and January are rare. Both mixed severity and replacement fires are most likely to occur during extreme droughts. High severity fires may also be associated with extreme wind events during any time of year.

Low Elevation Pine Woodland

Dominant Species (Reference Condition): *Pinus echinata, Pinus virginiana, Quercus coccinea,Q. falcata, Q. montana, Q. velutina, Q. stellata*

Dominant Species (Current Condition): *Pinus echinata, P. rigida, P. virginiana, P. strobus, Quercus coccinea, Q. falcata, Q. montana, Q. velutina, Acer rubrum*

LCF Mapping Rules: The two low-elevation pine types presented here are not distinguished by the current GRSM veg map. These systems were mapped using our pine map units (<2300' elevation) intersected with Simon's Low Elevation Pine system model. For reference conditions mapping, if current oak-pine types intersected with areas mapped as "Yellow Pine" by Miller in 1938, they were included as pine map units. Of those, the areas that intersected Simon's Low-Elevation Pine model were included here as Low-Elevation Pine. If our pine units (again, only those less than 2300') ***did not*** intersect with Simon's Low-Elevation Pine model, they were placed in our Low-Elevation Pine-Oak-Heath.



NVCS Classes and GRSM Veg Map Codes:

- 40% has no CEGL code –veg map codes are PI, PIr
  The most likely CEGL is currently: 7493 – SBR Escarpment Shortleaf Pine – Oak Forest
- 26% is undifferentiated 7119, 7078, 2591, 3560; veg map code PI/OzH
- 16% is undifferentiated 7097, 7119; veg map code PI-OzH
- 9% is 6271 – Chestnut Oak Forest (Xeric Ridge); veg map codes OzH/PI, OzH/PIv, OzH-PIs, OzH
- 3% is 7097 – Blue Ridge Table Mt. Pine – Pitch Pine Woodland (Typic Type); veg map code PIp, PIp/OzH, PIp-OzH
- 3% is undifferentiated 7100, 7944, 7519 – various White Pine types; veg map code PIs, PIs/OzHf
- Trace of 2591, 7219, 7517, 8558, 6192

S-Class Comparison:

- Landfire BPS 5713530 - Southern Appalachian Low-Elevation Pine Forest
  - Early 32%
  - Mid closed 2%
  - Mid open 32%
  - Late open 33%
  - Late closed 1%

- GRSM LCF Model – Reference Conditions:
  - Early 13%
  - Mid closed 10%
  - Mid open 30%
  - Late open 35%
  - Late closed 12%

- GRSM LCF Model - Current:
  - Early 3%
  - Mid closed 12%
  - Mid open 4%
  - Late open 5%
  - Late closed 72%

Physical Description (Geology, Soils, Topography):

Geology – Metasedimentary and sedimentary rocks of the Walden Creek, Chilhowee, Great Smoky, and Snowbird, Groups

> Mountains: Metasedimentary geology - Metasandstone, metasiltstone, metagraywacke, metaconglomerate, phyllite, slate, shale, -
>
> Western Foothills (Beard Cane to Chilhowee): "diverse" Sedimentary/metasedimentary geology: sandstone, shale, slate, siltstone, quartzite (which is metamorphic), isolated dolomite

Soils - Dystrudepts of the Ditney-Unicoi, Soco-Stecoah and Cataska-Sylco series; Hapludults of the Junaluska-Tsali series. These soils are generally nutrient-poor, well-drained, rocky to stony, and strongly acidic.

Topography – Low ridges and summits. Convex, low to middle slopes, and some upper slopes. Slopes have primarily south and west aspects. Elevations range from 900' to 2300'. This system is primarily limited to the lowest elevations in GRSM, and is distributed largely along the park boundary and in the western end of GRSM.

Vegetation Description:

The low-elevation pine system is rare in the Southern Appalachians, and it is one of the most departed from its reference conditions. Few good examples of the system remain within GRSM, but there remain exceptional stands of shortleaf pine, some of which have been aged at 200-300 years old. There also remain vital remnants of the diverse herb layer of xeric grasses and forbs, though these are largely relegated to trail-sides, roadsides, and burned areas that intersect areas where this system formerly existed.

Much of this system is thought to have existed as Shortleaf Pine/Little Bluestem Appalachian Woodland (CEGL 3560) under reference conditions (roughly pre-Columbian), though this association is not mapped in GRSM's vegetation map. Most of the shortleaf stands are better described today as CEGL 7078 or 7493, and this is likely due to homogenization and degradation of the low elevation pine system due to fire exclusion. The presence of Shortleaf Pine and a more abundant and diverse herb layer are the two things that differentiate this system from the related Low-Elevation Pine-Oak-Heath. Subtle differences in site conditions (topography, solar exposure, moisture index) are some of the primary factors separating the two low elevation pine types, and these site differences in turn contribute to a different disturbance ecology and differences in species dominance. Southern pine beetle has hastened the loss of shortleaf pine in many areas, but several sites have been partially restored by fire, and show great promise for further restoration.

Reference conditions were primarily pine to pine-oak woodlands with open subcanopies and shrub layers. Herb layers were diverse and had moderate to high cover. Dominant trees included shortleaf pine, Virginia pine, and various species of dry-site oaks, and these species accounted for most of the trees in the subcanopy and seedling layer. Shrub layers were open and included species such as *Vaccinium pallidum, V. hirsutum, V. stamineum, V. arboreum, Lyonia ligustrina, and Kalmia latifolia*. The herb layer was very diverse, and included dominants such as: *Schizachyrium scoparium, Danthonia sericea, Piptochaetium avenaceum, Pityopsis graminifolia, Baptisia tinctoria, Coreopsis major, Pteridium aquilinum, Solidago odora, and Eurybia surculosa*.

Current conditions range from reasonable remnants with canopy dominance or codominance by shortleaf pine to highly degraded examples with few of the characteristic herbs remaining and very little shortleaf pine. All of these current stands have advanced succession to a variety of hardwoods or white pine. Canopy hardwoods include the dry oaks, but subcanopies are dominated by red maple, black gum, and white pine. Numerous other species crowd the midstory, including sourwood, sassafras, and mountain laurel. Shrub layers include the characteristic *Vaccinium* spp., and herb layers are sparse.

Fire Regime:

Comparison with Landfire:

LCF	**Landfire (BPS 5713530)**
Surface fire – 10 year MFI	Surface Fire – 4 year
Mixed Fire – 74 year MFI	Mixed Fire – 145 year
Replacement – 145 years MFI	Replacement – 25 year

Description:

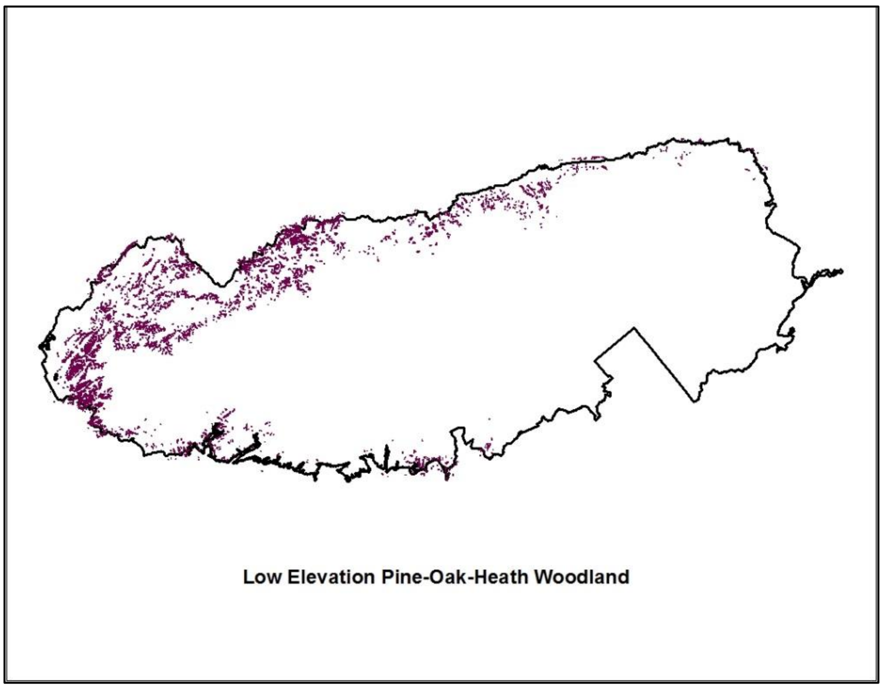
Under reference conditions, the low-elevation pine system experienced the most frequent fire of any system in the Great Smoky Mountains. Frequent, low severity fires are the norm, with mean fire-free intervals (MFI) of 8-11 years, on average. This system is included in Landfire Fire Regime Group 1. Fires can occur virtually any time of year, but most commonly occur during the dormant season, between November and May. Fires in the winter months of December and January are rare. Mixed severity fires, where fires top-kill 25-75% of the dominant vegetation (Landfire definition), are much less common, occurring every 50-125 years. Replacement fires (>75% top-kill) are rare events that occur every 100-200 years in an average stand. Both mixed severity and replacement fires are most likely to occur during the growing season and they are typically associated with several missed fire rotations and extreme droughts. High severity fires may also be associated with extreme wind events during any time of year.

Low Elevation Pine-Oak-Heath

Dominant Species (Reference Condition): *Pinus rigida, P. virginiana, Quercus coccinea, Kalmia latifolia*

Dominant Species (Current Condition): *P. rigida, P. virginiana, P. strobus, Quercus coccinea, Q. montana, Acer rubrum*

LCF Mapping Rules: The two low-elevation pine types presented here are not distinguished by the current GRSM veg map. These systems were mapped using our pine map units (<2300' elevation) intersected with Simon's Low Elevation Pine system model. For reference conditions mapping, if current oak-pine types intersected with areas mapped as "Yellow Pine" by Miller in 1938, they were included as "pine" map units. Of those, the areas that intersected Simon's Low-Elevation Pine model were included in the Low-Elevation Pine system. Those pine units that ***did not*** intersect with Simon's Low-Elevation Pine model (again, only those less than 2300'), were placed in this Low-Elevation Pine-Oak-Heath ecological system.



NVCS Classes and GRSM Veg Map Codes:

- 34% is undifferentiated 7119, 7078, 2591, 3560; veg map code PI/OzH
- 29% has no defined CEGL; veg map codes are PI and PIr
  The most likely CEGL is currently: 7119 – Appalachian Low Elevation Mixed Pine Forest
- 18% is undifferentiated 7097, 7119; veg map code PI-OzH
- 12% is 6271 – Chestnut Oak Forest (Xeric Ridge Type); veg map codes OzH, OzH/PI, OzH/PIv, OzH-PIs
- 4% is 7219 – Early Successional Appalachian Hardwood Forest: veg map code Hx, HxL, /T-T
- Trace of 2591, 7097, 8558, 7267

S-Class Comparison:

- Landfire BPS 5713520 - Southern Appalachian Montane Pine Forest and Woodland
  - Early 12%
  - Mid closed 3%
  - Mid open 25%
  - Late open 55%
  - Late closed 5%

- GRSM LCF Model - Reference Conditions:
  - Early 21%
  - Mid closed 13%
  - Mid open 30%
  - Late open 21%
  - Late closed 15%

- GRSM LCF Model - Current:
  - Early 2%
  - Mid closed 0%
  - Mid open 0%
  - Late open 13%
  - Late closed 84%

Physical Description (Geology, Soils, Topography):

Geology – Metasedimentary and sedimentary rocks of the Walden Creek, Chilhowee, Great Smoky, and Snowbird Groups

Mountains: Metasedimentary geology - Metasandstone, metasiltstone, metagraywacke, metaconglomerate, phyllite, slate, shale

Western Foothills (Beard Cane to Chilhowee): "diverse" Sedimentary/metasedimentary geology: sandstone, shale, slate, siltstone, quartzite (which is metamorphic), isolated dolomite

Soils - Dystrudepts of the Ditney-Unicoi, Soco-Stecoah and Cataska-Sylco series; Hapludults of the Junaluska-Tsali series. These soils are generally nutrient-poor, well-drained, rocky to stony, and strongly acidic.

Topography – Ridgetops and convex, steep middle to upper slopes. Slopes have primarily south and west aspects. Elevations range from 900' to 2300'.

Vegetation Description:

Vegetation is pine woodlands with a high percentage of early and mid-successional stand classes. Under reference conditions, most stands are open in the canopy and subcanopy, but have a moderate to high density of stems in the shrub layer. The herb layer is sparse to moderate in cover, depending on stand conditions. Pitch pine and Virginia pine are the characteristic trees, with scarlet oak, black oak, and blackjack oak frequently present. Under current conditions, red maple, black gum, white pine, and the dry oak spp. may have high densities in all size classes except the largest tree classes. Southern pine beetle has hastened the loss of the yellow pines in many areas, and most stands have at least some large standing dead or fallen pine trees.

Typical understory trees include sourwood, sassafras, and black locust. The density of the shrub layer is typically high, with high cover values for *Kalmia latifolia, Gaylussacia baccata, G. ursina, Vaccinium stamineum*, and *V. pallidum*. Under reference conditions, shrubs may have been shorter in stature and had more moderate cover, but the shrub *Kalmia latifolia* could become well-established and dense in stands where the fire-return interval exceeded the historical average. High cover of these shrubs is very common in contemporary, unburned stands.

The herb layer is also variable, ranging from sparse-to-moderate coverage by waxy-leaved evergreen subshrubs like *Gaultheria procumbens, Epigaea repens*, and *Galax urceolata* to sparse coverage by grasses and forbs including: S*chizachyrium scoparium, Dichanthelium commutatum, Pteridium aquilinum and Chimaphila maculata*. The vine species *Smilax rotundifolia* and *Smilax glauca* are also common.

Low Elevation Pine-Oak Heath is perhaps most closely related to Montane Pine-Oak-Heath (TMP/Pitch Pine), with which it shares a fire regime that is more mixed-severity than that of the Low Elevation Pine system. However, the species composition of the vegetation is transitional between Low Elevation Pine and the Montane Pine systems. It differs from Montane pine-oak-heath by occurring in less mountainous and isolated terrain and by the general absence of TMP.

Fire Regime:

Comparison with Landfire:

LCF	**Landfire (BPS 5713520)**
Surface fire – 14 year MFI	Surface Fire – 5 year
Mixed Fire – 55 year MFI	Mixed Fire – 101 year
Replacement – 115 years MFI	Replacement – 88 year

Description:

Low Elevation Pine-Oak-Heath has a mixed-severity fire regime, which contrasts with the geographically-related Low Elevation Pine system. This difference is due to the greater extremes of topographic exposure of the POH system, and the tendency of POH to occur in locations that are slightly more rugged and isolated than the Low Elevation Pine Woodlands. These more rugged, isolated landscapes have had a greater average distance from prehistoric and historic human use (thus less prone to be impacted by anthropogenic fire regimes) and smaller fire compartments. The effect of the greater isolation is less frequent fire and corresponding fuel buildup that tends to increase fire severity when fires do occur.

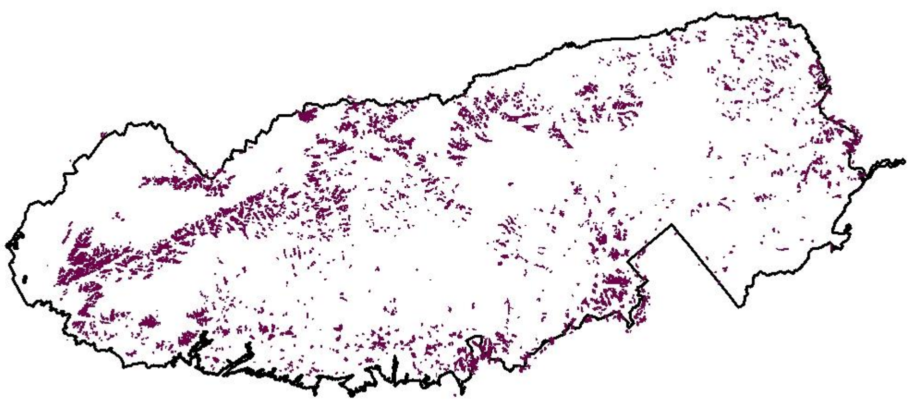
Surface fires occurred on average every 12-17 years, and mixed severity fires occur every 55 years on average. Due to fuel buildup processes, mixed severity fires are more likely to occur in closed s-classes that have missed one or more fire rotations. The relatively high frequency of these mixed severity fires best places this system into the Landfire Fire Regime Group III, though some stands in the system operate more as Fire Regime Group I. Fires can occur virtually any time of year, but most commonly occur during the dormant season, between November and May. Fires in the winter months of December and January are rare. Replacement fires (>75% top-kill) are more uncommon, but still occur on an average of every 115 years. Replacement fires are typically associated with several missed fire rotations and extreme droughts. High severity fires may also be associated with extreme wind events during any time of year.

Montane Pine-Oak-Heath

Dominant Species (Reference Condition): *Pinus pungens, Pinus rigida, Quercus montana, Kalmia latifolia*

Dominant Species (Current Condition): *Pinus pungens, Pinus rigida, Quercus montana, Q. coccinea, Kalmia latifolia, Acer rubrum, Oxydendrum arboreum, Nyssa sylvatica*

LCF Mapping Rules: All mapped Yellow Pine stands above 2300' elevation. For reference conditions mapping, if current oak-pine types intersected with areas mapped as "Yellow Pine" by Miller in 1938, they were included as pine map units.



Montane Pine-Oak-Heath Woodland

NVCS Classes and GRSM Veg Map Codes:

- 35% has no defined CEGL; veg map codes are PI and PIr
  The most likely CEGL is currently: 7097 – Blue Ridge Table Mountain Pine-Pitch Pine Woodland
- 25% is undifferentiated 7119, 7078, 2591, 3560; veg map code PI/OzH
- 12% is 8558; veg map code HxA, NxA, NHxAz
- 12% is undifferentiated 7097 and 7119; veg map code PI-OzH
- 8% is 6271 – Chestnut Oak Forest (Xeric Ridge); veg map codes OzH/PI, OzH/PIv, OzH-PIs, OzH
- 7% is 7097 – Blue Ridge Table Mountain Pine-Pitch Pine Woodland; veg map codes PIp, PIp/OzH, PIp-OzH

S-Class Comparison:

- Landfire BPS 5713520 - Southern Appalachian Montane Pine Forest and Woodland
  - Early 12%
  - Mid closed 3%
  - Mid open 25%
  - Late open 55%
  - Late closed 5%

- GRSM LCF Model - Reference Conditions:
  - Early 25%
  - Mid closed 16%
  - Mid open 25%
  - Late open 19%
  - Late closed 15%

- GRSM LCF Model - Current:
  - Early 6%
  - Mid closed 1%
  - Mid open 1%
  - Late open 14%
  - Late closed 78%

Physical Description (Geology, Soils, Topography):

Geology – Metasedimentary Great Smoky and Snowbird Groups

Mountains: Metasedimentary geology - Metasandstone, metasiltstone, metagraywacke, metaconglomerate, phyllite, slate, shale

Soils - Dystrudepts of the Ditney-Unicoi, Soco-Stecoah and Cataska-Sylco series; Hapludults of the Junaluska-Tsali series. These soils are generally nutrient-poor, well-drained, rocky to stony, and strongly acidic.

Topography – Exposed ridgetops and steep middle to upper slopes. Slopes are convex to flat. Slopes have primarily south and west aspects. Elevations mostly 2300' – 4000', with a few stands to 5000'.

Vegetation Description:

Vegetation is pine woodlands with a high percentage of early and mid-successional stand classes. Under reference conditions, most stands are open in the canopy and subcanopy, but have a moderate to high density of stems in the shrub layer. The herb layer is sparse to moderate in cover, depending on stand conditions. Table-mountain and pitch pine are the characteristic trees, with chestnut oak and scarlet oak frequently present. Under current conditions, red maple, black gum, white pine, and the dry oak spp. may have high densities in all size classes except the largest tree classes. Southern pine beetle has hastened the loss of the yellow pines in many areas, and most stands have at least some large standing dead or fallen pine trees.

Typical understory trees include sourwood, service berry, Fraser magnolia, and black locust. The density of the shrub layer is typically high, with high cover values for *Kalmia latifolia, Gaylussacia baccata, G. ursina, Vaccinium stamineum*, and *V. pallidum*. At elevations around 4000', *Pieris floribunda* can become a dominant shrub. Under reference conditions, shrubs may have been shorter in stature and had more moderate cover, but the shrub *Kalmia latifolia* could become well-established and dense in stands where the fire-return interval exceeded the historical average. High cover and high height (8'-10') of these shrubs is very common in contemporary, unburned stands.

The herb layer is also variable, ranging from sparse-to-moderate coverage by waxy-leaved evergreen subshrubs like *Gaultheria procumbens, Epigaea repens*, and *Galax urceolata* to sparse coverage by grasses and forbs including: S*chizachyrium scoparium, Dichanthelium commutatum, Pteridium aquilinum, Chimaphila maculata, Cleistesiopsis bifaria, and Cypripedium acuale*. The vine species *Smilax rotundifolia* and *Smilax glauca* are also common.

__Fire Regime:__

Comparison with Landfire:

LCF	**Landfire (BPS 5713520)**
Surface fire – 22 year MFI	Surface Fire – 5 year
Mixed Fire – 60 year MFI	Mixed Fire – 101 year
Replacement – 97 years MFI	Replacement – 88 year

Description:

Montane Pine-Oak-Heath has a mixed-severity fire regime. The system generally occurs on the most exposed, rugged, and isolated landscapes, which have had a greater average distance from prehistoric and historic human use (thus less prone to be impacted by anthropogenic fire regimes) and smaller fire compartments. The effect of the greater isolation is less frequent fire and corresponding fuel buildup that tends to increase fire severity when fires do occur.

Surface fires occurred on average every 20-25 years, and mixed severity fires occur every 60 years on average. Due to fuel buildup processes, mixed severity fires are more likely to occur in closed s-classes that have missed one or more fire rotations. The relatively high frequency of these mixed severity fires best places this system into the Landfire Fire Regime Group III, though some stands in the system operate more as Fire Regime Group I, with much more frequent surface fires. Fires can occur virtually any time of year, but most commonly occur during the dormant season, between November and May. Fires in the winter months of December and January are rare. Replacement fires (>75% top-kill) are more uncommon, but still occur on an average of every 97 years, making this system the most likely in GRSM to experience high-intensity stand replacement fires. Replacement fires are typically associated with several missed fire rotations and extreme droughts. High severity fires may also be associated with extreme wind events during any time of year.

Appendix 3. Back Test of Models for Dry Oak and Low Elevation Pine

"Back tests" were conducted on the models of two representative fire-dependent systems – Dry Oak Forest and Low Elevation Pine Forest – to help confirm the validity of the fire-return intervals and other key variables in the models. These tests were designed to roughly mimic the major human-caused disturbances in GRSM over the last century and see if the models would generate results that approximate actual current conditions.

Using ST-Sim, the back tests populated the reference condition s-classes as the Initial Conditions for these two systems as of 1910. It then simulated heavy logging (50% clearcut) over a 20 year period, and recorded the s-class outcomes after those simulations as new Initial Conditions as of 1930. It then simulated 85 years of 98% fire suppression and recorded the s-class outcomes after those simulations at the end of 85 years (i.e., 2015).

The table below shows the Actual Current % for each s-class as compared to the simulated current results (1910-2015 Back Test Model Run Outcomes) for both systems. A "departure score" was calculated to compare current to simulated outcomes. The comparison of results by s-class within the table and low "departure scores" of 12 for each of the two systems demonstrated that their models very closely predicted actual current conditions.

	Dry Oak Forest			Low Elevation Pine	
Vegetation Class	**Current %**	**1910-2015 BackTest Model Run Outcomes**		**Current %**	**1910-2015 BackTest Model Run Outcomes**
Early	2%	5%		3%	5%
Mid-Closed	0%	6%		12%	22%
Mid-Open	0%	0%		4%	1%
Late-Closed	90%	78%		72%	67%
Late-Open	8%	11%		5%	5%
Highly Departed Composition	0%	0%		3%	0%
Total Early/Open	10%	16%		12%	11%
Total Closed	90%	84%		85%	89%
"Departure" from Current		**12**			**12**

Appendix 4. Deterministic Transitions for ST-Sim ecological models.

Vegetation Type	From Class	To Class	Age Min	Age Max
RichAcidicCove	1-Early1:ALL	2-Mid1:CLS	0	10
RichAcidicCove	2-Mid1:CLS	3-Late1:CLS	11	80
RichAcidicCove	2-Mid1:OPN	3-Late1:CLS	11	80
RichAcidicCove	3-Late1:CLS	3-Late1:CLS	81	999
RichAcidicCove	3-Late1:OPN	3-Late1:OPN	81	999
DryMesicOak	1-Early1:ALL	2-Mid1:OPN	0	15
DryMesicOak	2-Mid1:CLS	3-Late1:CLS	16	75
DryMesicOak	2-Mid1:OPN	3-Late1:OPN	16	75
DryMesicOak	3-Late1:CLS	3-Late1:CLS	76	999
DryMesicOak	3-Late1:OPN	3-Late1:OPN	76	999
DryOak	1-Early1:ALL	2-Mid1:OPN	0	20
DryOak	2-Mid1:CLS	3-Late1:CLS	21	70
DryOak	2-Mid1:OPN	3-Late1:OPN	21	70
DryOak	3-Late1:CLS	3-Late1:CLS	71	999
DryOak	3-Late1:OPN	3-Late1:OPN	71	999
HighElevRedOak	1-Early1:ALL	2-Mid1:OPN	0	20
HighElevRedOak	2-Mid1:CLS	3-Late1:CLS	21	70
HighElevRedOak	2-Mid1:OPN	3-Late1:OPN	21	70
HighElevRedOak	3-Late1:CLS	3-Late1:CLS	71	999
HighElevRedOak	3-Late1:OPN	3-Late1:OPN	71	999
LowElevPineOakHeath	1-Early1:ALL	2-Mid1:OPN	0	17
LowElevPineOakHeath	2-Mid1:CLS	3-Late1:CLS	18	70
LowElevPineOakHeath	2-Mid1:OPN	3-Late1:OPN	18	70
LowElevPineOakHeath	3-Late1:CLS	3-Late1:CLS	71	999
LowElevPineOakHeath	3-Late1:OPN	3-Late1:OPN	71	999
LowElevationPine	1-Early1:ALL	2-Mid1:OPN	0	15
LowElevationPine	2-Mid1:CLS	3-Late1:CLS	16	70
LowElevationPine	2-Mid1:OPN	3-Late1:OPN	16	70
LowElevationPine	3-Late1:CLS	3-Late1:CLS	71	999
LowElevationPine	3-Late1:OPN	3-Late1:OPN	71	999
MesicOak	1-Early1:ALL	2-Mid1:OPN	0	10
MesicOak	2-Mid1:CLS	3-Late1:CLS	11	80
MesicOak	2-Mid1:OPN	3-Late1:OPN	11	80
MesicOak	3-Late1:CLS	3-Late1:CLS	81	999
MesicOak	3-Late1:OPN	3-Late1:OPN	81	999
MontanePineOakHeath	1-Early1:ALL	2-Mid1:OPN	0	20
MontanePineOakHeath	2-Mid1:CLS	3-Late1:CLS	21	70
MontanePineOakHeath	2-Mid1:OPN	3-Late1:OPN	21	70
MontanePineOakHeath	3-Late1:CLS	3-Late1:CLS	71	999
MontanePineOakHeath	3-Late1:OPN	3-Late1:OPN	71	999
NorthernHardwood	1-Early1:ALL	2-Mid1:CLS	0	15
NorthernHardwood	2-Mid1:CLS	3-Late1:CLS	16	75
NorthernHardwood	2-Mid1:OPN	3-Late1:OPN	16	75
NorthernHardwood	3-Late1:CLS	3-Late1:CLS	76	999
NorthernHardwood	Late1:OPN	3-Late1:OPN	76	999

Appendix 5. Probabilistic Transitions for ST-Sim ecological models.

Vegetation Type	From Class	To Class	Transition Type	Prob	Propr	Age Reset	TST Min
DryMesicOak	1-Early1:ALL	2-Mid1:CLS	AltSuccession	1.0000	1.0000	Yes	18
DryMesicOak	2-Mid1:OPN	2-Mid1:CLS	AltSuccession	1.0000	1.0000	No	25
DryMesicOak	3-Late1:OPN	3-Late1:CLS	AltSuccession	1.0000	1.0000	No	25
DryMesicOak	3-Late1:CLS	3-Late1:OPN	Insect/Disease	0.0025	1.0000	No	
DryMesicOak	3-Late1:OPN	3-Late1:OPN	Insect/Disease	0.0025	1.0000	No	
DryMesicOak	1-Early1:ALL	1-Early1:ALL	MixedFire	0.0200	1.0000	No	
DryMesicOak	2-Mid1:CLS	2-Mid1:OPN	MixedFire	0.0120	1.0000	No	
DryMesicOak	2-Mid1:OPN	2-Mid1:OPN	MixedFire	0.0050	1.0000	No	
DryMesicOak	3-Late1:CLS	3-Late1:OPN	MixedFire	0.0100	1.0000	No	
DryMesicOak	3-Late1:OPN	3-Late1:OPN	MixedFire	0.0050	1.0000	No	
DryMesicOak	1-Early1:ALL	1-Early1:ALL	ReplacementFire	0.0120	1.0000	Yes	
DryMesicOak	2-Mid1:CLS	1-Early1:ALL	ReplacementFire	0.0050	1.0000	Yes	
DryMesicOak	2-Mid1:OPN	1-Early1:ALL	ReplacementFire	0.0033	1.0000	Yes	
DryMesicOak	3-Late1:CLS	1-Early1:ALL	ReplacementFire	0.0050	1.0000	Yes	
DryMesicOak	3-Late1:OPN	1-Early1:ALL	ReplacementFire	0.0030	1.0000	Yes	
DryMesicOak	1-Early1:ALL	1-Early1:ALL	SurfaceFire	0.0340	1.0000	No	
DryMesicOak	2-Mid1:CLS	2-Mid1:CLS	SurfaceFire	0.0340	0.9500	No	
DryMesicOak	2-Mid1:CLS	2-Mid1:OPN	SurfaceFire	0.0340	0.0500	No	
DryMesicOak	2-Mid1:OPN	2-Mid1:OPN	SurfaceFire	0.0500	1.0000	No	
DryMesicOak	3-Late1:CLS	3-Late1:CLS	SurfaceFire	0.0310	0.9500	No	
DryMesicOak	3-Late1:CLS	3-Late1:OPN	SurfaceFire	0.0310	0.0500	No	
DryMesicOak	3-Late1:OPN	3-Late1:OPN	SurfaceFire	0.0450	1.0000	No	
DryMesicOak	2-Mid1:CLS	1-Early1:ALL	Wind/Weather/Stress	0.0020	1.0000	Yes	
DryMesicOak	2-Mid1:CLS	2-Mid1:OPN	Wind/Weather/Stress	0.0025	1.0000	No	
DryMesicOak	2-Mid1:OPN	1-Early1:ALL	Wind/Weather/Stress	0.0025	1.0000	Yes	
DryMesicOak	2-Mid1:OPN	2-Mid1:OPN	Wind/Weather/Stress	0.0025	1.0000	No	
DryMesicOak	3-Late1:CLS	1-Early1:ALL	Wind/Weather/Stress	0.0020	1.0000	Yes	
DryMesicOak	3-Late1:CLS	3-Late1:OPN	Wind/Weather/Stress	0.0025	1.0000	No	
DryMesicOak	3-Late1:OPN	1-Early1:ALL	Wind/Weather/Stress	0.0020	1.0000	Yes	
DryMesicOak	3-Late1:OPN	3-Late1:OPN	Wind/Weather/Stress	0.0025	1.0000	No	

DryOak	Early1:ALL	2-Mid1:CLS	AltSuccession	1.0000	1.0000	Yes	19
DryOak	2-Mid1:OPN	2-Mid1:CLS	AltSuccession	1.0000	1.0000	No	18
DryOak	3-Late1:OPN	3-Late1:CLS	AltSuccession	1.0000	1.0000	No	18
DryOak	2-Mid1:CLS	2-Mid1:CLS	Insect/Disease	0.0033	1.0000	No	
DryOak	2-Mid1:OPN	2-Mid1:OPN	Insect/Disease	0.0033	1.0000	No	
DryOak	3-Late1:CLS	3-Late1:OPN	Insect/Disease	0.0033	1.0000	No	
DryOak	3-Late1:OPN	3-Late1:OPN	Insect/Disease	0.0033	1.0000	No	
DryOak	1-Early1:ALL	1-Early1:ALL	MixedFire	0.0450	1.0000	No	
DryOak	2-Mid1:CLS	2-Mid1:OPN	MixedFire	0.0180	1.0000	No	
DryOak	2-Mid1:OPN	2-Mid1:OPN	MixedFire	0.0100	1.0000	No	
DryOak	3-Late1:CLS	3-Late1:OPN	MixedFire	0.0130	1.0000	No	
DryOak	3-Late1:OPN	3-Late1:OPN	MixedFire	0.0090	1.0000	No	
DryOak	1-Early1:ALL	1-Early1:ALL	ReplacementFire	0.0150	1.0000	Yes	
DryOak	2-Mid1:CLS	1-Early1:ALL	ReplacementFire	0.0100	1.0000	Yes	
DryOak	2-Mid1:OPN	1-Early1:ALL	ReplacementFire	0.0050	1.0000	Yes	
DryOak	3-Late1:CLS	1-Early1:ALL	ReplacementFire	0.0090	1.0000	Yes	
DryOak	3-Late1:OPN	1-Early1:ALL	ReplacementFire	0.0050	1.0000	Yes	
DryOak	1-Early1:ALL	1-Early1:ALL	SurfaceFire	0.0667	1.0000	No	
DryOak	2-Mid1:CLS	2-Mid1:CLS	SurfaceFire	0.0560	0.9500	No	
DryOak	2-Mid1:CLS	2-Mid1:OPN	SurfaceFire	0.0560	0.0500	No	
DryOak	2-Mid1:OPN	2-Mid1:OPN	SurfaceFire	0.0830	1.0000	No	
DryOak	3-Late1:CLS	3-Late1:CLS	SurfaceFire	0.0500	0.9500	No	
DryOak	3-Late1:CLS	3-Late1:OPN	SurfaceFire	0.0500	0.0500	No	
DryOak	3-Late1:OPN	3-Late1:OPN	SurfaceFire	0.0770	1.0000	No	
DryOak	2-Mid1:CLS	2-Mid1:OPN	Wind/Weather/Stress	0.0033	1.0000	No	
DryOak	2-Mid1:OPN	2-Mid1:OPN	Wind/Weather/Stress	0.0033	1.0000	No	
DryOak	3-Late1:CLS	1-Early1:ALL	Wind/Weather/Stress	0.0025	1.0000	Yes	
DryOak	3-Late1:CLS	3-Late1:OPN	Wind/Weather/Stress	0.0033	1.0000	No	
DryOak	3-Late1:OPN	1-Early1:ALL	Wind/Weather/Stress	0.0025	1.0000	Yes	
DryOak	3-Late1:OPN	3-Late1:OPN	Wind/Weather/Stress	0.0033	1.0000	No	

HighElevRedOak	Early1:ALL	2-Mid1:CLS	AltSuccession	1.0000	1.0000	Yes	19
HighElevRedOak	2-Mid1:OPN	2-Mid1:CLS	AltSuccession	1.0000	1.0000	No	20
HighElevRedOak	3-Late1:OPN	3-Late1:CLS	AltSuccession	1.0000	1.0000	No	20
HighElevRedOak	3-Late1:CLS	3-Late1:OPN	Insect/Disease	0.0033	1.0000	No	
HighElevRedOak	3-Late1:OPN	3-Late1:OPN	Insect/Disease	0.0033	1.0000	No	
HighElevRedOak	1-Early1:ALL	1-Early1:ALL	MixedFire	0.0200	1.0000	No	
HighElevRedOak	2-Mid1:CLS	2-Mid1:OPN	MixedFire	0.0110	1.0000	No	
HighElevRedOak	2-Mid1:OPN	2-Mid1:OPN	MixedFire	0.0080	1.0000	No	
HighElevRedOak	3-Late1:CLS	3-Late1:OPN	MixedFire	0.0100	1.0000	No	
HighElevRedOak	3-Late1:OPN	3-Late1:OPN	MixedFire	0.0070	1.0000	No	
HighElevRedOak	1-Early1:ALL	1-Early1:ALL	ReplacementFire	0.0150	1.0000	Yes	
HighElevRedOak	2-Mid1:CLS	1-Early1:ALL	ReplacementFire	0.0100	1.0000	Yes	
HighElevRedOak	2-Mid1:OPN	1-Early1:ALL	ReplacementFire	0.0050	1.0000	Yes	
HighElevRedOak	3-Late1:CLS	1-Early1:ALL	ReplacementFire	0.0050	1.0000	Yes	
HighElevRedOak	3-Late1:OPN	1-Early1:ALL	ReplacementFire	0.0040	1.0000	Yes	
HighElevRedOak	1-Early1:ALL	1-Early1:ALL	SurfaceFire	0.0400	1.0000	No	
HighElevRedOak	2-Mid1:CLS	2-Mid1:CLS	SurfaceFire	0.0270	0.9500	No	
HighElevRedOak	2-Mid1:CLS	2-Mid1:OPN	SurfaceFire	0.0270	0.0500	No	
HighElevRedOak	2-Mid1:OPN	2-Mid1:OPN	SurfaceFire	0.0400	1.0000	No	
HighElevRedOak	3-Late1:CLS	3-Late1:CLS	SurfaceFire	0.0250	0.9500	No	
HighElevRedOak	3-Late1:CLS	3-Late1:OPN	SurfaceFire	0.0250	0.0500	No	
HighElevRedOak	3-Late1:OPN	3-Late1:OPN	SurfaceFire	0.0360	1.0000	No	
HighElevRedOak	2-Mid1:CLS	2-Mid1:OPN	Wind/Weather/Stress	0.0025	1.0000	No	
HighElevRedOak	2-Mid1:OPN	2-Mid1:OPN	Wind/Weather/Stress	0.0025	1.0000	No	
HighElevRedOak	3-Late1:CLS	1-Early1:ALL	Wind/Weather/Stress	0.0025	1.0000	Yes	
HighElevRedOak	3-Late1:CLS	3-Late1:OPN	Wind/Weather/Stress	0.0025	1.0000	No	
HighElevRedOak	3-Late1:OPN	1-Early1:ALL	Wind/Weather/Stress	0.0025	1.0000	Yes	
HighElevRedOak	3-Late1:OPN	3-Late1:OPN	Wind/Weather/Stress	0.0025	1.0000	No	

LowElevationPine	Early1:ALL	2-Mid1:CLS	AltSuccession	1.0000	1.0000	Yes	9
LowElevationPine	2-Mid1:OPN	2-Mid1:CLS	AltSuccession	1.0000	1.0000	No	20
LowElevationPine	3-Late1:OPN	3-Late1:CLS	AltSuccession	1.0000	1.0000	No	20
LowElevationPine	2-Mid1:CLS	1-Early1:ALL	Insect/Disease	0.0033	1.0000	Yes	
LowElevationPine	2-Mid1:OPN	1-Early1:ALL	Insect/Disease	0.0033	1.0000	Yes	
LowElevationPine	3-Late1:CLS	1-Early1:ALL	Insect/Disease	0.0033	1.0000	Yes	
LowElevationPine	3-Late1:OPN	1-Early1:ALL	Insect/Disease	0.0033	1.0000	Yes	
LowElevationPine	1-Early1:ALL	1-Early1:ALL	MixedFire	0.0500	1.0000	No	
LowElevationPine	2-Mid1:CLS	2-Mid1:OPN	MixedFire	0.0200	1.0000	No	
LowElevationPine	2-Mid1:OPN	2-Mid1:OPN	MixedFire	0.0100	1.0000	No	
LowElevationPine	3-Late1:CLS	3-Late1:OPN	MixedFire	0.0130	1.0000	No	
LowElevationPine	3-Late1:OPN	3-Late1:OPN	MixedFire	0.0080	1.0000	No	
LowElevationPine	1-Early1:ALL	1-Early1:ALL	ReplacementFire	0.0100	1.0000	Yes	
LowElevationPine	2-Mid1:CLS	1-Early1:ALL	ReplacementFire	0.0100	1.0000	Yes	
LowElevationPine	2-Mid1:OPN	1-Early1:ALL	ReplacementFire	0.0050	1.0000	Yes	
LowElevationPine	3-Late1:CLS	1-Early1:ALL	ReplacementFire	0.0080	1.0000	Yes	
LowElevationPine	3-Late1:OPN	1-Early1:ALL	ReplacementFire	0.0050	1.0000	Yes	
LowElevationPine	1-Early1:ALL	1-Early1:ALL	SurfaceFire	0.1250	1.0000	No	
LowElevationPine	2-Mid1:CLS	2-Mid1:CLS	SurfaceFire	0.1000	0.9000	No	
LowElevationPine	2-Mid1:CLS	2-Mid1:OPN	SurfaceFire	0.1000	0.1000	No	
LowElevationPine	2-Mid1:OPN	2-Mid1:OPN	SurfaceFire	0.1250	1.0000	No	
LowElevationPine	3-Late1:CLS	3-Late1:CLS	SurfaceFire	0.0910	0.9000	No	
LowElevationPine	3-Late1:CLS	3-Late1:OPN	SurfaceFire	0.0910	0.1000	No	
LowElevationPine	3-Late1:OPN	3-Late1:OPN	SurfaceFire	0.1110	1.0000	No	
LowElevationPine	2-Mid1:CLS	2-Mid1:OPN	Wind/Weather/Stress	0.0033	1.0000	No	
LowElevationPine	2-Mid1:OPN	2-Mid1:OPN	Wind/Weather/Stress	0.0033	1.0000	No	
LowElevationPine	3-Late1:CLS	1-Early1:ALL	Wind/Weather/Stress	0.0025	1.0000	Yes	
LowElevationPine	3-Late1:CLS	3-Late1:OPN	Wind/Weather/Stress	0.0033	1.0000	No	
LowElevationPine	3-Late1:OPN	1-Early1:ALL	Wind/Weather/Stress	0.0025	1.0000	Yes	
LowElevationPine	3-Late1:OPN	3-Late1:OPN	Wind/Weather/Stress	0.0033	1.0000	No	

LowElevPineOakHeath	Early1:ALL	2-Mid1:CLS	AltSuccession	1.0000	1.0000	Yes	11
LowElevPineOakHeath	2-Mid1:OPN	2-Mid1:CLS	AltSuccession	1.0000	1.0000	No	16
LowElevPineOakHeath	3-Late1:OPN	3-Late1:CLS	AltSuccession	1.0000	1.0000	No	16
LowElevPineOakHeath	2-Mid1:CLS	1-Early1:ALL	Insect/Disease	0.0050	1.0000	Yes	
LowElevPineOakHeath	2-Mid1:OPN	1-Early1:ALL	Insect/Disease	0.0050	1.0000	Yes	
LowElevPineOakHeath	3-Late1:CLS	1-Early1:ALL	Insect/Disease	0.0050	1.0000	Yes	
LowElevPineOakHeath	3-Late1:OPN	1-Early1:ALL	Insect/Disease	0.0050	1.0000	Yes	
LowElevPineOakHeath	1-Early1:ALL	1-Early1:ALL	MixedFire	0.0667	1.0000	No	
LowElevPineOakHeath	2-Mid1:CLS	2-Mid1:OPN	MixedFire	0.0290	1.0000	No	
LowElevPineOakHeath	2-Mid1:OPN	2-Mid1:OPN	MixedFire	0.0133	1.0000	No	
LowElevPineOakHeath	3-Late1:CLS	3-Late1:OPN	MixedFire	0.0200	1.0000	No	
LowElevPineOakHeath	3-Late1:OPN	3-Late1:OPN	MixedFire	0.0100	1.0000	No	
LowElevPineOakHeath	2-Mid1:CLS	2-Mid1:OPN	Optional1	0.0040	1.0000	No	
LowElevPineOakHeath	3-Late1:CLS	3-Late1:OPN	Optional1	0.0040	1.0000	No	
LowElevPineOakHeath	1-Early1:ALL	1-Early1:ALL	ReplacementFire	0.0200	1.0000	Yes	
LowElevPineOakHeath	2-Mid1:CLS	1-Early1:ALL	ReplacementFire	0.0133	1.0000	Yes	
LowElevPineOakHeath	2-Mid1:OPN	1-Early1:ALL	ReplacementFire	0.0067	1.0000	Yes	
LowElevPineOakHeath	3-Late1:CLS	1-Early1:ALL	ReplacementFire	0.0100	1.0000	Yes	
LowElevPineOakHeath	3-Late1:OPN	1-Early1:ALL	ReplacementFire	0.0050	1.0000	Yes	
LowElevPineOakHeath	1-Early1:ALL	1-Early1:ALL	SurfaceFire	0.0830	1.0000	No	
LowElevPineOakHeath	2-Mid1:CLS	2-Mid1:CLS	SurfaceFire	0.0667	0.9000	No	
LowElevPineOakHeath	2-Mid1:CLS	2-Mid1:OPN	SurfaceFire	0.0667	0.1000	No	
LowElevPineOakHeath	2-Mid1:OPN	2-Mid1:OPN	SurfaceFire	0.0830	1.0000	No	
LowElevPineOakHeath	3-Late1:CLS	3-Late1:CLS	SurfaceFire	0.0590	0.9000	No	
LowElevPineOakHeath	3-Late1:CLS	3-Late1:OPN	SurfaceFire	0.0590	0.1000	No	
LowElevPineOakHeath	3-Late1:OPN	3-Late1:OPN	SurfaceFire	0.0770	1.0000	No	
LowElevPineOakHeath	2-Mid1:CLS	2-Mid1:OPN	Wind/Weather/Stress	0.0033	1.0000	No	
LowElevPineOakHeath	2-Mid1:OPN	2-Mid1:OPN	Wind/Weather/Stress	0.0033	1.0000	No	
LowElevPineOakHeath	3-Late1:CLS	1-Early1:ALL	Wind/Weather/Stress	0.0025	1.0000	Yes	
LowElevPineOakHeath	3-Late1:CLS	3-Late1:OPN	Wind/Weather/Stress	0.0033	1.0000	No	
LowElevPineOakHeath	3-Late1:OPN	1-Early1:ALL	Wind/Weather/Stress	0.0025	1.0000	Yes	
LowElevPineOakHeath	3-Late1:OPN	3-Late1:OPN	Wind/Weather/Stress	0.0033	1.0000	No	

MesicOak	Early1:ALL	2-Mid1:CLS	AltSuccession	1.0000	1.0000	Yes	20
MesicOak	2-Mid1:OPN	2-Mid1:CLS	AltSuccession	1.0000	1.0000	No	20
MesicOak	3-Late1:OPN	3-Late1:CLS	AltSuccession	1.0000	1.0000	No	20
MesicOak	3-Late1:CLS	3-Late1:OPN	Insect/Disease	0.0025	1.0000	No	
MesicOak	3-Late1:OPN	3-Late1:OPN	Insect/Disease	0.0025	1.0000	No	
MesicOak	1-Early1:ALL	1-Early1:ALL	MixedFire	0.0150	1.0000	No	
MesicOak	2-Mid1:CLS	2-Mid1:OPN	MixedFire	0.0070	1.0000	No	
MesicOak	2-Mid1:OPN	2-Mid1:OPN	MixedFire	0.0040	1.0000	No	
MesicOak	3-Late1:CLS	3-Late1:OPN	MixedFire	0.0060	1.0000	No	
MesicOak	3-Late1:OPN	3-Late1:OPN	MixedFire	0.0040	1.0000	No	
MesicOak	1-Early1:ALL	1-Early1:ALL	ReplacementFire	0.0100	1.0000	Yes	
MesicOak	2-Mid1:CLS	1-Early1:ALL	ReplacementFire	0.0050	1.0000	Yes	
MesicOak	2-Mid1:OPN	1-Early1:ALL	ReplacementFire	0.0030	1.0000	Yes	
MesicOak	3-Late1:CLS	1-Early1:ALL	ReplacementFire	0.0040	1.0000	Yes	
MesicOak	3-Late1:OPN	1-Early1:ALL	ReplacementFire	0.0030	1.0000	Yes	
MesicOak	1-Early1:ALL	1-Early1:ALL	SurfaceFire	0.0300	1.0000	No	
MesicOak	2-Mid1:CLS	2-Mid1:CLS	SurfaceFire	0.0270	0.9500	No	
MesicOak	2-Mid1:CLS	2-Mid1:OPN	SurfaceFire	0.0270	0.0500	No	
MesicOak	2-Mid1:OPN	2-Mid1:OPN	SurfaceFire	0.0300	1.0000	No	
MesicOak	3-Late1:CLS	3-Late1:CLS	SurfaceFire	0.0250	0.9500	No	
MesicOak	3-Late1:CLS	3-Late1:OPN	SurfaceFire	0.0250	0.0500	No	
MesicOak	3-Late1:OPN	3-Late1:OPN	SurfaceFire	0.0270	1.0000	No	
MesicOak	2-Mid1:CLS	1-Early1:ALL	Wind/Weather/Stress	0.0020	1.0000	Yes	
MesicOak	2-Mid1:CLS	2-Mid1:OPN	Wind/Weather/Stress	0.0025	1.0000	No	
MesicOak	2-Mid1:OPN	1-Early1:ALL	Wind/Weather/Stress	0.0020	1.0000	Yes	
MesicOak	2-Mid1:OPN	2-Mid1:OPN	Wind/Weather/Stress	0.0025	1.0000	No	
MesicOak	3-Late1:CLS	1-Early1:ALL	Wind/Weather/Stress	0.0020	1.0000	Yes	
MesicOak	3-Late1:CLS	3-Late1:OPN	Wind/Weather/Stress	0.0025	1.0000	No	
MesicOak	3-Late1:OPN	1-Early1:ALL	Wind/Weather/Stress	0.0020	1.0000	Yes	
MesicOak	3-Late1:OPN	3-Late1:OPN	Wind/Weather/Stress	0.0025	1.0000	No	

MontanePineOakHeath	Early1:ALL	2-Mid1:CLS	AltSuccession	1.0000	1.0000	Yes	14
MontanePineOakHeath	2-Mid1:OPN	2-Mid1:CLS	AltSuccession	1.0000	1.0000	No	20
MontanePineOakHeath	3-Late1:OPN	3-Late1:CLS	AltSuccession	1.0000	1.0000	No	20
MontanePineOakHeath	2-Mid1:CLS	1-Early1:ALL	Insect/Disease	0.0050	1.0000	Yes	
MontanePineOakHeath	2-Mid1:OPN	1-Early1:ALL	Insect/Disease	0.0050	1.0000	Yes	
MontanePineOakHeath	3-Late1:CLS	1-Early1:ALL	Insect/Disease	0.0050	1.0000	Yes	
MontanePineOakHeath	3-Late1:OPN	1-Early1:ALL	Insect/Disease	0.0050	1.0000	Yes	
MontanePineOakHeath	1-Early1:ALL	1-Early1:ALL	MixedFire	0.0400	1.0000	No	
MontanePineOakHeath	2-Mid1:CLS	2-Mid1:OPN	MixedFire	0.0200	1.0000	No	
MontanePineOakHeath	2-Mid1:OPN	2-Mid1:OPN	MixedFire	0.0133	1.0000	No	
MontanePineOakHeath	3-Late1:CLS	3-Late1:OPN	MixedFire	0.0150	1.0000	No	
MontanePineOakHeath	3-Late1:OPN	3-Late1:OPN	MixedFire	0.0120	1.0000	No	
MontanePineOakHeath	2-Mid1:CLS	2-Mid1:OPN	Optional1	0.0040	1.0000	No	
MontanePineOakHeath	3-Late1:CLS	3-Late1:OPN	Optional1	0.0040	1.0000	No	
MontanePineOakHeath	1-Early1:ALL	1-Early1:ALL	ReplacementFire	0.0200	1.0000	Yes	
MontanePineOakHeath	2-Mid1:CLS	1-Early1:ALL	ReplacementFire	0.0133	1.0000	Yes	
MontanePineOakHeath	2-Mid1:OPN	1-Early1:ALL	ReplacementFire	0.0080	1.0000	Yes	
MontanePineOakHeath	3-Late1:CLS	1-Early1:ALL	ReplacementFire	0.0120	1.0000	Yes	
MontanePineOakHeath	3-Late1:OPN	1-Early1:ALL	ReplacementFire	0.0067	1.0000	Yes	
MontanePineOakHeath	1-Early1:ALL	1-Early1:ALL	SurfaceFire	0.0500	1.0000	No	
MontanePineOakHeath	2-Mid1:CLS	2-Mid1:CLS	SurfaceFire	0.0450	0.9000	No	
MontanePineOakHeath	2-Mid1:CLS	2-Mid1:OPN	SurfaceFire	0.0450	0.1000	No	
MontanePineOakHeath	2-Mid1:OPN	2-Mid1:OPN	SurfaceFire	0.0500	1.0000	No	
MontanePineOakHeath	3-Late1:CLS	3-Late1:CLS	SurfaceFire	0.0400	0.9000	No	
MontanePineOakHeath	3-Late1:CLS	3-Late1:OPN	SurfaceFire	0.0400	0.1000	No	
MontanePineOakHeath	3-Late1:OPN	3-Late1:OPN	SurfaceFire	0.0450	1.0000	No	
MontanePineOakHeath	2-Mid1:CLS	2-Mid1:OPN	Wind/Weather/Stress	0.0033	1.0000	No	
MontanePineOakHeath	2-Mid1:OPN	2-Mid1:OPN	Wind/Weather/Stress	0.0033	1.0000	No	
MontanePineOakHeath	3-Late1:CLS	1-Early1:ALL	Wind/Weather/Stress	0.0025	1.0000	Yes	
MontanePineOakHeath	3-Late1:CLS	3-Late1:OPN	Wind/Weather/Stress	0.0033	1.0000	No	
MontanePineOakHeath	3-Late1:OPN	1-Early1:ALL	Wind/Weather/Stress	0.0025	1.0000	Yes	
MontanePineOakHeath	3-Late1:OPN	3-Late1:OPN	Wind/Weather/Stress	0.0033	1.0000	No	

NorthernHardwood	Mid1:OPN	2-Mid1:CLS	AltSuccession	1.0000	1.0000	No	25
NorthernHardwood	3-Late1:OPN	3-Late1:CLS	AltSuccession	1.0000	1.0000	No	25
NorthernHardwood	3-Late1:CLS	3-Late1:OPN	Insect/Disease	0.0050	1.0000	No	
NorthernHardwood	3-Late1:OPN	3-Late1:OPN	Insect/Disease	0.0050	1.0000	No	
NorthernHardwood	1-Early1:ALL	2-Mid1:OPN	MixedFire	0.0020	1.0000	Yes	
NorthernHardwood	2-Mid1:CLS	2-Mid1:OPN	MixedFire	0.0015	1.0000	No	
NorthernHardwood	2-Mid1:OPN	2-Mid1:OPN	MixedFire	0.0020	1.0000	No	
NorthernHardwood	3-Late1:CLS	3-Late1:OPN	MixedFire	0.0015	1.0000	No	
NorthernHardwood	3-Late1:OPN	3-Late1:OPN	MixedFire	0.0010	1.0000	No	
NorthernHardwood	2-Mid1:CLS	1-Early1:ALL	Optional1	0.0030	1.0000	Yes	
NorthernHardwood	2-Mid1:OPN	1-Early1:ALL	Optional1	0.0030	1.0000	Yes	
NorthernHardwood	3-Late1:CLS	1-Early1:ALL	Optional1	0.0030	1.0000	Yes	
NorthernHardwood	3-Late1:OPN	1-Early1:ALL	Optional1	0.0030	1.0000	Yes	
NorthernHardwood	1-Early1:ALL	1-Early1:ALL	ReplacementFire	0.0015	1.0000	Yes	
NorthernHardwood	2-Mid1:CLS	1-Early1:ALL	ReplacementFire	0.0015	1.0000	Yes	
NorthernHardwood	2-Mid1:OPN	1-Early1:ALL	ReplacementFire	0.0015	1.0000	Yes	
NorthernHardwood	3-Late1:CLS	1-Early1:ALL	ReplacementFire	0.0015	1.0000	Yes	
NorthernHardwood	3-Late1:OPN	1-Early1:ALL	ReplacementFire	0.0015	1.0000	Yes	
NorthernHardwood	1-Early1:ALL	1-Early1:ALL	SurfaceFire	0.0030	1.0000	No	
NorthernHardwood	2-Mid1:CLS	2-Mid1:CLS	SurfaceFire	0.0030	1.0000	No	
NorthernHardwood	2-Mid1:OPN	2-Mid1:OPN	SurfaceFire	0.0030	1.0000	No	
NorthernHardwood	3-Late1:CLS	3-Late1:CLS	SurfaceFire	0.0030	1.0000	No	
NorthernHardwood	3-Late1:OPN	3-Late1:OPN	SurfaceFire	0.0030	1.0000	No	
NorthernHardwood	2-Mid1:CLS	2-Mid1:OPN	Wind/Weather/Stress	0.0025	1.0000	No	
NorthernHardwood	2-Mid1:OPN	2-Mid1:OPN	Wind/Weather/Stress	0.0070	1.0000	No	
NorthernHardwood	3-Late1:CLS	3-Late1:OPN	Wind/Weather/Stress	0.0025	1.0000	No	
NorthernHardwood	3-Late1:OPN	3-Late1:OPN	Wind/Weather/Stress	0.0070	1.0000	No	

RichAcidicCove	Mid1:OPN	2-Mid1:CLS	AltSuccession	1.0000	1.0000	No	20
RichAcidicCove	3-Late1:OPN	3-Late1:CLS	AltSuccession	1.0000	1.0000	No	20
RichAcidicCove	2-Mid1:CLS	2-Mid1:OPN	Insect/Disease	0.0040	1.0000	No	
RichAcidicCove	2-Mid1:OPN	2-Mid1:OPN	Insect/Disease	0.0040	1.0000	No	
RichAcidicCove	3-Late1:CLS	3-Late1:OPN	Insect/Disease	0.0040	1.0000	No	
RichAcidicCove	3-Late1:OPN	3-Late1:OPN	Insect/Disease	0.0040	1.0000	No	
RichAcidicCove	1-Early1:ALL	1-Early1:ALL	MixedFire	0.0020	1.0000	No	
RichAcidicCove	2-Mid1:CLS	2-Mid1:OPN	MixedFire	0.0020	1.0000	No	
RichAcidicCove	2-Mid1:OPN	2-Mid1:OPN	MixedFire	0.0020	1.0000	No	
RichAcidicCove	3-Late1:CLS	3-Late1:OPN	MixedFire	0.0020	1.0000	No	
RichAcidicCove	3-Late1:OPN	3-Late1:OPN	MixedFire	0.0020	1.0000	No	
RichAcidicCove	2-Mid1:CLS	1-Early1:ALL	Optional1	0.0020	1.0000	Yes	
RichAcidicCove	2-Mid1:OPN	1-Early1:ALL	Optional1	0.0020	1.0000	Yes	
RichAcidicCove	3-Late1:CLS	1-Early1:ALL	Optional1	0.0020	1.0000	Yes	
RichAcidicCove	3-Late1:OPN	1-Early1:ALL	Optional1	0.0020	1.0000	Yes	
RichAcidicCove	1-Early1:ALL	1-Early1:ALL	ReplacementFire	0.0010	1.0000	Yes	
RichAcidicCove	2-Mid1:CLS	1-Early1:ALL	ReplacementFire	0.0010	1.0000	Yes	
RichAcidicCove	2-Mid1:OPN	1-Early1:ALL	ReplacementFire	0.0010	1.0000	Yes	
RichAcidicCove	3-Late1:CLS	1-Early1:ALL	ReplacementFire	0.0010	1.0000	Yes	
RichAcidicCove	3-Late1:OPN	1-Early1:ALL	ReplacementFire	0.0010	1.0000	Yes	
RichAcidicCove	1-Early1:ALL	1-Early1:ALL	SurfaceFire	0.0100	1.0000	No	
RichAcidicCove	2-Mid1:CLS	2-Mid1:CLS	SurfaceFire	0.0100	1.0000	No	
RichAcidicCove	2-Mid1:OPN	2-Mid1:OPN	SurfaceFire	0.0100	1.0000	No	
RichAcidicCove	3-Late1:CLS	3-Late1:CLS	SurfaceFire	0.0100	1.0000	No	
RichAcidicCove	3-Late1:OPN	3-Late1:OPN	SurfaceFire	0.0100	1.0000	No	
RichAcidicCove	2-Mid1:CLS	1-Early1:ALL	Wind/Weather/Stress	0.0020	1.0000	Yes	
RichAcidicCove	2-Mid1:CLS	2-Mid1:OPN	Wind/Weather/Stress	0.0030	1.0000	No	
RichAcidicCove	2-Mid1:OPN	2-Mid1:OPN	Wind/Weather/Stress	0.0030	1.0000	No	
RichAcidicCove	3-Late1:CLS	1-Early1:ALL	Wind/Weather/Stress	0.0020	1.0000	Yes	
RichAcidicCove	3-Late1:CLS	3-Late1:OPN	Wind/Weather/Stress	0.0030	1.0000	No	
RichAcidicCove	3-Late1:OPN	1-Early1:ALL	Wind/Weather/Stress	0.0020	1.0000	Yes	

Appendix 6. Fire in Reference Condition Models and Park Fire History Summary -- Annual average total acres burned by decade.

Modeled Fire in ST-Sim - Reference Conditions (NRV)				
Ecological System	**Estimated Acres**	**% ot Total Acres**	**AllFire Probability**	**Est. Acres/Yr Burned**
Dry Oak	78,800	15%	0.094	7,400
Dry-Mesic Oak	59,600	12%	0.053	3,200
Mesic Oak	60,400	12%	0.036	2,200
High Elev Red Oak	23,400	5%	0.049	1,100
Low Elevation Pine	17,100	3%	0.130	2,200
Low Elev Pine-Oak Heath	8,800	2%	0.116	1,000
Montane Pine-Oak Heath	18,700	4%	0.080	1,500
Cove	128,300	25%	0.006	800
No. Hardwoods	66,800	13%	0.002	100
Spruce-Fir	40,800	8%	0.001	40
Alluvial (use Cove FRI)	7,800	2%	0.006	50
Ave/Weighted Ave	510,500	100%	0.038	**19,600**
5 Focal Oak & Pine Systems	**183,000**	**36%**	0.084	**15,300**

Fire History in Park: Annual Average Acres by Decade 1920-2000				
Ave. 1920s				1,100
Ave. 1930s				300
Ave. 1940s				600
Ave. 1950s				200
Ave. 1960s				100
Ave. 1970s				400
Ave. 1980s				1,000
Ave. 1990s				400
1920-2000 Annual Average				**513**
Ave. % of Reference Condition Fire				**2.6%**

Fire History in Park: Annual Average Acres 2000 - 2012				
Prescribed Fire			1,075	5.5%
All Other Fire			1,460	7.4%
2000-2012 Annual Average				**2,535**
Ave. % of Reference Condition Fire				**12.9%**

Appendix 7. Excel model runs worksheet – summary all systems and scenarios.

Great Smoky Mountains National Park											
Departure from Natural Range of Variability											
Ecological System	**% of Acres**	**Acres**	**Current Ecological Departure**	**No Action Ecological Departure 20 Yrs**	**No Action Ecological Departure 40 Yrs**	**Max Mgmt Ecological Departure 20 Yrs**	**Current Mgmt (1500 Ac/Yr) Ecological Departure 20 Yrs**	**Preferred Mgmt (5000 Ac/Yr) Ecological Departure 20 Yrs**	**Preferred Restore & Maintain (5000 Ac/Yr) Ecological Departure 40 Yrs**	**Current Mgmt Restore & Maintain (1500 Ac/Yr) 40 Yrs**	**Max Mgmt Ecological Departure 40 Yrs**
Dry Oak Forest	16%	80,300	**66**	**56**	**51**	**28**	**54**	**50**	**42**	**48**	**20**
Dry-Mesic Oak Forest	13%	66,000	**57**	**48**	**45**	**32**	**47**	**45**	**38**	**43**	**21**
Mesic Oak Forest	12%	60,500	**32**	**30**	**34**	**26**					
High Elevation Red Oak Forest	4%	22,300	**59**	**44**	**40**	**24**					
Low Elevation Pine Forest	3%	17,800	**66**	**63**	**64**	**28**	**60**	**52**	**49**	**58**	**26**
Low Elevation Pine-Oak Heath	2%	8,800	**70**	**57**	**51**	**34**	**52**	**43**	**29**	**43**	**21**
Montane Pine-Oak Heath	4%	18,800	**64**	**51**	**45**	**32**	**50**	**46**	**36**	**42**	**17**
Cove Forest	24%	123,800	**30**	**22**	**16**						
Northern Hardwood Forest	13%	67,800	**25**	**14**	**12**						
Spruce-Fir Forest	8%	40,900									
Montane Alluvial	2%	7,900									
Total Acres		514,900									
		Total Acres				RxFire Acres / Year	RxFire Acres / Year	RxFire Acres / Year	RxFire Acres / Year	RxFire Acres / Year	RxFire Acres / Year
Dry Oak		80,300				9,000	450	1,500	1,500	450	9,000
Dry-Mesic Oak		66,000				3,750	225	750	750	225	3,750
Mesic Oak		60,500				3,000	-	-	-	-	3,000
High Elevation Red Oak		22,300				1,800	-	-	-	-	1,800
Low Elevation Pine		17,800				2,400	180	600	600	180	2,400
Low Elevation Pine-Oak Heath		8,800				1,500	150	500	500	150	1,500
Montane Pine-Oak Heath		18,800				2,700	120	400	400	120	2,700
All Other Systems		240,400				-	375	1,250	1,250	375	-
Total Acres Rx Fire						**24,150**	**1,500**	**5,000**	**5,000**	1,500	24,150
Ave. Annual Cost All RxFire	*$ 50*	*per acre*				**$1,208,000**	**$ 75,000**	**$ 250,000**	**$ 250,000**	**$ 75,000**	**$1,208,000**

Appendix 8. Excel model runs worksheet – Dry Oak Forest

Dry Oak Forest										
Vegetation Class	**NRV** Mean	**Current %**	**No Action - 20 Yrs**	**No Action 40 Yrs**	**Max Mgmt 20 Yrs**	**Current Mgmt 1.5K Parkwide - 20 Yrs**	**Preferred Mgmt 5K Parkwide - 20 Yrs**	**Restore-Maintain 40 Yrs**	**Current Level 40 Yrs**	**Max Mgmt 20 Yrs**
Early	17%	2%	6%	6%	17%	6%	8%	9%	6%	25%
Mid-Closed	9%	0%	2%	7%	1%	2%	2%	7%	7%	7%
Mid-Open	21%	0%	0%	0%	1%	0%	0%	2%	1%	4%
Late-Closed	24%	90%	80%	75%	46%	78%	74%	66%	72%	31%
Late-Open	29%	8%	12%	12%	35%	13%	16%	16%	14%	34%
Highly Departed Composition	0%	0%	0%	0%					0%	0%
Totals	100%	100%	100%	100%	100%	99%	100%	100%	100%	101%
Total Early/Open										
Total Closed	33%	90%	82%	82%	47%	80%	76%	73%	79%	38%
Ecological Departure		**66**	**56**	**51**	**28**	**54**	**50**	**42**	**48**	**20**
Open Canopy Departure		**57**	**49**	**49**	**14**	**47**	**43**	**40**	**46**	**5**
Total Management Cost					$ 9,000,000	$ 450,000	$ 1,500,000	$ 3,000,000	$ 900,000	###########
ROI					2.6	3.6	3.2	2.4	7.1	1.7
Treatments					**Max Mgmt 20 Yrs**	**Current Mgmt 1.5K Parkwide**	**Proposed Mgmt 5K Parkwide**	**Restore-Maintain 40 Yrs**	**Current Level 40 Yrs**	**Max Mgmt 40 Yrs**
RxFire-Restore (Realized Acres)					60,000	3,000	10,000	10,000	3,000	60,000
Acres/Yr Burned					9,000	450	1,500	1,500	450	9,000
Cost/Acre					$ 50	$ 50	$ 50	$ 50	$ 50	$ 50
# Years					20	20	20	20	20	20
RxFire-Restore (Realized Acres)								6,000	1,800	36,000
2nd 20 years								900	270	5,400
								$ 50	$ 50	$ 50
								20	20	20
Rx-Maintenance										
2nd 20 years								600	180	3,600
								$ 50	$ 50	$ 50
								20	20	20

Appendix 9. Excel model runs worksheet – Dry-Mesic Oak Forest.

Dry-Mesic Oak Forest

Vegetation Class	**NRV** Mean	**Current %**	**No Action - 20 Yrs**	**No Action 40 Yrs**	**Max Mgmt 20 Yrs**	**Current Mgmt 1.5K Parkwide - 20 Yrs**	**Preferred Mgmt 5K Parkwide - 20 Yrs**	**Restore-Maintain 40 Yrs**	**Current Level 40 Yrs**	**Max Mgmt 40 Yrs**
Early	9%	1%	3%	3%	9%	4%	5%	5%	4%	11%
Mid-Closed	9%	7%	5%	5%	4%	5%	4%	5%	5%	4%
Mid-Open	18%	1%	2%	3%	2%	2%	2%	4%	3%	8%
Late-Closed	32%	85%	76%	73%	60%	75%	73%	66%	71%	47%
Late-Open	31%	2%	10%	12%	20%	11%	12%	16%	13%	26%
Highly Departed Composition	0%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Totals	99%	100%	100%	100%	99%	101%	100%	100%	100%	100%
Total Early/Open										
Total Closed	41%	92%	81%	78%	64%	80%	77%	71%	76%	51%
Ecological Departure		**57**	**48**	**45**	**32**	**47**	**45**	**38**	**43**	**21**
Open Canopy Departure		**51**	**40**	**37**	**23**	**39**	**36**	**30**	**35**	**10**
Total Management Cost					$3,750,000	$ 225,000	$ 750,000	$ 1,500,000	$ 450,000	$ 7,500,000
ROI					2.8	2.9	2.6	3.1	7.3	2.5

Treatments	**Max Mgmt 20 Yrs**	**Current Mgmt 1.5K Parkwide**	**Proposed Mgmt 5K Parkwide**	**Restore-Maintain 40 Yrs**	**Current Level 40 Yrs**	**Max Mgmt 40 Yrs**
RxFire-Restore (Realized Acres)	25,000	1,500	5,000	5,000	1,500	25,000
Acres/Yr Burned	3,750	225	750	750	225	3,750
Cost/Acre	$ 50	$ 50	$ 50	$ 50	$ 50	$ 50
# Years	20	20	20	20	20	20
RxFire-Restore (Realized Acres)				3,000	900	15,000
2nd 20 years				450	135	2,250
				$ 50	$ 50	$ 50
				20	20	20
Rx-Maintenance						
2nd 20 years				300	90	1,500
				$ 50	$ 50	$ 50
				20	20	20

Appendix 10. Excel model runs worksheet – Low Elevation Pine Forest.

Low Elevation Pine Forest										
Vegetation Class	**NRV** Mean	**Current %**	**No Action - 20 Yrs**	**No Action 40 Yrs**	**Max Mgmt 20 Yrs**	**Current Mgmt 1.5K Parkwide - 20 Yrs**	**Preferred Mgmt 5K Parkwide - 20 Yrs**	**Restore-Maintain 40 Yrs**	**Current Level 40 Yrs**	**Max Mgmt 40 Yrs**
Early	13%	3%	5%	5%	17%	6%	9%	9%	6%	20%
Mid-Closed	10%	12%	16%	20%	12%	16%	15%	19%	19%	20%
Mid-Open	30%	4%	2%	2%	7%	2%	3%	4%	3%	11%
Late-Closed	12%	72%	66%	63%	31%	63%	56%	49%	58%	18%
Late-Open	35%	5%	8%	7%	31%	10%	14%	15%	10%	28%
Highly Departed Composition	0%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Totals	100%	100%	100%	100%	101%	100%	100%	99%	99%	100%
Total Early/Open										
Total Closed	22%	85%	82%	83%	43%	79%	71%	68%	77%	38%
Ecological Departure		**66**	**63**	**64**	**28**	**60**	**52**	**49**	**58**	**26**
Open Canopy Departure		**63**	**60**	**61**	**21**	**57**	**49**	**46**	**55**	**16**
Total Management Cost					$2,400,000	$ 180,000	$ 600,000	$ 1,200,000	$ 360,000	$ 4,800,000
ROI					2.7	3.0	3.3	2.2	3.0	1.4

Treatments			**Max Mgmt 20 Yrs**	**Current Mgmt 1.5K Parkwide**	**Proposed Mgmt 5K Parkwide**	**Restore-Maintain 40 Yrs**	**Current Level 40 Yrs**	**Max Mgmt 40 Yrs**
RxFire-Restore (Realized Acres)			16,000	1,200	4,000	4,000	1,200	16,000
Acres/Yr Burned			2,400	180	600	600	180	2,400
Cost/Acre			$ 50	$ 50	$ 50	$ 50	$ 50	$ 50
# Years			20	20	20	20	20	20
RxFire-Restore (Realized Acres)						2,400	720	9,600
2nd 20 years						360	108	1,440
						$ 50	$ 50	$ 50
						20	20	20
Rx-Maintenance						1,600	480	6,400
2nd 20 years						240	72	960
						$ 50	$ 50	$ 50
						20	20	20

Appendix 11. Excel model runs worksheet – Low Elevation Pine-Oak Heath.

Low Elevation Pine-Oak Heath

Vegetation Class	**NRV** Mean	**Current %**	**No Action - 20 Yrs**	**No Action 40 Yrs**	**Max Mgmt 20 Yrs**	**Current Mgmt 1.5K Parkwide - 20 Yrs**	**Preferred Mgmt 5K Parkwide - 20 Yrs**	**Restore-Maintain 40 Yrs**	**Current Level 40 Years**	**Max Mgmt 40 Yrs**
Early	21%	2%	9%	7%	25%	10%	13%	15%	11%	27%
Mid-Closed	13%	0%	7%	18%	7%	7%	7%	17%	18%	16%
Mid-Open	30%	0%	1%	3%	1%	1%	1%	7%	4%	13%
Late-Closed	15%	84%	71%	60%	24%	66%	54%	39%	52%	11%
Late-Open	21%	13%	11%	10%	41%	15%	24%	21%	13%	32%
Highly Departed Composition		1%	1%	1%	1%	1%	1%	1%	1%	1%
Totals	100%	100%	100%	99%	99%	100%	100%	100%	99%	100%
Total Early/Open										
Total Closed	28%	84%	78%	78%	31%	73%	61%	56%	70%	27%
Ecological Departure		**70**	**57**	**51**	**34**	**52**	**43**	**29**	**43**	**21**
Open Canopy Departure		**56**	**50**	**50**	**3**	**45**	**33**	**28**	**42**	**-1**
Total Management Cost					$1,500,000	$ 150,000	$ 499,950	$ 999,950	$ 300,000	$ 3,000,000
ROI					1.5	2.9	3.0	1.9	5.0	1.2

Treatments	**Max Mgmt 20 Yrs**	**Current Mgmt 1.5K Parkwide**	**Proposed Mgmt 5K Parkwide**	**Restore-Maintain 40 Yrs**	**Current Level 40 Years**	**Max Mgmt 40 Yrs**
RxFire-Restore (Realized Acres)	10,000	1,000	3,333	3,333	1,000	10,000
Acres/Yr Burned	1,500	150	500	500	150	1,500
Cost/Acre	$ 50	$ 50	$ 50	$ 50	$ 50	$ 50
# Years	20	20	20	20	20	20
RxFire-Restore (Realized Acres)				2,000	600	6,000
2nd 20 years				300	90	900
				$ 50	$ 50	$ 50
				20	20	20
Rx-Maintenance						
2nd 20 years				200	60	600
				$ 50	$ 50	$ 50
				20	20	20

Appendix 12. Excel model runs worksheet – Montane Pine-Oak Heath.

Montane Pine-Oak Heath										
Vegetation Class	**NRV** Mean	**Current %**	**No Action - 20 Yrs**	**No Action 40 Yrs**	**Max Mgmt 20 Yrs**	**Current Mgmt 1.5K Parkwide - 20 Yrs**	**Preferred Mgmt 5K Parkwide - 20 Yrs**	**Restore-Maintain 40 Yrs**	**Current Level 40 Yrs**	**Max Mgmt 40 Yrs**
Early	25%	6%	10%	10%	24%	12%	13%	14%	12%	29%
Mid-Closed	16%	1%	9%	19%	6%	9%	8%	18%	20%	14%
Mid-Open	25%	1%	1%	3%	3%	1%	1%	4%	4%	12%
Late-Closed	15%	78%	65%	56%	26%	64%	60%	48%	52%	13%
Late-Open	19%	14%	13%	11%	39%	14%	17%	14%	12%	31%
Highly Departed Composition	0%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Totals	100%	100%	99%	100%	99%	101%	100%	99%	101%	100%
Total Early/Open										
Total Closed	31%	79%	74%	75%	32%	73%	68%	66%	72%	27%
Ecological Departure		**64**	**51**	**45**	**32**	**50**	**46**	**36**	**42**	**17**
Open Canopy Departure		**48**	**43**	**44**	**1**	**42**	**37**	**35**	**41**	**-4**
Total Management Cost					$2,700,000	$ 120,000	$ 400,050	$ 800,050	$ 240,000	$ 5,400,000
ROI					1.5	1.6	2.3	2.1	8.6	1.3

Treatments	**Max Mgmt 20 Yrs**	**Current Mgmt 1.5K Parkwide**	**Proposed Mgmt 5K Parkwide**	**Restore-Maintain 40 Yrs**	**Current Level 40 Yrs**	**Max Mgmt 40 Yrs**
RxFire-Restore (Realized Acres)	18,000	800	2,667	2,667	800	18,000
Acres/Yr Burned	2,700	120	400	400	120	2,700
Cost/Acre	$ 50	$ 50	$ 50	$ 50	$ 50	$ 50
# Years	20	20	20	20	20	20
RxFire-Restore (Realized Acres)				1,600	480	10,800
2nd 20 years				240	72	1,620
				$ 50	$ 50	$ 50
				20	20	20
Rx-Maintenance						
2nd 20 years				160	48	1,080
				$ 50	$ 50	$ 50
				20	20	20

Attachment 09

Base Disturbance spreadsheet

Base Disturbance spreadsheet

period	PatchTotal	WF/noEE	Add EE	clusters	storms	insects	wf + ee
1	1752	381	0	762	600	771	381
2	1654	991	0	1982	450	213	991
3	1960	489	0	978	800	671	489
4	2372	1659	3912	3318	600	113	5571
5	3923	2868	420	5737	450	605	3288
6	1294	381	0	762	800	113	381
7	2190	991	0	1982	600	599	991
8	1052	489	0	978	450	113	489
9	3132	1659	3912	3318	800	673	5571
10	3581	2868	420	5737	600	113	3288
11	1480	381	0	762	450	649	381
12	1904	991	0	1982	800	113	991
13	1762	489	0	978	600	673	489
14	2222	1659	3912	3318	450	113	5571
15	4317	2868	420	5737	800	649	3288
16	1094	381	0	762	600	113	381
17	2090	991	0	1982	450	649	991
18	1402	489	0	978	800	113	489
19	2908	1659	3912	3318	600	649	5571
20	3431	2868	420	5737	450	113	3288
Average	2276	1278	866	2555	608	391	2144

1278

Attachment 10

Spectrum Alt E Tier 2 Outputs

output	mgmt_act	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Young Patch	M2 Dstb2		1482	3625	5028	6059	9727	10519	9797	6411	11536	11377	12028	10076	7373	10621	11533	11727	10148	6972	10025
Young Patch	Natural Disturbance	1483	2143	1958	3938	5699	1094	1356	756	2257	1417	441	880	651	1118	2487	376	965	677	1729	2905
Young Mgmt	Burning for Young Forest creation	981	1450	1613	1613	1680	1680	1727	1727	1727	1727	1727	1727	1727	1727	1727	1727	1727	1727	1727	1727
Young Mgmt	Clearcut with high retention	5683	7271	7426	9938	9848	9096	6922	8101	11078	9949	9782	8410	11011	11681	6224	5202	8844	12663	11355	7218
Young Mgmt	Clearcut with regular retention	26693	40516	51347	35671	24228	11422	21366	24025	30843	34706	44677	48342	37380	29014	19256	23104	24340	22923	31323	39301
Young Mgmt	Group Selection	1183	1395	1638	1930	2267	2671	3139	2671	3139	2671	3139	3317	3402	3317	3402	3317	3402	3317	2219	1922
Young Mgmt	Loftis Shelterwood	2510	1498		4024	4024	13411	12395	17747	15328	12435	12970	6092	9992	4253	13579	11731	11731	11002	12144	18041
Young Mgmt	Minimum Level	1419	352																		
Young Mgmt	Shelterwood 2-step with Loftis cut	1361	9494	16568	27607	37607	41795	32558	19209	14116	9590	4616	5221	13877	31826	33661	34132	26794	27118	22493	9290
Young Mgmt	shelterwood with conversion 2 period						1089	1521	1521	996	564	564						1089	1521	1521	432
Young Mgmt	Shelterwood with conversion 5 period	2131	3778	4251	2231	569		474	861	1356	882	2682	3306	3867	1680	1035	861	1356	882	503	1111
Young Mgmt	Thin and Burn	1222	178																		
Volume	Clearcut with high retention	12915	8997	9389	21092	9564	8131	13685	13290	18150	8130	10999	10875	16793	7638	9322	6719	17704	17268	7681	10383
Volume	Clearcut with regular retention	79529	42147	47685	15684	12249	15388	53491	21614	40586	49174	42781	44198	20562	20728	31183	37087	26059	19618	48331	38286
Volume	Group Selection	4594	5405	5356	6025	7411	8717	10257	8087	9518	8087	9518	10592	10537	10043	10314	10043	10314	10043	6724	5820
Volume	Loftis Shelterwood	1401		3352	6988	1642	24561	4132	28296	15194	10813	21161	2616	16292	547	20562	3843	17445	14789	5393	22566
Volume	Sanitation Thinning	923	934	595	1451	2677	2189	813	1157	1893	1533	482	1062	1530	1181	301					
Volume	Shelterwood 2-step with Loftis cut		23696	18224	37321	45460	29595	11543	15132	14788	2809		12009	22454	44774	28667	25647	7316	33890	17191	
Volume	shelterwood with conversion 2 period				1271	504	1705	1337		886						1271	504	1705	677	26	623
Volume	Shelterwood with conversion 5 period	3640	3007	1055		689	3491	3655	706	881		3895	2996	1784	952	846	6268	1570		15	2879
Volume	Thin and Burn	1875	1814	1172	63	2107	1814	1089	83	1974	2010	1089	83	99	196		83	99	196		
ThinAcre	Sanitation Thinning	2501	2500	1676	2501	5001	4176	1676	2501	5001	4176	1676	2501	5001	4176	1676					
ThinAcre	Shelterwood 2-step with Loftis cut			200	9	54															
ThinAcre	Thin and Burn	7500	7503	5025	296	8722	7503	4695	330	7974	8547	4695	330	474	1044		330	474	1044		
RegenAcre	Clearcut with high retention	3903	2822	2888	6304	2697	2362	3904	3878	5335	2776	3747	4074	5231	2376	2925	1944	5331	5388	2712	3917
RegenAcre	Clearcut with regular retention	24911	14818	16345	4508	3375	3666	14325	6034	10484	18188	16005	16913	6425	5676	7282	10146	6912	5865	18546	14890
RegenAcre	Loftis Shelterwood						4024		9521	2874	5352	7106		5897	195	3924	134	9521	2210		8792
RegenAcre	Shelterwood 2-step with Loftis cut		9440	7128	15258	19101	12175	4532	5888	6074	1013		5221	8656	17949	12464	11149	3181	12788	6524	
RegenAcre	shelterwood with conversion 2 period						1089	432		564								1089	432		
RegenAcre	Shelterwood with conversion 5 period					560	2019	1664	8				474	387	495		3306	561			474
OthrSheltAcr	Loftis Shelterwood	4024		9521	6898	5352	16627	2874	11249	7301	3924	6031	9716	6134	134	18313	5562	5897	8831	7242	6968
OthrSheltAcr	shelterwood with conversion 2 period				1089	432		564								1089	432			22	533
OthrHarvAcre	Group Selection	3590	4223	4969	5844	6877	8087	9518	8087	9518	8087	9518	10043	10314	10043	10314	10043	10314	10043	6724	5820
OldSerlOpen	Burn1		7418	93711	126513	166454	205602	232282	259995	261211	262645	237854	238825	238833	238833	238833	238833	238833	238833	238833	238833
OldSerlOpen	M2 Dstb2		84	380	971	2088	4212	5108	7161	8250	10698	11312	9839	8708	8733	8850	9004	9144	7845	6054	6500
OldSerlOpen	M2 Min2		151	417	501	501	501	507	643	643	731	580	314	241	386	386	597	643	669	709	743
OldSerlOpen	Thin and Burn		7500	13398	15836	16075	17771	19787	20028	20175	20177	20208	20357	21399	21546	21546	21546	21546	21546	21546	21546
OldSerlClose	Burn1	69051	87675	30912	43641	67727	74568	58337	33442	33645	34358	62152	63343	63343	63343	63343	63343	63343	63343	63343	63343
OldSerlClose	Burning for Young Forest creation	8903	12542	15406	18794	24801	26807	28416	26421	26546	27197	29781	29786	29786	29786	29786	29786	29786	29786	29786	29786
OldSerlClose	Clearcut with high retention	590	1119	559																	
OldSerlClose	Clearcut with regular retention	854	2201																		
OldSerlClose	Loftis Shelterwood	1219	1803	6508	7200	8328	1458	852	394	388	471	102	34						296		
OldSerlClose	M2 Dstb2													14	35	49	72	126	135	159	169
OldSerlClose	Minimum Level	40164	57445	75169	110128	162760	234299	297116	321185	325647	328942	331652	333686	335309	335767	336150	336150	336150	336150	336150	336150
OldSerlClose	Natural Disturbance	11027	15765	22251	25751	24178	22631	22141	22217	21519	20916	20636	19703	18712	17453	15374	16369	15359	14682	12953	10048
OldSerlClose	Sanitation Thinning										177	2593	5309	6677	6677	6677	6677	6677	6677	6677	6677
OldSerlClose	Shelterwood 2-step with Loftis cut		878	183																	
MixedAge	Group Selection					3590	7813	9192	10813	12721	14964	17605	17605	17605	17605	17605	19561	20357	20357	20357	20357
MidAgeOpen	Burn1		3596	6059	2479	1998	941	10	8												
MidAgeOpen	M2 Dstb2		439	1016	510	340		70	673	723	858	2650	2372	1147	1275	1695	3398	2447	1342	1299	1729
MidAgeOpen	M2 Min2		17	17	21	21		10	155	145	217	399	209	103	162	154	305	223	104	112	172
MidAgeOpen	Thin and Burn			239	535	1518	1222	178													
MidAgeClosed	Burn1	37205	12661	6530	5321	4500	3045	1191													
MidAgeClosed	Burning for Young Forest creation	3914	2959	1751	898	650	442	5													
MidAgeClosed	Clearcut with high retention	22920	18601	19079	18493	18787	18630	21599	21008	20369	21498	21665	23037	20436	19766	25223	26245	22603	18784	19772	23909
MidAgeClosed	Clearcut with regular retention	35151	34865	36724	55089	67578	77123	69739	63834	61497	57664	47133	43468	54990	63356	73114	69066	68020	69417	61047	52509
MidAgeClosed	Loftis Shelterwood	18066	17894	18273	16002	13211	8959	6019	5284	13549	16442	21804	28036	25011	30750	20078	21828	15791	19727	21088	15910
MidAgeClosed	M2 Dstb2					1482	3507	3725	5051	8123	4523	3613	2837	4619	7339	3794	3023	2679	4193	7543	4466
MidAgeClosed	Minimum Level	151370	92533	34763	13195	9665	7044	4498	2433	596	383										
MidAgeClosed	Natural Disturbance	12512	16139	15788	10187	5476	909	632	1979	1979	1979	1424									
MidAgeClosed	Sanitation Thinning	6677	6677	6677	6677	6677	6500	4084	1368												
MidAgeClosed	Shelterwood 2-step with Loftis cut	38180	22435	20943	21075	26446	30028	41299	57367	66200	71019	70772	72140	55808	32932	34772	40046	44413	48985	56625	69655
MidAgeClosed	shelterwood with conversion 2 period	656	564	338	147	119				1089	1521	1521	2085	2085	996	564	564				1089
MidAgeClosed	Shelterwood with conversion 5 period	1972	884	972	2992	4654	4749	4362	4347	3307	2146	861	1356	1356	3543	4188	4362	3867	4341	4720	1917
MidAgeClosed	Thin and Burn	867	1670	1518	1222																
LateSerlOpen	Burn1		44165	91638	73148	33688	11245	5970	6350	5142	3708	979	8								
LateSerlOpen	M2 Dstb2		204	546	1387	2142	4101	3883	2750	1895	948	1739	2590	4112	3842	4197	3854	3160	4715	4350	4756
LateSerlOpen	M2 Min2		110	84	23	23	163	223	87	98	155	155	372	544	426	554	371	309	467	377	409
LateSerlOpen	Thin and Burn	7500	7503	6391	3953	3953	2553	1581	1518	1371	1369	1338	1189	147							
LateSerlClos	Burn1	195866	146661	73326	51074	27809	6775	4386	2381	2178	1465	1191									
LateSerlClos	Burning for Young Forest creation	16541	14285	12629	10094	4335	2537	1365	790	665	14	5									
LateSerlClos	Clearcut with high retention	2246	4100	3998	2946	2691	3585	2867	2236											309	309
LateSerlClos	Clearcut with regular retention	29532	14694	3982	1491	564	3501	1215	4060	30		560	560				200	10	30		560
LateSerlClos	Loftis Shelterwood	13208	13808	10222	7777	9440	11175	15737	11578	5738	5655	127	841			1346	1444	7481	3978	1771	1052
LateSerlClos	M2 Dstb2									772	448	167	128	208	161	110	97	80	126	113	126
LateSerlClos	Minimum Level	142322	185167	225619	212422	163604	94758	34497	12514	9833	6757	4430	2396	838	383						
LateSerlClos	Natural Disturbance	21350	16672	9932	7221	6102	7260	6484	4812	2797	909	632	1979	1979	1979	1424					
LateSerlClos	Sanitation Thinning						177	2593	5309	6677	6500	4084	1368								
LateSerlClos	Shelterwood 2-step with Loftis cut	41068	47802	42915	31927	16556	8786	6752	4033	293		5221	3248	10924	15851	12176	6431	9402	4506	1491	1664
LateSerlClos	shelterwood with conversion 2 period	1429	1521	1747	1938	1966	996	564	564						1089	1521	1521	996	564	564	564
LateSerlClos	Shelterwood with conversion 5 period	1120	561				474	387	15	560	2195	1680	561								2195
LateSerlClos	Thin and Burn	11957	4695																		

Gaps	Clearcut with high retention	114	102	94	83	86	90	106	100	89	90	89	90	80	89	97	115	104	87	79	81
Gaps	Clearcut with regular retention	376	283	174	306	387	481	429	417	390	340	262	193	285	365	440	421	421	432	357	285
Gaps	Group Selection	114	98	74	66	57	46	32	16	16	16	16	16	4							
Gaps	Loftis Shelterwood	209	212	221	198	198	132	138	105	125	142	139	185	162	198	132	141	141	148	145	109
Gaps	Minimum Level	1810	1813	1813	1813	1813	1813	1813	1813	1813	1813	1813	1813	1813	1813	1813	1813	1813	1813	1813	1813
Gaps	Sanitation Thinning	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37
Gaps	Shelterwood 2-step with Loftis cut	511	455	413	312	243	210	285	382	422	443	477	478	428	312	262	241	337	349	387	407
Gaps	shelterwood with conversion 2 period	11	11	11	11	11	3	2	2	8	9	9	11	11	11	11	11	3	2	2	10
Gaps	Shelterwood with conversion 5 period	14	5	2	15	24	27	26	25	22	23	10	8	5	19	23	25	22	23	24	20
Gaps	Thin and Burn	100	105	106	106	106	106	106	106	106	106	106	106	106	106	106	106	106	106	106	106
Disturbance	M2 Dstb2						199	1873	745	2626	6912	1495	2391	1639	3636	5838	1217	2433	1229	3520	4643
Disturbance	Natural Disturbance	2499	3629	2927	5676	9646	1849	2289	1277	3817	2399	741	1488	1096	1898	4213	637	1638	1146	2706	4520
Burning	Burn1	382842	402838	405311	410042	379120	400350	400350	400350	379873	379298	379298	379298	379298	379298	379298	379298	379298	379298	379298	379298
Burning	Burning for Young Forest creation	39648	39648	39648	39648	42138	42138	42138	42138	42138	42138	42138	42138	42138	42138	42138	42138	42138	42138	42138	42138
Burning	Thin and Burn	7500	7503	5025	296	8722	7503	4695	330	7974	8547	4695	330	474	1044		330	474	1044		
AllHarvAcre	Clearcut with high retention	3903	2822	2888	6304	2697	2362	3904	3878	5335	2776	3747	4074	5231	2376	2925	1944	5331	5388	2712	3917
AllHarvAcre	Clearcut with regular retention	24911	14818	16345	4508	3375	3666	14325	6034	10484	18188	16005	16913	6425	5676	7282	10146	6912	5865	18546	14890
AllHarvAcre	Group Selection	3590	4223	4969	5844	6877	8087	9518	8087	9518	8087	9518	10043	10314	10043	10314	10043	10314	10043	6724	5820
AllHarvAcre	Loftis Shelterwood	4024		9521	6898	5352	20651	2874	20770	10175	9276	13137	9716	12031	329	22237	5696	15418	11041	7242	15760
AllHarvAcre	Sanitation Thinning	2501	2500	1676	2501	5001	4176	1676	2501	5001	4176	1676	2501	5001	4176	1676					
AllHarvAcre	Shelterwood 2-step with Loftis cut		9440	7328	15267	19155	12175	4532	5888	6074	1013		5221	8656	17949	12464	11149	3181	12788	6524	
AllHarvAcre	shelterwood with conversion 2 period				1089	432	1089	996		564						1089	432	1089	432	22	533
AllHarvAcre	Shelterwood with conversion 5 period	2020	1662	569		560	2019	2138	395	495		2187	1593	948	495	474	3693	1056		8	1577
AllHarvAcre	Thin and Burn	7500	7503	5025	296	8722	7503	4695	330	7974	8547	4695	330	474	1044		330	474	1044		

output	ForType	GA	Total Of amount	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
AllHarvAcre	01WP	BK	1865	57				196	362	216	8	122				196	362	197	8	141			
AllHarvAcre	01WP	BM	3453	312	149		36	112	238	359	125	459	149		36	112	238	359	125	459	149		36
AllHarvAcre	01WP	EE	15053	1571	207		293	336	595	1497	1318	2246	207	91	223	336	665	1395	1318	2325	207		223
AllHarvAcre	01WP	FL	5077	188	21		10		509	780	713	396	21		10		509	780	713	396	21		10
AllHarvAcre	01WP	GB	2166	42	28		84		140	411	188	155	28		84		140	411	188	155	28		84
AllHarvAcre	01WP	HD	10567	1462			145	331	443	1094	686	1769		24	145	331	443	1084	686	1779			145
AllHarvAcre	01WP	HI	6393	412			73	451	222	506	1219	529			51	451	211	402	1252	563			51
AllHarvAcre	01WP	NG	723						89	217	52	7					89	217	52				
AllHarvAcre	01WP	NM	6323	234			39	175	845	1232	224	559			39	175	837	1222	232	471			39
AllHarvAcre	01WP	NS	144	48								48								48			
AllHarvAcre	01WP	PL	954				4	11	207	151	69	33			4	11	207	151	69	33			4
AllHarvAcre	01WP	UM	5650	131	77			128	194	1608	502	220	77			128	194	1587	502	225	77		
Burning	01WP	BK	1337			9	9	29	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86
Burning	01WP	BM	10657			38	74	330	681	681	681	681	681	681	681	681	681	681	681	681	681	681	681
Burning	01WP	EE	29558			7	231	1345	1865	1865	1865	1865	1865	1865	1865	1865	1865	1865	1865	1865	1865	1865	1865
Burning	01WP	FL	9015			8	59	218	582	582	582	582	582	582	582	582	582	582	582	582	582	582	582
Burning	01WP	GB	2591			1	10	120	164	164	164	164	164	164	164	164	164	164	164	164	164	164	164
Burning	01WP	HD	43595			35	39	1536	2799	2799	2799	2799	2799	2799	2799	2799	2799	2799	2799	2799	2799	2799	2799
Burning	01WP	HI	10343			74	85	494	646	646	646	646	646	646	646	646	646	646	646	646	646	646	646
Burning	01WP	NG	718				3	40	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45
Burning	01WP	NM	8727			67	99	176	559	559	559	559	559	559	559	559	559	559	559	559	559	559	559
Burning	01WP	NS	440				8	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27
Burning	01WP	PL	2788			9	9	40	182	182	182	182	182	182	182	182	182	182	182	182	182	182	182
Burning	01WP	UM	11350			39	94	432	719	719	719	719	719	719	719	719	719	719	719	719	719	719	719
Disturbance	01WP	BK	193	23	132		10	5				10				1	2						10
Disturbance	01WP	BM	395			47	17	80	42	5		49			58			20	8	3			66
Disturbance	01WP	EE	1247	52	2	35	46	452	5	4	3			12			232			40	94	15	255
Disturbance	01WP	FL	106			28			27	23			2		22		2						2
Disturbance	01WP	Forest	4276									465	770	105	285	199	376	627	95	234	122	366	632
Disturbance	01WP	HD	2115	37	108	53	454	157	24	158	90	20	50	25		6	8	425	66	100		246	88
Disturbance	01WP	HI	109					75		5		6	20		3								
Disturbance	01WP	NG	4						2						2								
Disturbance	01WP	NM	700	33	14			201	76	10	32	83	214	17	20								
Disturbance	01WP	PL	304		118		39	12		117		4	5		7								2
Disturbance	01WP	UM	347	20	5	49	60	75		64	72									2			
Gaps	01WP	BK	56	4	4	4	4	3	1	0	1	3	4	4	4	3	1	0	1	3	4	4	4
Gaps	01WP	BM	67	4	4	4	5	5	4	2	1	1	3	4	5	5	4	2	1	1	3	4	5
Gaps	01WP	EE	383	22	22	22	27	26	23	17	13	7	13	19	27	26	23	17	13	7	13	19	27
Gaps	01WP	FL	140	10	10	10	10	10	8	4	1	2	6	9	10	10	8	4	1	2	6	9	10
Gaps	01WP	GB	42	3	3	3	3	3	3	1	0	0	2	3	3	3	3	1	0	0	2	3	3
Gaps	01WP	HD	270	13	13	14	20	18	16	12	11	5	10	13	20	18	16	12	11	5	10	13	20
Gaps	01WP	HI	179	12	12	12	13	10	9	7	4	4	6	12	13	10	9	7	4	4	6	12	13
Gaps	01WP	NG	14	1	1	1	1	1	1	0	0	0	1	1	1	1	1	0	0	0	1	1	1
Gaps	01WP	NM	193	13	13	13	14	13	9	3	3	5	11	12	14	13	9	3	3	5	11	12	14
Gaps	01WP	NS	0				0	0	0	0	0				0	0	0	0	0				0
Gaps	01WP	PL	28	2	2	2	2	2	1	0	0	1	2	2	2	2	1	0	0	1	2	2	2
Gaps	01WP	UM	154	11	11	11	11	11	10	2	0	1	9	11	11	11	10	2	0	1	9	11	11
LateSerlClos	01WP	BK	657	26	58	60	55	127	124	99	90	16	2										
LateSerlClos	01WP	BM	3530	356	435	518	495	409	351	396	290	146	76	30	8	8	8	4					
LateSerlClos	01WP	EE	10727	1416	1644	1231	1288	908	1559	1647	531	114	85	48	55	55	54	46				23	23
LateSerlClos	01WP	FL	3095	132	162	110	70	191	575	767	523	334	177	54									
LateSerlClos	01WP	Forest	302									98	42	4	63	12	11	13	11	9	14	12	13
LateSerlClos	01WP	GB	869	3	36	41	118	221	147	124	91	15	23	34	8	8							
LateSerlClos	01WP	HD	13313	3018	2986	2392	1804	743	730	687	342	176	134	93	73	73	31	31					
LateSerlClos	01WP	HI	2944	26	98	225	255	493	518	514	279	176	121	99								70	70
LateSerlClos	01WP	NG	159		2	2	12	12	42	42	15	8	5	5								7	7
LateSerlClos	01WP	NM	4995	127	255	302	377	781	705	969	837	270	139	27	5	5						98	98
LateSerlClos	01WP	NS	108			27	27	27	27														
LateSerlClos	01WP	PL	1284		2	158	298	290	297	127	61	26	10	15									
LateSerlClos	01WP	UM	2757	178	185	242	298	229	129	409	303	236	225	213	21	21	19	17				16	16
LateSerlOpen	01WP	BK	35								20	12	3										
LateSerlOpen	01WP	BM	150								50	50	50										
LateSerlOpen	01WP	EE	912								416	364	132										
LateSerlOpen	01WP	FL	147								67	55	25										
LateSerlOpen	01WP	Forest	6587			37	225	303	717	608	339	49	90	176	245	511	463	507	429	330	539	486	533
LateSerlOpen	01WP	GB	210								73	73	64										
LateSerlOpen	01WP	HD	538								241	186	111										
LateSerlOpen	01WP	HI	447								343	52	52										
LateSerlOpen	01WP	NG	108								37	37	34										
LateSerlOpen	01WP	NM	27								17	5	5										
LateSerlOpen	01WP	PL	45								15	15	15										
LateSerlOpen	01WP	UM	908								306	301	301										
MidAgeClosed	01WP	BK	12732	1080	961	912	958	667	274	83	259	558	774	782	904	708	346	149	337	558	755	763	904
MidAgeClosed	01WP	BM	21357	1705	1596	1439	1632	1566	1197	703	666	543	753	874	1293	1330	1092	769	756	535	745	870	1293
MidAgeClosed	01WP	EE	89001	6107	5809	5863	6803	6215	4496	3152	2846	1577	2866	4085	6062	5933	5359	4187	3205	1545	2733	4028	6130
MidAgeClosed	01WP	FL	34964	2682	2669	2698	2870	2738	1808	828	277	540	1299	2012	2398	2419	1910	1140	427	540	1299	2012	2398
MidAgeClosed	01WP	Forest	7498					98	322	440	752	1002	522	418	266	461	785	357	283	225	419	785	363
MidAgeClosed	01WP	GB	14066	1080	1019	1067	948	870	771	462	207	260	635	823	894	922	782	455	267	252	635	823	894
MidAgeClosed	01WP	HD	62089	4079	3849	3832	4882	4373	3673	2560	2196	1016	2068	2730	4323	3992	3573	2634	2279	943	2027	2713	4347
MidAgeClosed	01WP	HI	43358	3300	3231	3120	3407	2670	2323	1867	952	746	1252	2471	2949	2498	2287	1936	1135	783	1185	2367	2879
MidAgeClosed	01WP	NG	5337	414	412	412	402	402	281	64		89	306	358	365	365	276	59	7	96	313	358	358
MidAgeClosed	01WP	NM	45763	3869	3720	3754	3790	3051	2085	585	536	1064	2291	2515	3035	2860	2023	840	783	1149	2371	2505	2937
MidAgeClosed	01WP	NS	582	27	27		48	48	48	48	48				48	48	48	48	48				48
MidAgeClosed	01WP	PL	7800	961	889	686	519	493	272	82	15	222	373	442	471	460	253	106	48	222	373	442	471
MidAgeClosed	01WP	UM	41599	3354	3284	3233	3214	3102	2912	982	387	420	1949	2449	2652	2601	2407	820	446	415	1925	2411	2636
MidAgeOpen	01WP	Forest	2611		66	173	54	18					96	318	291	100	138	197	401	289	132	143	195
OldSerlClose	01WP	BK	1330				10	26	58	58	59	68	78	100	100	99	98	97	97	97	97	97	91
OldSerlClose	01WP	BM	10850	33	41	107	183	320	452	562	438	455	505	811	803	780	780	772	771	769	769	769	730
OldSerlClose	01WP	EE	35075	127	258	746	970	1543	1832	1888	1256	1290	1320	2472	2506	2506	2370	2365	2411	2387	2332	2323	2173
OldSerlClose	01WP	FL	7077	46	48	83	118	150	171	164	78	117	273	554	595	586	585	585	585	585	585	585	584
OldSerlClose	01WP	Forest	77													1	3	4	7	13	14	17	18

OldSerlClose	01WP	GB	1859					3	36	41	31	39	39	138	164	164	172	172	172	172	172	172	172
OldSerlClose	01WP	HD	57222	555	792	1586	2139	3116	3309	3413	2184	2171	2225	3728	3769	3765	3800	3548	3540	3481	3481	3336	3284
OldSerlClose	01WP	HI	6969				22	26	96	120	91	89	130	553	650	649	649	649	649	649	649	649	649
OldSerlClose	01WP	NG	458						1	0	2	2	5	42	46	45	45	45	45	45	45	45	45
OldSerlClose	01WP	NM	7528			1	85	127	198	205	237	500	477	570	573	565	570	570	570	570	570	570	570
OldSerlClose	01WP	NS	321							27	8	8	8	27	27	27	27	27	27	27	27	27	27
OldSerlClose	01WP	PL	2442						2	146	143	143	154	178	189	186	186	186	186	186	186	186	185
OldSerlClose	01WP	UM	8755	59	59	59	91	160	225	231	168	171	184	536	745	745	747	749	766	765	765	765	765
OldSerlOpen	01WP	BK	25									8	17										
OldSerlOpen	01WP	BM	618								206	206	206										
OldSerlOpen	01WP	EE	2430								698	750	982										
OldSerlOpen	01WP	FL	330								92	104	134										
OldSerlOpen	01WP	Forest	14646			8	19	188	215	395	819	1148	1051	1168	1190	1274	1367	1350	1316	1061	664	683	730
OldSerlOpen	01WP	GB	120								37	37	46										
OldSerlOpen	01WP	HD	3953								1256	1311	1386										
OldSerlOpen	01WP	HI	780								66	357	357										
OldSerlOpen	01WP	NG	3										3										
OldSerlOpen	01WP	NM	204								60	72	72										
OldSerlOpen	01WP	NS	57								19	19	19										
OldSerlOpen	01WP	PL	48								16	16	16										
OldSerlOpen	01WP	UM	106								32	37	37										
RegenAcre	01WP	BK	1865	57				196	362	216	8	122				196	362	197	8	141			
RegenAcre	01WP	BM	3453	312	149		36	112	238	359	125	459	149		36	112	238	359	125	459	149		36
RegenAcre	01WP	EE	15053	1571	207		293	336	595	1497	1318	2246	207	91	223	336	665	1395	1318	2325	207		223
RegenAcre	01WP	FL	5077	188	21		10		509	780	713	396	21		10		509	780	713	396	21		10
RegenAcre	01WP	GB	2166	42	28		84		140	411	188	155	28		84		140	411	188	155	28		84
RegenAcre	01WP	HD	10567	1462			145	331	443	1094	686	1769		24	145	331	443	1084	686	1779			145
RegenAcre	01WP	HI	6393	412			73	451	222	506	1219	529			51	451	211	402	1252	563			51
RegenAcre	01WP	NG	723						89	217	52	7					89	217	52				
RegenAcre	01WP	NM	6323	234			39	175	845	1232	224	559			39	175	837	1222	232	471			39
RegenAcre	01WP	NS	144	48								48								48			
RegenAcre	01WP	PL	954				4	11	207	151	69	33			4	11	207	151	69	33			4
RegenAcre	01WP	UM	5650	131	77			128	194	1608	502	220	77			128	194	1587	502	225	77		
Volume	01WP	BK	7843	242				825	1520	892	31	504				842	1550	830	31	576			
Volume	01WP	BM	14566	1318	633		142	462	997	1503	521	1939	636		145	468	1017	1532	530	1942	636		145
Volume	01WP	EE	62989	6588	870		1212	1410	2497	6226	5349	9447	888	353	954	1437	2816	5924	5397	9779	888		954
Volume	01WP	FL	21302	802	88		44		2138	3260	2942	1637	90		44		2180	3319	2984	1640	90		44
Volume	01WP	GB	9072	177	118		351		573	1705	790	642	119		358		582	1732	806	642	119		358
Volume	01WP	HD	44794	6217			611	1390	1857	4585	2859	7521		94	623	1417	1893	4630	2910	7564			623
Volume	01WP	HI	27047	1761			298	1900	925	2107	5120	2240			218	1930	893	1722	5348	2367			218
Volume	01WP	NG	3039						373	904	217	26					379	918	222				
Volume	01WP	NM	26682	1003			166	735	3541	5164	936	2306			169	749	3576	5224	984	1960			169
Volume	01WP	NS	612	204								204								204			
Volume	01WP	PL	4006				17	44	867	633	285	131			17	45	884	645	290	131			17
Volume	01WP	UM	23928	558	329			526	807	6761	2110	928	330			532	821	6795	2152	949	330		
Young Mgmt	01WP	BK	5607	63	63	57		196	558	774	586	346	130	122		196	558	755	567	346	149	141	
Young Mgmt	01WP	BM	10349	361	474	461	185	148	386	709	722	943	733	608	185	148	386	709	722	943	733	608	185
Young Mgmt	01WP	EE	45198	1956	1878	1778	500	629	1224	2428	3410	5061	3771	2544	521	650	1224	2396	3378	5038	3850	2532	430
Young Mgmt	01WP	FL	15298	246	238	209	31	10	519	1289	2002	1889	1130	417	31	10	519	1289	2002	1889	1130	417	31
Young Mgmt	01WP	GB	6436	95	123	70	112	84	224	551	739	754	371	183	112	84	224	551	739	754	371	183	112
Young Mgmt	01WP	HD	31865	1689	1689	1462	145	476	919	1868	2223	3549	2455	1793	169	500	919	1858	2213	3549	2465	1779	145
Young Mgmt	01WP	HI	19109	428	428	412	73	524	746	1179	1947	2254	1748	529	51	502	713	1064	1865	2217	1815	563	51
Young Mgmt	01WP	NG	2169						89	306	358	276	59	7			89	306	358	269	52		
Young Mgmt	01WP	NM	19067	322	322	234	39	214	1059	2252	2301	2015	783	559	39	214	1051	2234	2291	1925	703	471	39
Young Mgmt	01WP	NS	432	48	48	48						48	48	48						48	48	48	
Young Mgmt	01WP	PL	2854				4	15	222	369	427	253	102	33	4	15	222	369	427	253	102	33	4
Young Mgmt	01WP	UM	17001	163	227	208	77	128	322	1930	2304	2330	799	297	77	128	322	1909	2283	2314	804	302	77
Young Patch	01WP	BK	115	14	78		6	3				6				1	1						6
Young Patch	01WP	BM	237			29	12	47	25	3		29			34			12	5	2			39
Young Patch	01WP	EE	757	31	1	24	46	266	3	2	2			7			137			24	55	9	150
Young Patch	01WP	FL	63			17			16	14			1		13		1						1
Young Patch	01WP	Forest	16946		98	322	440	654	1052	1039	955	724	1176	1182	1266	1073	673	1092	1176	1235	1027	667	1095
Young Patch	01WP	HD	1264	22	64	32	281	93	14	93	53	12	30	15		4	5	251	39	59		145	52
Young Patch	01WP	HI	65					44		3		4	12		2								
Young Patch	01WP	NG	2						1						1								
Young Patch	01WP	NM	413	20	8			118	45	6	19	49	126	10	12								
Young Patch	01WP	PL	179		70		23	7		69		2	3		4								1
Young Patch	01WP	UM	214	12	3	30	43	44		38	43									1			
Disturbance	02SF	BK	485	37	3		5		7		3	249								90		56	35
Disturbance	02SF	BM	289	19		227	12							10		21							
Disturbance	02SF	EE	35						22				13										
Disturbance	02SF	FL	27						27														
Disturbance	02SF	Forest	1238							204			38	225	56	191	48	130	51	120	56	119	
Disturbance	02SF	GB	88	39	8													0		24		17	
Disturbance	02SF	HD	120	55			34				29									2			
Disturbance	02SF	NM	25		25																		
Disturbance	02SF	NS	323	23	33			154		18								95					
Disturbance	02SF	PL	212		14	24		68								34		19				47	6
Disturbance	02SF	UM	136	109							17	3											7
Gaps	02SF	BK	120	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Gaps	02SF	BM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gaps	02SF	GB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gaps	02SF	HD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gaps	02SF	NM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gaps	02SF	NS	60	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Gaps	02SF	PL	40	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Gaps	02SF	UM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LateSerlClos	02SF	BK	8832	3104	2649	1531	1474	74															
LateSerlClos	02SF	BM	2568	680	680	620	415	140	33														
LateSerlClos	02SF	EE	105				35	35	22	13													
LateSerlClos	02SF	Forest	118									14	14	68	4	3	3	2	2	2	2	2	2
LateSerlClos	02SF	GB	797	276	201	177	143																

LateSerlClos	02SF	HD	1086	251	251	286	264	33	1														
LateSerlClos	02SF	NM	1207	296	307	307	274	12	11														
LateSerlClos	02SF	NS	13419	2987	3892	3555	1142	936	906	1													
LateSerlClos	02SF	PL	7631	2501	2610	2111	190	150	35	34													
LateSerlClos	02SF	UM	660	219	219	212					2	2	2	2	2								
LateSerlOpen	02SF	Forest	2033			30	140	154	184	58		62	82	82	158	142	135	128	128	136	135	139	140
MidAgeClosed	02SF	BK	56	56																			
MidAgeClosed	02SF	BM	524	266	258																		
MidAgeClosed	02SF	EE	105	35	35	35																	
MidAgeClosed	02SF	Forest	3318					167	216	244	192	307	316	244	214	226	150	192	142	195	143	194	176
MidAgeClosed	02SF	HD	92	57	35																		
MidAgeClosed	02SF	NM	11	11																			
MidAgeClosed	02SF	NS	1179	1014	89	76																	
MidAgeClosed	02SF	PL	231	157	40	34																	
MidAgeClosed	02SF	UM	8				2	2	2	2													
MidAgeOpen	02SF	Forest	568		30	19					82	20		15	29		64	31	71	33	69	35	70
OldSerlClose	02SF	BK	136077	4219	4713	5830	5884	7282	7352	7349	7347	7200	7200	7200	7200	7200	7200	7200	7200	7147	7147	7114	7093
OldSerlClose	02SF	BM	11502	12	12	196	303	573	680	713	713	713	713	707	703	690	682	682	682	682	682	682	682
OldSerlClose	02SF	EE	31								13	13	5	0	0	0	0	0	0	0	0	0	0
OldSerlClose	02SF	FL	146	27	27	27	27	27	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OldSerlClose	02SF	Forest	34													2	2	4	4	5	5	6	6
OldSerlClose	02SF	GB	4674	24	78	99	133	276	276	276	276	276	276	276	276	276	276	276	276	262	262	252	252
OldSerlClose	02SF	HD	4355	29	29	29	31	248	280	281	264	264	264	264	264	264	264	264	264	263	263	263	263
OldSerlClose	02SF	NM	4957	25	10	0	33	295	296	307	307	307	307	307	307	307	307	307	307	307	307	307	307
OldSerlClose	02SF	NS	63785	105	96	433	2922	3037	3006	3900	3894	3894	3894	3894	3894	3894	3894	3838	3838	3838	3838	3838	3838
OldSerlClose	02SF	PL	43669	24	24	509	2454	2454	2542	2543	2577	2577	2577	2577	2577	2557	2543	2532	2532	2532	2532	2505	2501
OldSerlClose	02SF	UM	16932	709	665	672	884	884	884	884	874	872	872	872	872	874	874	874	874	874	874	874	870
OldSerlOpen	02SF	Forest	4473		83	98	108	115	173	322	387	283	220	225	229	296	338	370	235	209	222	274	286
Young Mgmt	02SF	UM	4	2	2																		
Young Patch	02SF	BK	287	22	2		3		4		2	147								53		33	21
Young Patch	02SF	BM	171	11		134	7							6		13							
Young Patch	02SF	EE	21						13				8										
Young Patch	02SF	FL	16						16														
Young Patch	02SF	Forest	5592		167	216	364	227	307	311	291	191	330	340	350	314	346	284	349	274	346	272	313
Young Patch	02SF	GB	52	23	5													0		14		10	
Young Patch	02SF	HD	70	32			20				17									1			
Young Patch	02SF	NM	15		15																		
Young Patch	02SF	NS	192	14	20			91		11								56					
Young Patch	02SF	PL	124		8	14		40								20		11				27	4
Young Patch	02SF	UM	80	64							10	2											4
AllHarvAcre	03SLP	FL	1102	142		338						142			338					142			
AllHarvAcre	03SLP	HI	1873	449		165					98	419	30		165				98	419		30	
AllHarvAcre	03SLP	NG	27	9								9								9			
AllHarvAcre	03SLP	NM	114			57									57								
Burning	03SLP	BM	1780	89	89	89	89	89	89	89	89	89	89	89	89	89	89	89	89	89	89	89	89
Burning	03SLP	EE	13140	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657
Burning	03SLP	FL	23600	1180	1180	1180	1180	1180	1180	1180	1180	1180	1180	1180	1180	1180	1180	1180	1180	1180	1180	1180	1180
Burning	03SLP	HD	1280	64	64	64	64	64	64	64	64	64	64	64	64	64	64	64	64	64	64	64	64
Burning	03SLP	HI	254840	12742	12742	12742	12742	12742	12742	12742	12742	12742	12742	12742	12742	12742	12742	12742	12742	12742	12742	12742	12742
Burning	03SLP	NG	2780	139	139	139	139	139	139	139	139	139	139	139	139	139	139	139	139	139	139	139	139
Burning	03SLP	NM	2200	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110
Burning	03SLP	PL	5240	262	262	262	262	262	262	262	262	262	262	262	262	262	262	262	262	262	262	262	262
Burning	03SLP	UM	10820	541	541	541	541	541	541	541	541	541	541	541	541	541	541	541	541	541	541	541	541
Disturbance	03SLP	BM	17												2						15		
Disturbance	03SLP	EE	483	42	27	5	87				106		9		7			66		65	17		52
Disturbance	03SLP	FL	461			10			5	19		254		5			72					42	54
Disturbance	03SLP	Forest	3344							168		43	605	129	213	186	370	508	91	163	110	270	488
Disturbance	03SLP	GB	1											1									
Disturbance	03SLP	HI	2611	122	249	172	369	823	15	109	16	52	75	20	52			79	2	91		176	189
Disturbance	03SLP	NG	32																19			13	
Disturbance	03SLP	NM	131							19			96		1		15						
Disturbance	03SLP	PL	2		2																		
Disturbance	03SLP	UM	441		5				91		19	152						173				1	
Gaps	03SLP	FL	39	2	2		1	1	3	3	3	2	2	2	1	1	1	3	3	2	2	2	3
Gaps	03SLP	HI	36	1	1	0	2	2	3	3	3	1	1	1	2	2	2	3	3	1	1	1	3
Gaps	03SLP	NG	0				0	0	0	0	0				0	0	0	0	0				0
Gaps	03SLP	NM	0	0	0				0	0	0	0	0	0				0	0	0	0	0	0
LateSerlClos	03SLP	BM	114	50	41	15		2	2	2	2												
LateSerlClos	03SLP	EE	958	47	25	104	104	146	123	175	112	70	52										
LateSerlClos	03SLP	FL	3907	676	654	180	129	82	352	435	427	200	96	338									338
LateSerlClos	03SLP	Forest	447									97	99	43	6	95	56	9	8	5	10	9	10
LateSerlClos	03SLP	GB	4					1	1	1	1												
LateSerlClos	03SLP	HD	96				32	32	32														
LateSerlClos	03SLP	HI	7578	2163	686	506	720	776	856	468	390	380	216	222							30		165
LateSerlClos	03SLP	NG	258	51	22	57	38	38		13	13	13	13										
LateSerlClos	03SLP	NM	778	70	69	12	19	19	131	120	112	112		57									57
LateSerlClos	03SLP	PL	12			3	4	4	1	0	0												
LateSerlClos	03SLP	UM	1673	324	175	175	62	204	302	205	162	63	1										
LateSerlOpen	03SLP	EE	45				15	15	15														
LateSerlOpen	03SLP	FL	377		94	94	21	56	56	56													
LateSerlOpen	03SLP	Forest	6538				104	248	765	783	758	575	67	111	258	378	324	402	327	252	410	372	404
LateSerlOpen	03SLP	HI	9941		644	132	3055	3055	3055														
LateSerlOpen	03SLP	NM	2		1	1																	
LateSerlOpen	03SLP	PL	348			37	116	116	79														
LateSerlOpen	03SLP	UM	98		38	21	13	13	13														
MidAgeClosed	03SLP	BM	8	2	2	2	2																
MidAgeClosed	03SLP	EE	1197	210	329	263	210	133	52														
MidAgeClosed	03SLP	FL	6966	288	365	455	593	511	576	480	480	338	338		142	142	142	480	480	338	338	338	142
MidAgeClosed	03SLP	Forest	6238					97	265	276	479	840	530	454	396	406	613	302	207	183	318	602	270
MidAgeClosed	03SLP	GB	4	1	1	1	1																
MidAgeClosed	03SLP	HD	96	32	32	32																	
MidAgeClosed	03SLP	HI	19303	4295	2458	2337	2074	1323	928	769	614	165	165	98	517	547	547	712	614	195	165	263	517

MidAgeClosed	03SLP	NG	227	38	38	13	22	22	22	9	9				9	9	9	9	9				9
MidAgeClosed	03SLP	NM	1075	19	131	131	112	112	57	57	57	57	57					57	57	57	57	57	
MidAgeClosed	03SLP	PL	128	122	5	1	0																
MidAgeClosed	03SLP	UM	1386	222	358	357	295	153	1														
MidAgeOpen	03SLP	EE	30		15	15																	
MidAgeOpen	03SLP	FL	168		56	56	56																
MidAgeOpen	03SLP	Forest	2242		66	180	150	188			67	67	17	215	120	46	107	133	303	221	101	109	152
MidAgeOpen	03SLP	HI	6110		3055	3055																	
MidAgeOpen	03SLP	PL	195		116	79																	
MidAgeOpen	03SLP	UM	26		13	13																	
OldSerlClose	03SLP	BM	769	9	3	29	44	44	44	44	44	46	46	46	45	44	44	44	44	44	35	35	35
OldSerlClose	03SLP	EE	8305	310	310	335	335	335	439	439	439	439	452	500	496	493	493	454	454	416	406	406	354
OldSerlClose	03SLP	FL	7875	47	63	199	250	379	379	379	379	456	458	551	549	549	507	478	478	478	478	436	382
OldSerlClose	03SLP	Forest	63													1	3	4	6	11	11	13	14
OldSerlClose	03SLP	GB	2									1	1	0	0	0	0	0	0	0	0	0	0
OldSerlClose	03SLP	HD	448							32	32	32	32	32	32	32	32	32	32	32	32	32	32
OldSerlClose	03SLP	HI	27448	989	346	538	806	867	1009	1485	1567	1570	1639	1756	1774	1753	1753	1706	1705	1651	1651	1536	1347
OldSerlClose	03SLP	NG	1053		3	6	25	25	63	63	63	63	63	76	76	76	76	76	65	65	65	52	52
OldSerlClose	03SLP	NM	361	40			12	12	12	12	12	12	67	29	28	28	19	13	13	13	13	13	13
OldSerlClose	03SLP	PL	240	10	9	9	9	9	12	13	13	13	13	13	13	13	13	13	13	13	13	13	13
OldSerlClose	03SLP	UM	3918	12	12	12	187	187	187	249	281	282	283	284	284	284	284	182	182	182	182	181	181
OldSerlOpen	03SLP	BM	285		15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
OldSerlOpen	03SLP	EE	628		22	22	22	22	22	37	37	37	37	37	37	37	37	37	37	37	37	37	37
OldSerlOpen	03SLP	FL	3483		62	62	135	156	156	156	212	212	212	212	212	212	212	212	212	212	212	212	212
OldSerlOpen	03SLP	Forest	13463							27	112	351	1109	1181	1191	1255	1322	1401	1479	1571	1327	552	585
OldSerlOpen	03SLP	HI	82274		1476	1988	2120	2120	2120	5175	5175	5175	5175	5175	5175	5175	5175	5175	5175	5175	5175	5175	5175
OldSerlOpen	03SLP	NG	494		26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
OldSerlOpen	03SLP	NM	777		40	40	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41
OldSerlOpen	03SLP	PL	1680		1	1	1	1	38	117	117	117	117	117	117	117	117	117	117	117	117	117	117
OldSerlOpen	03SLP	UM	2954		111	128	149	149	149	162	162	162	162	162	162	162	162	162	162	162	162	162	162
RegenAcre	03SLP	FL	1102	142		338						142			338					142			
RegenAcre	03SLP	HI	1873	449		165					98	419	30		165				98	419		30	
RegenAcre	03SLP	NG	27	9								9								9			
RegenAcre	03SLP	NM	114			57									57								
Volume	03SLP	FL	3521	434		1142						436			1073					436			
Volume	03SLP	HI	5893	1399		559					306	1302	97		525				306	1302		97	
Volume	03SLP	NG	87	29								29								29			
Volume	03SLP	NM	372			192									180								
Young Mgmt	03SLP	BM	20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Young Mgmt	03SLP	EE	275	9	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
Young Mgmt	03SLP	FL	3678	153	161	499	357	357	19	19	19	161	161	161	357	357	357	19	19	161	161	161	19
Young Mgmt	03SLP	HD	39	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Young Mgmt	03SLP	HI	6957	579	607	674	225	225	60	60	158	577	607	509	255	225	225	60	158	577	577	509	90
Young Mgmt	03SLP	NG	120	10	11	11	2	2	2	2	2	11	11	11	2	2	2	2	2	11	11	11	2
Young Mgmt	03SLP	NM	361	0	1	58	58	58	1	1	1	1	1	1	58	58	58	1	1	1	1	1	1
Young Mgmt	03SLP	PL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Young Mgmt	03SLP	UM	98	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Young Patch	03SLP	BM	10												1						9		
Young Patch	03SLP	EE	306	25	16	3	51				63		5		4			39		38	10		52
Young Patch	03SLP	FL	311			6			3	11		150		3			42					42	54
Young Patch	03SLP	Forest	13182		97	265	375	548	864	919	736	361	921	917	975	827	583	843	922	920	807	496	806
Young Patch	03SLP	GB	1											1									
Young Patch	03SLP	HI	1632	72	147	101	218	486	9	65	10	31	44	12	31			47	1	54		115	189
Young Patch	03SLP	NG	24																11			13	
Young Patch	03SLP	NM	78							11			57		1		9						
Young Patch	03SLP	PL	1		1																		
Young Patch	03SLP	UM	261		3				54		11	90						102				1	
AllHarvAcre	04PP	BK	637				10		10	199		199						10		10			199
AllHarvAcre	04PP	BM	649				68	65	67	78		43	29			1	29	67	36	68	65	12	21
AllHarvAcre	04PP	EE	4476				434	482	386	408		322	338			48	338	386	144	434	492		264
AllHarvAcre	04PP	FL	1276				138	181	138	52			129				129	138	52	138	181		
AllHarvAcre	04PP	GB	105				18	6	18	9		3						18	6	18	6		3
AllHarvAcre	04PP	HD	402				40	53	40	63		10						40	53	40	53		10
AllHarvAcre	04PP	HI	1045				135	115	132	86		18	44			3	44	132	71	135	115		15
AllHarvAcre	04PP	NG	83				6	5	2	13		17	5			4	5	2		6	5		13
AllHarvAcre	04PP	NM	1270				214	96	214	20		96				86		214	10	300	10	10	
AllHarvAcre	04PP	UM	768				113	73	82	68		39	13			31	13	82	60	113	73		8
Burning	04PP	BK	8776	257	257	459	459	459	459	459	459	459	459	459	459	459	459	459	459	459	459	459	459
Burning	04PP	BM	2616	116	116	116	117	156	127	127	127	128	156	127	127	128	156	127	127	128	156	127	127
Burning	04PP	EE	129132	5962	5962	6000	6048	6817	6479	6479	6479	6527	6817	6479	6479	6527	6817	6479	6479	6527	6817	6479	6479
Burning	04PP	FL	23652	916	916	916	916	1346	1217	1217	1217	1217	1346	1217	1217	1217	1346	1217	1217	1217	1346	1217	1217
Burning	04PP	GB	2248	86	86	86	86	119	119	119	119	119	119	119	119	119	119	119	119	119	119	119	119
Burning	04PP	HD	6652	115	115	115	115	387	387	387	387	387	387	387	387	387	387	387	387	387	387	387	387
Burning	04PP	HI	2076	88	88	88	91	140	96	96	96	99	140	96	96	99	140	96	96	99	140	96	96
Burning	04PP	NG	780	34	34	34	38	43	38	38	38	42	43	38	38	42	43	38	38	42	43	38	38
Burning	04PP	NM	8568	404	404	412	412	498	412	412	412	498	412	412	412	498	412	412	412	498	412	412	412
Burning	04PP	PL	5552	272	272	272	272	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279
Burning	04PP	UM	16218	747	747	778	809	825	812	812	812	843	825	812	812	843	825	812	812	843	825	812	812
Disturbance	04PP	BK	980		56	62		171		37				60		87		263	31		3	9	201
Disturbance	04PP	BM	780	25	3	1	59	306		135		22	1	4	58			112		34		20	
Disturbance	04PP	EE	4902	251	217	143	641	590	151	97	149	697	73	117	126	3	256	370		312	54	376	279
Disturbance	04PP	FL	399		57	45	44	203	13		11	5	9			2	7			2			1
Disturbance	04PP	Forest	6887							358	14	202	1569	140	404	178	637	978	205	347	244	571	1040
Disturbance	04PP	GB	41		21		12							2		6							
Disturbance	04PP	HD	46					5	7	5			4			25							
Disturbance	04PP	HI	383	3		121	20	156		31	15			3					3			31	
Disturbance	04PP	NG	245		87	8		45		16		80					3	6					
Disturbance	04PP	NM	504				145	185		3	57			13		20							81
Disturbance	04PP	NS	59	27												32							
Disturbance	04PP	PL	99		4				22		47						12	4				10	
Disturbance	04PP	UM	777	63	164	29	42	89	46		8	72		7		60	54	31	2			56	54
Gaps	04PP	BK	17	1	1	1	1	1	1	1	1	0	0	0	1	1	1	1	1	1	1	1	1

Gaps	04PP	BM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gaps	04PP	EE	111	5	7	7	7	7	4	3	3	5	6	6	7	7	7	7	7	4	3	3	6
Gaps	04PP	FL	33	1	2	2	2	2	1	1	1	2	2	2	2	2	2	2	2	1	1	1	2
Gaps	04PP	GB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gaps	04PP	HD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gaps	04PP	HI	14	1	1	1	1	1	0	0	0	1	1	1	1	1	1	1	1	0	0	0	1
Gaps	04PP	NG	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gaps	04PP	NM	46	2	2	3	3	3	1	1	1	3	3	3	3	3	3	3	3	1	1	1	3
Gaps	04PP	UM	14	1	1	1	1	1	0	0	0	1	1	1	1	1	1	1	1	0	0	0	1
LateSerlClos	04PP	BK	3503	748	478	436	209	209	199	199	199						10	10	10	199	199	199	199
LateSerlClos	04PP	BM	3428	916	758	615	364	134	79	43	42						67	103	103	78	42	42	42
LateSerlClos	04PP	EE	23495	7501	4800	3148	1789	733	410	264	274			47	480	480	866	963	530	418	264	264	264
LateSerlClos	04PP	FL	3526	1144	889	453	217	201	52								138	190	190	52			
LateSerlClos	04PP	Forest	479									219	94	8	11	19	16	18	17	13	22	20	22
LateSerlClos	04PP	GB	411	116	104	41	24	27	9	3	3						18	24	24	9	3	3	3
LateSerlClos	04PP	HD	1263	255	198	149	149	110	63	10	10						40	93	93	63	10	10	10
LateSerlClos	04PP	HI	2813	585	591	402	242	208	86	15	15						132	203	203	86	15	15	15
LateSerlClos	04PP	NG	639	257	206	40	37	2	13	13	13						2	2	2	13	13	13	13
LateSerlClos	04PP	NM	3146	839	671	433	227	224	20	10	10						214	224	224	20	10	10	10
LateSerlClos	04PP	NS	0		0	0	0	0															
LateSerlClos	04PP	PL	343	240	103																		
LateSerlClos	04PP	UM	2987	1073	610	383	225	154	68	8	8						82	142	142	68	8	8	8
LateSerlOpen	04PP	BK	56		28	28																	
LateSerlOpen	04PP	BM	180						1	30	30	30	30	30	29								
LateSerlOpen	04PP	EE	6616		1600	1488	1212		48	386	386	386	386	386	338								
LateSerlOpen	04PP	FL	1512		248	248	242			129	129	129	129	129	129								
LateSerlOpen	04PP	Forest	7443		149	157	100	78	31	14	6		143	318	444	770	683	758	703	544	879	799	867
LateSerlOpen	04PP	HI	297		5	5	5		3	47	47	47	47	47	44								
LateSerlOpen	04PP	NG	54						4	9	9	9	9	9	5								
LateSerlOpen	04PP	NM	649		129		4				86	86	86	86	86	86							
LateSerlOpen	04PP	PL	130		65	65																	
LateSerlOpen	04PP	UM	987		241	241	241		31	44	44	44	44	44	13								
MidAgeClosed	04PP	BK	1524	243	226							10	10	10	209	209	199	199	199				10
MidAgeClosed	04PP	BM	1051	48	75	74	50	12				67	103	103	145	145	78	42	42				67
MidAgeClosed	04PP	EE	9077	446	681	1094	429	81	10	57	480	866	1010	963	804	804	418	274	274				386
MidAgeClosed	04PP	FL	1521	46	129	129	129					138	190	190	190	190	52						138
MidAgeClosed	04PP	Forest	11038					219	577	582	746	1437	695	474	355	715	1245	614	447	399	677	1280	576
MidAgeClosed	04PP	GB	165	3	3	3	3					18	24	24	27	27	9	3	3				18
MidAgeClosed	04PP	HD	633	48	10	10	10					40	93	93	103	103	63	10	10				40
MidAgeClosed	04PP	HI	1448	30	62	62	59	13				132	203	203	218	218	86	15	15				132
MidAgeClosed	04PP	NG	169	17	22	22	18	13				2	2	2	15	15	13	13	13				2
MidAgeClosed	04PP	NM	1606	10	10	96	96	10				214	224	224	234	234	20	10	10				214
MidAgeClosed	04PP	NS	11	11																			
MidAgeClosed	04PP	UM	1009	58	53	53	13					82	142	142	150	150	68	8	8				82
MidAgeOpen	04PP	BM	60				1	30	29														
MidAgeOpen	04PP	EE	772				48	386	338														
MidAgeOpen	04PP	FL	258					129	129														
MidAgeOpen	04PP	Forest	4070			1					143	149	87	540	470	218	233	326	646	473	221	237	326
MidAgeOpen	04PP	HI	94				3	47	44														
MidAgeOpen	04PP	NG	18				4	9	5														
MidAgeOpen	04PP	NM	258					86	86	86													
MidAgeOpen	04PP	UM	88				31	44	13														
OldSerlClose	04PP	BK	13264	428	654	862	963	862	794	772	757	757	757	722	722	671	671	516	498	498	496	491	373
OldSerlClose	04PP	BM	5339	10	158	300	539	573	444	364	311	298	288	286	252	252	252	186	186	166	166	154	154
OldSerlClose	04PP	EE	63037	408	1340	2878	4241	4876	4318	4202	4076	3605	3283	3185	3111	3109	2958	2787	3220	3036	3004	2782	2618
OldSerlClose	04PP	FL	4671	5	12	398	590	468	240	235	229	221	214	210	210	209	205	205	205	204	204	204	203
OldSerlClose	04PP	Forest	124													2	6	8	11	21	22	26	28
OldSerlClose	04PP	GB	940	8	8	62	72	67	51	51	51	51	51	50	50	46	46	46	46	46	46	46	46
OldSerlClose	04PP	HD	1901	38	133	182	182	228	94	88	86	86	84	82	82	67	67	67	67	67	67	67	67
OldSerlClose	04PP	HI	1816	34	34	152	251	186	123	104	83	77	77	75	74	74	74	74	72	72	72	54	54
OldSerlClose	04PP	NG	1086	9	9	134	134	142	122	112	106	59	27	27	27	27	25	21	21	21	21	21	21
OldSerlClose	04PP	NM	3783	94	114	352	468	303	229	227	192	169	169	161	161	149	149	149	149	149	149	149	101
OldSerlClose	04PP	NS	488	32	32	32	32	32	32	32	32	32	32	32	32	13	13	13	13	13	13	13	13
OldSerlClose	04PP	PL	2102		70	171	171	171	154	145	117	98	98	98	98	98	91	89	89	89	89	83	83
OldSerlClose	04PP	UM	7609	195	313	457	572	573	496	478	473	427	399	395	394	359	327	309	308	308	308	275	243
OldSerlOpen	04PP	BK	2193				129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129	129
OldSerlOpen	04PP	BM	316						5	5	5	5	5	5	6	35	35	35	35	35	35	35	35
OldSerlOpen	04PP	EE	33976		43	155	450	1662	1902	1902	1902	1902	1902	1902	1950	2288	2288	2288	2288	2288	2288	2288	2288
OldSerlOpen	04PP	FL	7484		12	12	18	260	410	410	410	410	410	410	410	539	539	539	539	539	539	539	539
OldSerlOpen	04PP	Forest	18809			234	439	674	1423	1536	1675	1797	2148	2182	1104	461	325	352	458	864	914	1076	1147
OldSerlOpen	04PP	GB	240						16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
OldSerlOpen	04PP	HD	2025						135	135	135	135	135	135	135	135	135	135	135	135	135	135	135
OldSerlOpen	04PP	HI	519					5	9	9	9	9	9	9	12	56	56	56	56	56	56	56	56
OldSerlOpen	04PP	NG	106						2	2	2	2	2	2	6	11	11	11	11	11	11	11	11
OldSerlOpen	04PP	NM	3349		19	148	148	152	152	152	152	152	152	152	152	152	238	238	238	238	238	238	238
OldSerlOpen	04PP	PL	1165				65	65	69	69	69	69	69	69	69	69	69	69	69	69	69	69	69
OldSerlOpen	04PP	UM	4749				15	256	273	273	273	273	273	273	304	317	317	317	317	317	317	317	317
OthrSheltAcr	04PP	BK	418				10			199							10						199
OthrSheltAcr	04PP	BM	281				67	36		42							67	36				12	21
OthrSheltAcr	04PP	EE	1588				386	144		264							386	144					264
OthrSheltAcr	04PP	FL	380				138	52									138	52					
OthrSheltAcr	04PP	GB	54				18	6		3							18	6					3
OthrSheltAcr	04PP	HD	206				40	53		10							40	53					10
OthrSheltAcr	04PP	HI	436				132	71		15							132	71					15
OthrSheltAcr	04PP	NG	30				2			13							2						13
OthrSheltAcr	04PP	NM	468				214	10		10							214	10				10	
OthrSheltAcr	04PP	UM	300				82	60		8							82	60					8
RegenAcre	04PP	BK	219						10			199								10			
RegenAcre	04PP	BM	248						67	36		42								67	36		
RegenAcre	04PP	EE	1344						386	144		274								386	154		
RegenAcre	04PP	FL	380						138	52										138	52		
RegenAcre	04PP	GB	51						18	6		3								18	6		

RegenAcre	04PP	HD	196						40	53		10								40	53		
RegenAcre	04PP	HI	421						132	71		15								132	71		
RegenAcre	04PP	NG	17						2			13								2			
RegenAcre	04PP	NM	458						214	10		10								214	10		
RegenAcre	04PP	UM	292						82	60		8								82	60		
ThinAcre	04PP	BM	120				1	29				1	29			1	29			1	29		
ThinAcre	04PP	EE	1544				48	338				48	338			48	338			48	338		
ThinAcre	04PP	FL	516					129					129				129				129		
ThinAcre	04PP	HI	188				3	44				3	44			3	44			3	44		
ThinAcre	04PP	NG	36				4	5				4	5			4	5			4	5		
ThinAcre	04PP	NM	344					86				86				86				86			
ThinAcre	04PP	UM	176				31	13				31	13			31	13			31	13		
Volume	04PP	BK	831				11		15	233		313						11		15			233
Volume	04PP	BM	736				78	47	104	106		67	5			0	5	78	42	104	61	14	25
Volume	04PP	EE	4243				459	226	605	532		447	59			8	59	451	167	613	310		307
Volume	04PP	FL	1130				161	84	216	81			23				23	161	61	216	104		
Volume	04PP	GB	145				21	7	29	13		5						21	7	29	9		4
Volume	04PP	HD	549				47	62	63	95		15						47	62	63	84		11
Volume	04PP	HI	1206				155	91	206	130		25	8			1	8	154	83	207	120		18
Volume	04PP	NG	71				3	1	3	16		22	1			1	1	2		4	1		16
Volume	04PP	NM	1330				251	27	336	27		32				16		251	11	352	15	12	
Volume	04PP	UM	840				101	73	128	104		18	2			6	2	95	71	134	97		9
Young Mgmt	04PP	BK	853	6	10	10	10	10	20	20	20	209	209	209	10	10	10	10	10	20	20	20	10
Young Mgmt	04PP	BM	871	32	5	5	5	5	72	108	108	83	47	47	5	5	5	5	5	72	108	108	41
Young Mgmt	04PP	EE	7014	426	144	134	134	134	520	664	664	552	408	408	134	134	134	134	134	520	674	674	288
Young Mgmt	04PP	FL	1661	141	20	20	20	20	158	210	210	72	20	20	20	20	20	20	20	158	210	210	72
Young Mgmt	04PP	GB	231	2	4	4	4	4	22	28	28	13	7	7	4	4	4	4	4	22	28	28	10
Young Mgmt	04PP	HD	705	3	6	6	6	6	46	99	99	69	16	16	6	6	6	6	6	46	99	99	59
Young Mgmt	04PP	HI	1366	46	3	3	3	3	135	206	206	89	18	18	3	3	3	3	3	135	206	206	74
Young Mgmt	04PP	NG	95	6	2	2	2	2	4	4	4	15	15	15	2	2	2	2	2	4	4	4	2
Young Mgmt	04PP	NM	1643	88	91	5	5	5	219	229	229	25	15	15	5	5	5	5	5	219	229	229	15
Young Mgmt	04PP	PL	156	4	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Young Mgmt	04PP	UM	1144	21	13	13	13	13	95	155	155	81	21	21	13	13	13	13	13	95	155	155	73
Young Patch	04PP	BK	577		33	37		101		22				35		51		155	18		2	5	118
Young Patch	04PP	BM	462	15	2	1	35	181		80		13	1	2	34			66		20		12	
Young Patch	04PP	EE	3089	148	128	104	556	347	89	58	88	412	43	69	74	2	151	218		184	32	222	164
Young Patch	04PP	FL	236		34	27	26	120	8		6	3	5			1	4			1			1
Young Patch	04PP	Forest	27370		219	577	793	889	1566	1701	1587	841	2145	1876	2058	1635	1172	1739	1976	1957	1736	1067	1836
Young Patch	04PP	GB	24		12		7							1		4							
Young Patch	04PP	HD	27					3	4	3			2			15							
Young Patch	04PP	HI	228	2		71	12	93		19	9			2					2			18	
Young Patch	04PP	NG	146		51	5		27		10		47					2	4					
Young Patch	04PP	NM	300				86	110		2	34			8		12							48
Young Patch	04PP	NS	35	16												19							
Young Patch	04PP	PL	58		2				13		28						7	2				6	
Young Patch	04PP	UM	460	37	97	17	25	53	28		5	43		4		35	32	18	1			33	32
AllHarvAcre	05WpHw	BK	1038			72		69		58	169	151			50	22	69		97	160	121		
AllHarvAcre	05WpHw	BM	5509		21		1034	227		999	28	337	21		196	839	226	129	898	14	344		196
AllHarvAcre	05WpHw	EE	13206	265	1282	84	266	261	33	1204	38	2552		1547		508	116	63	1199	516	1990		1282
AllHarvAcre	05WpHw	FL	3924		122	214	215	81		583	131	555		122	214	279	17		714	139	416		122
AllHarvAcre	05WpHw	GB	780				69			72		249				69		72		5	244		
AllHarvAcre	05WpHw	HD	15548	480		3	3340	257	11	1139	140	835		480	3138	233	240	121	1058	154	781		3138
AllHarvAcre	05WpHw	HI	6831	216		786	724	223	5	767	272	436		216	626	989	123	345	372	341	390		
AllHarvAcre	05WpHw	NG	846	5		36	15	35		167		174		5	36	50		14	153	5	151		
AllHarvAcre	05WpHw	NM	4847	65	157		468	252	87	790		612		65	157	478	264	84	771	62	535		
AllHarvAcre	05WpHw	PL	1382					40	5	461	10	175					45	25	446	131	44		
AllHarvAcre	05WpHw	UM	4420			18	400	286		1022	14	470				530	174	177	859	92	378		
Burning	05WpHw	BK	40505	691	691	826	842	1560	2393	2393	2393	2393	2393	2393	2393	2393	2393	2393	2393	2393	2393	2393	2393
Burning	05WpHw	BM	139020	1068	1068	1156	2805	5243	8512	8512	8512	8512	8512	8512	8512	8512	8512	8512	8512	8512	8512	8512	8512
Burning	05WpHw	EE	266376	657	657	670	2078	9984	16822	16822	16822	16822	16822	16822	16822	16822	16822	16822	16822	16822	16822	16822	16822
Burning	05WpHw	FL	25863	54	54	66	106	578	1667	1667	1667	1667	1667	1667	1667	1667	1667	1667	1667	1667	1667	1667	1667
Burning	05WpHw	GB	31166			4	48	349	2051	2051	2051	2051	2051	2051	2051	2051	2051	2051	2051	2051	2051	2051	2051
Burning	05WpHw	HD	197585	240	240	310	807	5233	12717	12717	12717	12717	12717	12717	12717	12717	12717	12717	12717	12717	12717	12717	12717
Burning	05WpHw	HI	43826	56	56	61	87	876	2846	2846	2846	2846	2846	2846	2846	2846	2846	2846	2846	2846	2846	2846	2846
Burning	05WpHw	NG	3851	44	44	79	90	219	225	225	225	225	225	225	225	225	225	225	225	225	225	225	225
Burning	05WpHw	NM	73122	571	571	583	743	3109	4503	4503	4503	4503	4503	4503	4503	4503	4503	4503	4503	4503	4503	4503	4503
Burning	05WpHw	NS	6514	10	10	24	43	97	422	422	422	422	422	422	422	422	422	422	422	422	422	422	422
Burning	05WpHw	PL	31094	230	230	412	699	1623	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860
Burning	05WpHw	UM	83319	340	340	498	639	3817	5179	5179	5179	5179	5179	5179	5179	5179	5179	5179	5179	5179	5179	5179	5179
Disturbance	05WpHw	BK	47			2																45	
Disturbance	05WpHw	BM	235	12		7		52	1			70				27		24	3		30		9
Disturbance	05WpHw	EE	158	30	36	51	25				3	9		1		3							
Disturbance	05WpHw	FL	66		17	24	4		2			2		3			4				2	1	7
Disturbance	05WpHw	Forest	665						25		44	17	30	47	106	21	91	86	33	65	44	56	
Disturbance	05WpHw	HD	165	8									53										104
Disturbance	05WpHw	HI	34				2		13		1										18		
Disturbance	05WpHw	NG	51									4	44					3					
Disturbance	05WpHw	NM	237	20		2		40	45	65	3			6		24			10	10		7	5
Disturbance	05WpHw	PL	69		3	2	20						17						25				2
Disturbance	05WpHw	UM	247		17	8	59	37	6	25	8	28			3			53				1	2
Gaps	05WpHw	BK	54	3	3	3	3	3	3	3	2	2	2	3	3	3	3	3	3	2	2	2	3
Gaps	05WpHw	BM	247	16	16	16	11	10	10	11	12	10	14	14	15	11	10	11	11	12	10	14	13
Gaps	05WpHw	EE	812	43	41	42	42	48	48	43	43	31	37	30	42	41	48	48	43	41	31	37	33
Gaps	05WpHw	FL	124	8	8	7	6	7	8	6	5	3	6	6	7	6	7	8	5	5	3	7	6
Gaps	05WpHw	GB	14	1	1	1	1	1	1	1	1	0	0	0	1	1	1	1	1	1	0	0	0
Gaps	05WpHw	HD	604	37	37	37	23	22	22	34	35	31	36	33	21	20	22	38	34	35	31	36	20
Gaps	05WpHw	HI	224	15	15	12	9	8	11	11	11	9	13	13	12	8	8	9	11	11	11	13	14
Gaps	05WpHw	NG	28	2	2	2	2	2	2	1	1	0	1	1	2	2	2	2	1	1	0	1	1
Gaps	05WpHw	NM	160	11	10	10	8	8	8	6	7	5	9	9	10	8	7	8	6	7	5	9	9
Gaps	05WpHw	NS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gaps	05WpHw	PL	28	2	2	2	2	2	2	0	0	0	2	2	2	2	2	2	0	0	0	2	2
Gaps	05WpHw	UM	480	27	27	27	25	24	24	21	22	20	25	25	27	25	24	23	21	22	21	25	25

LateSerlClos	05WpHw	BK	9394	2140	2222	1842	1145	381	546	576	320	200	7	7	4	2	2						
LateSerlClos	05WpHw	BM	37316	5604	8282	9105	7656	3689	1631	496	552	163	54	63	7	7	7						
LateSerlClos	05WpHw	EE	73901	16955	16891	16805	12034	4335	656	462	2264	855	837	866	671	87	76	25				41	41
LateSerlClos	05WpHw	FL	7390	1165	1600	1666	893	567	392	323	430	110	84	70	30	28	28	4					
LateSerlClos	05WpHw	Forest	15									7	0	0	0	0	0	0	0	1	2	2	3
LateSerlClos	05WpHw	GB	8617	285	2010	2095	2033	1814	89	2	241	16	16	16									
LateSerlClos	05WpHw	HD	56403	8611	16076	14384	8531	5761	1616	344	788	103	25	134	15	15							
LateSerlClos	05WpHw	HI	12426	2065	2811	3014	1483	908	1070	394	436	66	49	73	3	2	2	2				24	24
LateSerlClos	05WpHw	NG	1682	23	222	218	267	247	278	114	206	54	4	9	4	4						16	16
LateSerlClos	05WpHw	NM	19171	2232	3193	4315	4081	2396	1707	309	680	109	54	54	6	5	2					14	14
LateSerlClos	05WpHw	NS	1730	276	442	442	404	166															
LateSerlClos	05WpHw	PL	6464	1675	1636	1033	970	372	398	99	106	33	25	13	31	31	22	20					
LateSerlClos	05WpHw	UM	22244	3384	4216	4707	4150	2609	1301	810	589	120	19	75	69	69	67	59					
LateSerlOpen	05WpHw	BM	364								167	143	54										
LateSerlOpen	05WpHw	EE	517								199	159	159										
LateSerlOpen	05WpHw	FL	57								19	19	19										
LateSerlOpen	05WpHw	Forest	1280				32	59	111	138	127	60	35	35	35	49	53	74	88	88	100	92	104
LateSerlOpen	05WpHw	HD	404								154	133	117										
LateSerlOpen	05WpHw	HI	315								105	105	105										
LateSerlOpen	05WpHw	NG	36								22	9	5										
LateSerlOpen	05WpHw	NM	110								44	33	33										
LateSerlOpen	05WpHw	PL	50								24	24	2										
LateSerlOpen	05WpHw	UM	601								201	201	199										
MidAgeClosed	05WpHw	BK	8676	1028	931	868	651	578	360	200	234	143	201	368	469	447	378	428	353	262	141	238	398
MidAgeClosed	05WpHw	BM	40445	6438	3476	2171	1845	1606	654	1455	1297	1289	2267	2288	2429	1611	1385	1452	1393	1605	1390	2288	2106
MidAgeClosed	05WpHw	EE	89904	8814	5594	5139	5279	6399	6234	5296	3266	2280	3471	1911	4438	3930	5361	5298	4607	4207	2280	3433	2667
MidAgeClosed	05WpHw	FL	26670	2295	1909	1505	1401	1521	1531	1111	860	660	1243	1228	1565	1286	1391	1605	1170	1048	632	1346	1363
MidAgeClosed	05WpHw	Forest	1384					42	71	61	35	77	113	125	78	99	124	69	80	72	75	122	141
MidAgeClosed	05WpHw	GB	6889	2156	431	339	339	265	265	334	69	69	141	141	390	321	321	249	318	313	141	141	146
MidAgeClosed	05WpHw	HD	82537	11498	3295	2711	2874	2725	1665	4793	4177	4107	5230	4890	2587	2354	2594	5611	4786	4872	4212	5270	2286
MidAgeClosed	05WpHw	HI	46480	3887	3027	1827	1897	1481	1864	2226	1996	1956	2723	2779	2587	1598	1691	1972	2589	2371	2326	2671	3012
MidAgeClosed	05WpHw	NG	6301	669	516	499	429	401	224	239	103	95	258	253	391	341	346	368	265	260	123	258	263
MidAgeClosed	05WpHw	NM	37038	4688	3643	2202	1823	1763	1285	1342	1017	1034	1821	1754	2209	1731	1532	1605	1312	1514	1063	1819	1881
MidAgeClosed	05WpHw	NS	166	166																			
MidAgeClosed	05WpHw	PL	9780	984	683	788	715	687	308	161	168	76	528	536	691	691	646	621	175	89	70	516	647
MidAgeClosed	05WpHw	UM	35466	4966	3412	2622	2029	1695	1360	896	861	773	1793	1799	2210	1680	1506	1329	1000	1082	881	1740	1832
MidAgeOpen	05WpHw	Forest	548		29	59	27			10	10	18		12	31	43	29	45	65	47	39	44	40
OldSerlClose	05WpHw	BK	55944	699	806	1188	2085	2860	2976	3039	2467	2540	2733	3455	3458	3460	3460	3462	3462	3462	3462	3435	3435
OldSerlClose	05WpHw	BM	152392	596	939	1330	2163	6191	9125	9591	7396	7451	7532	9994	10050	10034	10023	10016	10004	10004	9986	9986	9981
OldSerlClose	05WpHw	EE	333809	454	3584	4258	8918	16659	20545	20803	13149	13171	13197	21140	21360	22007	22019	22070	22095	22095	22095	22095	22095
OldSerlClose	05WpHw	FL	26218	6	13	130	808	1063	1427	1569	1175	1175	1200	1712	1755	1757	1755	1777	1781	1781	1780	1779	1775
OldSerlClose	05WpHw	Forest	0													0	0	0	0	0	0	0	0
OldSerlClose	05WpHw	GB	30022					285	2010	2033	1732	1734	1734	2035	2051	2051	2051	2051	2051	2051	2051	2051	2051
OldSerlClose	05WpHw	HD	234926	559	1038	3402	6666	9372	14497	14935	10740	10747	10808	15104	15223	15223	15239	15239	15239	15239	15239	15239	15178
OldSerlClose	05WpHw	HI	44606	123	212	426	1436	2190	2382	2696	2031	2050	2067	2836	2908	2909	2909	2909	2911	2911	2900	2900	2900
OldSerlClose	05WpHw	NG	3685				10	26	194	208	141	142	168	274	279	279	283	281	280	280	280	280	280
OldSerlClose	05WpHw	NM	71844	461	511	829	1055	2712	3724	4731	2489	2571	2629	4994	5040	5027	5020	5022	5016	5006	5006	5002	4999
OldSerlClose	05WpHw	NS	7107	14	14	14	52	293	459	459	404	404	404	459	459	459	459	459	459	459	459	459	459
OldSerlClose	05WpHw	PL	32899	27	382	1004	1120	1713	2029	2049	1155	1158	1165	2098	2100	2100	2109	2111	2116	2116	2116	2116	2115
OldSerlClose	05WpHw	UM	149448	2984	3809	4137	4868	6506	8146	8500	5840	5946	6046	9205	9268	9267	9269	9245	9283	9283	9283	9282	9281
OldSerlOpen	05WpHw	BK	2136								712	712	712										
OldSerlOpen	05WpHw	BM	6728								2197	2221	2310										
OldSerlOpen	05WpHw	EE	23051								7657	7697	7697										
OldSerlOpen	05WpHw	FL	1323								441	441	441										
OldSerlOpen	05WpHw	Forest	3088								47	130	225	271	274	292	331	333	365	343	245	109	123
OldSerlOpen	05WpHw	GB	903								301	301	301										
OldSerlOpen	05WpHw	HD	12874								4272	4293	4309										
OldSerlOpen	05WpHw	HI	2016								672	672	672										
OldSerlOpen	05WpHw	NG	351								107	120	124										
OldSerlOpen	05WpHw	NM	6985								2321	2332	2332										
OldSerlOpen	05WpHw	NS	156								52	52	52										
OldSerlOpen	05WpHw	PL	2710								896	896	918										
OldSerlOpen	05WpHw	UM	8672								2890	2890	2892										
RegenAcre	05WpHw	BK	1038			72		69		58	169	151			50	22	69		97	160	121		
RegenAcre	05WpHw	BM	5509		21		1034	227		999	28	337	21		196	839	226	129	898	14	344		196
RegenAcre	05WpHw	EE	13206	265	1282	84	266	261	33	1204	38	2552		1547		508	116	63	1199	516	1990		1282
RegenAcre	05WpHw	FL	3924		122	214	215	81		583	131	555		122	214	279	17		714	139	416		122
RegenAcre	05WpHw	GB	780				69			72		249				69		72		5	244		
RegenAcre	05WpHw	HD	15548	480		3	3340	257	11	1139	140	835		480	3138	233	240	121	1058	154	781		3138
RegenAcre	05WpHw	HI	6831	216		786	724	223	5	767	272	436		216	626	989	123	345	372	341	390		
RegenAcre	05WpHw	NG	846	5		36	15	35		167		174		5	36	50		14	153	5	151		
RegenAcre	05WpHw	NM	4847	65	157		468	252	87	790		612		65	157	478	264	84	771	62	535		
RegenAcre	05WpHw	PL	1382					40	5	461	10	175					45	25	446	131	44		
RegenAcre	05WpHw	UM	4420			18	400	286		1022	14	470				530	174	177	859	92	378		
Volume	05WpHw	BK	3465			246		244		207	594	518			162	68	225		299	508	394		
Volume	05WpHw	BM	18393		73		3650	805		3501	96	1188	60		557	2739	736	365	2916	38	1112		557
Volume	05WpHw	EE	43878	854	4555	272	941	887	113	4149	127	8826		5018		1564	361	185	3892	1459	6491		4184
Volume	05WpHw	FL	13058		434	760	763	276		2005	443	1917		398	698	884	55		2273	394	1360		398
Volume	05WpHw	GB	2602				244			241		882				224		202		14	795		
Volume	05WpHw	HD	48823	1588		9	11304	908	36	4013	488	2929		1508	8858	745	778	342	3433	477	2549		8858
Volume	05WpHw	HI	22764	684		2735	2571	772	15	2655	967	1527		680	2042	3160	398	974	1215	1097	1272		
Volume	05WpHw	NG	2833	17		128	53	113		589		607		17	118	147		39	499	14	492		
Volume	05WpHw	NM	16193	203	492		1661	890	295	2750		2138		202	492	1552	850	238	2510	175	1745		
Volume	05WpHw	PL	4556					143	16	1622	34	560					145	70	1452	371	143		
Volume	05WpHw	UM	14723			60	1420	997		3517	49	1641				1679	568	500	2795	261	1236		
Young Mgmt	05WpHw	BK	3405	101	10	82	82	151	79	137	237	388	330	161	60	82	151	101	176	267	388	291	131
Young Mgmt	05WpHw	BM	16423	22	35	35	1069	1275	1275	1240	1041	1378	400	372	231	1049	1275	1208	1267	1055	1270	372	554
Young Mgmt	05WpHw	EE	38502	1305	1795	1639	1640	620	569	1507	1284	3803	2599	4108	1556	2064	633	696	1387	1787	3714	2515	3281
Young Mgmt	05WpHw	FL	11728	200	122	336	551	510	296	664	714	1269	686	677	336	615	510	296	731	853	1269	555	538
Young Mgmt	05WpHw	GB	2340				69	69	69	72	72	321	249	249		69	69	141	72	77	249	249	244
Young Mgmt	05WpHw	HD	40612	580	570	486	3346	3603	3611	1410	1293	2117	978	1318	3621	3854	3614	597	1422	1336	1996	938	3922
Young Mgmt	05WpHw	HI	20550	261	228	1002	1510	1733	952	995	1044	1475	708	652	842	1831	1738	1457	840	1058	1103	731	390

Young Mgmt	05WpHw	NG	2562	17	17	41	51	86	50	202	167	341	174	179	41	91	86	64	167	172	309	156	151
Young Mgmt	05WpHw	NM	14798	145	273	229	632	727	814	1136	884	1409	619	684	229	707	906	833	1126	924	1375	604	542
Young Mgmt	05WpHw	NS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Young Mgmt	05WpHw	PL	4418	109	109	3	3	43	48	509	479	649	188	178	3	3	48	73	519	605	624	178	47
Young Mgmt	05WpHw	UM	13462	94	20	22	422	709	691	1313	1041	1511	489	475	5	535	709	886	1215	1133	1334	475	383
Young Patch	05WpHw	BK	29			2																27	
Young Patch	05WpHw	BM	142	7		7		31	1			41				16		14	2		18		5
Young Patch	05WpHw	EE	126	18	21	51	25				2	6		1		2							
Young Patch	05WpHw	FL	50		10	24	4		1			1		2			2				1	1	4
Young Patch	05WpHw	Forest	3118		42	86	86	44	92	131	209	151	182	226	259	197	195	216	218	234	210	175	165
Young Patch	05WpHw	HD	98	5									32										61
Young Patch	05WpHw	HI	22				2		8		1										11		
Young Patch	05WpHw	NG	30									2	26					2					
Young Patch	05WpHw	NM	142	12		2		24	27	38	2			4		14			6	6		4	3
Young Patch	05WpHw	PL	50		2	2	20						10						15				1
Young Patch	05WpHw	UM	176		11	8	59	22	4	15	5	16			2			32				1	1
AllHarvAcre	06SlpH	BM	56			14				14						14				14			
AllHarvAcre	06SlpH	EE	886	55	58			55	18		237		40		73				289	21	40		
AllHarvAcre	06SlpH	FL	3812		335	328	393		335	328	187				335	721			343	507			
AllHarvAcre	06SlpH	HI	3784	441	372	131	167	441		131	23		372		441	298			464	131	372		
AllHarvAcre	06SlpH	NG	289		15	58			12	58			3		12	58			12	58	3		
AllHarvAcre	06SlpH	NM	827	64	153			64	82		15		71		146				161		71		
AllHarvAcre	06SlpH	PL	222		74								74								74		
AllHarvAcre	06SlpH	UM	592		120	30			112	30			8		112	30			112	30	8		
Burning	06SlpH	EE	19640	982	982	982	982	982	982	982	982	982	982	982	982	982	982	982	982	982	982	982	982
Burning	06SlpH	FL	47180	2359	2359	2359	2359	2359	2359	2359	2359	2359	2359	2359	2359	2359	2359	2359	2359	2359	2359	2359	2359
Burning	06SlpH	HD	500	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
Burning	06SlpH	HI	126560	6328	6328	6328	6328	6328	6328	6328	6328	6328	6328	6328	6328	6328	6328	6328	6328	6328	6328	6328	6328
Burning	06SlpH	NG	180	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Burning	06SlpH	NM	5760	288	288	288	288	288	288	288	288	288	288	288	288	288	288	288	288	288	288	288	288
Burning	06SlpH	PL	520	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
Burning	06SlpH	UM	23860	1193	1193	1193	1193	1193	1193	1193	1193	1193	1193	1193	1193	1193	1193	1193	1193	1193	1193	1193	1193
Disturbance	06SlpH	BM	47			5		1														32	9
Disturbance	06SlpH	EE	673			14		135		46		148		3		12	78	127		87	7	15	1
Disturbance	06SlpH	FL	1272	42		44	387	52	34	25	58		16	28	86	13	61	73	9	53		91	200
Disturbance	06SlpH	Forest	3383							18		360	730	101	190	85	300	463	95	165	114	270	492
Disturbance	06SlpH	HI	1512	126	203	37	64	603		232	26		12	21	2	71		44	10	5		4	52
Disturbance	06SlpH	NG	75			35		2	20		7	1								10			
Disturbance	06SlpH	NM	58								50			8									
Disturbance	06SlpH	PL	148			55			27				25				19			8	14		
Disturbance	06SlpH	UM	435	3	83	1	7	35	31							15		126			7	95	32
Gaps	06SlpH	BM	0	0	0				0	0	0	0	0	0	0				0	0	0	0	0
Gaps	06SlpH	EE	12	0	0	1	1	1	1	1	0	0	0	1	1	1	1	1	0	0	0	1	1
Gaps	06SlpH	FL	83	5	5	3	1	2	4	6	5	5	5	6	5	1	1	2	6	5	5	5	6
Gaps	06SlpH	HI	92	4	2	1	3	5	6	7	7	7	5	5	2	2	2	5	7	7	5	5	5
Gaps	06SlpH	NG	0	0	0			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gaps	06SlpH	NM	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gaps	06SlpH	PL	0	0				0	0	0	0	0				0	0	0	0	0			
Gaps	06SlpH	UM	14	1	0			1	1	1	1	1	1	1	0	0	0	1	1	1	1	1	1
LateSerlClos	06SlpH	BM	220	14	14				0	41	41	41	41	14	14								
LateSerlClos	06SlpH	EE	1828	439	196	104	104	37	196	183	168	136	89	82					21				73
LateSerlClos	06SlpH	FL	8882	1758	1237	664	186	59	171	900	712	668	626	666	721				179				335
LateSerlClos	06SlpH	Forest	188									42	63	4	6	9	8	9	8	7	11	10	11
LateSerlClos	06SlpH	HI	7645	2305	813	541	550	346	163	274	199	638	497	580	298								441
LateSerlClos	06SlpH	NG	438	117	100	30	27		1	4	4	3	12	70	58								12
LateSerlClos	06SlpH	NM	952	276	58	58	58					64	146	146									146
LateSerlClos	06SlpH	PL	252	66	47	74	27	27	11	0													
LateSerlClos	06SlpH	UM	1676	580	34	0	70	46	14	137	136	136	239	142	30								112
LateSerlOpen	06SlpH	EE	6		6																		
LateSerlOpen	06SlpH	FL	173		31	16				42	42	42											
LateSerlOpen	06SlpH	Forest	5918		52	52	226	254	637	650	305	290	48	153	261	416	376	407	333	257	415	377	409
LateSerlOpen	06SlpH	HI	945		927	6				4	4	4											
LateSerlOpen	06SlpH	NG	2		2																		
LateSerlOpen	06SlpH	NM	34		34																		
LateSerlOpen	06SlpH	UM	298		274					8	8	8											
MidAgeClosed	06SlpH	BM	314		6	44	42	41	55	14	14	14	14						14	14	14	14	14
MidAgeClosed	06SlpH	EE	4982	37	300	478	536	553	366	338	113	58		237	237	277	277	350	113	113	73	289	237
MidAgeClosed	06SlpH	FL	17058	274	1046	1329	1039	1236	1431	1067	1056	1056	721	580	187	187	187	522	1056	1056	1056	1064	908
MidAgeClosed	06SlpH	Forest	5812					102	271	373	636	869	340	238	168	338	589	289	212	188	320	606	273
MidAgeClosed	06SlpH	HI	15178	747	996	964	1021	1197	1149	1142	1111	670	298	190	23	395	395	836	1111	1111	739	762	321
MidAgeClosed	06SlpH	NG	794		36	17	4	19	76	73	73	73	58			3	3	15	73	73	70	70	58
MidAgeClosed	06SlpH	NM	2350			15	79	232	232	232	217	153		15	15	86	86	232	217	217	146	161	15
MidAgeClosed	06SlpH	PL	926	82	82	22		74	74	74	74	74				74	74	74	74	74			
MidAgeClosed	06SlpH	UM	2391	157	116	210	136	256	286	150	150	150	30			8	8	120	150	150	142	142	30
MidAgeOpen	06SlpH	FL	210		42	42	42	42	42														
MidAgeOpen	06SlpH	Forest	2164		17	132	36	84			7	7	103	290	223	103	110	154	305	223	104	112	154
MidAgeOpen	06SlpH	HI	20		4	4	4	4	4														
MidAgeOpen	06SlpH	UM	40		8	8	8	8	8														
OldSerlClose	06SlpH	BM	337										0	41	41	41	41	41	41	41	41	9	0
OldSerlClose	06SlpH	EE	10043	490	424	553	553	582	556	570	554	554	560	565	573	566	520	445	445	394	390	375	374
OldSerlClose	06SlpH	FL	18525	508	319	551	682	761	741	740	707	728	1096	1360	1301	1259	1223	1180	1175	1144	1144	1053	853
OldSerlClose	06SlpH	Forest	62													1	3	4	6	10	11	13	14
OldSerlClose	06SlpH	HD	12	12																			
OldSerlClose	06SlpH	HI	17996	1659	485	626	789	808	929	855	830	821	955	985	984	941	941	915	909	906	906	902	850
OldSerlClose	06SlpH	NG	244			10	12	38	25	17	13	10	13	13	13	13	13	13	13	7	7	7	7
OldSerlClose	06SlpH	NM	1479	80	62	62	62	120	120	120	90	70	70	65	62	62	62	62	7	62	62	62	62
OldSerlClose	06SlpH	PL	1051	87	29	29	76	76	76	76	76	76	61	51	51	51	40	40	40	35	27	27	27
OldSerlClose	06SlpH	UM	8166	298	378	381	381	381	381	381	382	382	391	518	518	509	509	435	435	435	431	336	304
OldSerlOpen	06SlpH	EE	4763		245	251	251	251	251	251	251	251	251	251	251	251	251	251	251	251	251	251	251
OldSerlOpen	06SlpH	FL	7521		343	358	374	374	374	374	374	374	416	416	416	416	416	416	416	416	416	416	416
OldSerlOpen	06SlpH	Forest	12232				0	107	139	172	639	711	1060	1081	1104	1169	1027	1020	1097	879	873	560	594
OldSerlOpen	06SlpH	HD	228		12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12

OldSerlOpen	06SlpH	HI	44217		1447	2368	2374	2374	2374	2374	2374	2374	2378	2378	2378	2378	2378	2378	2378	2378	2378	2378	2378
OldSerlOpen	06SlpH	NG	36			2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
OldSerlOpen	06SlpH	NM	1543		49	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83
OldSerlOpen	06SlpH	PL	57		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
OldSerlOpen	06SlpH	UM	6388		72	346	346	346	346	346	346	346	354	354	354	354	354	354	354	354	354	354	354
RegenAcre	06SlpH	BM	28							14										14			
RegenAcre	06SlpH	EE	740		40			55	18		237		40						289	21	40		
RegenAcre	06SlpH	FL	2486				393		335	328	187					393			343	507			
RegenAcre	06SlpH	HI	2640		372		167	441		131	23		372			167			464	131	372		
RegenAcre	06SlpH	NG	149		3				12	58			3						12	58	3		
RegenAcre	06SlpH	NM	535		71			64	82		15		71						161		71		
RegenAcre	06SlpH	PL	222		74								74								74		
RegenAcre	06SlpH	UM	308		8				112	30			8						112	30	8		
Volume	06SlpH	BM	84			25				17						25				17			
Volume	06SlpH	EE	1684	103	118			68	23		491		81		137				527	55	81		
Volume	06SlpH	FL	7140		624	609	1027		412	403	489				624	1648			428	876			
Volume	06SlpH	HI	6796	820	789	243	435	542		161	47		753		820	683			589	161	753		
Volume	06SlpH	NG	451		29	107			15	71			7		22	107			15	71	7		
Volume	06SlpH	NM	1403	119	304			79	101		30		144		272				210		144		
Volume	06SlpH	PL	451		153								149								149		
Volume	06SlpH	UM	928		226	56			137	37			17		208	56			137	37	17		
Young Mgmt	06SlpH	BM	84			14	14	14								14	14	14					
Young Mgmt	06SlpH	EE	2908	299	341	125	70	12	12	12	249	249	289	52	125	85	85	12	228	249	289	73	52
Young Mgmt	06SlpH	FL	8398	210	381	701	1094	759	431	38	225	225	225	38	373	1094	1094	759	46	225	225	217	38
Young Mgmt	06SlpH	HI	8750	488	876	984	710	338	207	40	63	63	435	412	853	779	779	338	63	63	435	412	412
Young Mgmt	06SlpH	NG	447	0	15	73	73	58	0	0	0	0	3	3	15	70	70	58	0	0	3	3	3
Young Mgmt	06SlpH	NM	1694	81	235	220	156	3	3	3	18	18	89	74	220	149	149	3	18	18	89	74	74
Young Mgmt	06SlpH	PL	666	0	74	74	74	0	0	0	0	0	74	74	74	0	0	0	0	0	74	74	74
Young Mgmt	06SlpH	UM	1139	6	131	161	161	41	11	11	11	11	19	19	131	153	153	41	11	11	19	19	19
Young Patch	06SlpH	BM	45			3		1														32	9
Young Patch	06SlpH	EE	402			8		79		27		87		2		7	46	75		51	4	15	1
Young Patch	06SlpH	FL	872	25		26	229	31	20	15	35		9	17	51	8	36	43	5	31		91	200
Young Patch	06SlpH	Forest	13248		102	271	384	552	871	836	745	555	1006	907	970	773	551	822	932	926	818	502	725
Young Patch	06SlpH	HI	917	75	120	22	38	356		137	15		7	13	1	42		26	6	3		4	52
Young Patch	06SlpH	NG	45			21		1	12		4	1								6			
Young Patch	06SlpH	NM	35								30			5									
Young Patch	06SlpH	PL	88			33			16				15				11			5	8		
Young Patch	06SlpH	UM	309	2	49	1	4	21	18							9		74			4	95	32
AllHarvAcre	07PVH	BK	1131		34		111	3	99	104	8	176	37	73		97	3	22	147	15	107	65	30
AllHarvAcre	07PVH	BM	4161		423	64	295	191	434	359	124	306	614	75		282	67		430		349	148	
AllHarvAcre	07PVH	EE	5203			301	86	397	381	371	103	488	376	737		162	328		499	92	398	429	55
AllHarvAcre	07PVH	FL	5167		274	558	89	76	467	638	186	283	350	925	1	263	65		285	183	144	205	175
AllHarvAcre	07PVH	GB	450			77		1	1	77	42	1	1	120		42	1		1	42	1	1	42
AllHarvAcre	07PVH	HD	1891		398	108	18		435	126		75	398	145	20	18	20		55		18	37	20
AllHarvAcre	07PVH	HI	3117		476	200	130	7	514	305	17	182	483	255	14	147	21		143	42	112	38	31
AllHarvAcre	07PVH	NG	41			11		2		11			2	11			2				2		
AllHarvAcre	07PVH	NM	707			121	35	34		156		69		121		67			35	34	33	2	
AllHarvAcre	07PVH	PL	836			28	2		148	30		150		176		2			150		2	148	
AllHarvAcre	07PVH	UM	3688			550	126	18	135	671	109	267	12	794		241	12		256	120	133	135	109
Burning	07PVH	BK	342670	14672	14706	14800	14807	17727	17758	17724	17724	17731	17761	17724	17724	17731	17727	17724	17724	17731	17727	17724	17724
Burning	07PVH	BM	344215	15224	15647	15459	15395	17645	18001	17642	17578	17578	18068	17642	17578	17578	17645	17578	17578	17578	17645	17578	17578
Burning	07PVH	EE	725883	28930	28930	29587	29302	38292	37943	38244	37943	37980	38271	38244	37943	37980	38271	37943	37943	37980	38271	37943	37943
Burning	07PVH	FL	165766	5474	5748	6069	5520	8877	9087	9371	8813	8822	9151	9371	8813	8822	8877	8813	8813	8822	8877	8813	8813
Burning	07PVH	GB	42207	1577	1577	1654	1577	2230	2229	2306	2229	2229	2230	2306	2229	2229	2230	2229	2229	2229	2230	2229	2229
Burning	07PVH	HD	53144	2098	2496	2223	2115	2700	3098	2808	2700	2700	3098	2808	2700	2700	2700	2700	2700	2700	2700	2700	2700
Burning	07PVH	HI	91852	2485	2961	2715	2540	4988	5457	5181	4981	5006	5464	5181	4981	5006	4988	4981	4981	5006	4988	4981	4981
Burning	07PVH	NG	167053	6832	6832	6885	6874	8727	8725	8736	8725	8725	8727	8736	8725	8725	8727	8725	8725	8725	8727	8725	8725
Burning	07PVH	NM	268079	11780	11780	12131	12010	13784	13750	13871	13750	13784	13750	13871	13750	13784	13750	13750	13750	13784	13750	13750	13750
Burning	07PVH	NS	20636	903	903	943	943	1059	1059	1059	1059	1059	1059	1059	1059	1059	1059	1059	1059	1059	1059	1059	1059
Burning	07PVH	PL	89198	2777	2777	2872	2844	4867	4867	4895	4867	4867	4867	4895	4867	4867	4867	4867	4867	4867	4867	4867	4867
Burning	07PVH	UM	244428	9153	9153	9764	9219	12890	12872	13422	12872	12883	12884	13422	12872	12883	12884	12872	12872	12883	12884	12872	12872
Disturbance	07PVH	BK	1685	3	519	37	276							56	252				78	170		20	274
Disturbance	07PVH	BM	91		12	17			12							12				26			12
Disturbance	07PVH	EE	6666	379	97	351	852	766	299	1	67	863	726				370	902		156	410	163	264
Disturbance	07PVH	FL	24					7		17													
Disturbance	07PVH	Forest	8131							688	308	397	1165	202	475	222	742	1115	244	429		819	1325
Disturbance	07PVH	HI	7	7																			
Disturbance	07PVH	NS	826					610		75						141							
Disturbance	07PVH	UM	1444	66	83	118		589	30	23				156		129				17		233	
Gaps	07PVH	BK	14	1	1	1	1	1	1	0	0	0	1	1	1	1	1	1	0	0	0	1	1
Gaps	07PVH	BM	102	5	6	6	6	6	6	4	3	3	5	6	6	6	6	6	4	4	4	5	5
Gaps	07PVH	EE	161	6	8	9	9	9	9	9	9	6	6	6	9	9	9	9	9	9	9	6	6
Gaps	07PVH	FL	150	7	8	8	8	8	8	8	8	7	7	6	7	7	8	8	8	8	8	7	6
Gaps	07PVH	GB	20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Gaps	07PVH	HD	80	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Gaps	07PVH	HI	114	6	6	6	6	6	6	5	5	5	6	6	6	6	6	6	5	5	5	6	6
Gaps	07PVH	NG	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gaps	07PVH	NM	20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Gaps	07PVH	PL	15	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	0	0
Gaps	07PVH	UM	109	6	6	6	6	6	6	5	5	4	5	5	6	6	6	6	5	5	5	5	5
LateSerlClos	07PVH	BK	14555	9097	2259	1426	728	379	180	102	82	8	8					104	22	87	65	8	
LateSerlClos	07PVH	BM	18127	8459	2400	2309	2044	1310	524	342	11							295	137	148	148		
LateSerlClos	07PVH	EE	41069	20188	6773	5308	3647	945	420	395	436	55	55		454	454	454	524	48	429	429	55	
LateSerlClos	07PVH	FL	12909	5099	2388	1558	1295	544	250	379	368	175	175	1				80	12	205	205	174	1
LateSerlClos	07PVH	Forest	209									3	7	10	14	23	21	23	21	16	25	22	24
LateSerlClos	07PVH	GB	1840	1184	316	31	31	32	32	43	43	42	42							1	1	42	
LateSerlClos	07PVH	HD	2986	1723	446	197	177	114	57	39	59	22	20	20				18		37	37		20
LateSerlClos	07PVH	HI	9095	3083	1698	1488	1507	730	180	52	69	31	31	14				105		38	38	17	14
LateSerlClos	07PVH	NG	11603	3987	2876	2356	1756	613	15														
LateSerlClos	07PVH	NM	9224	6363	872	717	728	404	51	16	16	16						35	2	2	2		
LateSerlClos	07PVH	NS	2858	478	685	685	685	325															
LateSerlClos	07PVH	PL	6041	2307	1102	885	782	221	150	148	148							2		148	148		

LateSerlClos	07PVH	UM	20236	7602	3901	3059	2642	1615	263	192	244	109	109					121		135	135	109	
LateSerlOpen	07PVH	BK	18850		6105	5403	3755	1343	1219	547	266	189	10	10	3								
LateSerlOpen	07PVH	BM	20276		5605	5393	4868	2573	890	612	67	67	67	67	67								
LateSerlOpen	07PVH	EE	35848		12460	11678	7473	1577	427	378	386	369	365	365	349	21							
LateSerlOpen	07PVH	FL	12096		2819	3251	2482	2213	822	128	84	84	76	73	64								
LateSerlOpen	07PVH	Forest	8474		29	9	5	5				107	275	398	557	916	829	896	826	657	1022	930	1013
LateSerlOpen	07PVH	GB	2770		729	777	634	535	89	1	1	1	1	1	1								
LateSerlOpen	07PVH	HD	4462		1260	1368	916	711	159	48													
LateSerlOpen	07PVH	HI	5494		1421	1479	1044	998	312	87	41	41	32	32	7								
LateSerlOpen	07PVH	NG	3403		1098	978	776	299	162	80	2	2	2	2	2								
LateSerlOpen	07PVH	NM	14822		5108	4164	3325	1734	192	42	61	60	34	34	34	34							
LateSerlOpen	07PVH	NS	522		396	42	42	42															
LateSerlOpen	07PVH	PL	2896		872	795	662	232	110	75	75	75											
LateSerlOpen	07PVH	UM	11314		3530	3437	2219	1182	694	88	47	47	23	23	18	6							
MidAgeClosed	07PVH	BK	2144	724	191	83	37	34	26				104	104	169	169	177	73	73	8	8	82	82
MidAgeClosed	07PVH	BM	4649	1070	202	202	202	135	124				295	419	430	430	430	135	11			282	282
MidAgeClosed	07PVH	EE	8481	457	776	1323	663	300	147	89	454	454	524	572	499	499	554	484	436	55	55	70	70
MidAgeClosed	07PVH	FL	4604	314	475	480	368	288	214	5			80	92	285	285	459	380	368	175	175	81	80
MidAgeClosed	07PVH	Forest	12478					268	688	590	530	1335	687	574	431	840	1426	710	547	486	960	1665	741
MidAgeClosed	07PVH	GB	432	32	44	44	44	42	11						1	1	43	43	43	42	42		
MidAgeClosed	07PVH	HD	694	105	39	59	20	20	20	20			18	18	55	55	55	57	57	20	20	38	18
MidAgeClosed	07PVH	HI	1851	223	169	186	76	69	31	17			105	105	143	143	160	69	69	31	31	119	105
MidAgeClosed	07PVH	NG	84	78	2	2	2																
MidAgeClosed	07PVH	NM	454	93	34	52	34						35	35	35	35	35					33	33
MidAgeClosed	07PVH	NS	685	685																			
MidAgeClosed	07PVH	PL	1429	225	225	225							2	2	150	150	150	148	148			2	2
MidAgeClosed	07PVH	UM	3425	339	252	273	179	161	102	52			121	121	256	256	365	244	244	109	109	121	121
MidAgeOpen	07PVH	BK	438		239	179	7	10	3														
MidAgeOpen	07PVH	BM	134					67	67														
MidAgeOpen	07PVH	EE	751				16	365	349	21													
MidAgeOpen	07PVH	FL	154		4	4	9	73	64														
MidAgeOpen	07PVH	Forest	5013								275	291	282	625	547	271	279	386	743	544	270	172	328
MidAgeOpen	07PVH	GB	2					1	1														
MidAgeOpen	07PVH	HI	64				25	32	7														
MidAgeOpen	07PVH	NG	4					2	2														
MidAgeOpen	07PVH	NM	154		26	26		34	34	34													
MidAgeOpen	07PVH	UM	88		18	18	5	23	18	6													
OldSerlClose	07PVH	BK	30639	915	1349	2060	2555	2794	1539	1539	1559	1568	1568	1535	1386	1386	1386	1386	1340	1240	1240	1228	1066
OldSerlClose	07PVH	BM	21785	159	452	464	637	1371	1070	1076	1283	1283	1283	1283	1283	1276	1276	1276	1276	1261	1261	1261	1254
OldSerlClose	07PVH	EE	106817	5215	5687	6622	7921	10026	5893	5785	5746	5210	4782	4782	4782	4782	4564	4032	4486	4394	4152	4056	3900
OldSerlClose	07PVH	FL	4424	107	42	314	661	1424	137	127	124	124	124	124	124	124	124	124	124	124	124	124	124
OldSerlClose	07PVH	Forest	156													3	7	10	14	26	28	33	35
OldSerlClose	07PVH	GB	979	7	87	295	295	295															
OldSerlClose	07PVH	HD	1352	81	19	160	211	274	39	39	39	39	41	41	41	41	41	41	41	41	41	41	41
OldSerlClose	07PVH	HI	4821	28	24	34	85	862	218	255	255	255	255	255	255	255	255	255	255	255	255	255	255
OldSerlClose	07PVH	NG	35015	306	112	621	1199	2342	2015	2030	2030	2030	2030	2030	2030	2030	2030	2030	2030	2030	2030	2030	2030
OldSerlClose	07PVH	NM	12005	573	777	827	719	1043	526	526	526	526	542	542	542	542	542	542	542	542	542	542	542
OldSerlClose	07PVH	NS	2689	193	219	219	199	199	222	178	148	148	148	148	148	65	65	65	65	65	65	65	65
OldSerlClose	07PVH	PL	4525	77	61	250	543	1104	166	166	166	166	166	166	166	166	166	166	166	166	166	166	166
OldSerlClose	07PVH	UM	22113	722	609	835	1264	1943	1271	1245	1236	1236	1236	1144	1144	1068	1068	1068	1068	1058	1058	920	920
OldSerlOpen	07PVH	BK	130418		315	1077	2968	5380	6973	7648	7929	8006	8185	8185	8192	8195	8195	8195	8195	8195	8195	8195	8195
OldSerlOpen	07PVH	BM	129166		1213	1489	2099	4394	7168	7513	8058	8058	8058	8058	8058	8125	8125	8125	8125	8125	8125	8125	8125
OldSerlOpen	07PVH	EE	285838		341	1424	5806	11702	17197	17574	17587	17604	17608	17608	17624	17952	17973	17973	17973	17973	17973	17973	17973
OldSerlOpen	07PVH	FL	78946		65	191	983	1252	4304	5062	5106	5106	5114	5117	5126	5190	5190	5190	5190	5190	5190	5190	5190
OldSerlOpen	07PVH	Forest	19651		152	457	670	939	1733	1870	1916	1577	1577	1372	583	492	554	398	557	1023	1104	1294	1383
OldSerlOpen	07PVH	GB	18492		59	88	231	330	1102	1191	1191	1191	1191	1191	1191	1192	1192	1192	1192	1192	1192	1192	1192
OldSerlOpen	07PVH	HD	28693		145	145	605	810	1654	1765	1813	1813	1813	1813	1813	1813	1813	1813	1813	1813	1813	1813	1813
OldSerlOpen	07PVH	HI	45073		40	182	632	678	2621	2853	2899	2899	2908	2908	2933	2940	2940	2940	2940	2940	2940	2940	2940
OldSerlOpen	07PVH	NG	37349		285	416	640	1117	2179	2263	2341	2341	2341	2341	2341	2343	2343	2343	2343	2343	2343	2343	2343
OldSerlOpen	07PVH	NM	104325		212	1277	2257	3848	6260	6410	6425	6426	6452	6452	6452	6452	6486	6486	6486	6486	6486	6486	6486
OldSerlOpen	07PVH	NS	9276		56	410	430	430	530	530	530	530	530	530	530	530	530	530	530	530	530	530	530
OldSerlOpen	07PVH	PL	36537		349	454	622	1052	2183	2218	2218	2218	2293	2293	2293	2293	2293	2293	2293	2293	2293	2293	2293
OldSerlOpen	07PVH	UM	100688		340	983	2249	3286	5608	6226	6273	6273	6297	6297	6302	6314	6320	6320	6320	6320	6320	6320	6320
OthrSheltAcr	07PVH	BK	708				104		65	104	8	65		8		82		22	147	8	22	65	8
OthrSheltAcr	07PVH	BM	1720				295	124	11	295	124	11				282			430			148	
OthrSheltAcr	07PVH	EE	2216				70	48	381	70	103	381		55		70			499	55		429	55
OthrSheltAcr	07PVH	FL	1839				80	12	193	80	186	194		174	1	80			285	174		205	175
OthrSheltAcr	07PVH	GB	172						1		42	1		42					1	42		1	42
OthrSheltAcr	07PVH	HD	280				18		37	18		57			20	18			55			37	20
OthrSheltAcr	07PVH	HI	682				105		38	105	17	52		17	14	105			143	17		38	31
OthrSheltAcr	07PVH	NM	140				35			35						33			35			2	
OthrSheltAcr	07PVH	PL	600				2		148	2		148				2			150			148	
OthrSheltAcr	07PVH	UM	1460				121		135	121	109	135		109		121			256	109		135	109
RegenAcre	07PVH	BK	281									104		65		8					82		22
RegenAcre	07PVH	BM	712									295	124	11							282		
RegenAcre	07PVH	EE	624									70	48	381		55					70		
RegenAcre	07PVH	FL	540									80	12	193		174	1				80		
RegenAcre	07PVH	GB	43											1		42							
RegenAcre	07PVH	HD	93									18		37			20				18		
RegenAcre	07PVH	HI	279									105		38		17	14				105		
RegenAcre	07PVH	NM	68									35									33		
RegenAcre	07PVH	PL	152									2		148							2		
RegenAcre	07PVH	UM	486									121		135		109					121		
ThinAcre	07PVH	BK	142		34		7	3	34			7	37			7	3			7	3		
ThinAcre	07PVH	BM	1729		423	64		67	423	64			490	64			67				67		
ThinAcre	07PVH	EE	2363			301	16	349		301		37	328	301		37	328			37	328		
ThinAcre	07PVH	FL	2788		274	558	9	64	274	558		9	338	558		9	64			9	64		
ThinAcre	07PVH	GB	235			77		1		77			1	77			1				1		
ThinAcre	07PVH	HD	1518		398	108			398	108			398	108									
ThinAcre	07PVH	HI	2156		476	200	25	7	476	200		25	483	200		25	7			25	7		
ThinAcre	07PVH	NG	41			11		2		11			2	11			2				2		
ThinAcre	07PVH	NM	499			121		34		121		34		121		34				34			

ThinAcre	07PVH	PL	84			28				28				28									
ThinAcre	07PVH	UM	1742			550	5	18		550		11	12	550		11	12			11	12		
Volume	07PVH	BK	1114		7		32	0	27	149	3	284	7	134		38	0	6	115	3	174	85	50
Volume	07PVH	BM	3040		89	13	97	45	92	435	149	585	320	33		74	13		381		508	206	
Volume	07PVH	EE	3447			63	27	86	114	163	76	664	153	846		135	69		201	23	193	568	66
Volume	07PVH	FL	3051		58	117	26	16	115	227	69	421	91	725	2	343	14		150	47	152	269	209
Volume	07PVH	GB	271			16		0	0	16	13	2	0	79		81	0		0	11	0	2	51
Volume	07PVH	HD	712		84	22	6		96	48		92	84	93	29	4	38		31		31	48	6
Volume	07PVH	HI	1494		100	42	37	1	111	190	5	255	101	134	19	64	27		137	10	186	50	25
Volume	07PVH	NG	6			2		0		2			0	2			0				0		
Volume	07PVH	NM	346			26	11	7		77		74		26		16			41	7	58	3	
Volume	07PVH	PL	809			6	1		48	9		215		291		0			41		4	194	
Volume	07PVH	UM	2442			116	40	4	41	289	35	413	3	524		240	3		181	31	214	177	131
Young Mgmt	07PVH	BK	2400	70	71	71	71	71	71	175	175	240	136	144	79	79	71	71	153	153	175	158	166
Young Mgmt	07PVH	BM	4996	265	121	121	121	121	121	416	540	551	256	132	121	121	121	121	403	403	403	269	269
Young Mgmt	07PVH	EE	6645	596	276	166	166	166	166	236	284	665	595	602	221	221	166	166	236	236	236	595	650
Young Mgmt	07PVH	FL	2722	285	17	12	12	12	12	92	104	297	217	379	187	187	13	12	92	92	92	217	391
Young Mgmt	07PVH	GB	185	12								1	1	43	42	42						1	43
Young Mgmt	07PVH	HD	471	22	24	4	4	4	4	22	22	59	41	41	24	24	24	4	22	22	22	41	41
Young Mgmt	07PVH	HI	1478	56	42	25	25	25	25	130	130	168	63	80	56	56	39	25	130	130	130	63	80
Young Mgmt	07PVH	NG	3980	123	203	203	203	203	203	203	203	203	203	203	203	203	203	203	203	203	203	203	203
Young Mgmt	07PVH	NM	1316	67	87	53	53	53	53	88	88	88	53	53	53	53	53	53	86	86	86	55	55
Young Mgmt	07PVH	PL	1066	10	16	16	16	16	16	18	18	166	164	164	16	16	16	16	18	18	18	164	164
Young Mgmt	07PVH	UM	3368	162	127	69	69	69	69	190	190	325	204	313	178	178	69	69	190	190	190	204	313
Young Patch	07PVH	BK	995	2	306	22	163							33	149				46	100		12	162
Young Patch	07PVH	BM	53		7	10			7							7				15			7
Young Patch	07PVH	EE	4117	223	57	207	689	452	176	1	39	509	428				218	532		92	242	96	156
Young Patch	07PVH	FL	14					4		10													
Young Patch	07PVH	Forest	32385		268	688	996	1125	1870	2170	2024	1133	2126	2198	2381	1919	1408	2041	2288	2290	1851	1386	2223
Young Patch	07PVH	HI	4	4																			
Young Patch	07PVH	NS	487					360		44						83							
Young Patch	07PVH	UM	854	39	49	70		348	18	14				92		76				10		138	
AllHarvAcre	08Doak	BK	2385	89	216	299	99	10	334	210	2	45	299	336	18	81		81	39			209	18
AllHarvAcre	08Doak	BM	19733	2082	1374	1270	691	1944	1904	1264	424	2166	1986	1318	166	752	20	409	660	206	284	738	75
AllHarvAcre	08Doak	EE	5347	1146	400	96	5	1102	355	115	77	1124	355	89	20	113	51		14	69	63	90	63
AllHarvAcre	08Doak	FL	2721	165	165	323	165	13	341	102	8	11	330	339	8	165		165	19	13		389	
AllHarvAcre	08Doak	GB	2157	332	158	28	72	60	253	228		83	230	51		272		72	23			295	
AllHarvAcre	08Doak	HD	11048	1866	1086	185	90	2027	1124	256	180	2040	1203	263	16	40		3	294	46	26	267	36
AllHarvAcre	08Doak	HI	1449	9	87	215	113	28	96	26	28		124	215	104	9		37			28	198	132
AllHarvAcre	08Doak	NG	787	109	52		78		122			39	122		8	70		70		39		70	8
AllHarvAcre	08Doak	NM	9206	478	1021	305	429	399	484	611	692	49	500	581	481	478	582	32	159	383	13	599	930
AllHarvAcre	08Doak	NS	2568	190	488		68	86	262	104	226	86	262		68	104	226					104	294
AllHarvAcre	08Doak	PL	13224	2316	1003	132	40	2620	1203		322	2669	1226	321	39	114			462	175	99	423	60
AllHarvAcre	08Doak	UM	8634	459	702	914	222	458	744	1117	199	741	704	1155		269	2		245	255	39	210	199
Burning	08Doak	BK	100083	5054	6062	6056	5846	5843	5650	5644	5434	4513	4721	4715	4505	4505	4505	4505	4505	4505	4505	4505	4505
Burning	08Doak	BM	185549	13046	14058	13904	12767	10076	9207	8907	7979	9374	8949	8649	7721	7658	7575	7575	7721	7658	7575	7575	7575
Burning	08Doak	EE	89528	6035	5806	5490	5456	5558	4621	4291	4280	4937	4231	3901	3890	3881	3876	3876	3890	3881	3876	3876	3876
Burning	08Doak	FL	13047	436	763	708	598	848	958	895	801	575	727	664	570	562	562	562	570	562	562	562	562
Burning	08Doak	GB	18851	1431	1655	1525	1497	890	925	795	767	820	918	788	760	760	760	760	760	760	760	760	760
Burning	08Doak	HD	116490	9185	9355	8468	8283	7227	5956	5053	4900	6441	5649	4746	4593	4578	4577	4577	4593	4578	4577	4577	4577
Burning	08Doak	HI	9011	686	806	745	719	381	451	390	364	363	450	389	363	363	363	363	363	363	363	363	363
Burning	08Doak	NG	17042	1009	1289	1237	1237	886	824	772	772	747	799	747	747	747	747	747	747	747	747	747	747
Burning	08Doak	NM	177304	10510	12055	11839	11603	9076	8982	8659	8637	7929	8381	8058	8036	7929	7929	7929	8036	7929	7929	7929	7929
Burning	08Doak	NS	30876	1977	2303	2041	2041	1660	1779	1517	1517	1402	1569	1307	1307	1307	1307	1307	1307	1307	1307	1307	1307
Burning	08Doak	PL	660271	46615	47355	46391	46392	34303	32701	31698	31737	31008	29265	28262	28301	28316	28262	28262	28301	28316	28262	28262	28262
Burning	08Doak	UM	94578	6904	7225	7437	6542	4476	4718	4930	4016	4332	4550	4760	3846	3881	3848	3846	3846	3881	3848	3846	3846
Disturbance	08Doak	BK	893			108	60									20	134	341			114	22	94
Disturbance	08Doak	BM	1408	51			7	620		114	17	5	464	54						5		8	63
Disturbance	08Doak	EE	431		27			282	75							15	28						4
Disturbance	08Doak	FL	107	10						13								14					70
Disturbance	08Doak	Forest	4724						100		185	637	640	137	252	135	409	651	112	268	147	385	666
Disturbance	08Doak	GB	2																			2	
Disturbance	08Doak	HD	383	2	14					58					36	52			91	92			38
Disturbance	08Doak	HI	178	34												4		30				110	
Disturbance	08Doak	NG	180		61		30	35		17	27										10		
Disturbance	08Doak	NM	1076	17	193	30	496	14		43		47					47	59	5	17	1		107
Disturbance	08Doak	NS	54									1						24					29
Disturbance	08Doak	PL	383			9	47	134		149		3					31	10					
Disturbance	08Doak	UM	835	95	115	125	30		60	34	2				165	22	1			29		143	14
Gaps	08Doak	BK	40	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Gaps	08Doak	BM	512	27	27	27	25	25	25	26	25	24	25	26	27	25	25	25	26	26	26	25	25
Gaps	08Doak	EE	220	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
Gaps	08Doak	FL	32	2	2	1	1	1	2	2	2	2	2	1	1	1	2	2	2	2	2	1	1
Gaps	08Doak	GB	29	1	1	1	2	2	2	1	1	1	2	2	2	1	1	1	2	2	2	1	1
Gaps	08Doak	HD	415	21	21	21	21	21	21	21	20	20	20	21	21	21	21	21	21	21	21	20	20
Gaps	08Doak	HI	32	2	2	1	1	1	2	2	2	2	2	1	1	1	2	2	2	2	2	1	1
Gaps	08Doak	NG	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gaps	08Doak	NM	176	11	8	8	8	9	9	9	8	8	10	11	9	7	6	8	10	11	11	9	6
Gaps	08Doak	NS	690	35	34	34	34	35	35	35	34	34	34	35	35	35	34	34	34	35	35	35	34
Gaps	08Doak	PL	370	19	19	19	19	19	19	19	18	17	17	18	19	19	19	19	19	19	19	17	17
Gaps	08Doak	UM	331	17	17	17	17	17	17	16	16	16	17	16	16	16	17	17	17	17	17	16	15
LateSerlClos	08Doak	BK	3670	2744	541	104	1	40	40	39					81				2	39	39		
LateSerlClos	08Doak	BM	17244	7905	3914	1512	826	424	478	357	174	20			409			190	208	408	324	75	20
LateSerlClos	08Doak	EE	3783	2565	537	357	0	0	75	75	81	6	6							57		18	6
LateSerlClos	08Doak	FL	1221	701	278	0	13	13	13	5	11				165					11	11		
LateSerlClos	08Doak	Forest	115									1	3	5	9	14	13	13	10	8	13	12	14
LateSerlClos	08Doak	GB	643	338	118			23	23	23					72					23	23		
LateSerlClos	08Doak	HD	4689	2360	713	147	98	128	162	162	111				3			87	215	290	177	36	
LateSerlClos	08Doak	HI	306	129	28	0	28	28	28						9				28	28			
LateSerlClos	08Doak	NG	770	349	241	110									70								
LateSerlClos	08Doak	NM	6423	3302	1379	1033	421	16	16	16	13	13	13		32			36	52	52	16		13
LateSerlClos	08Doak	NS	1632	1003	628	1																	

LateSerlClos	08Doak	PL	11156	6740	1117	342	33	423	571	543	159								223	522	423	60	
LateSerlClos	08Doak	UM	7555	3341	1870	379	336	73	272	230	230							203	168	212	42	199	
LateSerlOpen	08Doak	BK	434	8	216	210																	
LateSerlOpen	08Doak	BM	5014	1673	1374	1094	182	168	231	209	83												
LateSerlOpen	08Doak	EE	1493	1056	355	25		14	19	19	5												
LateSerlOpen	08Doak	FL	291		165	102		8	8	8													
LateSerlOpen	08Doak	Forest	5541		84	248	121	59	48	5		50	147	211	369	575	533	570	466	374	580	524	577
LateSerlOpen	08Doak	GB	246	60	158	28																	
LateSerlOpen	08Doak	HD	3161	1863	1072	181	18	16	4	4	1	1	1										
LateSerlOpen	08Doak	HI	113		87	26																	
LateSerlOpen	08Doak	NG	52		52																		
LateSerlOpen	08Doak	NM	910		452	188	67	107	48	48													
LateSerlOpen	08Doak	NS	348	86	262																		
LateSerlOpen	08Doak	PL	3598	2316	1003			39	79	79	54	14	14										
LateSerlOpen	08Doak	UM	2265	438	702	914	90	5	24	21	37	18	16										
MidAgeClosed	08Doak	BK	2447	147	147	39	39		89	188	188	188	188	101	39	39	128	146	225	188	188	99	81
MidAgeClosed	08Doak	BM	11454	1185	813	600	377	174	49	429	457	457	647	802	593	593	716	546	752	504	504	614	642
MidAgeClosed	08Doak	EE	2586	152	140	132	217	216	141	51	46	46	136	135	192	102	121	127	217	159	159	51	46
MidAgeClosed	08Doak	FL	4088	34	34	37	24	11	224	389	391	391	391	165	11	11	237	237	402	378	378	165	178
MidAgeClosed	08Doak	Forest	7386					124	307	428	714	903	405	318	245	467	822	384	324	264	450	829	402
MidAgeClosed	08Doak	GB	2727	23	23	23	223	200	200	72	72	72	272	272	223	23	23	23	295	272	272	72	72
MidAgeClosed	08Doak	HD	3080	282	189	247	238	125	89	92	26	12	99	218	304	304	349	262	123	39	39	17	26
MidAgeClosed	08Doak	HI	3244	28	28	28			189	302	302	302	302	141	28	28	217	321	302	302	302	113	9
MidAgeClosed	08Doak	NG	1209				39	39	39	117	117	78	78	78	39	39	39	47	117	78	78	78	109
MidAgeClosed	08Doak	NM	17914	550	506	29	475	1028	1097	1044	845	845	1327	1460	1067	621	504	842	1304	1490	1490	975	415
MidAgeClosed	08Doak	NS	3650				104	330	330	294	68	68	172	398	330	226		68	172	398	398	294	
MidAgeClosed	08Doak	PL	6256	716	716	692	624	159	6	6	61	61	61	223	522	522	643	643	420	60	60		61
MidAgeClosed	08Doak	UM	4305	589	332	342	269	251	52	23	21		203	203	268	268	467	264	264	199	199	35	56
MidAgeOpen	08Doak	BM	440			148	209	83															
MidAgeOpen	08Doak	EE	38			14	19	5															
MidAgeOpen	08Doak	FL	16			8	8																
MidAgeOpen	08Doak	Forest	2882							40	40	64	222	414	311	156	155	218	425	306	152	166	213
MidAgeOpen	08Doak	HD	11			4	4	1	1	1													
MidAgeOpen	08Doak	NM	96			48	48																
MidAgeOpen	08Doak	PL	200			39	79	54	14	14													
MidAgeOpen	08Doak	UM	95			5	19	37	18	16													
OldSerlClose	08Doak	BK	44602	3165	5152	3344	2871	2847	2847	1916	1837	1800	1800	1916	1916	1904	1825	1624	1624	1624	1557	1544	1489
OldSerlClose	08Doak	BM	59698	4297	7294	3642	3399	3587	3410	3088	2637	2581	2325	2387	2345	2345	2345	2345	2345	2342	2347	2337	2300
OldSerlClose	08Doak	EE	46123	2862	4501	2687	2808	2642	2485	2069	1841	1859	1859	2075	2069	2060	2044	2044	2044	2044	2044	2044	2042
OldSerlClose	08Doak	FL	4872	608	862	611	365	365	365	146	103	103	103	133	133	133	133	125	125	125	125	125	84
OldSerlClose	08Doak	Forest	86													1	3	5	9	15	16	18	19
OldSerlClose	08Doak	GB	1880	682	744	157	22	22	22	15	38	15	15	15	15	15	15	15	15	15	15	14	14
OldSerlClose	08Doak	HD	40199	4991	5636	2380	1953	2040	2042	1615	1476	1512	1512	1590	1569	1538	1538	1538	1484	1430	1517	1430	1408
OldSerlClose	08Doak	HI	6923	943	943	415	286	286	286	313	285	285	285	285	285	283	283	265	265	265	265	200	200
OldSerlClose	08Doak	NG	7051	812	832	496	396	363	349	314	243	232	232	280	280	280	280	280	280	280	274	274	274
OldSerlClose	08Doak	NM	74625	7868	8693	4682	4049	3881	3875	3213	2479	2451	2432	3161	3148	3148	3120	3085	3082	3072	3107	3071	3008
OldSerlClose	08Doak	NS	138667	7551	7438	7177	7034	7034	7034	6834	6806	6805	6805	6825	6825	6825	6825	6811	6811	6811	6811	6811	6794
OldSerlClose	08Doak	PL	116927	22949	27569	7341	6620	6522	6473	3351	2583	2441	2440	2880	2880	2880	2862	2856	2856	2856	2856	2856	2856
OldSerlClose	08Doak	UM	55095	4187	5138	2669	2691	2942	2907	2576	2435	2620	2620	2537	2440	2427	2426	2426	2426	2409	2577	2325	2317
OldSerlOpen	08Doak	BK	63261		8	2214	2823	2823	2823	3755	3755	3755	3755	3755	3755	3755	3755	3755	3755	3755	3755	3755	3755
OldSerlOpen	08Doak	BM	183383		1673	8092	9682	9822	9842	10078	10246	10329	10329	10329	10329	10329	10329	10329	10329	10329	10329	10329	10329
OldSerlOpen	08Doak	EE	71781		1056	3369	3630	3630	3630	4016	4030	4035	4035	4035	4035	4035	4035	4035	4035	4035	4035	4035	4035
OldSerlOpen	08Doak	FL	13272			379	562	562	562	781	802	802	802	802	802	802	802	802	802	802	802	802	802
OldSerlOpen	08Doak	Forest	14090				236	566	1012	1109	1285	1304	1327	1512	1534	385	247	272	380	625	680	781	835
OldSerlOpen	08Doak	GB	17815		60	895	986	986	986	993	993	993	993	993	993	993	993	993	993	993	993	993	993
OldSerlOpen	08Doak	HD	135962		1863	6584	7229	7235	7247	7553	7557	7557	7557	7558	7558	7558	7558	7558	7558	7558	7558	7558	7558
OldSerlOpen	08Doak	HI	8432			428	470	470	470	471	471	471	471	471	471	471	471	471	471	471	471	471	471
OldSerlOpen	08Doak	NG	11198			495	609	609	609	634	634	634	634	634	634	634	634	634	634	634	634	634	634
OldSerlOpen	08Doak	NM	109589			4899	5567	5575	5634	6235	6283	6283	6283	6283	6283	6283	6283	6283	6283	6283	6283	6283	6283
OldSerlOpen	08Doak	NS	26530		86	1236	1312	1312	1312	1512	1520	1520	1520	1520	1520	1520	1520	1520	1520	1520	1520	1520	1520
OldSerlOpen	08Doak	PL	506437		2316	24322	25348	25348	25348	28410	28825	28865	28865	28879	28879	28879	28879	28879	28879	28879	28879	28879	28879
OldSerlOpen	08Doak	UM	92433		438	4070	4927	5012	5012	5172	5184	5203	5205	5221	5221	5221	5221	5221	5221	5221	5221	5221	5221
OthrSheltAcr	08Doak	BK	561	81			81	2	37		2	37	81			81			39			120	
OthrSheltAcr	08Doak	BM	4461	409			599	203	121	190	278	141	409	75	20	594			514	75	20	738	75
OthrSheltAcr	08Doak	EE	90								18	6		18	6					18	6		18
OthrSheltAcr	08Doak	FL	869	165			165		11			11	165			165			11			176	
OthrSheltAcr	08Doak	GB	452	72			72		23			23	72			72			23			95	
OthrSheltAcr	08Doak	HD	1215	3			90	128	49	87	164	49	3	36		3			264	36		267	36
OthrSheltAcr	08Doak	HI	157	9			9	28			28		9			9		28			28	9	
OthrSheltAcr	08Doak	NG	350	70			70						70			70						70	
OthrSheltAcr	08Doak	NM	407	32			68	16		36	16	13	32		13	32			52		13	84	
OthrSheltAcr	08Doak	PL	1932					223	200		283	200		60					423	60		423	60
OthrSheltAcr	08Doak	UM	1776				203		42	203	199	42		199		35			245	199		210	199
RegenAcre	08Doak	BK	522			89	18		81				2	126	18			81				89	18
RegenAcre	08Doak	BM	1914					48	409			269	203	169		75	20	409		48	264		
RegenAcre	08Doak	EE	816	90	45			46		90	45	57		46		108	51			46	57	90	45
RegenAcre	08Doak	FL	1019			213		13	165					237				165		13		213	
RegenAcre	08Doak	GB	967	200					72	200				23		200		72				200	
RegenAcre	08Doak	HD	427		14			9	3			127	128	58		36		3	14	9	26		
RegenAcre	08Doak	HI	953			189	104		9				28	189	104			9				189	132
RegenAcre	08Doak	NG	281	39			8		70			39			8			70		39			8
RegenAcre	08Doak	NM	6628	446	569	69	361	383	32	446	569	36	16	452	361	446	582	32		383		515	930
RegenAcre	08Doak	NS	1524	104	226		68			104	226				68	104	226					104	294
RegenAcre	08Doak	PL	864					61				99	223	261		60				61	99		
RegenAcre	08Doak	UM	546	21								226		42		199				21	37		
ThinAcre	08Doak	BK	1302	8	216	210		8	216	210		8	216	210									
ThinAcre	08Doak	BM	13358	1673	1374	1270	92	1693	1374	1074	146	1756	1374	1074	146	83			146	83			
ThinAcre	08Doak	EE	4441	1056	355	96	5	1056	355	25	14	1061	355	25	14	5			14	5			
ThinAcre	08Doak	FL	833		165	110			165	102	8		165	102	8				8				
ThinAcre	08Doak	GB	738	60	158	28		60	158	28		60	158	28									
ThinAcre	08Doak	HD	9406	1863	1072	185		1890	1072	169	16	1864	1072	169	16	1			16	1			
ThinAcre	08Doak	HI	339		87	26			87	26			87	26									

ThinAcre	08Doak	NG	156		52				52				52										
ThinAcre	08Doak	NM	2171		452	236			452	129	107		452	129	107				107				
ThinAcre	08Doak	NS	1044	86	262			86	262			86	262										
ThinAcre	08Doak	PL	10428	2316	1003	132	40	2336	1003		39	2370	1003		39	54			39	54			
ThinAcre	08Doak	UM	6312	438	702	914	19	458	702	914		473	704	914		35	2			35	2		
Volume	08Doak	BK	1673	30	54	245	162	2	226	52	2	56	74	262	28	98		139	9			206	28
Volume	08Doak	BM	10229	572	344	305	736	580	1222	550	341	1071	808	683	66	699	38	705	347	105	436	530	91
Volume	08Doak	EE	2497	499	204	11	1	344	88	136	76	323	88	98	12	165	77		4	71	82	130	88
Volume	08Doak	FL	2624	58	42	468	255	24	376	25	2	13	77	394	2	200		285	4	18		381	
Volume	08Doak	GB	2188	537	39	7	110	15	190	297		48	54	50		377		124	6			334	
Volume	08Doak	HD	4108	467	305	47	32	519	283	173	191	744	507	193	4	72		5	100	21	37	365	43
Volume	08Doak	HI	1892	3	22	416	239	8	39	7	40		78	301	162	10		22			36	296	213
Volume	08Doak	NG	834	119	13		126		155			74	28		12	85		121		74		15	12
Volume	08Doak	NM	12400	1206	1573	200	827	853	177	734	876	74	150	696	609	688	851	55	42	557	3	838	1391
Volume	08Doak	NS	2910	289	645		149	22	66	151	328	22	66		107	151	328					151	435
Volume	08Doak	PL	5596	579	251	11	9	747	311		338	977	667	558	9	128			118	114	141	565	73
Volume	08Doak	UM	4114	164	176	228	70	113	187	530	64	609	176	601		403	0		104	90	64	295	240
Young Mgmt	08Doak	BK	2643	31	31	143	242	245	156	60	62	99	99	186	167	248	159	141	60	60	60	188	206
Young Mgmt	08Doak	BM	7992	87	58	61	470	529	529	317	472	672	482	402	222	631	508	488	264	312	391	535	562
Young Mgmt	08Doak	EE	3529	143	173	189	99	106	106	202	201	258	168	187	136	226	207	201	111	112	169	259	276
Young Mgmt	08Doak	FL	2904	11	11	213	378	392	179	14	1	12	12	238	227	392	166	166	1	14	14	238	225
Young Mgmt	08Doak	GB	2765	200	200	201	73	73	73	201	201	224	24	24	1	273	273	273	1	1	1	224	224
Young Mgmt	08Doak	HD	2093	77	91	15	18	16	16	102	221	310	223	140	51	54	9	9	20	29	55	305	332
Young Mgmt	08Doak	HI	2462	0	0	189	302	302	113	0	28	28	28	189	293	302	113	9	0	0	28	217	321
Young Mgmt	08Doak	NG	969	42	42	44	83	85	85	8	8	47	47	47	16	86	86	78	8	47	47	47	16
Young Mgmt	08Doak	NM	19739	507	1076	1165	1112	947	878	982	1184	1184	702	569	943	1421	1538	1164	686	500	500	1067	1614
Young Mgmt	08Doak	NS	4008	107	333	336	300	74	74	111	337	337	233	7	75	179	405	337	233	7	7	111	405
Young Mgmt	08Doak	PL	6092	89	89	114	114	189	189	199	361	660	660	558	259	259	138	138	138	199	298	721	720
Young Mgmt	08Doak	UM	2974	88	57	50	29	33	33	238	238	303	100	299	234	234	35	35	70	91	93	268	446
Young Patch	08Doak	BK	526			64	35									12	79	201			67	13	55
Young Patch	08Doak	BM	832	30			4	366		68	10	3	274	32						3		5	37
Young Patch	08Doak	EE	253		16			166	44							9	16						2
Young Patch	08Doak	FL	63	6						8								8					41
Young Patch	08Doak	Forest	18771		124	366	527	798	1255	1172	1138	900	1174	1276	1321	1111	768	1184	1264	1332	1117	753	1191
Young Patch	08Doak	GB	1																			1	
Young Patch	08Doak	HD	225	1	8					34					21	31			54	54			22
Young Patch	08Doak	HI	105	20												2		18				65	
Young Patch	08Doak	NG	107		36		18	21		10	16										6		
Young Patch	08Doak	NM	636	10	114	18	293	8		25		28					28	35	3	10	1		63
Young Patch	08Doak	NS	32									1						14					17
Young Patch	08Doak	PL	226			5	28	79		88		2					18	6					
Young Patch	08Doak	UM	491	56	68	73	18		35	20	1				97	13	1			17		84	8
AllHarvAcre	09Ioak	BK	21514	537	271	2099	128	1585	2118	77	2584	241	1064	434	2113	195	14	2537	1198	1979	729	685	926
AllHarvAcre	09Ioak	BM	22042	129	790	1697	40	480	2331	511	2939	22	609	1559	1697	787		2239	572	2955	517	129	2039
AllHarvAcre	09Ioak	EE	34286	6529	87	1168	2392	562	813	283	977	384	7125	314	1255	609	1884	877	424	344	695	6565	999
AllHarvAcre	09Ioak	FL	9417	21	1279	542	645		746	138	79	622	21	971	674	607	529	341	543	79	403	184	993
AllHarvAcre	09Ioak	GB	87569	1512	5036	10560	3003	1131	7480	328	6596	788	2643	7171	10566	1895	2738	5335	3547	5389	2031	1527	8293
AllHarvAcre	09Ioak	HD	49135	2677	426	2394	2455	7018	3285	1138	1522	927	3250	1029	489	5573	124	6863	2960	1862	141	3268	1734
AllHarvAcre	09Ioak	HI	9507	203	24	1491	753	22	244	131	510	331	225	688	1140	998	618	204	193	488	331	225	688
AllHarvAcre	09Ioak	NG	4751	438	343	183	42		280		173	219	438	376	530	227	16	245	35	173	203	438	392
AllHarvAcre	09Ioak	NM	86124	3921	7214	2168	4509	2179	6201	82	4753	4797	5154	6870	5254	273	4427	6342	1093	3386	4471	5483	7547
AllHarvAcre	09Ioak	NS	4184	256	591	943	168			4		4	256		1534		164		4			260	
AllHarvAcre	09Ioak	PL	28976	1355	1150	2518	218	3416	944	249	760	983	1355	2579	2518	678	126	3834	526	835	998	1374	2560
AllHarvAcre	09Ioak	UM	26573	383	88	1865	739	4003	2498	737	756	1248	400	748	1952	766		4993	1984	292	1923	433	765
Burning	09Ioak	BK	194638	13383	14004	14004	14004	10006	9695	9695	9695	8346	8346	8346	8346	8346	8346	8346	8346	8346	8346	8346	8346
Burning	09Ioak	BM	371782	25731	27903	27903	27903	18841	17755	17755	17755	15853	15853	15853	15853	15853	15853	15853	15853	15853	15853	15853	15853
Burning	09Ioak	EE	261515	18140	19128	19128	19128	13279	12814	12814	12814	11202	11188	11188	11188	11188	11188	11188	11188	11188	11188	11188	11188
Burning	09Ioak	FL	33523	2538	2758	2758	2758	1537	1433	1433	1433	1409	1406	1406	1406	1406	1406	1406	1406	1406	1406	1406	1406
Burning	09Ioak	GB	306891	23803	23905	23905	23905	13957	13967	13967	13967	12988	12957	12957	12957	12957	12957	12957	12957	12957	12957	12957	12957
Burning	09Ioak	HD	300113	21404	23265	23265	23265	14703	13821	13821	13821	12751	12727	12727	12727	12727	12727	12727	12727	12727	12727	12727	12727
Burning	09Ioak	HI	48218	2792	3446	3446	3446	2726	2444	2444	2444	2106	2084	2084	2084	2084	2084	2084	2084	2084	2084	2084	2084
Burning	09Ioak	NG	96676	6885	7580	7580	7580	4726	4396	4396	4396	4103	4094	4094	4094	4094	4094	4094	4094	4094	4094	4094	4094
Burning	09Ioak	NM	544660	37924	39194	39194	39194	27726	27092	27092	27092	23346	23346	23346	23346	23346	23346	23346	23346	23346	23346	23346	23346
Burning	09Ioak	NS	19266	1115	1327	1327	1327	1114	1008	1008	1008	836	836	836	836	836	836	836	836	836	836	836	836
Burning	09Ioak	PL	195752	11014	12799	12799	12799	11583	10705	10705	10705	8560	8553	8553	8553	8553	8553	8553	8553	8553	8553	8553	8553
Burning	09Ioak	UM	275296	19906	21842	21842	21842	13282	12337	12337	12337	11641	11630	11630	11630	11630	11630	11630	11630	11630	11630	11630	11630
Disturbance	09Ioak	BK	742	29		27	150	140		7	12	20	111			11	68	27	66	34			40
Disturbance	09Ioak	BM	1536	121	22	27	42	280	1	7	7	1	235		3		139	57				407	187
Disturbance	09Ioak	EE	507	31			37	155			8	11			11						52		202
Disturbance	09Ioak	FL	53			7	4								9				2	31			
Disturbance	09Ioak	Forest	5713							346	194	475	1054	247	373	212	587	871	183	410	239	522	
Disturbance	09Ioak	GB	575			13	423					15			52		72						
Disturbance	09Ioak	HD	311	90	178		8			3		2	30										
Disturbance	09Ioak	HI	108			15	24	15	2		41	8				3							
Disturbance	09Ioak	NG	472		124			32		1			10					93	7		174		31
Disturbance	09Ioak	NM	2209		177	310	214	639	201	202	41	12	12	10	194	62		14	7	112	2		
Disturbance	09Ioak	PL	1233	3	2	4	4	114		51	4	88	22	3	42			122					774
Disturbance	09Ioak	UM	1790	82	83	64	25	53	215	14	50	362	3	51	8	115	20	354	91			3	197
Gaps	09Ioak	BK	2309	123	121	119	121	116	105	106	109	120	117	119	119	121	123	112	106	106	114	117	115
Gaps	09Ioak	BM	1512	85	79	79	80	86	70	67	63	79	81	74	74	75	86	74	70	67	75	78	70
Gaps	09Ioak	EE	1772	71	70	64	92	93	98	112	109	110	68	69	62	103	92	101	100	113	109	69	67
Gaps	09Ioak	FL	318	23	14	11	7	16	16	19	19	19	20	15	14	11	12	16	15	19	17	20	15
Gaps	09Ioak	GB	2652	176	142	97	89	124	124	141	132	176	167	129	85	96	124	146	122	141	154	167	120
Gaps	09Ioak	HD	2550	155	153	136	125	83	93	101	142	145	148	146	147	119	125	96	108	102	134	146	146
Gaps	09Ioak	HI	378	24	24	13	10	10	21	24	24	23	23	20	13	11	10	18	20	24	23	23	20
Gaps	09Ioak	NG	308	15	13	12	15	17	18	18	18	17	14	13	11	14	15	18	18	18	17	14	13
Gaps	09Ioak	NM	5953	325	277	280	276	320	295	325	316	308	282	268	279	306	305	305	301	325	317	283	260
Gaps	09Ioak	NS	358	20	16	10	11	15	21	22	22	22	20	20	10	12	11	21	21	22	22	20	20
Gaps	09Ioak	PL	1861	107	99	81	88	72	90	90	113	107	100	89	77	85	96	94	91	90	104	99	89
Gaps	09Ioak	UM	1738	107	106	93	92	65	68	65	88	93	97	102	93	92	92	78	67	65	83	95	97
LateSerlClos	09Ioak	BK	70796	21886	20040	13534	6700	2256	1417	1248	308	112	104	40	46	44	1081	1137	45	650	148		
LateSerlClos	09Ioak	BM	75426	23318	21803	8899	6462	6286	2436	1942	996	771	768	45	47	47	26	574	511	495			

LateSerlClos	09Ioak	EE	56974	18087	17720	8360	3988	1327	817	839	285	281	270	131	47	1931	37	419	277	910	440	404	404
LateSerlClos	09Ioak	FL	12678	3566	2767	1288	677	708	413	435	474	28	28	608	480	521	11	409			197	34	34
LateSerlClos	09Ioak	Forest	467									210	90	8	13	19	17	19	16	14	21	19	21
LateSerlClos	09Ioak	GB	99077	29746	26600	9511	7783	7423	2354	3086	1777	1664	1658	46	42	2774	14	3263	57	1264	15		
LateSerlClos	09Ioak	HD	111541	27831	26569	14675	13983	3760	2362	2026	1590	1021	958	435	2411	72	6453	2875	1077	737	1296	705	705
LateSerlClos	09Ioak	HI	15050	4605	4136	1365	423	397	499	769	716	491	488	39	390	633	15	40		22	22		
LateSerlClos	09Ioak	NG	15537	5135	4689	1835	887	706	612	419	335	224	214	384	37	25		35					
LateSerlClos	09Ioak	NM	163447	42579	33935	24842	12946	10090	8133	6670	4581	347	326	3233	189	4595	1000	1524	1027	2394	2720	1158	1158
LateSerlClos	09Ioak	NS	8420	3564	2641	973	467	4	4					591		164			4	4	4		
LateSerlClos	09Ioak	PL	61114	19322	14845	9126	5753	933	1507	1781	1665	653	586	4	8	134	3424	511	249	174	159	140	140
LateSerlClos	09Ioak	UM	74008	19249	19340	9602	8779	4621	2305	1984	1022	121	41	165	86	85	4056	1516	261	725	50		
LateSerlOpen	09Ioak	BK	10218			4713	3011	1852	275	113	112	96	29	17									
LateSerlOpen	09Ioak	BM	28549			10913	11345	4391	351	382	373	366	237	191									
LateSerlOpen	09Ioak	EE	11718			6454	4328	522	161	75	72	62	39	5									
LateSerlOpen	09Ioak	FL	2600			839	676	464	200	120	93	89	83	36									
LateSerlOpen	09Ioak	Forest	12055			97	352	788	1383	1384	864	417	138	300	490	744	705	776	671	568	817	741	820
LateSerlOpen	09Ioak	GB	21696			8357	6048	4524	892	688	627	245	193	122									
LateSerlOpen	09Ioak	HD	12222			6517	2829	1391	536	264	249	224	160	52									
LateSerlOpen	09Ioak	HI	2767			987	1087	236	4	101	108	108	108	28									
LateSerlOpen	09Ioak	NG	5679			1772	1968	1553	102	97	57	57	57	16									
LateSerlOpen	09Ioak	NM	18011			5155	4522	2989	1094	1462	946	837	746	260									
LateSerlOpen	09Ioak	NS	882			336	380	158	2	2	2	2											
LateSerlOpen	09Ioak	PL	4025			1834	1179	297	105	151	151	151	114	43									
LateSerlOpen	09Ioak	UM	17772			6035	6146	2106	1125	770	486	464	441	199									
MidAgeClosed	09Ioak	BK	51808	2210	1805	1478	1539	1210	1210	1133	2142	4047	3683	4059	4002	4347	3627	1947	1966	1316	2988	3696	3403
MidAgeClosed	09Ioak	BM	56533	4324	3221	2389	2303	2215	1689	1044	981	3214	3636	3317	3337	3386	4923	2654	2183	1688	3363	3846	2820
MidAgeClosed	09Ioak	EE	132076	1762	1281	1480	7380	7226	8016	9987	9934	10087	4184	4848	3862	7821	8047	8920	9014	10147	9928	4130	4022
MidAgeClosed	09Ioak	FL	37582	1220	735	565	525	1743	1999	2347	2309	2765	2882	1596	1588	1102	1808	1925	2253	2760	2374	2896	2190
MidAgeClosed	09Ioak	Forest	10732					210	556	546	769	1045	600	487	375	680	1118	548	500	418	626	1128	1126
MidAgeClosed	09Ioak	GB	295041	8193	4622	4094	4117	8852	15073	16654	16553	23115	21931	18147	11804	10584	17244	17133	16805	18273	21470	23490	16887
MidAgeClosed	09Ioak	HD	164301	5170	3444	2477	2827	2719	4461	5742	12088	13047	13677	13824	12061	10339	4843	4296	7721	7209	11184	13604	13568
MidAgeClosed	09Ioak	HI	37575	1064	1042	1039	1182	1046	2233	2351	2351	2391	2323	2306	1015	592	1080	2180	2428	3024	2824	2796	2308
MidAgeClosed	09Ioak	NG	17642	1030	600	508	892	1203	1136	1056	1056	999	603	260	280	634	807	1302	1356	1356	1153	792	619
MidAgeClosed	09Ioak	NM	314153	13997	10396	9010	12126	17547	14296	16600	17091	20212	16373	11541	16214	15708	19081	18517	18435	20468	18867	15483	12191
MidAgeClosed	09Ioak	NS	23164	6	6	4	260	847	1790	1954	1954	1954	1702	1111	168	260	260	1794	1790	1954	1954	1698	1698
MidAgeClosed	09Ioak	PL	115769	2203	2419	2382	3489	4053	5677	5292	8592	8582	7568	6588	5049	6094	4414	6923	6766	6718	8653	7897	6410
MidAgeClosed	09Ioak	UM	108038	6004	3884	2560	2313	1926	2871	2484	6428	7900	8517	9092	7996	7853	3893	4327	3854	3129	6348	8212	8447
MidAgeOpen	09Ioak	BK	146			57	51	24	14														
MidAgeOpen	09Ioak	BM	961			276	321	193	171														
MidAgeOpen	09Ioak	EE	72			32	22	18															
MidAgeOpen	09Ioak	FL	248			45	84	83	36														
MidAgeOpen	09Ioak	Forest	4815		143	280	156	41			138	216	268	528	437	248	234	320	583	421	237	260	305
MidAgeOpen	09Ioak	GB	1129			577	241	189	122														
MidAgeOpen	09Ioak	HD	458			100	185	121	52														
MidAgeOpen	09Ioak	HI	70			3	23	23	21														
MidAgeOpen	09Ioak	NG	67			9	21	21	16														
MidAgeOpen	09Ioak	NM	2496			826	760	672	238														
MidAgeOpen	09Ioak	NS	4			2	2																
MidAgeOpen	09Ioak	PL	258			52	115	81	10														
MidAgeOpen	09Ioak	UM	1558			454	464	441	199														
OldSerlClose	09Ioak	BK	242470	2704	4800	4740	11441	15292	14381	13297	13646	13651	13586	13541	13541	13536	13513	13500	13481	13461	13461	13461	13437
OldSerlClose	09Ioak	BM	155419	2052	4190	5088	6547	7420	9414	8200	8709	8944	8808	8714	8712	8711	8650	8640	8642	8642	8642	8402	8292
OldSerlClose	09Ioak	EE	112628	2587	3445	2636	4535	7346	7790	6130	6004	6008	6015	6015	6042	6004	6014	6014	6051	6051	6020	6020	5901
OldSerlClose	09Ioak	FL	1779	21	68	11	62	92	116	98	98	107	107	107	102	98	101	108	111	93	93	93	93
OldSerlClose	09Ioak	Forest	129													2	6	8	13	21	23	27	29
OldSerlClose	09Ioak	GB	24646	1143	2943	2220	2404	2897	1628	751	869	869	869	869	838	817	803	786	788	788	788	788	788
OldSerlClose	09Ioak	HD	133838	2935	5463	5239	2921	7233	8247	7325	7269	7275	7319	7307	7244	7250	7253	7253	7261	7261	7261	7261	7261
OldSerlClose	09Ioak	HI	12661	115	641	530	565	732	887	664	648	651	651	651	651	649	648	663	663	663	663	663	663
OldSerlClose	09Ioak	NG	38713	1162	1634	995	1566	1759	2056	2076	2151	2151	2155	2151	2151	2151	2176	2121	2117	2117	2014	2014	1996
OldSerlClose	09Ioak	NM	466872	15612	21514	13354	20729	23985	25169	24739	24826	24850	24859	24848	24729	24636	24725	24729	24767	24701	24700	24700	24700
OldSerlClose	09Ioak	NS	21130	135	467	637	873	1340	1340	1167	1167	1167	1167	1167	1167	1167	1167	1167	1167	1167	1167	1167	1167
OldSerlClose	09Ioak	PL	138879	3470	6851	4603	7016	8938	9203	7112	7145	7139	7157	7146	7120	7103	7103	7035	7039	7039	7039	7039	6582
OldSerlClose	09Ioak	UM	119572	3422	5534	4795	4733	5341	6911	6418	6660	6595	6528	6497	6471	6400	6357	6210	6164	6164	6164	6162	6046
OldSerlOpen	09Ioak	BK	134162			1918	3936	5122	6709	8233	8234	8250	8317	8329	8346	8346	8346	8346	8346	8346	8346	8346	8346
OldSerlOpen	09Ioak	BM	247150			1676	2285	9367	13429	15471	15480	15487	15616	15662	15853	15853	15853	15853	15853	15853	15853	15853	15853
OldSerlOpen	09Ioak	EE	182585			2582	5213	9023	9402	11099	11116	11126	11149	11183	11188	11188	11188	11188	11188	11188	11188	11188	11188
OldSerlOpen	09Ioak	FL	22239			385	619	832	1143	1283	1313	1317	1323	1370	1406	1406	1406	1406	1406	1406	1406	1406	1406
OldSerlOpen	09Ioak	Forest	24451						18	184	819	1333	1957	2125	2151	2363	2578	2630	2563	2043	1450	1076	1161
OldSerlOpen	09Ioak	GB	206280			2962	5658	7234	10933	12239	12330	12712	12764	12835	12957	12957	12957	12957	12957	12957	12957	12957	12957
OldSerlOpen	09Ioak	HD	211083			4088	8621	10123	11047	12438	12478	12503	12567	12675	12727	12727	12727	12727	12727	12727	12727	12727	12727
OldSerlOpen	09Ioak	HI	32873			404	611	1462	1696	1960	1976	1976	1976	2056	2084	2084	2084	2084	2084	2084	2084	2084	2084
OldSerlOpen	09Ioak	NG	66378			1663	1802	2217	3673	3988	4037	4037	4037	4078	4094	4094	4094	4094	4094	4094	4094	4094	4094
OldSerlOpen	09Ioak	NM	384097			12982	14317	15938	18267	21884	22400	22509	22600	23086	23346	23346	23346	23346	23346	23346	23346	23346	23346
OldSerlOpen	09Ioak	NS	13364			219	281	505	661	834	834	834	836	836	836	836	836	836	836	836	836	836	836
OldSerlOpen	09Ioak	PL	140167			3622	5108	6024	6287	8396	8402	8402	8439	8510	8553	8553	8553	8553	8553	8553	8553	8553	8553
OldSerlOpen	09Ioak	UM	186214			3467	4316	8379	9602	10850	11144	11166	11189	11431	11630	11630	11630	11630	11630	11630	11630	11630	11630
OthrSheltAcr	09Ioak	BK	10878	96		1867	128	527	1963	32	594	110	96	67	1881	128		2441	81	67	574	145	81
OthrSheltAcr	09Ioak	BM	11984	40		1697	40	480	1719		1227	22	40	747	1697	40		2199		747	502	40	747
OthrSheltAcr	09Ioak	EE	5674	343			508	562	88	165	788	88	377	226		383		500	42	226	500	379	499
OthrSheltAcr	09Ioak	FL	1994			76	138		341	138	3	287		3	98	138		341	138	3	265		25
OthrSheltAcr	09Ioak	GB	28998			3708	271	1131	4219	271	2755	517		1624	3714	271		5335	286	1624	1627	15	1630
OthrSheltAcr	09Ioak	HD	17574	2169			2394	573	80	225	1522	143	2169	949	63	2230		80	93	949	80	2201	1654
OthrSheltAcr	09Ioak	HI	3384	4			135	22	200	131	510	200	4	488		135		200	153	488	200	26	488
OthrSheltAcr	09Ioak	NG	1762	42			42		203		173	219	42	173	16	42		203		173	203	42	189
OthrSheltAcr	09Ioak	NM	24900			2168	82	1233	4719	82	1424	2551		191	2168	82		5396	638	191	3228	556	191
OthrSheltAcr	09Ioak	NS	16				4			4									4			4	
OthrSheltAcr	09Ioak	PL	6176	92			92		843		586	843	92	586		92		824	19	586	824	111	586
OthrSheltAcr	09Ioak	UM	6299	263		5	739	17	727	476	43	722	263	26	5	739		744	476	26	739	263	26
RegenAcre	09Ioak	BK	10636	441	271	232		1058	155	45	1990	131	968	367	232	67	14	96	1117	1912	155	540	845
RegenAcre	09Ioak	BM	10058	89	790				612	511	1712		569	812		747		40	572	2208	15	89	1292
RegenAcre	09Ioak	EE	28612	6186	87	1168	1884		725	118	189	296	6748	88	1255	226	1884	377	382	118	195	6186	500
RegenAcre	09Ioak	FL	7423	21	1279	466	507		405		76	335	21	968	576	469	529		405	76	138	184	968

RegenAcre	09Ioak	GB	58571	1512	5036	6852	2732		3261	57	3841	271	2643	5547	6852	1624	2738		3261	3765	404	1512	6663
RegenAcre	09Ioak	HD	31561	508	426	2394	61	6445	3205	913		784	1081	80	426	3343	124	6783	2867	913	61	1067	80
RegenAcre	09Ioak	HI	6123	199	24	1491	618		44			131	221	200	1140	863	618	4	40		131	199	200
RegenAcre	09Ioak	NG	2989	396	343	183			77				396	203	514	185	16	42	35			396	203
RegenAcre	09Ioak	NM	61224	3921	7214		4427	946	1482		3329	2246	5154	6679	3086	191	4427	946	455	3195	1243	4927	7356
RegenAcre	09Ioak	NS	4168	256	591	943	164					4	256		1534		164					256	
RegenAcre	09Ioak	PL	22800	1263	1150	2518	126	3416	101	249	174	140	1263	1993	2518	586	126	3010	507	249	174	1263	1974
RegenAcre	09Ioak	UM	20274	120	88	1860		3986	1771	261	713	526	137	722	1947	27		4249	1508	266	1184	170	739
Volume	09Ioak	BK	31744	1257	778	1360	146	2592	3224	149	4749	424	2069	944	1055	251	25	2606	2623	3258	1067	1416	1751
Volume	09Ioak	BM	31435	281	2215	618	60	140	4075	1175	4385	29	1088	3055	416	1433		2284	1316	4212	674	231	3748
Volume	09Ioak	EE	74016	16279	199	3298	4867	166	1525	531	1270	760	16501	468	3106	876	4333	773	896	329	1082	15521	1236
Volume	09Ioak	FL	18620	62	3148	1097	1211		1122	196	148	1078	53	2231	1373	1112	1207	159	1103	129	559	427	2205
Volume	09Ioak	GB	161711	4480	13060	20496	6371	357	13171	515	9691	1214	5844	15721	17962	3046	6294	4973	7838	6761	2819	3781	17317
Volume	09Ioak	HD	83200	2238	979	5509	3440	15029	6654	2421	1198	1836	2960	1479	1076	9953	266	14277	6680	2331	201	3126	1547
Volume	09Ioak	HI	17320	597	56	4151	1465	7	160	176	188	506	539	1050	2833	1806	1422	57	260	120	466	527	934
Volume	09Ioak	NG	8276	1039	789	508	64		225		54	287	994	609	1237	397	29	120	80	42	250	994	558
Volume	09Ioak	NM	162633	11505	18923	767	10207	2559	7460	116	8769	8518	11998	15021	7631	372	10181	5653	1292	6053	6837	12779	15992
Volume	09Ioak	NS	10582	732	1360	2737	379			5		7	636		3706		378		1			641	
Volume	09Ioak	PL	60213	3574	3227	7380	434	7856	464	574	586	1482	3164	5203	6262	1197	290	7068	1170	718	1411	3188	4965
Volume	09Ioak	UM	51576	455	203	5410	564	9173	4236	1271	1667	1997	391	1339	4830	489		9797	4055	613	3335	476	1275
Young Mgmt	09Ioak	BK	31102	531	733	944	599	1386	3080	3061	2653	922	1286	974	1025	680	342	1963	3016	3061	1891	1331	1624
Young Mgmt	09Ioak	BM	29389	190	915	879	830	40	2309	2780	3275	1028	606	1648	1626	1577	40	1737	2269	2780	1600	1117	2143
Young Mgmt	09Ioak	EE	80496	6505	6502	7441	3482	3395	2609	665	1416	1253	7156	6631	7667	1858	3516	2261	2272	506	1195	7029	7137
Young Mgmt	09Ioak	FL	20774	88	1325	1766	2252	973	988	619	619	600	483	1189	1325	1770	1571	1049	1126	619	808	449	1155
Young Mgmt	09Ioak	GB	166700	2022	6955	13400	14620	9584	9701	7297	8561	2103	3287	8683	15030	13518	9590	6440	9972	7297	5349	3344	9947
Young Mgmt	09Ioak	HD	94890	692	1011	3328	5050	11069	9711	8619	2747	2350	1720	2096	1946	6001	5113	9238	7603	8455	3921	2092	2128
Young Mgmt	09Ioak	HI	18702	199	223	1714	2137	2113	662	171	193	353	421	887	1827	2007	2137	997	789	171	371	421	909
Young Mgmt	09Ioak	NG	8928	488	831	922	568	225	77	35	35	203	599	772	1099	757	584	54	35	35	238	599	772
Young Mgmt	09Ioak	NM	173347	4947	11664	11135	11641	5373	9023	4678	6126	7191	11030	12955	11326	7405	7513	7541	8078	4678	5953	10899	14191
Young Mgmt	09Ioak	NS	12256	256	847	1790	1698	1107	164	4	4	4	256	256	1790	1534	1698	164	164			260	260
Young Mgmt	09Ioak	PL	65619	1402	2432	4931	3886	6152	3643	3674	432	1406	2420	3982	5517	4346	2736	3136	3551	3674	1754	2529	4016
Young Mgmt	09Ioak	UM	60810	211	249	2068	2211	6109	5762	6236	2975	2234	1617	918	2093	2237	2211	4255	5975	6236	3692	1878	1643
Young Patch	09Ioak	BK	448	17		17	97	83		4	7	12	65			7	40	16	39	20			24
Young Patch	09Ioak	BM	919	72	13	26	26	165	1	4	4	1	139		2		82	34				240	110
Young Patch	09Ioak	EE	316	19			37	91			5	7			7						31		119
Young Patch	09Ioak	FL	35			7	4								5				1	18			
Young Patch	09Ioak	Forest	26003		210	556	750	1015	1513	1770	1578	1112	1794	1816	1861	1589	1178	1685	1777	1883	1605	1140	1171
Young Patch	09Ioak	GB	345			13	250					9			31		42						
Young Patch	09Ioak	HD	187	53	105		8			2		1	18										
Young Patch	09Ioak	HI	70			15	14	9	1		24	5				2							
Young Patch	09Ioak	NG	280		73			20		1			6					55	4		103		18
Young Patch	09Ioak	NM	1327		104	188	144	378	119	119	24	7	7	6	115	37		8	4	66	1		
Young Patch	09Ioak	PL	732	2	1	4	4	68		30	2	52	13	2	25			72					457
Young Patch	09Ioak	UM	1087	49	49	63	18	32	127	8	29	214	2	30	5	68	12	209	54			2	116
AllHarvAcre	10CvHw	BK	27710	473	472	2714	597	1620	1881	2184	1057	1373	1518	2714	862	1373	1640	2031	668	1110	1140	2018	265
AllHarvAcre	10CvHw	BM	45030	2519	3486	349	3705	1076	3690	787	3097	2444	4181	2083	2768	1976	3773	786	2723	289	3052	2246	
AllHarvAcre	10CvHw	EE	37612	1748	3275	1482	39	977	2438	183	1744	2604	2051	159	2347	4851	3673	278	2308	1911	2892	344	2308
AllHarvAcre	10CvHw	FL	15661	42	536	216	1173	1222	79	1399	450	1222	8	1315		3072	81	1363		1363	464	1656	
AllHarvAcre	10CvHw	GB	16660	84	2036	4		2156	520	828	127	766	2128	654		690	520	690		724	3788	945	
AllHarvAcre	10CvHw	HD	30667	2613	337	2259	498	3356	367	2676	1308	2893	436	2383	765	2826	715	2508	278	2339	1519	313	278
AllHarvAcre	10CvHw	HI	5021	34	29	430	29	825	424	34	284	186	59	412	29	69	42	51	29	51	820	1184	
AllHarvAcre	10CvHw	NG	2859	208	54	585	10	46		38	41	229	80	534	10	60	87	36		219	73	549	
AllHarvAcre	10CvHw	NM	54664	1461	991	879	3407	2236	991	5261	3731	4577	1490	3582	1426	4985	2972	3838	966	3628	4053	4190	
AllHarvAcre	10CvHw	NS	5406	667	77	32	913	110	77	32	51	110	783	32	178	324	852	32	152	32	152	673	127
AllHarvAcre	10CvHw	PL	27657	2119	861	3226	2035	805	1443	1317	863	805	2318	1114	538	1656	5052	1359	8	273	333	1532	
AllHarvAcre	10CvHw	UM	33397	1037	864	390	1324	2740	4161	872	1639	1857	1554	216	2000	3149	2664	374	1290	451	4957	637	1221
Disturbance	10CvHw	BK	338	73	20	7		140	12	9	10			15								27	25
Disturbance	10CvHw	BM	278	24	2	14	4		9			37			142			20			20	4	2
Disturbance	10CvHw	EE	503	34	49	91		49	13	83			44		88						3	34	15
Disturbance	10CvHw	FL	69	5		15	15	8	7	3												4	12
Disturbance	10CvHw	Forest	1467						47	91			196	125		210	24	277	86	188	125	98	
Disturbance	10CvHw	GB	68		22		27										5						14
Disturbance	10CvHw	HD	164	37		6		14		15											7	29	56
Disturbance	10CvHw	HI	51	3	7	3	10				20										3	3	2
Disturbance	10CvHw	NG	39	1					3													8	27
Disturbance	10CvHw	NM	238	3		18	38	7	5	20				5			125	3				6	8
Disturbance	10CvHw	NS	132		10	6	2	23	29		35											8	19
Disturbance	10CvHw	PL	400	25	34	99	17				64	90					10	30	8		21	2	
Disturbance	10CvHw	UM	547	10	10		89		86		2	170		25					70		37	26	22
Gaps	10CvHw	BK	2492	137	136	129	124	122	125	121	122	124	126	122	122	122	126	125	125	126	124	117	117
Gaps	10CvHw	BM	2955	158	159	143	151	151	150	152	150	143	142	133	141	140	150	147	152	153	154	143	143
Gaps	10CvHw	EE	2292	125	111	103	113	127	133	126	124	116	115	118	128	99	96	96	119	111	108	107	117
Gaps	10CvHw	FL	385	27	25	25	18	21	15	22	20	20	20	21	21	11	11	11	21	21	19	18	18
Gaps	10CvHw	GB	1038	65	53	53	53	56	49	47	55	57	47	48	49	61	58	58	58	61	38	36	36
Gaps	10CvHw	HD	742	53	39	40	39	38	38	34	34	34	35	38	38	39	37	36	36	38	32	32	32
Gaps	10CvHw	HI	194	13	13	11	11	6	6	6	10	11	11	10	11	11	13	13	13	13	8	2	2
Gaps	10CvHw	NG	427	22	22	19	20	20	23	23	23	22	22	19	20	20	23	23	23	22	22	19	20
Gaps	10CvHw	NM	5386	296	294	292	281	276	276	278	255	251	258	269	273	271	259	258	263	275	259	251	251
Gaps	10CvHw	NS	750	37	37	37	36	36	36	41	41	41	37	37	37	39	35	35	36	40	40	36	36
Gaps	10CvHw	PL	2811	146	140	128	127	132	142	149	147	150	144	146	146	149	124	122	127	152	152	144	144
Gaps	10CvHw	UM	4273	224	226	225	224	217	203	199	205	219	222	222	224	213	210	210	218	220	199	196	197
LateSerlClos	10CvHw	BK	79232	5515	10665	13774	15231	11532	7523	4372	2783	3089	1633	1300	652	32	32		247	488	364		
LateSerlClos	10CvHw	BM	88116	3542	11999	18421	19416	17168	8760	2102	1667	1584	1392	1309	373	124	87	4			2	2	164
LateSerlClos	10CvHw	EE	62808	9049	12948	12847	12132	6695	1863	1159	1365	1535	1268	1085	164	160	112		142	142	142		
LateSerlClos	10CvHw	FL	10485	472	909	1760	2077	1987	1587	699	231	175	170	51	42	42	41	15		79	148		
LateSerlClos	10CvHw	Forest	155									81	34	2	2	13	2	3	3	4	4	3	4
LateSerlClos	10CvHw	GB	31751	736	2894	3893	6939	5867	4507	3407	225	11		21	48	48	48	27	1540	1540			
LateSerlClos	10CvHw	HD	25204	1134	1514	4197	4813	4299	3640	1341	1183	933	617	85	16	349	12		530	530			11
LateSerlClos	10CvHw	HI	10218	724	961	1642	2086	1108	510	363	212	70	47	58	39	21	21	10	791	1173	382		
LateSerlClos	10CvHw	NG	13278	875	1755	3050	2998	2570	1708	195	19	20	20	22	22	12	12						
LateSerlClos	10CvHw	NM	164685	2942	14358	30941	36715	36158	27142	9692	2477	1549	1270	767	220	179	158	38			79		
LateSerlClos	10CvHw	NS	23226	1001	3719	5835	4833	4502	2447	364	133	134	134	83	23	8	8	2					

LateSerlClos	10CvHw	PL	86965	8566	18049	19660	15106	12421	4208	1181	1192	2042	1869	1202	1135	147	147	17			23		
LateSerlClos	10CvHw	UM	143297	5142	12298	23494	30184	27830	18591	7383	4706	4395	3691	1808	523	235	166	89		2684	26	26	26
LateSerlOpen	10CvHw	Forest	2957				87	149	246	312	277	287	55	87	87	82	107	159	190	203	210	198	221
MidAgeClosed	10CvHw	BK	66540	16334	11133	6477	4204	4634	2969	2370	2085	1758	1953	1098	1098	1921	1799	1659	1534	1433	1085	262	734
MidAgeClosed	10CvHw	BM	130967	21619	13372	9025	6887	6450	6988	6339	5399	4319	3916	3406	4117	4993	4706	5108	5415	5912	5581	3624	3791
MidAgeClosed	10CvHw	EE	122652	10663	4482	4865	7070	8413	7644	7197	6569	4703	5287	6884	7013	3104	2588	6425	6847	5162	4578	6287	6871
MidAgeClosed	10CvHw	FL	45541	4403	3557	2532	1426	1458	2593	2367	2006	2183	2630	2511	2504	888	807	2516	2597	2518	1985	1798	2262
MidAgeClosed	10CvHw	Forest	3272					128	191	118	82	144	200	210	236	274	327	253	226	202	150	237	294
MidAgeClosed	10CvHw	GB	75722	9465	5364	4467	3421	2586	2448	3877	4424	4486	2485	2576	4677	4715	4195	4195	3175	3141	893	672	4460
MidAgeClosed	10CvHw	HD	44126	6595	5833	3155	2583	2288	1952	1719	1038	1360	1903	1914	2072	1779	1679	1510	1417	1586	875	819	2049
MidAgeClosed	10CvHw	HI	27888	2415	2209	1115	548	944	888	1537	1651	1633	1858	1621	1641	2001	1988	2006	1228	846	846	61	852
MidAgeClosed	10CvHw	NG	17503	3248	2298	476	354	930	927	915	884	693	644	317	397	881	794	808	895	712	639	309	382
MidAgeClosed	10CvHw	NM	204571	43762	33276	16264	8032	6001	7355	6708	4326	5454	7239	7629	8090	7340	5359	6021	8002	8212	5046	3684	6771
MidAgeClosed	10CvHw	NS	30450	5359	2690	1201	927	913	1702	1651	1591	1576	870	864	1568	1354	706	920	1568	1568	1568	927	927
MidAgeClosed	10CvHw	PL	132884	17456	7361	4820	5551	7652	8326	7385	7518	6796	5721	5528	6911	6188	2054	2597	6731	6974	6626	5182	5507
MidAgeClosed	10CvHw	UM	162672	33885	26941	14736	6744	5973	5388	4524	5676	5908	6009	6068	6090	4897	4318	5588	6167	3406	2397	2145	5812
MidAgeOpen	10CvHw	Forest	1178		87	149	62			19	55	36		46	96	50	73	31	111	76	94	104	89
MixedAge	10CvHw	BK	25058					279	682	1513	1513	1513	1778	1778	1778	1778	1778	1778	1778	1778	1778	1778	1778
MixedAge	10CvHw	BM	44881						2723	3011	3011	3011	3011	3011	3011	3011	3011	3011	3011	3012	3012	3012	3012
MixedAge	10CvHw	EE	19904							47	47	47	1168	1228	1228	1228	1228	1228	2415	2510	2510	2510	2510
MixedAge	10CvHw	FL	15396					42	42	42	42	1222	1222	1222	1222	1222	1222	1222	1222	1363	1363	1363	1363
MixedAge	10CvHw	GB	7696							4	4	616	616	616	616	616	616	616	616	690	690	690	690
MixedAge	10CvHw	HD	39808					2082	2082	2259	2259	2339	2617	2617	2617	2617	2617	2617	2617	2617	2617	2617	2617
MixedAge	10CvHw	HI	1047					34	63	63	63	63	63	63	63	63	63	63	63	80	80	80	80
MixedAge	10CvHw	NG	432									36	36	36	36	36	36	36	36	36	36	36	36
MixedAge	10CvHw	NM	55036					879	1845	1845	1845	1845	1845	4426	4426	4426	4426	4426	4426	4594	4594	4594	4594
MixedAge	10CvHw	NS	1458						25	57	57	57	57	57	57	57	57	57	184	184	184	184	184
MixedAge	10CvHw	PL	3708					208	216	216	216	216	216	216	216	216	216	216	216	281	281	281	281
MixedAge	10CvHw	UM	12610					66	135	135	135	135	714	714	714	714	714	714	1356	1591	1591	1591	1591
OldSerlClose	10CvHw	BK	294680	620	841	1557	2373	6135	11383	15084	17116	17426	18882	19238	19880	20500	20500	20532	20532	20532	20532	20516	20501
OldSerlClose	10CvHw	BM	318993	280	381	722	944	3690	12268	19086	20360	20632	20826	20992	21848	22060	22077	22148	22144	22144	22132	22130	22129
OldSerlClose	10CvHw	EE	217562	68	186	210	1246	6552	11609	12915	13236	13247	13359	13636	14505	14522	14522	14634	14634	14634	14632	14612	14603
OldSerlClose	10CvHw	FL	33698		12	27	164	391	743	1690	2162	2218	2218	2363	2387	2387	2388	2414	2429	2429	2429	2427	2420
OldSerlClose	10CvHw	Forest	24													1	2	2	2	3	4	5	5
OldSerlClose	10CvHw	GB	77345	2	2	2	11	378	1356	2355	5410	5624	5635	5635	5635	5635	5632	5651	5678	5678	5678	5678	5670
OldSerlClose	10CvHw	HD	81158	37	231	270	552	823	1734	4456	4835	5033	5191	5735	5804	5808	5808	5820	5820	5820	5816	5799	5766
OldSerlClose	10CvHw	HI	18914	107	129	153	266	453	712	1004	1179	1179	1202	1202	1231	1249	1249	1260	1270	1270	1268	1266	1265
OldSerlClose	10CvHw	NG	69667	917	973	1113	1341	1778	2641	4163	4339	4348	4348	4358	4358	4368	4368	4380	4380	4380	4380	4375	4359
OldSerlClose	10CvHw	NM	558862	245	321	910	1349	3061	12698	29870	37192	38161	38461	39081	39664	39705	39652	39720	39757	39757	39757	39753	39748
OldSerlClose	10CvHw	NS	81675	121	153	165	577	908	3010	5138	5410	5410	5410	5467	5529	5544	5544	5550	5552	5552	5552	5547	5536
OldSerlClose	10CvHw	PL	309315	247	477	616	3711	6470	14981	18782	18817	18877	19014	19811	19895	20883	20877	20985	20985	20982	20969	20968	20968
OldSerlClose	10CvHw	UM	471620	390	834	1865	2533	4813	12413	24814	28864	29362	30067	32012	33376	33664	33733	33810	33858	33830	33809	33793	33780
OldSerlOpen	10CvHw	Forest	7163								87	149	535	553	571	714	750	807	828	829	817	246	277
OthrHarvAcre	10CvHw	BK	15737	279	403	1110	403	1110	668	1110	668	1110	668	1110	668	1110	668	1110	668	1110	668	831	265
OthrHarvAcre	10CvHw	BM	27103		2723	288	2723	288	2723	288	2723	288	2723	288	2723	289	2723	289	2723	289	2723	289	
OthrHarvAcre	10CvHw	EE	16126			47		47	1121	107	1121	107	1121	107	2308	202	2308	202	2308	202	2308	202	2308
OthrHarvAcre	10CvHw	FL	10382	42		42		1222		1222		1222		1222		1363		1363		1363		1321	
OthrHarvAcre	10CvHw	GB	5228			4		616		616		616		616		690		690		690		690	
OthrHarvAcre	10CvHw	HD	23195	2082		2259		2339	278	2339	278	2339	278	2339	278	2339	278	2339	278	2339	278	257	278
OthrHarvAcre	10CvHw	HI	635	34	29	34	29	34	29	34	29	34	29	34	29	51	29	51	29	51	29	17	
OthrHarvAcre	10CvHw	NG	288					36		36		36		36		36		36		36		36	
OthrHarvAcre	10CvHw	NM	35344	879	966	879	966	879	966	3460	966	3460	966	3460	966	3628	966	3628	966	3628	966	2749	
OthrHarvAcre	10CvHw	NS	1148		25	32	25	32	25	32	25	32	25	32	152	32	152	32	152	32	152	32	127
OthrHarvAcre	10CvHw	PL	2204	208	8	208	8	208	8	208	8	208	8	208	8	273	8	273	8	273	8	65	
OthrHarvAcre	10CvHw	UM	9997	66	69	66	69	66	648	66	648	66	648	66	1290	301	1290	301	1290	301	1290	235	1221
RegenAcre	10CvHw	BK	4665			823		247	363	293	195			823			122	140			472	1187	
RegenAcre	10CvHw	BM	12411	2474	20	61	937		224	499	329	1368	715	1795		899	307	497			329	1957	
RegenAcre	10CvHw	EE	15606	1709	2526	1383		142	516	24	584	1709	129			3861	564	24		1709	584	142	
RegenAcre	10CvHw	FL	5279		536	174	1173		79	177	450		8	93		1709	81				464	335	
RegenAcre	10CvHw	GB	11432	84	2036			1540	520	212	127	150	2128	38			520			34	3788	255	
RegenAcre	10CvHw	HD	4063	44	337		11	530	89	337	543	67	158	44			437	169			1241	56	
RegenAcre	10CvHw	HI	4386			396		791	395		255	152	30	378		18	13				791	1167	
RegenAcre	10CvHw	NG	2501	198	54	585				2	31	183	80	498		14	87			183	73	513	
RegenAcre	10CvHw	NM	15925	122			1981	872		1801	2305	632	499	122		872	1981	210			3087	1441	
RegenAcre	10CvHw	NS	3712	641			862						706			214	648					641	
RegenAcre	10CvHw	PL	15373	1381	786	2175	1497		525	266	325		1400	63		786	4134	243			325	1467	
RegenAcre	10CvHw	UM	12865	261		324	545	1169	2718	806	281	286	111	150		1343	579	73		150	3667	402	
ThinAcre	10CvHw	BK	7308	194	69	781	194	263	850	781	194	263	850	781	194	263	850	781					
ThinAcre	10CvHw	BM	5516	45	743		45	788	743		45	788	743		45	788	743						
ThinAcre	10CvHw	EE	5880	39	749	52	39	788	801	52	39	788	801	52	39	788	801	52					
ThinAcre	10CvHw	HD	3409	487			487	487			487	487			487	487							
ThinAcre	10CvHw	NG	70	10			10	10			10	10			10	10							
ThinAcre	10CvHw	NM	3395	460	25		460	485	25		460	485	25		460	485	25						
ThinAcre	10CvHw	NS	546	26	52		26	78	52		26	78	52		26	78	52						
ThinAcre	10CvHw	PL	10080	530	67	843	530	597	910	843	530	597	910	843	530	597	910	843					
ThinAcre	10CvHw	UM	10535	710	795		710	1505	795		710	1505	795		710	1505	795						
Volume	10CvHw	BK	33749	408	542	4525	509	1925	2273	2368	1463	1186	1063	3916	747	1164	1393	1681	668	1110	2109	4434	265
Volume	10CvHw	BM	71765	9035	3822	568	6037	744	3889	2065	3680	4433	5513	6975	2742	3598	3804	1858	2723	289	3680	6310	
Volume	10CvHw	EE	65360	5789	7279	3912	22	896	3505	226	2797	5853	1729	123	2657	11248	4232	289	2308	5593	4000	594	2308
Volume	10CvHw	FL	27239	54	1485	596	4181	1552	218	1712	1291	1222	23	1515		6794	223	1363		1363	1362	2285	
Volume	10CvHw	GB	41063	310	7097	6		5053	1860	1280	352	1046	6690	759		710	1639	690		798	11364	1409	
Volume	10CvHw	HD	37300	3023	933	2309	316	4069	673	3475	2055	2671	716	2502	486	2432	1521	2873	278	2339	3940	411	278
Volume	10CvHw	HI	13428	43	37	1444	29	2225	1133	34	734	456	113	1228	29	106	71	51	29	51	2220	3395	
Volume	10CvHw	NG	8405	663	172	2012	6	52		44	112	615	250	1606	5	77	241	36		612	241	1661	
Volume	10CvHw	NM	85227	1783	1242	879	6720	4239	978	9493	8074	5362	2355	3917	1162	6524	6455	4291	966	3628	10420	6739	
Volume	10CvHw	NS	13592	2319	52	41	2609	75	51	32	37	64	2522	32	199	773	1957	32	152	32	152	2334	127
Volume	10CvHw	PL	53571	5438	2206	6604	4464	504	2278	1497	1337	402	5416	662	234	2599	12026	1202	8	273	1138	5283	
Volume	10CvHw	UM	52734	1222	389	1082	1992	5062	8752	2357	1844	1496	1258	540	1772	5010	3058	533	1290	774	11610	1472	1221
Young Mgmt	10CvHw	BK	14541	116	133	1188	956	612	831	1021	709	560	221	1188	1044	365	343	627	361	365	693	1933	1275
Young Mgmt	10CvHw	BM	33901	2607	3393	176	1897	1032	1123	818	1727	1792	2982	2605	2694	994	2105	899	1396	95	1228	2381	1957
Young Mgmt	10CvHw	EE	36668	1837	4235	3925	1383	158	1028	576	978	2329	2208	165	762	3928	5187	655	786	1776	3055	793	904
Young Mgmt	10CvHw	FL	14103	137	536	724	1347	1576	79	659	627	853	8	504	93	2158	1790	530		449	464	1234	335

Young Mgmt	10CvHw	GB	24695	185	2120	2038		1744	2060	936	339	481	2278	2370	38	228	520	748		262	3822	4271	255
Young Mgmt	10CvHw	HD	15910	866	381	1082	11	1312	711	1197	972	1381	317	973	136	771	529	1377	261	771	1333	1381	148
Young Mgmt	10CvHw	HI	9023	49	10	407	406	802	1196	406	265	418	192	419	388	35	41	30	10	17	801	1964	1167
Young Mgmt	10CvHw	NG	5135	235	252	639	585	12		14	33	226	263	590	498	26	101	99		195	256	598	513
Young Mgmt	10CvHw	NM	44361	1254	441	290	2300	3143	1191	2943	4425	4079	1450	1763	441	2070	3172	3389	529	1198	3406	5436	1441
Young Mgmt	10CvHw	NS	7796	641	649	10	870	872	8	10	8	10	714	716	50	224	912	658	50	10	50	651	683
Young Mgmt	10CvHw	PL	31705	1681	2170	3029	3675	1565	528	859	594	393	1403	1531	66	876	4923	4467	246	90	328	1814	1467
Young Mgmt	10CvHw	UM	29348	596	284	346	892	1736	4101	3546	1301	589	611	283	576	1443	2348	752	499	250	4243	4147	805
Young Patch	10CvHw	BK	204	44	12	7		83	7	5	6			9								16	15
Young Patch	10CvHw	BM	172	15	1	14	4		5			22			84			12			12	2	1
Young Patch	10CvHw	EE	335	20	29	91		29	8	49			26		52						2	20	9
Young Patch	10CvHw	FL	53	3		15	15	5	4	2												2	7
Young Patch	10CvHw	Forest	6881		128	219	219	91	171	322	398	331	497	466	416	501	374	521	469	502	478	394	384
Young Patch	10CvHw	GB	51		13		27										3						8
Young Patch	10CvHw	HD	99	22		6		8		9											4	17	33
Young Patch	10CvHw	HI	36	2	4	3	10				12										2	2	1
Young Patch	10CvHw	NG	24	1					2													5	16
Young Patch	10CvHw	NM	165	2		18	38	4	3	12				3			74	2				4	5
Young Patch	10CvHw	NS	82		6	6	2	14	17		21											5	11
Young Patch	10CvHw	PL	285	15	20	99	17				38	53					6	18	5		13	1	
Young Patch	10CvHw	UM	359	6	6		89		51		1	100		15					41		21	16	13

Attachment 11

Climate Change: Atmospheric Carbon Dioxide

Climate Change: Atmospheric Carbon Dioxide

BY REBECCA LINDSEY | REVIEWED BY ED DLUGOKENCKY
PUBLISHED AUGUST 14, 2020 | UPDATED OCTOBER 7, 2021

HIGHLIGHTS

- Human activities have increased the concentration of carbon dioxide in our atmosphere, amplifying Earth's natural greenhouse effect.
- Despite the global pandemic, the global average amount of carbon dioxide hit a new record high in 2020: 412.5 parts per million.
- The annual rate of increase in atmospheric carbon dioxide over the past 60 years is about 100 times faster than previous natural increases, such as those that occurred at the end of the last ice age 11,000-17,000 years ago.
- The ocean has absorbed enough carbon dioxide to lower its pH by 0.1 units, a 30% increase in acidity.

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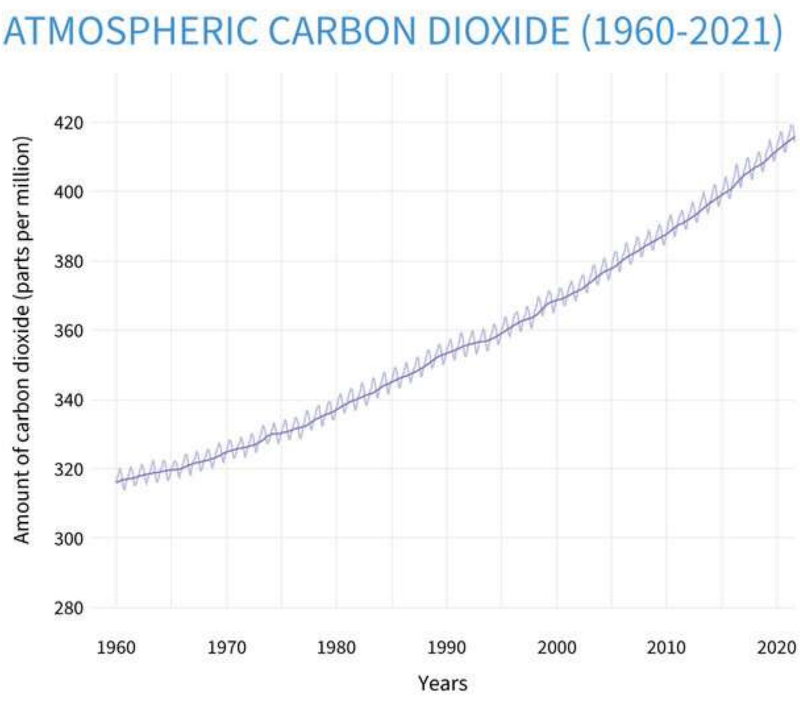
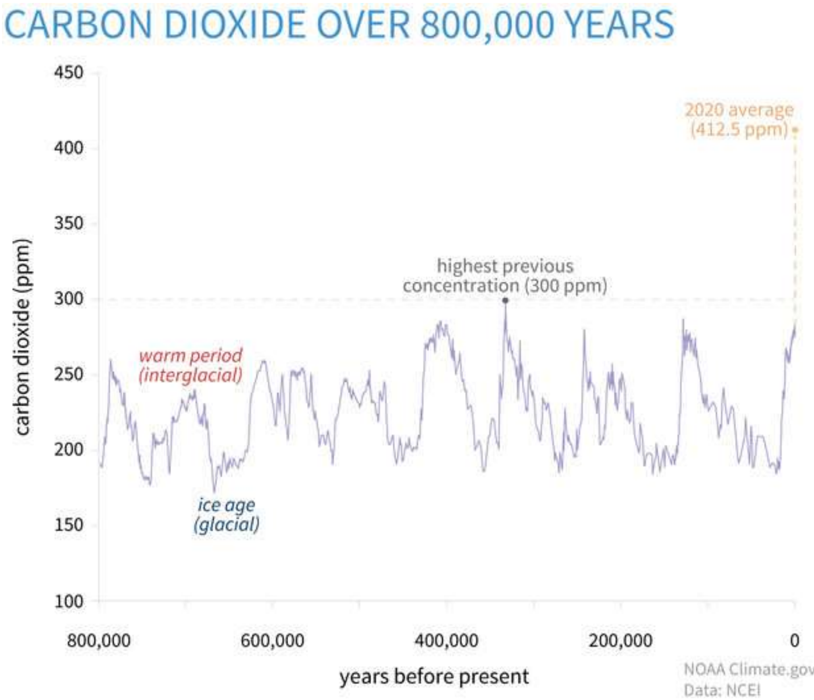
Based on preliminary analysis, the global average atmospheric carbon dioxide in 2020 was 412.5 parts per million (ppm for short), setting a new record high amount despite the economic slowdown due to the COVID-19 pandemic. In fact, the jump of 2.6 ppm over 2019 levels was the fifth-highest annual increase in NOAA's 63-year record. Since 2000, the global atmospheric carbon dioxide amount has grown by 43.5 ppm, an increase of 12 percent.



The modern record of atmospheric carbon dioxide levels began with observations recorded at Mauna Loa Observatory in Hawaii. This graph shows the station's monthly average carbon dioxide measurements since 1960 in parts per million (ppm). The seasonal cycle of highs and lows (small peaks and valleys) is driven by summertime growth and winter decay of Northern Hemisphere vegetation. The long-term trend of rising carbon dioxide levels is driven by human activities. NOAA Climate.gov image, based on data from NOAA Global Monitoring Lab.

Carbon dioxide levels today are higher than at any point in at least the past 800,000 years. In fact, the last time the atmospheric CO_2 amounts were this high was more than 3 million years ago, during the Mid-Pliocene Warm Period, when temperature was 2°–3°C (3.6°–5.4°F) higher than during the pre-industrial era, and sea level was 15–25 meters (50–80 feet) higher than today.



Global atmospheric carbon dioxide concentrations (CO_2) in parts per million (ppm) for the past 800,000 years. The peaks and valleys track ice ages (low CO_2) and warmer interglacials (higher CO_2). During these cycles, CO_2 was never higher than 300 ppm. On the geologic time scale, the increase (orange dashed line) looks virtually instantaneous. Graph by NOAA Climate.gov based on data from Lüthi, et al., 2008, via NOAA NCEI Paleoclimatology Program. *[Correction: August 20, 2020. An earlier version of this image had an error in the time scaling on the X axis. This affected the apparent duration and timing of the most recent ice ages, but did not affect the modern or paleoclimate carbon dioxide values.]*

Carbon dioxide concentrations are rising mostly because of the fossil fuels that people are burning for energy. Fossil fuels like coal and oil contain carbon that plants pulled out of the atmosphere through photosynthesis over many millions of years; we are returning that carbon to the atmosphere in just a few hundred years. According to *State of the Climate in 2019* from NOAA and the American Meteorological Society,

> From 1850 to 2018, 440 ± 20 Pg C (1 Pg C = 10^{15} g C) were emitted as CO_2 from fossil fuel burning (Friedlingstein et al. 2019). For 2018 alone, global fossil fuel emissions reached 10 ± 0.5 Pg C yr−1 for the first time in history (Friedlingstein et al. 2019). About half of the CO_2 emitted since 1850 remains in the atmosphere. The rest of it has partially dissolved in the world's oceans… . While the terrestrial biosphere is currently also a sink for fossil fuel CO_2, the cumulative emissions of CO_2 from land use changes such as deforestation cancel terrestrial uptake over the 1850–2018 period (Friedlingstein et al. 2019).

Each year we put more carbon dioxide into the atmosphere than natural processes can remove, which means the net global amount of carbon dioxide rises. The more we overshoot what natural processes remove, the faster the annual growth rate. In the 1960s, the global growth rate of atmospheric carbon dioxide was roughly 0.6 ± 0.1 ppm per year. Between 2009-18, however, the growth rate has been 2.3 ppm per year. [These statistics, along with the final global average for the prior year, are updated each year in the American Meteorological Society's *State of the Climate Report*, which comes out in late summer]. The annual rate of increase in atmospheric carbon dioxide over the past 60 years is about 100 times faster than previous natural increases, such as those that occurred at the end of the last ice age 11,000-17,000 years ago.

Why carbon dioxide matters

Carbon dioxide is a greenhouse gas: a gas that absorbs and radiates heat. Warmed by sunlight, Earth's land and ocean surfaces continuously radiate thermal infrared energy (heat). Unlike oxygen or nitrogen (which make up most of our atmosphere), greenhouse gases absorb that heat and release it gradually over time, like bricks in a fireplace after the fire goes out. Without this natural greenhouse effect, Earth's average annual temperature would be below freezing instead of close to 60°F. But increases in greenhouse gases have tipped the Earth's energy budget out of balance, trapping additional heat and raising Earth's average temperature.

Carbon dioxide is the most important of Earth's long-lived greenhouse gases. It absorbs less heat per molecule than the greenhouse gases methane or nitrous oxide, but it's more abundant, and it stays in the atmosphere much longer. Increases in atmospheric carbon dioxide are responsible for about two-thirds of the total energy imbalance that is causing Earth's temperature to rise.

Another reason carbon dioxide is important in the Earth system is that it dissolves into the ocean like the fizz in a can of soda. It reacts with water molecules, producing carbonic acid and lowering the ocean's pH (raising its acidity). Since the start of the Industrial Revolution, the pH of the ocean's surface waters has dropped from 8.21 to 8.10. This drop in pH is called *ocean acidification*.

A drop of 0.1 may not seem like a lot, but the pH scale is logarithmic; a 1-unit drop in pH means a tenfold increase in acidity. A change of 0.1 means a roughly 30% increase in acidity. Increasing acidity interferes with the ability of marine life to extract calcium from the water to build their shells and skeletons

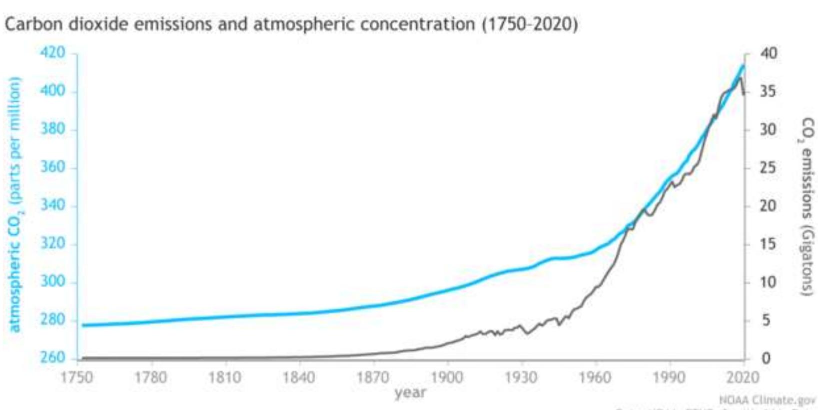
(**left**) A healthy ocean snail has a transparent shell with smoothly contoured ridges. (**right**) A shell exposed to more acidic, corrosive waters is cloudy, ragged, and pockmarked with 'kinks' and weak spots. Photos courtesy Nina Bednarsek, NOAA PMEL.

Past and future carbon dioxide

Natural increases in carbon dioxide concentrations have periodically warmed Earth's temperature during ice age cycles over the past million years or more. The warm episodes (interglacials) began with a small increase in sunlight due to a tiny wobble in Earth's axis of rotation or in the path of its orbit around the Sun.

That little bit of extra sunlight caused a little bit of warming. As the oceans warmed, they outgassed carbon dioxide—like a can of soda going flat in the heat of a summer day. The extra carbon dioxide in the atmosphere amplified the initial warming.

Based on air bubbles trapped in mile-thick ice cores (and other paleoclimate evidence), we know that during the ice age cycles of the past million years or so, carbon dioxide never exceeded 300 ppm. Before the Industrial Revolution started in the mid-1700s, the global average amount of carbon dioxide was about 280 ppm.



The amount of carbon dioxide in the atmosphere (blue line) has increased along with human emissions (gray line) since the start of the Industrial Revolution in 1750. Emissions rose slowly to about 5 billion tons per year in the mid-20th century before skyrocketing to more than 35 billion tons per year by the end of the century. NOAA Climate.gov graph, adapted from original by Dr. Howard Diamond (NOAA ARL). Atmospheric CO_2 data from NOAA and ETHZ. CO_2 emissions data from Our World in Data and the Global Carbon Project.

By the time continuous observations began at Mauna Loa Volcanic Observatory in 1958, global atmospheric carbon dioxide was already 315 ppm. On May 9, 2013, the daily average carbon dioxide measured at Mauna Loa surpassed 400 ppm for the first time on record. Less than two years later, in 2015, the global amount went over 400 ppm for the first time. If global energy demand continues to grow and to be met mostly with fossil fuels, atmospheric carbon dioxide is projected to exceed 900 ppm by the end of this century.

More on carbon dioxide

[NOAA carbon dioxide observations]

[Carbon cycle factsheet]

[Carbon dioxide emissions by country over time]

[Comparing greenhouse gases by their global warming potential]

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Attachment 12

Federally listed species and SCC spreadsheets

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1	OBJECTID	EO_ID	SCI_NAME	EO_NUM	COM_NAME	SURVEYDATE	LAST_OBS	FIRST_OBS	EO_STATUS	EO_RANK	ACCURACY	NC_STATUS	USA_STATUS	S_RANK	RND_S_RANK	G_RANK	RND_G_RANK	HAB_TYPE	NAME_CATGY	TAXO_GROUP
2	302	33948	Aquila chrysaetos	4	Golden Eagle	2013-02	2013-02	2013-01	Current	D	1-Very High	SR	BGPA	SXB,S1N	SXB,S1N	G5	G5	Upland	Animal	Bird
3	366	33947	Aquila chrysaetos	3	Golden Eagle	2013-02	2013-02	2013-01	Current	D	1-Very High	SR	BGPA	SXB,S1N	SXB,S1N	G5	G5	Upland	Animal	Bird
4	917	33944	Aquila chrysaetos	1	Golden Eagle	2014-03	2014-03	2013-01	Current	D	2-High	SR	BGPA	SXB,S1N	SXB,S1N	G5	G5	Upland	Animal	Bird
5	1547	4165	Patera clarki nantahala	1	Noonday Globe	2017	2017	1976-08	Current	AC	3-Medium	T	T	S1	S1	G3T1T2	T1	Upland	Animal	Freshwater or Terrestrial Gastropod
6	1576	21349	Alasmidonta raveneliana	70	Appalachian Elktoe	2018-10-31	2018-10-31	1991-10-16	Current	A	3-Medium	E	E	S1	S1	G1	G1	Aquatic	Animal	Freshwater Bivalve
7	5406	32162	Myotis septentrionalis	44	Northern Long-eared Bat	2005-07-27	2005-07-27	2005-07-27	Current	E	3-Medium	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal
8	7542	21097	Alasmidonta raveneliana	20	Appalachian Elktoe	2018-11-26	2018-11-26	2000-07-07	Current	CDr	3-Medium	E	E	S1	S1	G1	G1	Aquatic	Animal	Freshwater Bivalve
9	8822	10334	Glaucomys sabrinus coloratus	2	Carolina Northern Flying Squirrel	2017-03-09	2017-03-09	1941-08-19	Current	E	2-High	E	E	S2	S2	G5T2	T2	Upland	Animal	Mammal
10	8909	15740	Myotis sodalis	5	Indiana Bat	2012-06-12	2012-06-12	1999-07	Current	BC	2-High	E	E	S1S2	S1	G2	G2	Upland	Animal	Mammal
11	9092	19748	Glaucomys sabrinus coloratus	8	Carolina Northern Flying Squirrel	2017-02-28	2017-02-28	1989-07-23	Current	E	2-High	E	E	S2	S2	G5T2	T2	Upland	Animal	Mammal
12	9785	34230	Data Sensitive Record - contact the NCNHP	0	Data Sensitive Record - contact the NCNHP		2003-02-07		Current	D?	3-Medium		T						Animal	
13	10063	32875	Myotis septentrionalis	88	Northern Long-eared Bat	2007-07-11	2007-07-11	2004-05-17	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal
14	11073	22419	Data Sensitive Record - contact the NCNHP	0	Data Sensitive Record - contact the NCNHP		2003-06-17		Current	C	3-Medium		T						Animal	
15	11581	5203	Data Sensitive Record - contact the NCNHP	0	Data Sensitive Record - contact the NCNHP		2015-10-19		Current	A	3-Medium		T						Animal	
16	12768	32884	Myotis septentrionalis	97	Northern Long-eared Bat	2011-07-29	2011-07-29	2004-05-21	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal
17	14109	32880	Myotis septentrionalis	93	Northern Long-eared Bat	2007	2007	2004	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal
18	15586	9862	Data Sensitive Record - contact the NCNHP	0	Data Sensitive Record - contact the NCNHP		2005-09-10		Current	D	3-Medium		T						Plant	
19	15993	32163	Myotis septentrionalis	45	Northern Long-eared Bat	2014-06-30	2014-06-30	2006-06-22	Current	E	3-Medium	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal
20	17144	2322	Data Sensitive Record - contact the NCNHP	0	Data Sensitive Record - contact the NCNHP		1998		Current	F	3-Medium		T						Plant	
21	18682	26221	Myotis sodalis	8	Indiana Bat	2008-06-03	2008-06-03	2008-06-03	Current	E	3-Medium	E	E	S1S2	S1	G2	G2	Upland	Animal	Mammal
22	19870	17748	Data Sensitive Record - contact the NCNHP	0	Data Sensitive Record - contact the NCNHP		2007-06-26		Current	CD	3-Medium		T						Animal	
23	20160	10450	Gymnoderma lineare	51	Rock Gnome Lichen	2008-07-03	2008-07-03	1997-09-09	Current	A	3-Medium	E	E	S3	S3	G3	G3	Upland	Plant	Lichen
24	20676	32773	Myotis septentrionalis	55	Northern Long-eared Bat	2012-05-28	2012-05-28	2008-07-22	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal
25	20795	34790	Myotis septentrionalis	204	Northern Long-eared Bat	2012-08-15	2012-08-15	2000-08-15	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal
26	20850	32794	Myotis septentrionalis	76	Northern Long-eared Bat	2014-06-20	2014-06-20	2000-05-23	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal
27	20950	25178	Haliaeetus leucocephalus	137	Bald Eagle	2015-02	2015-02	2007	Current	E	3-Medium	T	BGPA	S3B,S3N	S3B,S3N	G5	G5	Wetland	Animal	Bird
28	20965	28682	Myotis sodalis	11	Indiana Bat	2005-06-07	2005-06-07	2005-06-07	Current	E	3-Medium	E	E	S1S2	S1	G2	G2	Upland	Animal	Mammal
29	21135	32792	Myotis septentrionalis	74	Northern Long-eared Bat	2011-07-20	2011-07-20	2007-06-20	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal
30	21501	32780	Myotis septentrionalis	62	Northern Long-eared Bat	2016-06-28	2016-06-28	2008-07-02	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal
31	21743	27985	Myotis sodalis	10	Indiana Bat	2015-07-17	2015-07-17	2008-05-28	Current	E	2-High	E	E	S1S2	S1	G2	G2	Upland	Animal	Mammal
32	22117	22242	Haliaeetus leucocephalus	119	Bald Eagle	2015-02	2015-02	2005	Current	E	2-High	T	BGPA	S3B,S3N	S3B,S3N	G5	G5	Wetland	Animal	Bird
33	22407	29171	Haliaeetus leucocephalus	176	Bald Eagle	2011	2011	2010	Current	E	2-High	T	BGPA	S3B,S3N	S3B,S3N	G5	G5	Wetland	Animal	Bird
34	22499	24771	Haliaeetus leucocephalus	136	Bald Eagle	2010	2010	2007-04-17	Current	E	2-High	T	BGPA	S3B,S3N	S3B,S3N	G5	G5	Wetland	Animal	Bird
35	22689	32164	Myotis septentrionalis	46	Northern Long-eared Bat	2011-07-16	2011-07-16	1994-Post	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal
36	23026	34176	Myotis septentrionalis	135	Northern Long-eared Bat	2017-06-21	2017-06-21	2001-05-16	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal
37	23273	32452	Myotis sodalis	14	Indiana Bat	2012-07-20	2012-07-20	2011-06-06	Current	E	2-High	E	E	S1S2	S1	G2	G2	Upland	Animal	Mammal
38	23289	32923	Myotis septentrionalis	102	Northern Long-eared Bat	2004-08-09	2004-08-09	2004-06-26	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal
39	23306	32795	Myotis septentrionalis	77	Northern Long-eared Bat	2011-06-06	2011-06-06	2008-06-03	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal
40	23596	14324	Spiraea virginiana	25	Virginia Spiraea	2018-06-13	2018-06-13	2000-05-15	Current	BC	2-High	T	T	S2	S2	G2	G2	Wetland	Plant	Vascular Plant
41	23848	21783	Myotis grisescens	2	Gray Bat	2018-07-16	2018-07-16	2005-07-12	Current	E	1-Very High	E	E	S1	S1	G4	G4	Upland	Animal	Mammal
42	23937	34167	Myotis septentrionalis	128	Northern Long-eared Bat	2002-08-08	2002-08-08	2002-08-06	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal
43	24077	32788	Myotis septentrionalis	70	Northern Long-eared Bat	2011-05-23	2011-05-23	2008-06-03	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal
44	24096	32922	Myotis septentrionalis	101	Northern Long-eared Bat	2004-06-10	2004-06-10	2004-06-05	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal

	U	V	W	X	Y	Z	AA	AB
1	HAB_COM	ELEMENT_ID	DATA_SENS	[illegible]	ACRES	MIN_ELEV	MAX_ELEV	SURVEYSITE
2	MC: grass balds or fields at remote and extensive forests in higher mountains, near water impoundments or large lakes in coastal areas [regular wintering sites]	16187	N	N	[illegible]	[illegible]	-1	Big Bald
3	MC: grass balds or fields at remote and extensive forests in higher mountains, near water impoundments or large lakes in coastal areas [regular wintering sites]	16187	N	N	[illegible]	[illegible]	-1	[illegible]
4	MC: grass balds or fields at remote and extensive forests in higher mountains, near water impoundments or large lakes in coastal areas [regular wintering sites]	16187	N	N	2857.08	4176	-1	Unaka Mountains
5	M: Nantahala Gorge (endemic to this site)	16237	N	N	1180.67	-1	-1	Nantahala Gorge
6	M: Tennessee drainages	16784	N	Y	1128.38	-1	-1	FBR/Nolichucky River Subbasin
7	MPC: roosts in hollow trees and buildings (warmer months), in caves and mines (winter); mainly in the mountains	18218	N	N	123.41	-1	-1	Lloyd Cove
8	M: Tennessee drainages	16784	N	Y	60.54	-1	-1	LTN/Cheoah River
9	M: high elevation forests, mainly spruce-fir	17146	N	N	39.29	5000	-1	Great Craggy Mountains and Black Mountains
10	M: roosts in hollow trees or under loose bark and snags (warmer months), in caves (winter)	15481	N	N	38.34	3200	4150	SANTEETLAH CREEK
11	M: high elevation forests, mainly spruce-fir	17146	N	N	35.49	-1	-1	Shining Rock and Middle Prong Wilderness areas
12		0	Y		0	0	0	
13	MPC: roosts in hollow trees and buildings (warmer months), in caves and mines (winter); mainly in the mountains	18218	N	N	29.99	-1	-1	Trimont Ridge: Roosting and Mist-net
14		0	Y		0	0	0	
15		0	Y		0	0	0	
16	MPC: roosts in hollow trees and buildings (warmer months), in caves and mines (winter); mainly in the mountains	18218	N	N	14	-1	-1	Upper Burningtown Creek Watershed
17	MPC: roosts in hollow trees and buildings (warmer months), in caves and mines (winter); mainly in the mountains	18218	N	N	8.94	-1	-1	Trimont Ridge - Wolfpen Gap
18		0	Y		0	0	0	
19	MPC: roosts in hollow trees and buildings (warmer months), in caves and mines (winter); mainly in the mountains	18218	N	N	7.71	-1	-1	Pisgah Education Center
20		0	Y		0	0	0	
21	M: roosts in hollow trees or under loose bark and snags (warmer months), in caves (winter)	15481	N	N	6.45	2000	2100	Grassy Branch of Bear Creek
22		0	Y		0	0	0	
23	M: high elevation rock outcrops in humid gorges	17966	N	N	3.95	4370	4450	Scaly Mountain
24	MPC: roosts in hollow trees and buildings (warmer months), in caves and mines (winter); mainly in the mountains	18218	N	N	3.1	-1	-1	Nantahala National Forest: FSR-82-1 at Elbow Creek
25	MPC: roosts in hollow trees and buildings (warmer months), in caves and mines (winter); mainly in the mountains	18218	N	N	2.96	-1	-1	NCDOT TIP No. R-2822B ; Upper Santeetlah Lake/Snowbird Creek - mist net areas
26	MPC: roosts in hollow trees and buildings (warmer months), in caves and mines (winter); mainly in the mountains	18218	N	N	2.9	-1	-1	Upper Santeetlah Creek watershed - mist net areas
27	MPCT: mature forests near large bodies of water (nesting); rivers, lakes, and sounds (foraging) [breeding evidence only]	20537	N	N	2.87	-1	-1	Graham #1 - Santeetlah
28	M: roosts in hollow trees or under loose bark and snags (warmer months), in caves (winter)	15481	N	N	2.87	1700	1800	Cheoah River at SR 1146/SR 1134 ; NCDOT TIP No. B-3335
29	MPC: roosts in hollow trees and buildings (warmer months), in caves and mines (winter); mainly in the mountains	18218	N	N	2.62	-1	-1	Cornsilk Branch/Long Branch - mist net areas
30	MPC: roosts in hollow trees and buildings (warmer months), in caves and mines (winter); mainly in the mountains	18218	N	N	2.17	-1	-1	North Shoal Creek - mist net areas
31	M: roosts in hollow trees or under loose bark and snags (warmer months), in caves (winter)	15481	N	N	1.95	1500	2200	North Shoal Creek/Shuler Creek - roost and mist net sites
32	MPCT: mature forests near large bodies of water (nesting); rivers, lakes, and sounds (foraging) [breeding evidence only]	20537	N	N	1.93	-1	-1	Swain #1 - Fontana Lake
33	MPCT: mature forests near large bodies of water (nesting); rivers, lakes, and sounds (foraging) [breeding evidence only]	20537	N	N	1.93	3200	-1	Macon #1 - Nantahala Lake - Camp Sequoyah
34	MPCT: mature forests near large bodies of water (nesting); rivers, lakes, and sounds (foraging) [breeding evidence only]	20537	N	N	1.93	1525	1600	Cherokee #1 - Nottely River
35	MPC: roosts in hollow trees and buildings (warmer months), in caves and mines (winter); mainly in the mountains	18218	N	N	1.93	-1	-1	Hurricane Ridge: Pigeon River
36	MPC: roosts in hollow trees and buildings (warmer months), in caves and mines (winter); mainly in the mountains	18218	N	N	1.61	-1	-1	Stecoah Creek - mist net areas
37	M: roosts in hollow trees or under loose bark and snags (warmer months), in caves (winter)	15481	N	N	1.45	-1	-1	Wildcat Gap Area
38	MPC: roosts in hollow trees and buildings (warmer months), in caves and mines (winter); mainly in the mountains	18218	N	N	1.45	-1	-1	Shooting Creek Area: Wayah Rain Springs-2 and -4, Wayah Tuni Creek-1
39	MPC: roosts in hollow trees and buildings (warmer months), in caves and mines (winter); mainly in the mountains	18218	N	N	1.45	-1	-1	Laurel Branch/Stecoah Creek
40	M: riverbanks	17050	N	Y	1.11	1500	1700	Cheoah River Floodplain: Boaze sites 1-6 [river miles 5-7] (Sub EO of EO 057)
41	M: roosts in caves; forages mainly over open water	20829	N	N	0.96	1800	2300	Pigeon Ford Rare Species Habitat - mist net areas
42	MPC: roosts in hollow trees and buildings (warmer months), in caves and mines (winter); mainly in the mountains	18218	N	N	0.96	-1	-1	Big Snowbird Creek
43	MPC: roosts in hollow trees and buildings (warmer months), in caves and mines (winter); mainly in the mountains	18218	N	N	0.96	-1	-1	Bear Creek
44	MPC: roosts in hollow trees and buildings (warmer months), in caves and mines (winter); mainly in the mountains	18218	N	N	0.96	-1	-1	Chestnut Knob: Wayah Wine Springs-1 and Wayah Wine Springs-3

	AC	AD	AE	AF	AG	AH
1	DIRECTIONS	EO_DATA	SURVEYORS	GEN_DESC	PROT_COM	MGMT_COM
2	[illegible]	[illegible]	[illegible]	[illegible]		
3	[illegible]	[illegible]	[illegible]	[illegible]		
4	[illegible]	[illegible]	[illegible]	[illegible]		
5	[illegible]	[illegible]		[illegible]		
6	[illegible]	[illegible]			[illegible]	
7	[illegible]	[illegible]	[illegible]			
8	[illegible]	[illegible]			[illegible]	
9	[illegible]	[illegible]	[illegible]		REGISTERED AREAS	
10	[illegible]	[illegible]	[illegible]	UNDER BARK OF LARGE TREES		
11	[illegible]	[illegible]	[illegible]			[illegible]
12						
13	[illegible]	[illegible]	[illegible]			
14						
15						
16	[illegible]	[illegible]	[illegible]			
17	[illegible]	[illegible]	[illegible]			
18						
19	[illegible]	[illegible]	[illegible]			
20						
21	[illegible]	[illegible]	[illegible]	[illegible]		
22						
23	[illegible]	[illegible]	[illegible]	[illegible]		NOT IN SUITABLE TIMBER BASE.
24	[illegible]	[illegible]	[illegible]			
25	[illegible]	[illegible]	[illegible]			
26	[illegible]	[illegible]	[illegible]			
27	[illegible]	[illegible]	[illegible]	[illegible]		
28	[illegible]	[illegible]	[illegible]	[illegible]		
29	[illegible]	[illegible]	[illegible]			
30	[illegible]	[illegible]	[illegible]			
31	[illegible]	[illegible]	[illegible]			
32	[illegible]	[illegible]	[illegible]	[illegible]		
33	[illegible]	[illegible]	[illegible]	[illegible]		
34	[illegible]	[illegible]	[illegible]	[illegible]		
35	[illegible]	[illegible]	[illegible]			
36	[illegible]	[illegible]	[illegible]			
37	[illegible]	[illegible]	[illegible]			
38	[illegible]	[illegible]	[illegible]			
39	[illegible]	[illegible]	[illegible]			
40	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
41	[illegible]	[illegible]	[illegible]	[illegible]		
42	[illegible]	[illegible]	[illegible]			
43	[illegible]	[illegible]	[illegible]			
44	[illegible]	[illegible]	[illegible]			

	AI	AJ	AK	AL	AM	AN	AO	AP	AQ
1	REFERENCE	VERSION_AUTH	VERSION_DATE	DATA_DATE	Shape_Length	Shape_Area		COM_NAME	Count
2	Kelly, Chris. 2014. Unpublished Golden Eagle winter records, NC WRC database.	LeGrand	2014-09-26	2019-10-07	[illegible]	[illegible]		Golden Eagle	[illegible]
3	Kelly, Chris. 2014. Unpublished Golden Eagle winter records, NC WRC database.	LeGrand	2014-09-26	2019-10-07	[illegible]	[illegible]		Noonday Globe	[illegible]
4	Kelly, Chris. 2014. Unpublished Golden Eagle winter records, NC WRC database.	LeGrand	2014-09-26	2019-10-07	59128.08537	124453791.9		Appalachian Elktoe	2
5	2013. Fridell, John. USFWS. Noonday Globe Patera (=Mesodon) clarki nantahala 5-Year Review: Summary and Evaluation; U.S. Fish and Wildlife Service. 1978. Determination That Seven Eastern US Land Snails are Endangered or Threatened Species. Federal Regis	Ratcliffe	2017-12-20	2019-10-07	57832.25176	51429712.43		Northern Long-eared Bat	54
6	Bryan, S.A. 1995. NC NHP Special Animal Survey Forms; Mays, Jason. 2014. Alasmidonta raveneliana data from Cane River upstream of dam. Email and spreadsheet; will be in PAWS; McGrath, C. 1998. Mountain Aquatic Survey. North Carolina Wildlife Resource	Hannon	2019-08-09	2019-10-07	828752.586	49152094.5		Carolina Northern Flying Squirrel	2
7	N.C. Wildlife Resources Commission. 2007. Annual Program Report, 2005-2006 -- Wildlife Diversity Program; N.C. Wildlife Resources Commission. 2014. Bat data provided by Gabrielle Graeter (NCWRC), Raleigh. Data submitted August 1, 2014.	Mason	2014-11-04	2019-10-07	8232.366964	5375775.771		Indiana Bat	8
8	MOLLUSCA SURVEY: CHEOAH RIVER, GRAHAM COUNTY, NORTH CAROLINA. JULY 2000. FOR NORMANDEAU ASSOCIATES, INC. BY PENNINGTON AND ASSOCIATES, INC; NC WRC Aquatics Database. Queried in February2005; NC WRC Aquatics Database. Annual maintenance update	Hannon	2019-06-11	2019-10-07	90728.72249	2637138.565		Data Sensitive Record - contact the NCNH	10
9	Boynton, Allen. 1991. NCWRC Wildlife Observation Form; Contributed. Field forms or similar data contributed to the NC NHP by persons or organizations outside the program; Handley Jr., C. O. 1953. A new flying squirrel from the southern Appalachian Moun	Wojcik	2018-01-09	2019-10-07	40412.25097	1711297.947		Rock Gnome Lichen	1
10	Miscellaneous. Information obtained from miscellaneous sources such as e-mail lists, newspaper articles, environmental assesment reports or other; N.C. Wildlife Resources Commission. 2008. Annual Program Report: 2007-2008. NC WRC Wildlife Diversity Prog	Mason	2016-12-16	2019-10-07	8824.940409	1670273.174		Bald Eagle	6
11	Boynton, Allen. 1991. NCWRC Wildlife Observation Form; Contributed. Field forms or similar data contributed to the NC NHP by persons or organizations outside the program; Kelly, C. 2017. Records of Glaucomys sabrinus coloratus observed in western North	Mason	2019-07-02	2019-10-07	36586.10364	1546073.571		Virginia Spiraea	1
12				2019-10-07	4116.206681	1343959.067		Gray Bat	2
13	N.C. Wildlife Resources Commission. 2014. Bat data provided by Gabrielle Graeter (NCWRC), Raleigh. Data submitted August 1, 2014; O'Keefe, J. 2007. Northern long-eared bat roost locations from 2004-2007 - Excel spreadsheet; O'Keefe, Joy. 2012. Bat mist	Mason	2015-12-28	2019-10-07	29826.11962	1306233.422		Total	90
14				2019-10-07	6697.899362	950010.3394			
15				2019-10-07	3568.780992	807133.0842			
16	N.C. Wildlife Resources Commission. 2014. Bat data provided by Gabrielle Graeter (NCWRC), Raleigh. Data submitted August 1, 2014; O'Keefe, J. 2007. Northern long-eared bat roost locations from 2004-2007 - Excel spreadsheet; O'Keefe, Joy. 2012. Bat mist	Mason	2015-12-29	2019-10-07	14236.68917	610024.876			
17	N.C. Wildlife Resources Commission. 2014. Bat data provided by Gabrielle Graeter (NCWRC), Raleigh. Data submitted August 1, 2014; O'Keefe, J. 2007. Northern long-eared bat roost locations from 2004-2007 - Excel spreadsheet; O'Keefe, Joy. 2012. Bat mist	Mason	2015-12-22	2019-10-07	8105.253628	389535.5749			
18				2019-10-07	2058.091763	335985.9854			
19	N.C. Wildlife Resources Commission. 2007. Annual Program Report, 2005-2006 -- Wildlife Diversity Program; N.C. Wildlife Resources Commission. 2014. Bat data provided by Gabrielle Graeter (NCWRC), Raleigh. Data submitted August 1, 2014; N.C. Wildlife Re	Mason	2017-08-29	2019-10-07	2058.139023	336001.4176			
20				2019-10-07	2058.09834	335988.136			
21	N.C. Department of Transportation. 2015. Field survey forms and related documents contributed by NCDOT staff or NCDOT consultants in 2015; N.C. Department of Transportation. Field survey forms and related documents contributed by NCDOT staff or NCDOT co	Mason	2015-04-29	2019-10-07	1881.914022	280925.5586			
22				2019-10-07	2055.909444	192799.7373			
23	GARY KAUFFMAN. SEPTEMBER 1997. (USFS SURVEY, DISKFILE).	Schwartzman	2009-04-14	2019-10-07	1778.736843	172210.4659			
24	N.C. Wildlife Resources Commission. 2014. Bat data provided by Gabrielle Graeter (NCWRC), Raleigh. Data submitted August 1, 2014; O'Keefe, J. 2009. Northern long-eared bat roost locations from 2009 - Excel spreadsheet.; O'Keefe, Joy. 2012. Bat mist net	Mason	2015-12-15	2019-10-07	2170.494124	134820.4267			
25	Eco-Tech, Inc. 2001. Tapoco Project -- Rare, Threatened, and Endangered Species Inventory: Indiana Bat survey. The Nature Conservancy; N.C. Department of Transportation. 2015. Field survey forms and related documents contributed by NCDOT staff or NCDOT	Mason	2015-03-11	2019-10-07	2999.550575	129007.2442			
26	N.C. Wildlife Resources Commission. 2014. Bat data provided by Gabrielle Graeter (NCWRC), Raleigh. Data submitted August 1, 2014; N.C. Wildlife Resources Commission. 2016. Documents containing data contributed by NCWRC staff in 2016; O'Keefe, Joy. 2012	Mason	2016-12-14	2019-10-07	3149.016947	126310.0525			
27	Allen, D. H. 2007. Bald Eagle Nest Locations for 2007. N.C. Wildlife Resources Commission; Allen, D. H. 2008. Bald Eagle Nest Locations for 2008. N.C. Wildlife Resources Commission. ; Allen, D. H. 2009. Bald Eagle Nest Locations for 2009. N.C. Wildlife	Ratcliffe	2016-01-20	2019-10-07	1254.614315	124856.7776			
28	Miller, Melissa. 2010. NC NHP Special Animal Survey Forms. ; N.C. Department of Transportation. 2015. Field survey forms and related documents contributed by NCDOT staff or NCDOT consultants in 2015; N.C. Wildlife Resources Commission. 2016. Field surv	Mason	2017-10-18	2019-10-07	1254.66531	124866.9408			
29	N.C. Wildlife Resources Commission. 2014. Bat data provided by Gabrielle Graeter (NCWRC), Raleigh. Data submitted August 1, 2014; N.C. Wildlife Resources Commission. 2016. Field survey forms and related documents or communications contributed by NCWRC s	Mason	2017-10-17	2019-10-07	2858.598722	114318.9542			
30	N.C. Wildlife Resources Commission. 2014. Bat data provided by Gabrielle Graeter (NCWRC), Raleigh. Data submitted August 1, 2014; N.C. Wildlife Resources Commission. 2016. Documents containing data contributed by NCWRC staff in 2016; N.C. Wildlife Reso	Mason	2017-11-13	2019-10-07	1342.019641	94741.8002			
31	N.C. Wildlife Resources Commission. 2008. Annual Program Report: 2007-2008. NC WRC Wildlife Diversity Program. Can be obtained from: http://www.ncwildlife.org/Conserving/Programs/WildlifeDiversityProgram/WDPQuarterlyReports.aspx (accessed August 2013);	Mason	2016-12-16	2019-10-07	3013.234964	84922.57026			
32	Allen, D. H. 2006. Bald Eagle Nest Locations for 2006; NC WRC database; Allen, D. H. 2007. Bald Eagle Nest Locations for 2007. N.C. Wildlife Resources Commission; Allen, D. H. 2008. Bald Eagle Nest Locations for 2008. N.C. Wildlife Resources Commission	Ratcliffe	2016-01-26	2019-10-07	1029.02894	83993.71524			
33	Allen, D.H. 2012. Bald Eagle Nest Locations for 2005-2012. N.C. Wildlife Resources Comission; Kelly, Chris. 2010. New mountain EO records, sent to NHP via e-mail.	Wojcik	2018-04-10	2019-10-07	1029.058896	83998.6085			
34	Allen, D. H. 2007. Bald Eagle Nest Locations for 2007. N.C. Wildlife Resources Commission; Allen, D. H. 2008. Bald Eagle Nest Locations for 2008. N.C. Wildlife Resources Commission. ; Allen, D. H. 2009. Bald Eagle Nest Locations for 2009. N.C. Wildlife	Wojcik	2018-04-10	2019-10-07	1029.069563	84000.3544			
35	N.C. Wildlife Resources Commission. 2007. Annual Program Report, 2005-2006 -- Wildlife Diversity Program; N.C. Wildlife Resources Commission. 2014. Bat data provided by Gabrielle Graeter (NCWRC), Raleigh. Data submitted August 1, 2014; Webster, David.	Mason	2014-11-18	2019-10-07	2058.295512	84013.12142			
36	N.C. Department of Transportation. 2015. Field survey forms and related documents contributed by NCDOT staff or NCDOT consultants in 2015; N.C. Wildlife Resources Commission. 2014. Bat data provided by Gabrielle Graeter (NCWRC), Raleigh. Data submitted	Mason	2018-08-15	2019-10-07	2017.079858	70032.41632			
37	O'Keefe, Joy. 2012. Bat mist netting and roosting survey results 2004-2012. Indiana State University.	Mason	2013-08-23	2019-10-07	1543.721634	63009.84106			
38	N.C. Wildlife Resources Commission. 2014. Bat data provided by Gabrielle Graeter (NCWRC), Raleigh. Data submitted August 1, 2014; O'Keefe, J. 2013. Conservation of Habitat for Virginia Big-eared Bats in Western North Carolina;	Mason	2014-10-31	2019-10-07	1543.721634	63009.84106			
39	N.C. Wildlife Resources Commission. 2014. Bat data provided by Gabrielle Graeter (NCWRC), Raleigh. Data submitted August 1, 2014; O'Keefe, Joy. 2012. Bat mist netting and roosting survey results 2004-2012. Indiana State University.	Mason	2014-11-07	2019-10-07	1543.694209	63007.5968			
40	N.C. Department of Transportation. 2018. Geospatial files and related documents, including field observations, submitted by Eric Black, North State Engineering, for NCDOT's Project ATLAS Cardamine micranthera, Thalictrum cooleyi, Carex lutea, Rhus micha	Mason	2018-12-12	2019-10-07	2428.066257	48300.26681			
41	McGrath, Chris. 2005. NC NHP Special Animal Survey Form; N.C. Wildlife Resources Commission. 2007. Annual Program Report, 2005-2006 -- Wildlife Diversity Program; N.C. Wildlife Resources Commission. 2014. Bat data provided by Gabrielle Graeter (NCWRC),	Mason	2018-08-07	2019-10-07	1029.147756	42006.56071			
42	N.C. Department of Transportation. 2015. Field survey forms and related documents contributed by NCDOT staff or NCDOT consultants in 2015; N.C. Wildlife Resources Commission. 2014. Bat data provided by Gabrielle Graeter (NCWRC), Raleigh. Data submitted	Mason	2014-11-06	2019-10-07	1029.147756	42006.56071			
43	N.C. Department of Transportation. 2015. Field survey forms and related documents contributed by NCDOT staff or NCDOT consultants in 2015; N.C. Wildlife Resources Commission. 2014. Bat data provided by Gabrielle Graeter (NCWRC), Raleigh. Data submitted	Mason	2015-04-29	2019-10-07	1029.0716	42000.33598			
44	N.C. Wildlife Resources Commission. 2014. Bat data provided by Gabrielle Graeter (NCWRC), Raleigh. Data submitted August 1, 2014; O'Keefe, Joy. 2012. Bat mist netting and roosting survey results 2004-2012. Indiana State University.	Mason	2014-10-31	2019-10-07	1029.147756	42006.56071			

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	AJ	AK	AL
45	24797	32787	Myotis septentrionalis	69	Northern Long-eared Bat	2010-07-11	2010-07-11	2004-Pre	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal	Mason	2017-10-17	2019-10-07
46	24865	34148	Myotis septentrionalis	125	Northern Long-eared Bat	2017-06-08	2017-06-08	2002-07-29	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal	Mason	2018-08-15	2019-10-07
47	25106	34368	Myotis septentrionalis	186	Northern Long-eared Bat	2011-08-02	2011-08-02	2011-08-02	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal	Mason	2014-12-04	2019-10-07
48	25115	32785	Myotis septentrionalis	67	Northern Long-eared Bat	2009-06-03	2009-06-03	2004-Pre	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal	Mason	2014-10-30	2019-10-07
49	25153	34303	Myotis septentrionalis	177	Northern Long-eared Bat	2011-08-01	2011-08-01	2011-08-01	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal	Mason	2014-11-21	2019-10-07
50	25198	32769	Myotis septentrionalis	53	Northern Long-eared Bat	2009-06-03	2009-06-03	2009-06-03	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal	Mason	2014-10-29	2019-10-07
51	25569	34296	Myotis septentrionalis	172	Northern Long-eared Bat	2011-08-03	2011-08-03	2011-08-03	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal	Mason	2014-11-20	2019-10-07
52	25586	34127	Data Sensitive Record - contact the NCNHP	0	Data Sensitive Record - contact the NCNHP		2014-02-01		Current	C	2-High		T						Animal				2019-10-07
53	25651	32127	Myotis septentrionalis	34	Northern Long-eared Bat	2011-08-03	2011-08-03	1994-Post	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal	Mason	2014-11-24	2019-10-07
54	25730	35257	Myotis grisescens	5	Gray Bat	2018-06-28	2018-06-28	2014-06-30	Current	E	2-High	E	E	S1	S1	G4	G4	Upland	Animal	Mammal	Mason	2019-02-25	2019-10-07
55	25814	32778	Myotis septentrionalis	60	Northern Long-eared Bat	2009-06-03	2009-06-03	2009-06-03	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal	Mason	2014-10-29	2019-10-07
56	25840	34211	Myotis septentrionalis	143	Northern Long-eared Bat	2011-07-27	2011-07-27	2006-07-25	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal	Mason	2017-09-01	2019-10-07
57	25856	32784	Myotis septentrionalis	66	Northern Long-eared Bat	2009-06-03	2009-06-03	2004-Pre	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal	Mason	2014-10-30	2019-10-07
58	25913	34138	Myotis septentrionalis	121	Northern Long-eared Bat	2001-06-30	2001-06-30	2001-06-30	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal	Mason	2014-10-31	2019-10-07
59	25945	33025	Haliaeetus leucocephalus	211	Bald Eagle	2013-09-26	2013-early	2013-early	Current	E	2-High	T	BGPA	S3B,S3N	S3B,S3N	G5	G5	Wetland	Animal	Bird	Wojcik	2018-04-10	2019-10-07
60	25952	34369	Myotis septentrionalis	187	Northern Long-eared Bat	2011-08-02	2011-08-02	2011-08-02	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal	Mason	2014-12-04	2019-10-07
61	25953	34208	Myotis septentrionalis	140	Northern Long-eared Bat	2008-06-03	2008-06-03	2008-06-03	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal	Mason	2014-11-12	2019-10-07
62	25958	36543	Data Sensitive Record - contact the NCNHP	0	Data Sensitive Record - contact the NCNHP		2017-05-11		Current	C	2-High		T						Plant				2019-10-07
63	25983	34215	Myotis septentrionalis	145	Northern Long-eared Bat	2007-06-22	2007-06-22	2007-06-22	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal	Mason	2014-11-13	2019-10-07
64	26017	39072	Haliaeetus leucocephalus	279	Bald Eagle	2019-01	2019-01	2019-01	Current	E	2-High	T	BGPA	S3B,S3N	S3B,S3N	G5	G5	Wetland	Animal	Bird	Ratcliffe	2019-03-12	2019-10-07
65	26130	34295	Myotis septentrionalis	171	Northern Long-eared Bat	2005-06-14	2005-06-14	2005-06-14	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal	Mason	2014-11-19	2019-10-07
66	26133	34136	Myotis septentrionalis	120	Northern Long-eared Bat	2002-06-30	2002-06-30	2002-06-30	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal	Mason	2014-10-30	2019-10-07
67	26141	32781	Myotis septentrionalis	63	Northern Long-eared Bat	2009-06-03	2009-06-03	2008-07-28	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal	Mason	2014-10-29	2019-10-07
68	26197	34126	Myotis septentrionalis	113	Northern Long-eared Bat	2008-07-09	2008-07-09	2008-07-09	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal	Mason	2014-10-29	2019-10-07
69	26267	34371	Myotis septentrionalis	189	Northern Long-eared Bat	2011-08-02	2011-08-02	2011-08-02	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal	Mason	2014-12-04	2019-10-07
70	26417	34124	Myotis septentrionalis	111	Northern Long-eared Bat	2008-07-16	2008-07-16	2008-07-16	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal	Mason	2014-10-29	2019-10-07
71	26687	32160	Myotis septentrionalis	42	Northern Long-eared Bat	2006-06-28	2006-06-28	2004-Pre	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal	Mason	2014-11-21	2019-10-07
72	26714	32451	Myotis sodalis	13	Indiana Bat	2011-10-08	2011-10-08	2011-10-08	Current	E	2-High	E	E	S1S2	S1	G2	G2	Upland	Animal	Mammal	Mason	2014-09-11	2019-10-07
73	26843	32796	Myotis septentrionalis	78	Northern Long-eared Bat	2012-07-18	2012-07-18	2012-07-18	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal	Mason	2014-01-09	2019-10-07
74	26961	34147	Myotis septentrionalis	124	Northern Long-eared Bat	2004-08-10	2004-08-10	2004-08-10	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal	Mason	2014-11-04	2019-10-07
75	27060	32921	Myotis septentrionalis	100	Northern Long-eared Bat	2004-06-04	2004-06-04	2004-06-04	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal	Mason	2014-02-27	2019-10-07
76	27101	32786	Myotis septentrionalis	68	Northern Long-eared Bat	2009-06-03	2009-06-03	2004-Pre	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal	Mason	2014-10-30	2019-10-07
77	27174	34285	Myotis septentrionalis	162	Northern Long-eared Bat	2007-06-13	2007-06-13	2007-06-13	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal	Mason	2014-11-18	2019-10-07
78	27177	32775	Myotis septentrionalis	57	Northern Long-eared Bat	2010-05-26	2010-05-26	2008-07-17	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal	Mason	2014-10-29	2019-10-07
79	27198	34209	Myotis septentrionalis	141	Northern Long-eared Bat	2008-06-03	2008-06-03	2008-06-03	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal	Mason	2014-11-12	2019-10-07
80	27332	34133	Myotis septentrionalis	118	Northern Long-eared Bat	2003-07-28	2003-07-28	2002-06-30	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal	Mason	2014-10-30	2019-10-07
81	27348	32872	Myotis septentrionalis	85	Northern Long-eared Bat	2004-06-18	2004-06-18	2004-06-18	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal	Mason	2014-11-04	2019-10-07
82	27418	32783	Myotis septentrionalis	65	Northern Long-eared Bat	2011-06-30	2011-06-30	2008-07-03	Current	BC	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal	LeGrand	2015-10-20	2019-10-07
83	27452	32835	Myotis septentrionalis	82	Northern Long-eared Bat	2010-07-11	2010-07-11	2010-07-11	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal	Mason	2014-11-12	2019-10-07
84	27471	25085	Data Sensitive Record - contact the NCNHP	0	Data Sensitive Record - contact the NCNHP		2007-06-24		Current	CD	3-Medium		T						Animal				2019-10-07
85	27648	37004	Myotis septentrionalis	230	Northern Long-eared Bat	2010-07-16	2010-07-16	2010-07-04	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal	Mason	2016-12-02	2019-10-07
86	27967	35099	Myotis septentrionalis	211	Northern Long-eared Bat	2008-08-12	2008-08-12	2008-08-06	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal	Mason	2015-04-29	2019-10-07
87	28239	37037	Myotis sodalis	21	Indiana Bat	2010-07-04	2010-07-04	2010-07-04	Current	E	2-High	E	E	S1S2	S1	G2	G2	Upland	Animal	Mammal	Mason	2016-12-16	2019-10-07
88	28241	37013	Myotis septentrionalis	231	Northern Long-eared Bat	2010-07-12	2010-07-12	2010-07-12	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal	Mason	2016-12-07	2019-10-07
89	28255	37003	Myotis septentrionalis	229	Northern Long-eared Bat	2009-06-11	2009-06-11	2009-06-11	Current	E	2-High	T	T	S2	S2	G1G2	G1	Upland	Animal	Mammal	Mason	2016-12-02	2019-10-07
90	28494	32131	Data Sensitive Record - contact the NCNHP	0	Data Sensitive Record - contact the NCNHP		2006-01-13		Current	D	2-High		T						Animal				2019-10-07
91	28948	32453	Myotis sodalis	15	Indiana Bat	2012-07-26	2012-07-26	2012-07-15	Current	E	2-High	E	E	S1S2	S1	G2	G2	Upland	Animal	Mammal	Mason	2013-08-23	2019-10-07

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA
1	NHEO_2019.OBJECTID	NHEO_2019.EO_ID	NHEO_2019.SCI_NAME	NHEO_2019.EO_NUM	NHEO_2019.COM_NAME	NHEO_2019.SURVEYDATE	NHEO_2019.LAST_OBS	NHEO_2019.FIRST_OBS	NHEO_2019.EO_STATUS	NHEO_2019.EO_RANK	NHEO_2019.ACCURACY	NHEO_2019.NC_STATUS	NHEO_2019.USA_STATUS	NHEO_2019.S_RANK	NHEO_2019.RND_S_RANK	NHEO_2019.G_RANK	NHEO_2019.RND_G_RANK	NHEO_2019.HAB_TYPE	NHEO_2019.NAME_CATGY	NHEO_2019.TAXO_GROUP	NHEO_2019.HAB_COM	NHEO_2019.ELEMENT_ID	NHEO_2019.DATA_SENS	NHEO_2019.HQR	NHEO_2019.ACRES	NHEO_2019.MIN_ELEV	NHEO_2019.MAX_ELEV
2	441	18954	Moxostoma sp. 2	2	Sicklefin Redho	2018-08-25	2018-08-25	1981-07-21	Current	E	3-Medium	T		S2	S2	G1G2	G1	Aquatic	Animal	Freshwater Fish	M: Hiwassee and Little Tennessee drainages	18280	N	Y	4037.73	-1	-1
3	459	4497	Moxostoma sp. 2	1	Sicklefin Redho	2018-10-16	2018-10-16	1962-09-13	Current	E	3-Medium	T		S2	S2	G1G2	G1	Aquatic	Animal	Freshwater Fish	M: Hiwassee and Little Tennessee drainages	18280	N	Y	3885.73	-1	-1
4	761	10129	Platanthera grandiflora	16	Large Purple-fr	1995-06-07	1995-06-07	1995-06-07	Current	CD	4-Low	T		S2	S2	G5	G5	Wetland	Plant	Vascular Plant	M: bogs, seeps, grassy balds, high elevation moist forests and banks	16622	N	N	3085.3	3900	3900
5	1020	36150	Perimyotis subflavus	61	Tricolored Bat	2001-12-17	2001-12-17	2001-12-17	Current	E	5-Very Low	SR		S3	S3	G2G3	G2	Upland	Animal	Mammal	MPSC: roosts in clumps of leaves (mainly in summer), caves, rock crevices, and other dark and sheltered	18194	N	N	2301.16	-1	-1
6	1064	6235	Thermopsis fraxinifolia	10	Ash-leaved Gol	2013-06-24	2013-06-24	1921-07-10	Current	B	4-Low	SC-V		S2?	S2	G3?	G3	Upland	Plant	Vascular Plant	MP: dry ridges	16770	N	N	2108.28	3000	3700
7	1203	9171	Setophaga cerulea	21	Cerulean Warbl	2001-05-18	2001-05-18	1987-05-19	Current	E	4-Low	SC		S2B	S2B	G4	G4	Upland	Animal	Bird	MC: mature hardwood forests; steep slopes and coves in mountains, natural levees in Coastal Plain [breeding evidence only]	17322	N	N	1735.49	3000	-1
8	1728	4142	Lampsilis fasciola	1	Wavyrayed Lam	2018-10-31	2018-10-31	1992-07-19	Current	E	3-Medium	SC		S2	S2	G5	G5	Aquatic	Animal	Freshwater Bivalve	M: French Broad, Pigeon, Hiwassee, and Little Tennessee drainages	16263	N	N	942.98	-1	-1
9	1732	12354	Percina caprodes	1	Logperch	2017-10-04	2017-10-04	1962	Current	E	3-Medium	T		S1	S1	G5	G5	Aquatic	Animal	Freshwater Fish	M: Tennessee drainages	19841	N	N	933.32	-1	-1
10	1846	36495	Celastrus scandens	33	American Bitter	2010-2012	2012-05-23 or b	2010-04-29 or a	Current	E	3-Medium	E		S2?	S2	G5	G5	Upland	Plant	Vascular Plant	MP: cove forests and rich woods	18143	N	N	817.54	-1	-1
11	1883	33228	Diervilla rivularis	3	Riverbank Bush	2000-08-20	2000-08-20	1999-07-04	Current	E	3-Medium	T		S1	S1	G3	G3	Upland	Plant	Vascular Plant	M: forests	21638	N	N	782.46	-1	-1
12	2253	28870	Bromus ciliatus	10	Fringed Brome	2007	2007	2007	Current	E	4-Low	SR-P		S1	S1	G5	G5	Upland	Plant	Vascular Plant	M: moist areas near high elevation grassy balds	37841	N	N	730.65	-1	-1
13	2377	11080	Etheostoma acuticeps	3	Sharphead Dart	2017-06-29	2017-06-29	1977-09-24	Current	E	3-Medium	T		S1	S1	G3	G3	Aquatic	Animal	Freshwater Fish	M: Toe and Cane drainages	19081	N	Y	640.29	-1	-1
14	2406	5359	Packera millefolium	6	Divided-leaf Ra	2001-2004	2001-2004	1958-07	Current	E	2-High	T		S2	S2	G3	G3	Upland	Plant	Vascular Plant	M: granitic domes, other outcrops	15876	N	N	625.25	-1	-1
15	2488	17245	Cottus carolinae	1	Banded Sculpin	2019-02-27	2019-02-27	1987	Current	E	3-Medium	SC		S1	S1	G5	G5	Aquatic	Animal	Freshwater Fish	M: French Broad and Pigeon drainages	16453	N	N	583.86	-1	-1
16	2579	19712	Percina squamata	2	Olive Darter	2011-10-05	2011-10-05	1888	Current	E	3-Medium	SC		S2	S2	G3	G3	Aquatic	Animal	Freshwater Fish	M: Tennessee drainages	18174	N	Y	534.88	-1	-1
17	2757	3894	Bryoxiphium norvegicum	3	Sword Moss	1992-08-29	1992-08-29	1973-04-02	Current	B	4-Low	SR-O		S1	S1	G5?	G5	Wetland	Plant	Moss	M: rocks in humid gorges, spray zones of waterfalls	20687	N	N	493.65	2800	-1
18	2866	7865	Carex projecta	2	Necklace Sedge	2003-05-05	1958-07	1958-07	Current	F	4-Low	SR-P		S1	S1	G5	G5	Wetland	Plant	Vascular Plant	CMP: bogs, marshes, swamps, brownwater floodplain forests and openings	15969	N	N	493.65	-1	-1
19	2897	17532	Bryoxiphium norvegicum	4	Sword Moss	1992-08-29	1992-08-29	1975-04-06	Current	B	4-Low	SR-O		S1	S1	G5?	G5	Wetland	Plant	Moss	M: rocks in humid gorges, spray zones of waterfalls	20687	N	N	493.65	-1	-1
20	3148	7587	Packera millefolium	22	Divided-leaf Ra	1991	1991	1989-Pre	Current	E	4-Low	T		S2	S2	G3	G3	Upland	Plant	Vascular Plant	M: granitic domes, other outcrops	15876	N	N	403.62	4000	4280
21	3189	16625	Buckleya distichophylla	12	Piratebush	1991-09-20	1991-09-20	1991-09-20	Current	D	4-Low	T		S2	S2	G3	G3	Upland	Plant	Vascular Plant	M: bluffs, dry slopes, forests on lower slopes	16404	N	N	397.56	-1	-1
22	3199	4859	Platanthera grandiflora	15	Large Purple-fr	1991	1991	1989-Pre	Current	E	4-Low	T		S2	S2	G5	G5	Wetland	Plant	Vascular Plant	M: bogs, seeps, grassy balds, high elevation moist forests and banks	16622	N	N	394.12	-1	-1
23	3276	11139	Cambarus georgiae	1	Little Tennesse	2009-07-08	2009-07-08	1957-06-26	Current	E	3-Medium	SC		S2	S2	G2G3	G2	Aquatic	Animal	Crustacean	M: streams in Little Tennessee drainage	15327	N	N	370.44	-1	-1
24	3352	15664	Crocanthemum bicknellii	3	Plains Sunrose	1989-Pre	1989-Pre	1951-08	Current	E	4-Low	SC-V		S1	S1	G5	G5	Upland	Plant	Vascular Plant	M: rock outcrops, glades, fens	20521	N	N	350.73	5749	-1
25	3366	1365	Sporobolus heterolepis	1	Prairie Dropsee	2013-07-11	2013-07-11	1973	Current	A	3-Medium	T		S1	S1	G5	G5	Upland	Plant	Vascular Plant	M: olivine barrens	18496	N	N	346.11	-1	-1
26	3368	23497	Lampsilis fasciola	8	Wavyrayed Lam	2014-09-24	2014-09-24	1998-05-27	Current	E	3-Medium	SC		S2	S2	G5	G5	Aquatic	Animal	Freshwater Bivalve	M: French Broad, Pigeon, Hiwassee, and Little Tennessee drainages	16263	N	N	345.85	-1	-1
27	3370	33962	Ranunculus fascicularis	1	Thick-root Butt	2011-Pre	2011-Pre	2011-Pre	Current	E	4-Low	SR-P		S1	S1	G5	G5	Upland	Plant	Vascular Plant	MP: serpentine and diabase barrens	18492	N	N	345.49	-1	-1
28	3385	6279	Adlumia fungosa	31	Climbing Fumit	1991-09-20	1991-09-20	1991-09-20	Current	E	4-Low	SC-V		S2	S2	G4	G4	Upland	Plant	Vascular Plant	M: coves and cliffs	15870	N	N	342.67	-1	-1
29	3423	35719	Cottus carolinae	10	Banded Sculpin	2002-07-24	2002-07-24	1993-05-07	Current	E	3-Medium	SC		S1	S1	G5	G5	Aquatic	Animal	Freshwater Fish	M: French Broad and Pigeon drainages	16453	N	N	334.14	-1	-1
30	3467	5545	Phegopteris connectilis	3	Northern Beech	1982-06-10	1982-06-10	1982-06-10	Current	D	4-Low	E		S2	S2	G5	G5	Wetland	Plant	Vascular Plant	M: spray zone of waterfalls, spruce-fir forests, high elevation seepage bogs	21086	N	N	325.72	-1	-1
31	3484	2440	Frasera caroliniensis	15	Columbo	1996-07-09	1996-07-09	1993-10-27	Current	A	3-Medium	SR-P		S2S3	S2	G5	G5	Upland	Plant	Vascular Plant	M: deciduous forests on mafic soil	17919	N	N	323.08	2650	3300
32	3572	14541	Rhabdoweisia crenulata	1	Himalayan Ribb	1999-04-01	1988	1965-07-20	Current	E	4-Low	SR-D		S1	S1	G3G5	G4	Upland	Plant	Moss	M: moist rocks in cove forests in humid gorges	19859	N	N	305.86	3300	-1
33	3884	28450	Elimia christyi	1	Christy's Elimia	2019-05-01	2019-05-01	1882-Pre	Current	E	3-Medium	E		S1	S1	G2	G2	Aquatic	Animal	Freshwater or Ter	M: Hiwassee River and tributaries	39411	N	N	252.27	-1	-1
34	3962	21762	Alasmidonta varicosa	34	Brook Floater	2019-03-25	2019-03-25	1989-06-07	Current	A	3-Medium	E		S3	S3	G3	G3	Aquatic	Animal	Freshwater Bivalve	MP: Cape Fear drainage, also along Blue Ridge escarpment of Catawba and Yadkin-Pee Dee drainages	18650	N	Y	244.28	-1	-1
35	4120	22467	Thalictrum macrostylum	7	Small-leaved M	2013-07-11	2013-07-11	1951-07-24	Current	A	2-High	SR-T		S2	S2	G3G4	G3	Wetland	Plant	Vascular Plant	CSPM: bogs and wet woods	19756	N	N	224.03	-1	-1
36	4189	11279	Frasera caroliniensis	4	Columbo	2006-Spring	2006-Spring	1950-07-14	Current	AB	3-Medium	SR-P		S2S3	S2	G5	G5	Upland	Plant	Vascular Plant	M: deciduous forests on mafic soil	17919	N	N	213.16	2400	-1
37	4192	19568	Villosa vanuxemensis	2	Mountain Creek	2006-08-02	2006-08-02	1965-Pre	Current	E	3-Medium	T		S1?	S1	G4	G4	Aquatic	Animal	Freshwater Bivalve	M: Hiwassee River; documented from Hiwassee and French Broad drainages in Tennessee	21136	N	Y	212.73	-1	-1
38	4338	25310	Hexastylis contracta	11	Mountain Heart	2007-06-21	2007-06-21	2007-05-24	Current	A?	2-High	E		S1	S1	G3	G3	Upland	Plant	Vascular Plant	M: acidic forests under rhododendron	18930	N	N	197.68	1350	1610
39	4346	16449	Percina squamata	10	Olive Darter	2008-10-07	2008-10-07	1980-06	Current	E	3-Medium	SC		S2	S2	G3	G3	Aquatic	Animal	Freshwater Fish	M: Tennessee drainages	18174	N	Y	196.51	-1	-1
40	4526	16620	Pleurobema oviforme	2	Tennessee Clu	2014-09-24	2014-09-24	1998-05-27	Current	E	3-Medium	E		S1	S1	G2G3	G2	Aquatic	Animal	Freshwater Bivalve	M: French Broad, Little Tennessee, and Hiwassee drainages	21532	N	Y	181.58	-1	-1
41	4740	25074	Myotis leibii	36	Eastern Small-f	2006-07-27	2006-07-27	2005-07-27	Current	E	4-Low	SC		S2	S2	G4	G4	Upland	Animal	Mammal	M: roosts in hollow trees and in rock crevices (warmer months), in caves and mines (winter)	19689	N	N	161.23	-1	-1
42	4801	14681	Draba ramosissima	13	Branching Drab	1991-09-20	1991-09-20	1991-09-20	Current	CD	4-Low	SC-V		S2	S2	G4	G4	Upland	Plant	Vascular Plant	MP: calcareous and mafic rock outcrops	18188	N	N	156.19	-1	-1
43	4816	4765	Adlumia fungosa	28	Climbing Fumit	1991-09-20	1991-09-20	1991-09-20	Current	E	4-Low	SC-V		S2	S2	G4	G4	Upland	Plant	Vascular Plant	M: coves and cliffs	15870	N	N	155.5	-1	-1
44	4871	16119	Sphagnum squarrosum	4	Squarrose Peat	1930-07-29	1930-07-29	1930-06	Current	F	4-Low	SR-P		S1	S1	G5	G5	Wetland	Plant	Moss	M: spray zones of waterfalls, seepage in spruce-fir forests	19013	N	N	150.12	-1	-1
45	4935	16976	Adlumia fungosa	29	Climbing Fumit	1990-05-16	1990-05-16	1990-05-16	Current	E	4-Low	SC-V		S2	S2	G4	G4	Upland	Plant	Vascular Plant	M: coves and cliffs	15870	N	N	147.91	-1	-1
46	4977	1666	Plagiochila echinata	2	A Liverwort	1995-10-1	1995-10-1	1961-Pre	Current	E	4-Low	SR-L		S1	S1	G2	G2	Wetland	Plant	Liverwort	M: rocks and streambanks in humid gorges, spray zone of waterfalls	16067	N	N	143.02	2600	2800
47	5057	25154	Plethodon welleri	14	Weller's Salama	2014-09-28	2014-09-28	1992	Current	B	3-Medium	SC		S2	S2	G3	G3	Upland	Animal	Amphibian	M: high elevation forests in northern mountains, mainly in spruce-fir and to a lesser degree, northern hardwood forests	20991	N	N	137.64	3500	4400
48	5125	13835	Frasera caroliniensis	16	Columbo	2008-09-17	2008-09-17	1993-12-01	Current	AB	4-Low	SR-P		S2S3	S2	G5	G5	Upland	Plant	Vascular Plant	M: deciduous forests on mafic soil	17919	N	N	134	2500	2800
49	5139	14365	Arabis patens	6	Spreading Rock	1998-07-09	1998-07-09	1974-06	Current	A?	3-Medium	SR-T		S1	S1	G3	G3	Upland	Plant	Vascular Plant	M: thin soils around limestone and nutrient-rich seepage from amphibolite	21658	N	N	133.34	-1	-1
50	5177	23336	Pohlia lescuriana	3	Spherical Bulb	2003-12-20	2003-12-20	2003-12-20	Current	E	2-High	SR-T		S1?	S1	G4G5	G4	Upland	Plant	Moss	MP: on wet, noncalcareous soil in open areas	38455	N	N	130.03	-1	-1
51	5269	24181	Huperzia porophila	22	Rock Fir-clubm	2006-07-31	2006-07-31	2006-07-31	Current	CD	3-Medium	SR-P		S2	S2	G4	G4	Wetland	Plant	Vascular Plant	M: in spray zone of waterfalls	16317	N	N	125.78	-1	-1
52	5313	15085	Plagiochila virginica var. virginica	1	A Liverwort	2012-06-07	2012-06-07	1953-07-27	Current	E	2-High	SR-L		S1	S1	G3T3	T3	Upland	Plant	Liverwort	CM: on limestone	15100	N	N	123.89	2200	2800
53	5338	36046	Myotis lucifugus	62	Little Brown Ba	2011-07-26	2011-07-26	2007-07-09	Current	E	3-Medium	SR		S2	S2	G3	G3	Upland	Animal	Mammal	MPC: roosts in buildings (summer), in caves and mines (winter)	15533	N	N	123.41	-1	-1
54	5409	23205	Solidago simulans	17	Granite Dome	1997-05-04	1997-05-04	1997-05-04	Current	E	3-Medium	SR-L		S2	S2	G2	G2	Upland	Plant	Vascular Plant	M: high and low elevation granitic domes south of the Asheville Basin	17664	N	N	123.41	-1	-1
55	5505	36166	Perimyotis subflavus	75	Tricolored Bat	2011-07-26	2011-07-26	2006-07-13	Current	E	4-Low	SR		S3	S3	G2G3	G2	Upland	Animal	Mammal	MPSC: roosts in clumps of leaves (mainly in summer), caves, rock crevices, and other dark and sheltered	18194	N	N	123.41	-1	-1
56	5572	10843	Silene ovata	36	Mountain Catch	1991-10-04	1991-10-04	1991-10-04	Current	D	3-Medium	SC-V		S3	S3	G3	G3	Upland	Plant	Vascular Plant	M: rich slopes, cove forests, montane oak-hickory forests	17844	N	N	123.41	3440	-1
57	5634	13405	Rhododendron vaseyi	3	Pink-shell Azale	1989-Pre	1989-Pre	1917-05-06	Current	E	3-Medium	SR-L		S3	S3	G3	G3	Wetland	Plant	Vascular Plant	M: high elevation oak forests, heath balds, spruce-fir forests, and rocky areas	21648	N	N	123.41	-1	-1
58	5659	36148	Perimyotis subflavus	59	Tricolored Bat	2008-08-02	2008-08-02	2008-08-02	Current	E	3-Medium	SR		S3	S3	G2G3	G2	Upland	Animal	Mammal	MPSC: roosts in clumps of leaves (mainly in summer), caves, rock crevices, and other dark and sheltered	18194	N	N	123.41	-1	-1
59	6098	17454	Draba ramosissima	3	Branching Drab	1998-07-09	1998-07-09	1967-04	Current	A	3-Medium	SC-V		S2	S2	G4	G4	Upland	Plant	Vascular Plant	MP: calcareous and mafic rock outcrops	18188	N	N	107.39	1300	1650
60	6160	36761	Packera serpenticola	1	Buck Creek Ra	2013-07-11	2013-07-11	1974-06-11	Current	A	3-Medium	SR-L		S1	S1	G1	G1	Upland	Plant	Vascular Plant	M: Serpentine barrens	377012	N	N	104.14	3346	3346

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
61	6174	9441	Carex purpurifera	5	Purple Sedge	2005-05-23	2005-05-23	1994-04-29	Current	A	3-Medium	SC-V		S3
62	6201	18455	Muhlenbergia glomerata	2	Spiked Muhly	1995-09-10	1995-09-10	1951-08-24	Current	D	3-Medium	SC-V		S1
63	6211	33511	Parnassia grandifolia	24	Bigleaf Grass-o	1995-09-09	1995-09-09	1995-09-09	Current	E	3-Medium	T		S2
64	6396	11274	Plethodon welleri	8	Weller's Salama	2012-03-22	2012-03-22	1992	Current	E	3-Medium	SC		S2
65	6422	4453	Euphorbia purpurea	10	Glade Spurge	2014-05-17	2014-05-17	1978-09-16	Current	AB	3-Medium	SR-T		S3
66	6498	15274	Euphorbia purpurea	6	Glade Spurge	2008-07-04	2008-07-04	1972	Current	A	3-Medium	SR-T		S3
67	6601	23236	Fothergilla major	52	Large Witch-alc	2006-04-15	2006-04-15	2006-04-15	Current	E	3-Medium	SR-T		S3
68	6660	7170	Frasera caroliniensis	11	Columbo	2007-04-30	2007-04-30	1972-06	Current	A	3-Medium	SR-P		S2S3
69	6668	15692	Homalia trichomanoides	2	Lime Homalia	2002-05-18	2002-05-18	1951-08-23	Current	E	3-Medium	SR-P		S1
70	6813	9546	Euphorbia purpurea	13	Glade Spurge	2006-10-03	2006-10-03	1991-06-24	Current	B	3-Medium	SR-T		S3
71	6893	24107	Cambarus parrishi	8	Hiwassee Head	2017-10-30	2017-10-30	1984-09-22	Current	BC	3-Medium	SC		S1
72	6901	27905	Drepanolejeunea appalachiana	14	A Liverwort	2005-06-15	2005-06-15	2005-06-15	Current	E	3-Medium	SC-V		S1
73	7031	21727	Alasmidonta varicosa	30	Brook Floater	2018-10-23	2018-10-23	1987-08-20	Current	B	3-Medium	E		S3
74	7104	9880	Scopelophila cataractae	1	Agoyan Catarac	2018-05-28	2018-05-28	1965-07-20	Current	E	3-Medium	SR-D		S1
75	7236	2580	Acrobolbus ciliatus	4	A Liverwort	1994-06-21	1994-06-21	1956	Current	E	2-High	SC-V		S1
76	7249	16280	Sorex palustris punctulatus	10	Southern Wate	2004-04-30	2004-04-30	1995-06-16	Current	B?	3-Medium	SR		S3
77	7377	24105	Cambarus parrishi	6	Hiwassee Head	2017-10-30	2017-10-30	1960-Pre	Current	E	3-Medium	SC		S1
78	7443	7025	Deschampsia cespitosa ssp. glauca	1	Tufted Hairgras	1992-07	1992-07	1952	Current	A	3-Medium	T		S1
79	7633	28599	Lampsilis fasciola	13	Wavyrayed Lam	2018-11-26	2018-11-26	2007-09-04	Current	Er	3-Medium	SC		S2
80	7636	31089	Etheostoma vulneratum	14	Wounded Darte	2018-08-07	2018-08-07	2009-07-23	Current	Er	3-Medium	SC		S2
81	7844	35437	Plethodon aureolus	13	Tellico Salaman	2011-09-01	2011-09-01	1983-06	Current	E	2-High	SR		S2?
82	8017	25102	Carex roanensis	25	Roan Sedge	2003-06-19	2003-06-19	2003-06-19	Current	E	3-Medium	SR-T		S2
83	8040	11630	Taxiphyllum alternans	1	Japanese Yew-	1972-10-15	1972-10-15	1972-10-15	Current	E	3-Medium	SR-O		S1
84	8312	19360	Frasera caroliniensis	19	Columbo	2009-06-22	2009-06-22	1995-10-27	Current	AB	2-High	SR-P		S2S3
85	8351	9709	Cardamine clematitis	12	Mountain Bitter	1992-08-20	1992-08-20	1992-06-10	Current	B?	3-Medium	SR-T		S2S3
86	8473	22024	Plagiochila sullivantii var. sullivantii	18	A Liverwort	1994-06-17	1994-06-17	1994-06-17	Current	E	2-High	SR-T		S2
87	8558	6692	Lysimachia fraseri	27	Fraser's Loose	1997-06-24	1997-06-24	1992-07	Current	B	3-Medium	E		S3
88	8598	228	Frasera caroliniensis	17	Columbo	2005-05-05	2005-05-05	1994-07-14	Current	A	3-Medium	SR-P		S2S3
89	8625	25311	Hexastylis contracta	12	Mountain Heart	2007-06-21	2007-06-21	2007-06-21	Current	A?	2-High	E		S1
90	8884	9163	Radula voluta	1	A Liverwort	2008-09-04	2008-09-04	1953-09-02	Current	E	2-High	SR-D		S1
91	8892	39248	Noturus flavus	5	Stonecat	2018-10-23	2018-10-23	2018-10-23	Current	E	3-Medium	E		S1
92	9047	38355	Sorex palustris punctulatus	27	Southern Wate	2006-08-25	2006-08-25	2006-08-25	Current	E	3-Medium	SR		S3
93	9095	24980	Hexastylis contracta	9	Mountain Heart	2007-08-29	2007-08-29	2007-04-09	Current	B	2-High	E		S1
94	9111	12457	Lysimachia fraseri	24	Fraser's Loose	2013-06-27	2013-06-27	1992-08-18	Current	AB	3-Medium	E		S3
95	9240	23052	Sorex palustris punctulatus	15	Southern Wate	2005-04-04	2005-04-04	2005-03-26	Current	B?	3-Medium	SR		S3
96	9355	15714	Cambarus chaugaensis	1	Chauga Crayfis	2012-06-14	2012-06-14	1988-01-19	Current	E	3-Medium	SC		S2
97	9516	14494	Dichodontium pellucidum	9	Transparent Fo	1972-10-15	1972-10-15	1972-10-15	Current	E	3-Medium	SR-P		S2
98	9541	28661	Thaspium pinnatifidum	8	Mountain Thas	1997-07-12	1997-07-12	1842-09	Current	E	3-Medium	T		S1
99	9648	15618	Tortula ammonsiana	2	Ammons's Tort	1995-09-23	1953-09-01	1953-09-01	Current	F	3-Medium	SR-O		S1
100	9663	19809	Porella wataugensis	5	A Liverwort	1994-06-20	1994-06-20	1953	Current	E	3-Medium	SR-L		S1
101	9707	21905	Lejeunea blomquistii	3	A Liverwort	1994-06-13	1994-06-13	1994-06-13	Current	E	3-Medium	SC-V		S1
102	9717	36152	Perimyotis subflavus	63	Tricolored Bat	2002-06-30	2002-06-30	2002-06-30	Current	E	3-Medium	SR		S3
103	9719	14821	Liatris aspera	9	Rough Blazing-s	1988-07-24	1969-09	1969-09	Current	F	3-Medium	T		S1
104	9723	21805	Plagiochila echinata	7	A Liverwort	1998-April to N	1998	1998	Current	E	3-Medium	SR-L		S1
105	9748	36043	Myotis lucifugus	59	Little Brown Ba	2012-07-09	2012-07-09	2008-06-03	Current	E	4-Low	SR		S2
106	9826	21844	Plagiochila sullivantii var. sullivantii	15	A Liverwort	1998-April to N	1998	1998	Current	E	3-Medium	SR-T		S2
107	9829	34121	Myotis leibii	91	Eastern Small-f	2001-06-30	2001-06-30	2001-06-30	Current	E	3-Medium	SC		S2
108	9843	22725	Sphagnum flexuosum	2	Flexuous Peatm	1990-08-21	1990-08-21	1990-08-21	Current	E	3-Medium	SR-P		S1
109	9852	36162	Perimyotis subflavus	71	Tricolored Bat	2008-06-03	2008-06-03	2008-06-03	Current	E	3-Medium	SR		S3
110	9855	19905	Carex purpurifera	7	Purple Sedge	1996-07-12	1996-07-12	1996-06-13	Current	A	3-Medium	SC-V		S3
111	9863	17249	Carex hitchcockiana	2	Hitchcock's Se	1996-07-12	1996-07-12	1996-07-12	Current	B	3-Medium	SC-V		S1
112	9872	26293	Silene ovata	50	Mountain Catch	2008-05-13	2008-05-13	2008-05-13	Current	C	3-Medium	SC-V		S3
113	9977	19323	Plethodon welleri	5	Weller's Salama	2014-04-25	2014-04-25	1945-05-29	Current	A	3-Medium	SC		S2
114	10163	38358	Sorex palustris punctulatus	30	Southern Wate	2006-07-20	2006-07-20	2006-07-19	Current	E	3-Medium	SR		S3
115	10164	34842	Oenothera perennis	22	Perennial Sundr	2013-06-12	2013-06-12	2012-06-25	Current	A	3-Medium	SC-V		S2
116	10566	28632	Setophaga cerulea	57	Cerulean Warbl	2017-05-17	2017-05-17	2010	Current	B?	1-Very High	SC		S2B
117	10625	38357	Sorex palustris punctulatus	29	Southern Wate	2006-05-10	2006-05-10	2006-05-10	Current	E	2-High	SR		S3
118	10788	25498	Plethodon cheoah	3	Cheoah Bald Sa	2019-06-14	2019-06-14	1985-10-13	Current	B?	3-Medium	SR		S1S2
119	10849	2576	Buckleya distichophylla	7	Piratebush	2008-06-17	2008-06-17	1987-05-11	Current	B	3-Medium	T		S2
120	10931	6078	Buckleya distichophylla	10	Piratebush	2002-04-20	2002-04-20	1994-07-01	Current	A	3-Medium	T		S2

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB
121	10986	402	Cardamine rotundifolia	11	Mountain Wate	2012-08-17	2012-08-17	1995-06	Current	A	3-Medium	T		S2	S2	G4	G4	Wetlan	Plant	Vascular Plant	MP: seeps, banks of mountain brooks	15915	N	N	22.51	3420	3520	BEARWALLOW GAP ; Pigeonroost Creek Forests and Seeps
122	11064	25458	Cambarus chaugaensis	3	Chauga Crayfis	2012-06-13	2012-06-13	2001-07-23	Current	E	3-Medium	SC		S2	S2	G2	G2	Aquatic	Animal	Crustacean	M: streams in Savannah drainage (endemic to northwest South Carolina and adjacent North Carolina and	18799	N	N	21.93	-1	-1	SAV/Whitewater River
123	11083	7309	Crocanthemum propinquum	12	Creeping Sunro	1991-10-04	1991-10-04	1991-10-04	Current	D	3-Medium	T		S1	S1	G4	G4	Upland	Plant	Vascular Plant	MP: rock outcrops, glades	20201	N	N	21.77	3560	-1	Hurricane Ridge
124	11271	27907	Drepanolejeunea appalachiana	16	A Liverwort	2005-12-08	2005-12-08	2005-12-08	Current	E	3-Medium	SC-V		S1	S1	G2?	G2	Upland	Plant	Liverwort	M: on moist rock, rhododendron bark, and rhododendron leaves in humid	15695	N	N	20.29	-1	-1	Nantahala National Forest: Dry Falls Area
125	11500	26292	Phlox subulata	10	Moss Pink	2018-09-24	2018-09-24	2008-05-13	Current	C?	3-Medium	SR-P		S1	S1	G5	G5	Upland	Plant	Vascular Plant	M: outcrops and glades, especially over mafic rocks	16741	N	N	19.24	3700	3800	Rock Knob
126	11502	2937	Draba ramosissima	8	Branching Drab	2008-05-13	2008-05-13	1985-09-01	Current	AB	3-Medium	SC-V		S2	S2	G4	G4	Upland	Plant	Vascular Plant	MP: calcareous and mafic rock outcrops	18188	N	N	19.22	3400	-1	PAYNES KNOB-ROCK KNOB
127	11536	25109	Sorex palustris punctulatus	20	Southern Wate	2004-05-03	2004-05-03	2004-04-30	Current	E	3-Medium	SR		S3	S3	G5T3	T3	Wetlan	Animal	Mammal	M: stream banks in montane forests	17355	N	N	18.93	-1	-1	Roaring Fork
128	11554	16977	Adlumia fungosa	30	Climbing Fumit	1994-10-04	1994-10-04	1994-10-04	Current	D	3-Medium	SC-V		S2	S2	G4	G4	Upland	Plant	Vascular Plant	M: coves and cliffs	15870	N	N	18.77	2800	-1	Hurricane Creek Forests
129	11584	23395	Monarda media	2	Purple Bee-balr	1992-08-04	1992-08-04	1992-08-04	Current	C	3-Medium	SR-P		S1?	S1	G4?	G4	Upland	Plant	Vascular Plant	M: grassy balds	15466	N	N	18.51	4760	-1	Jackson County; Cold Spring G
130	11649	17438	Cardamine rotundifolia	5	Mountain Wate	2012-07-27	2012-07-27	1993	Current	B	3-Medium	T		S2	S2	G4	G4	Wetlan	Plant	Vascular Plant	MP: seeps, banks of mountain brooks	15915	N	N	18.06	3320	-1	IN SEVERAL BOGGY WETLANDS AT THE HEAD OF PATE CREEK AND TRIBUTARIES, ON U.S. FOR
131	11769	27983	Myotis leibii	40	Eastern Small-f	2008-10-13	2008-10-13	2008-10-13	Current	D	3-Medium	SC		S2	S2	G4	G4	Upland	Animal	Mammal	M: roosts in hollow trees and in rock crevices (warmer months), in caves and mines	19689	N	N	17.91	3400	3450	Heady Mountain Gap
132	11787	14815	Rhododendron vaseyi	44	Pink-shell Azale	2007-08-14	2007-08-14	1989	Current	A	2-High	SR-L		S3	S3	G3	G3	Wetlan	Plant	Vascular Plant	M: high elevation oak forests, heath balds, spruce-fir forests, and rocky areas	21648	N	N	17.84	4200	4440	SHELTON PISGAH MOUNTA
133	11878	6712	Viola appalachiensis	2	Appalachian Vi	2014-05-17	2014-05-17	1997-05-02	Current	AB	3-Medium	SC-V		S2	S2	G4	G4	Upland	Plant	Vascular Plant	M: olivine barrens and alluvial forests	15711	N	N	17.36	3280	3360	Nantahala National Forest: Bry Branch Falls and Cove
134	11978	27111	Frasera caroliniensis	25	Columbo	2008-08-29	2008-08-29	2006-08-07	Current	A?	2-High	SR-P		S2S3	S2	G5	G5	Upland	Plant	Vascular Plant	M: deciduous forests on mafic soil	17919	N	N	16.86	2760	2960	Chimney Knob (Little Chimney Knob) - Macon Co.
135	12201	13678	Carex careyana	1	Carey's Sedge	2014-05-24	2014-05-24	1992-04-27	Current	A	3-Medium	T		S1	S1	G4G5	G4	Upland	Plant	Vascular Plant	M: rich cove forests	19723	N	N	15.49	3400	-1	Brown Mountain/Hench Knob
136	12223	17921	Scutellaria saxatilis	16	Rock Skullcap	2012-09-19	2012-09-19	1995-07-27	Current	C	3-Medium	SR-T		S2	S2	G3G4	G3	Upland	Plant	Vascular Plant	MP: northern hardwoods forests, rocky woodlands	19148	N	N	15.43	3800	4100	LITTLE BALD KNOB
137	12225	11030	Thermopsis fraxinifolia	22	Ash-leaved Gol	2001-06-14	2001-06-14	1994-05-22	Current	C	3-Medium	SC-V		S2?	S2	G3?	G3	Upland	Plant	Vascular Plant	MP: dry ridges	16770	N	N	15.43	2360	2460	NORTH MILLS RIVER
138	12230	18218	Adlumia fungosa	8	Climbing Fumit	1993-06	1993-06	1955-08	Current	BC	3-Medium	SC-V		S2	S2	G4	G4	Upland	Plant	Vascular Plant	M: coves and cliffs	15870	N	N	15.43	1960	2210	Pisgah National Forest, Hot Sp Window Macrosite: Spring Cre Gorge (This is a sub EO of 03
139	12234	22023	Plagiochila sullivantii var. sullivantii	17	A Liverwort	1994-06-12	1994-06-12	1994-06-12	Current	E	2-High	SR-T		S2	S2	G2T2	T2	Wetlan	Plant	Liverwort	M: on moist rocks, in spray zones of waterfalls and in spruce-fir forests	15964	N	N	15.43	2800	3200	Linville Mountain Dolomite Area North Fork of Catawba River.
140	12302	11508	Rhododendron vaseyi	36	Pink-shell Azale	1996-05-07	1996-05-07	1992-05	Current	B	3-Medium	SR-L		S3	S3	G3	G3	Wetlan	Plant	Vascular Plant	M: high elevation oak forests, heath balds, spruce-fir forests, and rocky areas	21648	N	N	15.43	4200	5000	Herrin Knob
141	12316	7704	Platanthera grandiflora	17	Large Purple-fri	1995-07-05	1995-07-05	1995-07-05	Current	CD	3-Medium	T		S2	S2	G5	G5	Wetlan	Plant	Vascular Plant	M: bogs, seeps, grassy balds, high elevation moist forests and banks	16622	N	N	15.43	4500	4650	PARK CREEK/PAT STABLE BRANCH HEADWATERS
142	12404	12195	Adlumia fungosa	19	Climbing Fumit	1991-09-11	1991-09-11	1991-05-22	Current	A	3-Medium	SC-V		S2	S2	G4	G4	Upland	Plant	Vascular Plant	M: coves and cliffs	15870	N	N	15.43	2800	3200	GOLDEN RIDGE: FROM THE HEADWATERS OF TRIBUTARIES OF HORSE BRANCH EXTENDING NORT
143	12480	33121	Cambarus chaugaensis	9	Chauga Crayfis	2019-05-13	2019-05-13	2012-06-13	Current	E	3-Medium	SC		S2	S2	G2	G2	Aquatic	Animal	Crustacean	M: streams in Savannah drainage (endemic to northwest South Carolina and adjacent North Carolina and	18799	N	N	15.12	-1	-1	SAV/Thompson River
144	12485	10834	Glyceria nubigena	7	Smoky Mounta	2011-09-01	2011-09-01	1982-06-06	Current	B	2-High	SR-L		S2	S2	G2G3	G2	Wetlan	Plant	Vascular Plant	M: high elevation seeps	15798	N	Y	15.1	5300	-1	Stratton Bald Ridge
145	12786	30152	Carex purpurifera	21	Purple Sedge	2011-05-05	2011-05-05	2011-05-05	Current	A	3-Medium	SC-V		S3	S3	G4?	G4	Upland	Plant	Vascular Plant	M: low elevation, rich forests over limestone or marble	21008	N	N	13.89	-1	-1	Tyre Knob
146	12848	32661	Cottus carolinae	9	Banded Sculpin	2010-10-05	2010-10-05	2009-10-06	Current	E	3-Medium	SC		S1	S1	G5	G5	Aquatic	Animal	Freshwater Fish	M: French Broad and Pigeon drainages	16453	N	N	13.56	-1	-1	FRB/Pigeon River-Big Creek
147	12872	36047	Myotis lucifugus	63	Little Brown Ba	2011-07-16	2011-07-16	2000-08-07	Current	E	2-High	SR		S2	S2	G3	G3	Upland	Animal	Mammal	MPC: roosts in buildings (summer), in caves and mines (winter)	15533	N	N	13.4	-1	-1	FR 288W along or close to the Pigeon River
148	12922	23794	Sedum glaucophyllum	15	Cliff Stonecrop	1992	1992	1992	Current	E	3-Medium	SR-P		S2	S2	G4	G4	Upland	Plant	Vascular Plant	PM: rock outcrops, mainly calcareous or mafic	21984	N	N	13.09	-1	-1	BLACK MOUNTAIN/PARKER KNOB
149	12930	36067	Myotis lucifugus	81	Little Brown Ba	2006-08-25	2006-08-25	2006-08-25	Current	E	4-Low	SR		S2	S2	G3	G3	Upland	Animal	Mammal	MPC: roosts in buildings (summer), in caves and mines (winter)	15533	N	N	13.04	-1	-1	Wallace Branch
150	12946	23201	Solidago simulans	13	Granite Dome (	1992-05-25	1992-05-25	1992-05-25	Current	E	3-Medium	SR-L		S2	S2	G2	G2	Upland	Plant	Vascular Plant	M: high and low elevation granitic domes south of the Asheville Basin	17664	N	N	12.96	-1	-1	Macon County; Jones Knob
151	12987	20493	Oenothera perennis	15	Perennial Sund	2002-06-06	2002-06-06	2002-06-06	Current	B?	3-Medium	SC-V		S2	S2	G5	G5	Wetlan	Plant	Vascular Plant	MPC: wet meadows and bogs	16125	N	N	12.82	3035	3045	Miser Creek Wildlife Fields
152	13266	15865	Setophaga cerulea	41	Cerulean Warbl	2014-05-13	2014-05-13	1998	Current	B	3-Medium	SC		S2B	S2B	G4	G4	Upland	Animal	Bird	MC: mature hardwood forests; steep slopes and coves in mountains, natural levees in Coastal Plain [breeding evidence only]	17322	N	N	11.57	3400	3800	Hazanet Knob area
153	13384	27931	Viola appalachiensis	16	Appalachian Vi	2003-07-24	2003-07-24	2003-07-24	Current	B?	3-Medium	SC-V		S2	S2	G4	G4	Upland	Plant	Vascular Plant	M: olivine barrens and alluvial forests	15711	N	N	11.02	2600	3000	Nantahala National Forest: Appletree Branch
154	13573	18298	Carex hitchcockiana	1	Hitchcock's Se	2014-05-24	2014-05-24	1992-05-28	Current	B	3-Medium	SC-V		S1	S1	G5	G5	Upland	Plant	Vascular Plant	M: moist to dryish forests over calcareous or mafic rocks	17332	N	N	10.2	2900	3000	BROWN MOUNTAIN/HENCH KNOB
155	13887	21872	Porella wataugensis	8	A Liverwort	1994-06-17	1994-06-17	1994-06-17	Current	E	2-High	SR-L		S1	S1	G1G2Q	G1	Upland	Plant	Liverwort	M: on rocks in humid gorges	18990	N	N	9.64	-1	2800	Nantahala National Forest, Santeetlah Creek.
156	14044	13762	Viola appalachiensis	5	Appalachian Vi	2011	2011	1998-08-27	Current	B	3-Medium	SC-V		S2	S2	G4	G4	Upland	Plant	Vascular Plant	M: olivine barrens and alluvial forests	15711	N	N	9.16	3440	3480	NANTAHALA RIVER FOREST GAP BOG (Sub EO of EO 01
157	14049	13715	Carex purpurifera	6	Purple Sedge	2013-04-29	2013-04-29	1995-05-12	Current	B?	3-Medium	SC-V		S3	S3	G4?	G4	Upland	Plant	Vascular Plant	M: low elevation, rich forests over limestone or marble	21008	N	N	9.16	2300	2700	BEARPEN GAP
158	14174	15936	Lonicera canadensis	6	American Fly-h	2013-09-17	2013-09-17	1991-10-21	Current	C	3-Medium	SR-P		S2	S2	G5	G5	Wetlan	Plant	Vascular Plant	M: bogs, moist woods	18312	N	N	8.68	4900	4900	Charley Bald/Buck Knob
159	14184	8260	Cardamine clematitis	11	Mountain Bitter	2013-09-17	2013-09-17	1991-10-21	Current	B?	2-High	SR-T		S2S3	S2	G3	G3	Wetlan	Plant	Vascular Plant	M: high elevation seeps, shaded outcrops, and streambanks	19516	N	N	8.68	4700	5000	Nantahala NF, Charley Bald (S EO of EO 040)
160	14225	28287	Pycnanthemum curvipes	5	Tennessee Mo	2006-10-02	2006-10-02	2006-10-02	Current	BC	3-Medium	SR-T		S1	S1	G3	G3	Upland	Plant	Vascular Plant	M: dry rocky woodlands and rock outcrops	39819	N	N	8.6	1920	2150	High Ridge
161	14317	13467	Diarrhena americana	1	Eastern Beakg	2014-05-24	2014-05-24	1995-08-06	Current	C	3-Medium	E		S1	S1	G4G5	G4	Upland	Plant	Vascular Plant	M: rich cove forest	20528	N	N	8.26	3400	-1	Brown Mountain/Hench Knob
162	14360	1978	Carex purpurifera	4	Purple Sedge	1994-05-18	1994-09	1994-05-18	Current	B	3-Medium	SC-V		S3	S3	G4?	G4	Upland	Plant	Vascular Plant	M: low elevation, rich forests over limestone or marble	21008	N	N	8.2	2100	2450	Farley Branch (Yellow Creek Mountains)
163	14366	1307	Silene ovata	18	Mountain Catch	2009-07-23	2009-07-23	1979-Pre	Current	D	3-Medium	SC-V		S3	S3	G3	G3	Upland	Plant	Vascular Plant	M: rich slopes, cove forests, montane oak-hickory forests	17844	N	N	8.2	3800	3900	"GAP ABOVE SHOOKVILLE, COWEE RIDGE, MACON-JACKSON LINE" ; South face Little Hogback Mountain
164	14388	7187	Silene ovata	43	Mountain Catch	2009-06-02	2009-06-02	2000-09-17	Current	B?	3-Medium	SC-V		S3	S3	G3	G3	Upland	Plant	Vascular Plant	M: rich slopes, cove forests, montane oak-hickory forests	17844	N	N	8.2	3800	4340	SAVANNAH RIDGE WASH BRANCH
165	14391	27901	Carex purpurifera	15	Purple Sedge	2008-08-18	2008-08-18	2008-08-18	Current	D	2-High	SC-V		S3	S3	G4?	G4	Upland	Plant	Vascular Plant	M: low elevation, rich forests over limestone or marble	21008	N	N	8.2	-1	-1	Nantahala National Forest: Bea Branch of Tellico River
166	14396	13967	Silene ovata	25	Mountain Catch	2014-05-24	2014-05-24	1992-07-04	Current	D	3-Medium	SC-V		S3	S3	G3	G3	Upland	Plant	Vascular Plant	M: rich slopes, cove forests, montane oak-hickory forests	17844	N	N	8.2	3500	3500	Brown Mountain/Hench Knob
167	14433	36138	Perimyotis subflavus	51	Tricolored Bat	2008-07-17	2008-07-17	2008-07-17	Current	E	3-Medium	SR		S3	S3	G2G3	G2	Upland	Animal	Mammal	MPSC: roosts in clumps of leaves (mainly in summer), caves, rock crevices, and other dark and sheltered	18194	N	N	8.11	-1	-1	Halls Knob
168	14640	21874	Porella wataugensis	9	A Liverwort	1994-06-12	1994-06-12	1990	Current	E	3-Medium	SR-L		S1	S1	G1G2Q	G1	Upland	Plant	Liverwort	M: on rocks in humid gorges	18990	N	N	7.71	3040	3200	North Fork of Catawba River.
169	14641	22999	Silene ovata	47	Mountain Catch	1999-08-31	1999-08-31	1999-08-31	Current	B	3-Medium	SC-V		S3	S3	G3	G3	Upland	Plant	Vascular Plant	M: rich slopes, cove forests, montane oak-hickory forests	17844	N	N	7.71	3630	3630	Pisgah NF, Long Arm Ridge
170	14685	17857	Hexalectris spicata	31	Crested Coralrc	1992-08-21	1992-08-21	1992-08-21	Current	D	3-Medium	SR-P		S2	S2	G5	G5	Upland	Plant	Vascular Plant	PMC: dry or mesic woods on basic soils	21674	N	N	7.71	2000	2000	BURRELL COVE/LAKE CHATUGE
171	14708	14020	Trillium simile	32	Sweet White T	1996-06-05	1996-06-05	1996-06-05	Current	C	3-Medium	T		S2	S2	G3	G3	Upland	Plant	Vascular Plant	MP: rich coves	19583	N	N	7.71	2520	-1	MILL CREEK
172	14722	13328	Silene ovata	23	Mountain Catch	1992	1992	1992	Current	A	3-Medium	SC-V		S3	S3	G3	G3	Upland	Plant	Vascular Plant	M: rich slopes, cove forests, montane oak-hickory forests	17844	N	N	7.71	4500	4500	Black Mountain/Parker Knob
173	14730	15134	Thaspium pinnatifidum	6	Mountain Thas	1982	1977-08	1977-08	Current	F	3-Medium	T		S1	S1	G2G3	G2	Upland	Plant	Vascular Plant	M: calcareous slopes	16497	N	N	7.71	-1	-1	Hot Springs Window Macrosite
174	14768	22145	Carex cherokeensis	5	Cherokee Sedg	2002	2002	2002	Current	E	3-Medium	E		S1	S1	G4G5	G4	Upland	Plant	Vascular Plant	MP: floodplains	20056	N	N	7.71	1400	-1	Pisgah NF, Polecat Hollow.
175	14820	12085	Filipendula rubra	9	Queen-of-the-p	1990-06-08	1990-06-08	1989-03-12	Current	E	3-Medium	E		S1	S1	G4G5	G4	Wetlan	Plant	Vascular Plant	M: bogs, wet meadows	18467	N	N	7.71	3320	3360	FIRESCALD RIDGE BOG
176	14843	5134	Lonicera canadensis	7	American Fly-h	1992-09-10	1992-09-10	1992-06-26	Current	D	3-Medium	SR-P		S2	S2	G5	G5	Wetlan	Plant	Vascular Plant	M: bogs, moist woods	18312	N	N	7.71	4600	4600	Rich Mountain/Sugar Creek
177	14862	6079	Buckleya distichophylla	9	Piratebush	1993-06-01	1993-06-01	1993-05-30	Current	C	3-Medium	T		S2	S2	G3	G3	Upland	Plant	Vascular Plant	M: bluffs, dry slopes, forests on lower slopes	16404	N	N	7.71	2600	2800	Nolichucky River Gorge
178	14867	7009	Hexastylis rhombiformis	7	French Broad H	1986	1986	1986	Current	C	3-Medium	SR-L		S3	S3	G3	G3	Upland	Plant	Vascular Plant	MP: cove forests	21745	N	N	7.71	2600	-1	ON WEST SIDE OF NORTH FORK OF FRENCH BROAD RIVER ON NORTH SIDE OF
179	14890	17236	Oenothera perennis	9	Perennial Sund	2000-07	2000-07	1994-06-15	Current	A?	3-Medium	SC-V		S2	S2	G5	G5	Wetlan	Plant	Vascular Plant	MPC: wet meadows and bogs	16125	N	N	7.71	3200	-1	DICKS CREEK
180	14895	21119	Huperzia porophila	20	Rock Fir-clubm	1995	1995	1995	Current	E	3-Medium	SR-P		S2	S2	G4	G4	Wetlan	Plant	Vascular Plant	M: in spray zone of waterfalls	16317	N	N	7.71	-1	-1	Nantahala National Forest, Escarpment Gorges Macrosite Cane Creek
181	14922	16076	Adlumia fungosa	17	Climbing Fumit	1994-08-28	1994-08-28	1931-06-23	Current	AB	3-Medium	SC-V		S2	S2	G4	G4	Upland	Plant	Vascular Plant	M: coves and cliffs	15870	N	N	7.71	3200	3400	Dogwood Flats, Twelve Mile St Road

182	15051	13311	Silene ovata		39	Mountain Catch	2008-06-11	2008-06-11	1983-08-16	Current	C	3-Medium	SC-V		S3
183	15088	7076	Entodon compressus		2	Flattened Ento	1973-05-12	1973-05-12	1972-10-15	Current	E	3-Medium	SR-P		S1
184	15128	21335	Thermopsis mollis		52	Appalachian Go	2002-06-21	2002-06-21	2002-06-21	Current	D	3-Medium	SC-V		S2
185	15162	20668	Adlumia fungosa		35	Climbing Fumit	2010-06-13	2010-06-13	2004-07-23	Current	A	3-Medium	SC-V		S2
186	15167	36155	Perimyotis subflavus		66	Tricolored Bat	2011-05-23	2011-05-23	2011-05-23	Current	E	2-High	SR		S3
187	15174	14503	Botrychium matricariifolium		5	Daisy-leaf Moo	1997-06-17	1997-06-17	1997-06-17	Current	A	3-Medium	SR-P		S1
188	15204	23433	Plagiomnium rostratum		1	Long-beaked Th	2000-09-02	2000-09-02	2000-09-02	Current	E	3-Medium	SR-P		S1?
189	15213	13000	Frasera caroliniensis		12	Columbo	1992-08-21	1992-08-21	1992-08-21	Current	B	3-Medium	SR-P		S2S3
190	15218	19431	Lysimachia fraseri		26	Fraser's Loose	1997-06-23	1997-06-23	1992-07-28	Current	C	3-Medium	E		S3
191	15264	15497	Platanthera grandiflora		12	Large Purple-fri	1994-06-23	1994-06-23	1994-06-23	Current	BC	3-Medium	T		S2
192	15289	15260	Frasera caroliniensis		9	Columbo	1994-05-22	1994-05-22	1992-04-10	Current	A	3-Medium	SR-P		S2S3
193	15356	18653	Lysimachia fraseri		31	Fraser's Loose	1994-10-20	1994-10-20	1994-10-20	Current	C	3-Medium	E		S3
194	15361	12038	Lonicera canadensis		15	American Fly-h	1993-07	1993-07	1993-07	Current	C	3-Medium	SR-P		S2
195	15388	36066	Myotis lucifugus		80	Little Brown Ba	2001-06-30	2001-06-30	2001-06-30	Current	E	3-Medium	SR		S2
196	15417	8815	Rhododendron vaseyi		38	Pink-shell Azale	1992-09-03	1992-09-03	1992-09-03	Current	C	3-Medium	SR-L		S3
197	15426	7522	Frasera caroliniensis		13	Columbo	1992-06-04	1992-06-04	1992-06-04	Current	A	3-Medium	SR-P		S2S3
198	15474	11047	Carex purpurifera		3	Purple Sedge	1994-06-23	1994-06-23	1994-06-23	Current	BC	3-Medium	SC-V		S3
199	15487	6140	Adlumia fungosa		23	Climbing Fumit	1993-08-17	1993-08-17	1993-06-23	Current	D	3-Medium	SC-V		S2
200	15557	21873	Plagiochila echinata		8	A Liverwort	1994-08-06	1994-08-06	1994-06-17	Current	E	3-Medium	SR-L		S1
201	15612	13739	Frasera caroliniensis		14	Columbo	1993-09-29	1993-09-29	1993-09-29	Current	A?	3-Medium	SR-P		S2S3
202	15632	8474	Rhododendron vaseyi		37	Pink-shell Azale	1992-05	1992-05	1992-05	Current	B?	3-Medium	SR-L		S3
203	15704	6357	Scutellaria saxatilis		14	Rock Skullcap	2012-09-19	2012-09-19	1995-07-25	Current	B	3-Medium	SR-T		S2
204	15727	10697	Lonicera canadensis		11	American Fly-h	2008-06-23	2008-06-23	1949-08-18	Current	CD	3-Medium	SR-P		S2
205	15762	2315	Silene ovata		26	Mountain Catch	1990-12-31	1990-12-31	1990-12-31	Current	D	3-Medium	SC-V		S3
206	15780	1434	Viola appalachiensis		4	Appalachian Vio	1998-06-02	1998-06-02	1998-06-02	Current	A	3-Medium	SC-V		S2
207	15800	4146	Silene ovata		33	Mountain Catch	1989-09-12	1989-09-12	1988-09-07	Current	E	3-Medium	SC-V		S3
208	15812	22307	Schlotheimia lancifolia		10	Highlands Moss	1996	1956-11-01	1956-11-01	Current	F	3-Medium	SR-O		S1
209	15844	128	Adlumia fungosa		18	Climbing Fumit	1991-08-27	1991-08-27	1991-08-27	Current	A	3-Medium	SC-V		S2
210	15863	12196	Adlumia fungosa		20	Climbing Fumit	1991-08-27	1991-08-27	1991-08-27	Current	A	3-Medium	SC-V		S2
211	15902	980	Silene ovata		28	Mountain Catch	1991-07-23	1991-07-23	1991-06-27	Current	A	3-Medium	SC-V		S3
212	15990	6658	Silene ovata		24	Mountain Catch	1992	1992	1992	Current	A	3-Medium	SC-V		S3
213	16049	36186	Perimyotis subflavus		94	Tricolored Bat	2006-07-21	2006-07-21	2006-06-11	Current	E	3-Medium	SR		S3
214	16103	14893	Silene ovata		42	Mountain Catch	1998-11-05	1998-11-05	1998-11-05	Current	B	3-Medium	SC-V		S3
215	16114	9898	Scutellaria saxatilis		15	Rock Skullcap	1995-07-27	1995-07-27	1995-07-27	Current	B	3-Medium	SR-T		S2
216	16123	7429	Trientalis borealis		4	Starflower	1993-06-16	1993-06-16	1993-06-16	Current	A	3-Medium	E		S1
217	16138	11582	Setophaga cerulea		35	Cerulean Warbl	2008-05-30	2008-05-30	1994	Current	BC	3-Medium	SC		S2B
218	16173	5766	Schlotheimia lancifolia		1	Highlands Moss	1994-11	1958-05-25	1958-05-25	Current	F	3-Medium	SR-O		S1
219	16181	17461	Packera millefolium		9	Divided-leaf Ra	1992-07-20	1992-07-20	1992-05-01	Current	D	3-Medium	T		S2
220	16190	17233	Oenothera perennis		10	Perennial Sund	1994-06-23	1994-06-23	1994-06-23	Current	CD	3-Medium	SC-V		S2
221	16199	18474	Encalypta procera		2	Extinguisher M	1973-05-12	1973-05-12	1972-10-15	Current	E	3-Medium	SR-D		S1
222	16255	8436	Lonicera canadensis		10	American Fly-h	1992-07-20	1992-07-20	1992-07-20	Current	B	3-Medium	SR-P		S2
223	16329	35438	Plethodon aureolus		14	Tellico Salaman	2008-06-02	2008-06-02	2008-06-02	Current	E	3-Medium	SR		S2?
224	16345	20399	Cephaloziella spinicaulis		5	A Liverwort	1999-04-16	1999-04-16	1999-04-16	Current	E	3-Medium	SR-P		S1
225	16507	2832	Phegopteris connectilis		1	Northern Beech	2013-07-11	2013-07-11	1936-08-22	Current	B	3-Medium	E		S2
226	16510	17590	Carex projecta		10	Necklace Sedg	1995-05-15	1995-05-15	1995-05-15	Current	B	3-Medium	SR-P		S1
227	16539	16731	Silene ovata		27	Mountain Catch	1990-06-25	1990-06-25	1990-06-25	Current	C	3-Medium	SC-V		S3
228	16546	36100	Myotis lucifugus		112	Little Brown Ba	2018-06-28	2018-06-28	2006-06-22	Current	E	2-High	SR		S2
229	16688	454	Cephaloziella spinicaulis		4	A Liverwort	1997-10-05	1997-10-05	1997-10-05	Current	CD	3-Medium	SR-P		S1
230	16715	10755	Silene ovata		22	Mountain Catch	1992-09-12	1992-09-12	1992-09-12	Current	CD	3-Medium	SC-V		S3
231	16727	18627	Drepanolejeunea appalachiana		11	A Liverwort	1998-08-14	1998-08-14	1998-08-14	Current	E	3-Medium	SC-V		S1
232	16760	23432	Plagiomnium ellipticum		1	Marsh Magnific	1987-10-03	1987-10-03	1987-10-03	Current	E	3-Medium	SR-P		S1?
233	16773	6177	Silene ovata		31	Mountain Catch	1994-06-30	1994-09	1994-06-30	Current	D	3-Medium	SC-V		S3
234	16783	1491	Pedicularis lanceolata		9	Swamp Lousew	1994-06-23	1994-06-23	1994-06-23	Current	D	3-Medium	T		S1
235	16845	6190	Hexastylis rhombiformis		5	French Broad H	1986	1986	1982-04-22	Current	D	3-Medium	SR-L		S3
236	16890	36147	Perimyotis subflavus		58	Tricolored Bat	2009-06-03	2009-06-03	2009-06-03	Current	E	2-High	SR		S3
237	16966	8577	Hexalectris spicata		30	Crested Coralro	1992-07-16	1992-07-16	1992-07-16	Current	D	3-Medium	SR-P		S2
238	16969	9555	Glyceria laxa		11	Lax Mannagras	2008-07-09	2008-07-09	1973-07-13	Current	B	3-Medium	SR-P		S2
239	17122	10969	Lonicera canadensis		25	American Fly-h	1996-06-12	1996-06-12	1996-06-12	Current	D	3-Medium	SR-P		S2
240	17489	21338	Thermopsis mollis		54	Appalachian Go	2002-07-28	2002-07-28	2002-07-28	Current	B	3-Medium	SC-V		S2
241	17501	7789	Buckleya distichophylla		1	Piratebush	2008-05-13	2008-05-13	1954-05-08	Current	BC	3-Medium	T		S2
242	17530	2512	Viola appalachiensis		6	Appalachian Vio	1998-07-22	1998-07-22	1997-07	Current	D	3-Medium	SC-V		S2
243	17598	8238	Lysimachia fraseri		1	Fraser's Loose	2007	2007	1970-07-10	Current	D?	3-Medium	E		S3
244	17600	12878	Lonicera canadensis		8	American Fly-h	1992-09-10	1992-09-10	1992-09-10	Current	D	3-Medium	SR-P		S2

245	17701	7495	Silene ovata		41	Mountain Catch	1998-10-15	1998-10-15	1998-10-15	Current	B	3-Medium	SC-V		S3	S3	G3	G3	Upland	Plant	Vascular Plant	M: rich slopes, cove forests, montane oak-hickory forests	17844	N	N
246	17750	9408	Huperzia porophila		12	Rock Fir-clubm	1995	1995	1987-05-20	Current	CD	3-Medium	SR-P		S2	S2	G4	G4	Wetlan	Plant	Vascular Plant	M: in spray zone of waterfalls	16317	N	N
247	17870	19353	Helenium brevifolium		15	Littleleaf Sneez	1981	1981	1981	Current	E	3-Medium	E		S1	S1	G4	G4	Wetlan	Plant	Vascular Plant	PMC: bogs, seeps, riverbanks, other wet sites	17568	N	N
248	17920	16302	Trientalis borealis		3	Starflower	1991-10-03	1991-10-03	1991-09-10	Current	B	3-Medium	E		S1	S1	G5	G5	Upland	Plant	Vascular Plant	M: coves, northern hardwood forest	16077	N	N
249	17970	3485	Buckleya distichophylla		13	Piratebush	1991-09-20	1991-09-20	1991-09-20	Current	D	3-Medium	T		S2	S2	G3	G3	Upland	Plant	Vascular Plant	M: bluffs, dry slopes, forests on lower slopes	16404	N	N
250	17981	13334	Viola appalachiensis		3	Appalachian Vio	1998-04-25	1998-04-25	1998-04-25	Current	B	3-Medium	SC-V		S2	S2	G4	G4	Upland	Plant	Vascular Plant	M: olivine barrens and alluvial forests	15711	N	N
251	18120	10096	Carex roanensis		2	Roan Sedge	2003-06-08	2003-06-08	1995-05-18	Current	CD	3-Medium	SR-T		S2	S2	G2G3	G2	Upland	Plant	Vascular Plant	M: forests	21915	N	N
252	18139	7091	Rhododendron vaseyi		43	Pink-shell Azale	1990	1990	1989	Current	E	3-Medium	SR-L		S3	S3	G3	G3	Wetlan	Plant	Vascular Plant	M: high elevation oak forests, heath balds, spruce-fir forests, and rocky areas	21648	N	N
253	18149	9802	Chamerion platyphyllum		7	Fireweed	2007-12	2007-12	1997-10-17	Current	B	3-Medium	E		S1	S1	G5T5	T5	Upland	Plant	Vascular Plant	M: grassy balds, roadsides, disturbed areas	19751	N	N
254	18261	28054	Euphorbia purpurea		33	Glade Spurge	2009-07-24	2009-07-24	2009-05-19	Current	A	1-Very High	SR-T		S3	S3	G3	G3	Upland	Plant	Vascular Plant	M: forests, especially over mafic rock	18229	N	N
255	18506	28053	Euphorbia purpurea		32	Glade Spurge	2009-08-18	2009-08-18	2009-08-18	Current	B	1-Very High	SR-T		S3	S3	G3	G3	Upland	Plant	Vascular Plant	M: forests, especially over mafic rock	18229	N	N
256	18698	2614	Euphorbia purpurea		5	Glade Spurge	2014-08-07	2014-08-07	1968-05	Current	B	2-High	SR-T		S3	S3	G3	G3	Upland	Plant	Vascular Plant	M: forests, especially over mafic rock	18229	N	N
257	18729	20603	Spigelia marilandica		1	Pink-root	1999-09-15	1999-09-15	1999-06-18	Current	E	3-Medium	T		S1	S1	G4	G4	Upland	Plant	Vascular Plant	M: open woods	21415	N	N
258	18731	36027	Myotis lucifugus		50	Little Brown Ba	2010-06-19	2010-06-19	2008-06-12	Current	B	2-High	SR		S2	S2	G3	G3	Upland	Animal	Mammal	MPC: roosts in buildings (summer), in caves and mines (winter)	15533	N	N
259	18912	36140	Perimyotis subflavus		53	Tricolored Bat	2017-06-06	2017-06-06	2008-07-03	Current	E	3-Medium	SR		S3	S3	G2G3	G2	Upland	Animal	Mammal	MPSC: roosts in clumps of leaves (mainly in summer), caves, rock crevices, and other dark and sheltered places	18194	N	N
260	18917	28639	Desmognathus wrighti		39	Southern Pygm	2016-05-10	2016-05-10	1969-06-14	Current	A	3-Medium	SR		S2S3	S2	G3	G3	Upland	Animal	Amphibian	M: mid to high elevation forests, often in spruce-fir; west of the French Broad River	18108	N	N
261	18962	14255	Lilium grayi		7	Gray's Lily	1988-06-20	1988-06-20	1970-06	Current	B	2-High	T		S1S2	S1	G1G2	G1	Wetlan	Plant	Vascular Plant	M: bogs, wet meadows, seeps, grassy balds, high elevation forests	15294	N	Y
262	18974	36165	Perimyotis subflavus		74	Tricolored Bat	2018-07-16	2018-07-16	2000	Current	E	2-High	SR		S3	S3	G2G3	G2	Upland	Animal	Mammal	MPSC: roosts in clumps of leaves (mainly in summer), caves, rock crevices, and other dark and sheltered places	18194	N	N
263	18983	27919	Rhododendron cumberlandense		9	Cumberland Az	2008-06-10	2008-06-10	2008-06-10	Current	AB	2-High	SR-P		S1	S1	G4?	G4	Upland	Plant	Vascular Plant	M: grassy or shrub balds	17485	N	N
264	19062	30176	Liatris aspera		55	Rough Blazing-s	2011-10-04	2011-10-04	2011-10-04	Current	C	3-Medium	T		S1	S1	G4G5	G4	Upland	Plant	Vascular Plant	M: glades, open woods, fens	16045	N	N
265	19078	27911	Frasera caroliniensis		27	Columbo	2009-08-04	2009-08-04	2005-07-19	Current	B	2-High	SR-P		S2S3	S2	G5	G5	Upland	Plant	Vascular Plant	M: deciduous forests on mafic soil	17919	N	N
266	19268	27863	Cambarus chaugaensis		6	Chauga Crayfis	2010-06-07	2010-06-07	2001-07-19	Current	E	3-Medium	SC		S2	S2	G2	G2	Aquatic	Animal	Crustacean	M: streams in Savannah drainage (endemic to northwest South Carolina and adjacent North Carolina and	18799	N	N
267	19304	27110	Frasera caroliniensis		24	Columbo	2008-08-25	2008-08-25	1999	Current	BC	2-High	SR-P		S2S3	S2	G5	G5	Upland	Plant	Vascular Plant	M: deciduous forests on mafic soil	17919	N	N
268	19387	29985	Plethodon ventralis		10	Southern Zigza	2017-03-30	2017-03-30	2011-03-26	Current	B?	2-High	SC		S1	S1	G4	G4	Upland	Animal	Amphibian	M: moist areas of talus slopes or rock outcrops in hardwood forests	16567	N	N
269	19832	13924	Euphorbia purpurea		21	Glade Spurge	1996-04-26	1996-04-26	1992-04-26	Current	E	3-Medium	SR-T		S3	S3	G3	G3	Upland	Plant	Vascular Plant	M: forests, especially over mafic rock	18229	N	N
270	19872	33118	Cambarus chaugaensis		7	Chauga Crayfis	2012-06-13	2012-06-13	2012-06-13	Current	E	3-Medium	SC		S2	S2	G2	G2	Aquatic	Animal	Crustacean	M: streams in Savannah drainage (endemic to northwest South Carolina and adjacent North Carolina and	18799	N	N
271	20061	34795	Perimyotis subflavus		10	Tricolored Bat	2012-08-15	2012-08-15	2000-08-13	Current	E	2-High	SR		S3	S3	G2G3	G2	Upland	Animal	Mammal	MPSC: roosts in clumps of leaves (mainly in summer), caves, rock crevices, and other dark and sheltered places	18194	N	N
272	20218	36072	Myotis lucifugus		86	Little Brown Ba	2011-08-01	2011-08-01	2011-08-01	Current	E	2-High	SR		S2	S2	G3	G3	Upland	Animal	Mammal	MPC: roosts in buildings (summer), in caves and mines (winter)	15533	N	N
273	20258	26629	Fothergilla major		62	Large Witch-ald	1992-09-08	1992-09-08	1969-05	Current	E	2-High	SR-T		S3	S3	G3	G3	Upland	Plant	Vascular Plant	MP: dry ridgetop or bluff forests, seepage wetlands, and Piedmont longleaf pine	19549	N	N
274	20272	33396	Hexastylis rhombiformis		92	French Broad H	1992-06-14	1992-06-14	1992-06-14	Current	E	2-High	SR-L		S3	S3	G3	G3	Upland	Plant	Vascular Plant	MP: cove forests	21745	N	N
275	20284	36195	Perimyotis subflavus		103	Tricolored Bat	2011-08-01	2011-08-01	2011-08-01	Current	E	2-High	SR		S3	S3	G2G3	G2	Upland	Animal	Mammal	MPSC: roosts in clumps of leaves (mainly in summer), caves, rock crevices, and other dark and sheltered	18194	N	N
276	20305	27902	Carex purpurifera		16	Purple Sedge	2006-06-01	2006-06-01	2006-06-01	Current	D	2-High	SC-V		S3	S3	G4?	G4	Upland	Plant	Vascular Plant	M: low elevation, rich forests over limestone or marble	21008	N	N
277	20441	20350	Desmognathus wrighti		25	Southern Pygm	2018-09-20	2018-09-20	1972-06-29	Current	A?	3-Medium	SR		S2S3	S2	G3	G3	Upland	Animal	Amphibian	M: mid to high elevation forests, often in spruce-fir; west of the French Broad River	18108	N	N
278	20529	34987	Myotis lucifugus		12	Little Brown Ba	2014-07-28	2014-07-28	2001-07-10	Current	E	2-High	SR		S2	S2	G3	G3	Upland	Animal	Mammal	MPC: roosts in buildings (summer), in caves and mines (winter)	15533	N	N
279	20549	12401	Lysimachia fraseri		9	Fraser's Loose	2012	2012	1986-07-23	Current	A?	2-High	E		S3	S3	G3	G3	Upland	Plant	Vascular Plant	M: wet forest borders, roadsides, alluvial meadows	18303	N	N
280	20568	16451	Lysimachia fraseri		5	Fraser's Loose	2012	2007-06-15	1946	Current	D	3-Medium	E		S3	S3	G3	G3	Upland	Plant	Vascular Plant	M: wet forest borders, roadsides, alluvial meadows	18303	N	N
281	20622	25285	Huperzia porophila		26	Rock Fir-clubm	2007-05-02	2007-05-02	2007-05-02	Current	C	2-High	SR-P		S2	S2	G4	G4	Wetlan	Plant	Vascular Plant	M: in spray zone of waterfalls	16317	N	N
282	20657	24509	Lysimachia fraseri		44	Fraser's Loose	2005-05-25	2005-05-25	2005-05-25	Current	B	3-Medium	E		S3	S3	G3	G3	Upland	Plant	Vascular Plant	M: wet forest borders, roadsides, alluvial meadows	18303	N	N
283	20692	17912	Plethodon ventralis		6	Southern Zigza	2014-04-25	2014-04-25	1994-04-04	Current	B	2-High	SC		S1	S1	G4	G4	Upland	Animal	Amphibian	M: moist areas of talus slopes or rock outcrops in hardwood forests	16567	N	N
284	20858	36024	Myotis lucifugus		48	Little Brown Ba	2010-07-17	2010-07-17	2003-07-28	Current	E	2-High	SR		S2	S2	G3	G3	Upland	Animal	Mammal	MPC: roosts in buildings (summer), in caves and mines (winter)	15533	N	N
285	20860	29795	Scutellaria saxatilis		21	Rock Skullcap	2011-08-12	2011-08-12	2011-08-12	Current	A	2-High	SR-T		S2	S2	G3G4	G3	Upland	Plant	Vascular Plant	MP: northern hardwoods forests, rocky woodlands	19148	N	N
286	20931	27453	Setophaga cerulea		56	Cerulean Warbl	2008-07-23	2008-07-23	2008-07-23	Current	CD	3-Medium	SC		S2B	S2B	G4	G4	Upland	Animal	Bird	MC: mature hardwood forests; steep slopes and coves in mountains, natural levees in Coastal Plain [breeding evidence only]	17322	N	N
287	20950	25178	Haliaeetus leucocephalus		137	Bald Eagle	2015-02	2015-02	2007	Current	E	3-Medium	T	BGPA	S3B,S3N	S3B,S3N	G5	G5	Wetlan	Animal	Bird	MPCT: mature forests near large bodies of water (nesting); rivers, lakes, and sounds (foraging) [breeding evidence only]	20537	N	N
288	20999	31686	Celastrus scandens		29	American Bitter	2012-09-20	2012-09-20	2012-09-20	Current	B	2-High	E		S2?	S2	G5	G5	Upland	Plant	Vascular Plant	MP: cove forests and rich woods	18143	N	N
289	21063	35253	Perimyotis subflavus		34	Tricolored Bat	2002-08-08	2002-08-08	2002-08-07	Current	E	2-High	SR		S3	S3	G2G3	G2	Upland	Animal	Mammal	MPSC: roosts in clumps of leaves (mainly in summer), caves, rock crevices, and other dark and sheltered places	18194	N	N
290	21164	27908	Euphorbia purpurea		28	Glade Spurge	2014-07-31	2014-07-31	2002-08-14	Current	C	2-High	SR-T		S3	S3	G3	G3	Upland	Plant	Vascular Plant	M: forests, especially over mafic rock	18229	N	N
291	21192	20606	Spigelia marilandica		3	Pink-root	2010-06-18	2010-06-18	1999-06-18	Current	E	2-High	T		S1	S1	G4	G4	Upland	Plant	Vascular Plant	M: open woods	21415	N	N
292	21215	7582	Cardamine rotundifolia		6	Mountain Wate	2012-07-27	2012-07-27	1993-07-10	Current	D	3-Medium	T		S2	S2	G4	G4	Wetlan	Plant	Vascular Plant	MP: seeps, banks of mountain brooks	15915	N	N
293	21275	27932	Viola appalachiensis		17	Appalachian Vio	2003-07-24	2003-07-24	2003-07-24	Current	CD	2-High	SC-V		S2	S2	G4	G4	Upland	Plant	Vascular Plant	M: olivine barrens and alluvial forests	15711	N	N
294	21297	30327	Solidago simulans		45	Granite Dome G	2011-05-11	2011-05-11	2011-05-11	Current	A	2-High	SR-L		S2	S2	G2	G2	Upland	Plant	Vascular Plant	M: high and low elevation granitic domes south of the Asheville Basin	17664	N	N
295	21325	38925	Desmognathus wrighti		65	Southern Pygm	2018-05-09	2018-05-09	2018-05-09	Current	E	2-High	SR		S2S3	S2	G3	G3	Upland	Animal	Amphibian	M: mid to high elevation forests, often in spruce-fir; west of the French Broad	18108	N	N
296	21326	30328	Spigelia marilandica		5	Pink-root	2011-09-07	2011-09-07	2011-09-07	Current	E	2-High	T		S1	S1	G4	G4	Upland	Plant	Vascular Plant	M: open woods	21415	N	N
297	21349	36187	Perimyotis subflavus		95	Tricolored Bat	2007-05-29	2007-05-29	2004-07-18	Current	E	3-Medium	SR		S3	S3	G2G3	G2	Upland	Animal	Mammal	MPSC: roosts in clumps of leaves (mainly in summer), caves, rock crevices, and other dark and sheltered	18194	N	N
298	21354	27315	Solidago simulans		34	Granite Dome G	2015-05-09	2015-05-09	2008-07-15	Current	A	2-High	SR-L		S2	S2	G2	G2	Upland	Plant	Vascular Plant	M: high and low elevation granitic domes south of the Asheville Basin	17664	N	N
299	21383	10743	Lysimachia fraseri		2	Fraser's Loose	2012	2012	1969	Current	B	2-High	E		S3	S3	G3	G3	Upland	Plant	Vascular Plant	M: wet forest borders, roadsides, alluvial meadows	18303	N	N
300	21725	6959	Lysimachia fraseri		8	Fraser's Loose	1997-06-24	1997-06-24	1965-08-12	Current	C	2-High	E		S3	S3	G3	G3	Upland	Plant	Vascular Plant	M: wet forest borders, roadsides, alluvial meadows	18303	N	N
301	21745	20366	Desmognathus wrighti		28	Southern Pygm	2011-07	2011-07	2004-05-03	Current	A?	2-High	SR		S2S3	S2	G3	G3	Upland	Animal	Amphibian	M: mid to high elevation forests, often in spruce-fir; west of the French Broad River	18108	N	N
302	21803	31108	Botrychium lanceolatum var. angustisegmentu		8	Lance-leaf Moo	1993-06-28	1993-06-28	1993-06-28	Current	E	2-High	SR-P		S1	S1	G5T4	T4	Upland	Plant	Vascular Plant	MP: cove forests	18882	N	N
303	21840	26501	Carex baileyi		16	Bailey's Sedge	2007-06-13	2007-06-13	2007-06-13	Current	E	2-High	SR-P		S2	S2	G4	G4	Wetlan	Plant	Vascular Plant	M: bogs and seeps	15216	N	N
304	21859	24496	Chelone obliqua var. erwiniae		7	Erwin's Turtleh	2009-08-25	2009-08-25	2006-10-02	Current	AB	2-High	SR-T		S2	S2	G4T2T4Q	T3	Wetlan	Plant	Vascular Plant	M: streambanks, swamp forests	406407	N	N
305	21871	36188	Perimyotis subflavus		96	Tricolored Bat	2001-06-30	2001-06-30	2001-06-30	Current	E	2-High	SR		S3	S3	G2G3	G2	Upland	Animal	Mammal	MPSC: roosts in clumps of leaves (mainly in summer), caves, rock crevices, and other dark and sheltered	18194	N	N

308	21898	36069	Myotis lucifugus	83	Little Brown Ba	2006-06-29	2006-06-29	2006-06-29	Current	E	2-High	SR		S2	S2	G3	G3	Upland	Animal
309	21909	34185	Setophaga cerulea	61	Cerulean Warbl	2014-05-12	2014-05-12	2014-05-12	Current	E	2-High	SC		S2B	S2B	G4	G4	Upland	Animal
310	21922	20404	Adlumia fungosa	34	Climbing Fumit	2008-07-01	2003-09-10	2003-09-10	Current	D	2-High	SC-V		S2	S2	G4	G4	Upland	Plant
311	21927	27906	Drepanolejeunea appalachiana	15	A Liverwort	2005-06-21	2005-06-21	2005-06-21	Current	E	2-High	SC-V		S1	S1	G2?	G2	Upland	Plant
312	21954	36183	Perimyotis subflavus	91	Tricolored Bat	2005-08-14	2005-08-14	2004-07-12	Current	E	2-High	SR		S3	S3	G2G3	G2	Upland	Animal
313	21978	36112	Myotis lucifugus	124	Little Brown Ba	2011-08-03	2011-08-03	2011-08-03	Current	E	3-Medium	SR		S2	S2	G3	G3	Upland	Animal
314	22009	27903	Carex purpurifera	17	Purple Sedge	2006-08-07	2006-08-07	2006-08-07	Current	D	2-High	SC-V		S3	S3	G4?	G4	Upland	Plant
315	22057	36156	Perimyotis subflavus	67	Tricolored Bat	2006-07-25	2006-07-25	2006-07-25	Current	E	2-High	SR		S3	S3	G2G3	G2	Upland	Animal
316	22072	29192	Carex purpurifera	18	Purple Sedge	2011-06-28	2011-06-28	2010-06-10	Current	C	2-High	SC-V		S3	S3	G4?	G4	Upland	Plant
317	22082	36126	Perimyotis subflavus	41	Tricolored Bat	2011-08-02	2011-08-02	2011-08-02	Current	E	2-High	SR		S3	S3	G2G3	G2	Upland	Animal
318	22089	14559	Hexastylis rhombiformis	6	French Broad H	2009-04-28	2009-04-28	1986	Current	C	2-High	SR-L		S3	S3	G3	G3	Upland	Plant
319	22114	33394	Hexastylis rhombiformis	91	French Broad H	1992	1992	1992	Current	E	2-High	SR-L		S3	S3	G3	G3	Upland	Plant
320	22116	27169	Parnassia grandifolia	22	Bigleaf Grass-o	1999	1999	1999	Current	D	2-High	T		S2	S2	G3	G3	Wetlan	Plant
321	22117	22242	Haliaeetus leucocephalus	119	Bald Eagle	2015-02	2015-02	2005	Current	E	2-High	T	BGPA	S3B,S3N	S3B,S3N	G5	G5	Wetlan	Animal
322	22129	25099	Carex roanensis	23	Roan Sedge	2003-06-19	2003-06-19	2003-06-19	Current	E	2-High	SR-T		S2	S2	G2G3	G2	Upland	Plant
323	22137	36185	Perimyotis subflavus	93	Tricolored Bat	2005-08-01	2005-08-01	2005-08-01	Current	E	2-High	SR		S3	S3	G2G3	G2	Upland	Animal
324	22164	4720	Oenothera perennis	13	Perennial Sund	1998-06-20	1998-06-20	1998-06-20	Current	D	2-High	SC-V		S2	S2	G5	G5	Wetlan	Plant
325	22172	25243	Acrobolbus ciliatus	9	A Liverwort	2007-05-02	2007-05-02	2007-05-02	Current	B	2-High	SC-V		S1	S1	G3?	G3	Upland	Plant
326	22183	22968	Platanthera grandiflora	24	Large Purple-fr	2005-08-28	2005-08-28	2005-08-28	Current	C	2-High	T		S2	S2	G5	G5	Wetlan	Plant
327	22187	35008	Perimyotis subflavus	19	Tricolored Bat	2016-06-21	2016-06-21	2008-07-21	Current	E	2-High	SR		S3	S3	G2G3	G2	Upland	Animal
328	22198	36014	Myotis lucifugus	45	Little Brown Ba	2006-07-11	2006-07-11	2002-06-30	Current	E	2-High	SR		S2	S2	G3	G3	Upland	Animal
329	22220	36019	Myotis lucifugus	46	Little Brown Ba	2008-08-02	2008-08-02	2008-08-02	Current	E	2-High	SR		S2	S2	G3	G3	Upland	Animal
330	22223	25868	Sparganium emersum	3	Greenfruit Bur-	2006-06-23	2006-06-23	2006-06-23	Current	B?	2-High	T		S1	S1	G5	G5	Wetlan	Plant
331	22225	23223	Hexastylis rhombiformis	28	French Broad H	2006-04-11	2006-04-11	2006-04-11	Current	D	2-High	SR-L		S3	S3	G3	G3	Upland	Plant
332	22235	36032	Myotis lucifugus	52	Little Brown Ba	2011-07-27	2011-07-27	2006-07-25	Current	E	2-High	SR		S2	S2	G3	G3	Upland	Animal
333	22250	21170	Draba ramosissima	14	Branching Drab	2008-07-01	2008-07-01	1997-06-22	Current	D	2-High	SC-V		S2	S2	G4	G4	Upland	Plant
334	22261	36045	Myotis lucifugus	61	Little Brown Ba	2007-06-13	2007-06-13	2007-06-13	Current	E	3-Medium	SR		S2	S2	G3	G3	Upland	Animal
335	22292	23141	Pedicularis lanceolata	11	Swamp Lousew	2008-09-23	2008-09-23	2005-08-29	Current	B?	2-High	T		S1	S1	G5	G5	Wetlan	Plant
336	22299	36196	Perimyotis subflavus	104	Tricolored Bat	2011-08-01	2011-08-01	2011-08-01	Current	E	2-High	SR		S3	S3	G2G3	G2	Upland	Animal
337	22308	34756	Myotis lucifugus	1	Little Brown Ba	2012-08-15	2012-08-15	2000-07-14	Current	E	2-High	SR		S2	S2	G3	G3	Upland	Animal
338	22309	36021	Myotis lucifugus	47	Little Brown Ba	2008-07-30	2008-07-30	2008-07-30	Current	B?	2-High	SR		S2	S2	G3	G3	Upland	Animal
339	22357	36070	Myotis lucifugus	84	Little Brown Ba	2005-07-19	2005-07-19	2005-07-19	Current	E	2-High	SR		S2	S2	G3	G3	Upland	Animal
340	22385	36281	Perimyotis subflavus	137	Tricolored Bat	2018-06-28	2018-06-28	2006-06-22	Current	E	2-High	SR		S3	S3	G2G3	G2	Upland	Animal
341	22391	36151	Perimyotis subflavus	62	Tricolored Bat	2008-07-30	2008-07-30	2008-07-30	Current	E	2-High	SR		S3	S3	G2G3	G2	Upland	Animal
342	22407	29171	Haliaeetus leucocephalus	176	Bald Eagle	2011	2011	2010	Current	E	2-High	T	BGPA	S3B,S3N	S3B,S3N	G5	G5	Wetlan	Animal
343	22418	24497	Chelone obliqua var. erwiniae	8	Erwin's Turtleh	2006-10-02	2006-10-02	2006-10-02	Current	BC	2-High	SR-T		S2	S2	G4T2T4Q	T3	Wetlan	Plant
344	22423	36136	Perimyotis subflavus	50	Tricolored Bat	2011-08-03	2011-08-03	2011-08-03	Current	E	2-High	SR		S3	S3	G2G3	G2	Upland	Animal
345	22481	28874	Delphinium exaltatum	19	Tall Larkspur	2009-07-09	2009-07-09	2009-07-09	Current	B	2-High	E		S2	S2	G3	G3	Upland	Plant
346	22499	24771	Haliaeetus leucocephalus	136	Bald Eagle	2010	2010	2007-04-17	Current	E	2-High	T	BGPA	S3B,S3N	S3B,S3N	G5	G5	Wetlan	Animal
347	22508	36113	Myotis lucifugus	125	Little Brown Ba	2011-08-02	2011-08-02	2011-08-02	Current	E	2-High	SR		S2	S2	G3	G3	Upland	Animal
348	22519	25183	Packera millefolium	41	Divided-leaf Ra	2007-Summer	2007-Summer	2007-Summer	Current	E	2-High	T		S2	S2	G3	G3	Upland	Plant
349	22529	34760	Myotis lucifugus	3	Little Brown Ba	2012-08-12	2012-08-12	2000-07-10	Current	E	2-High	SR		S2	S2	G3	G3	Upland	Animal
350	22559	26678	Hymenophyllum tayloriae	16	Gorge Filmy Fe	2007-08-14	2007-08-14	2007-08-14	Current	C	2-High	SR-O		S1S2	S1	G2	G2	Upland	Plant
351	22592	22609	Silene ovata	46	Mountain Catch	2005-08-28	2005-08-28	2005-08-28	Current	D	2-High	SC-V		S3	S3	G3	G3	Upland	Plant
352	22609	27909	Euphorbia purpurea	29	Glade Spurge	2002-06-17	2002-06-17	2002-06-17	Current	D	2-High	SR-T		S3	S3	G3	G3	Upland	Plant
353	22644	35155	Myotis lucifugus	18	Little Brown Ba	2004-08-02	2004-08-02	2002-07-28	Current	B?	2-High	SR		S2	S2	G3	G3	Upland	Animal
354	22660	36035	Myotis lucifugus	54	Little Brown Ba	2007-06-22	2007-06-22	2007-06-22	Current	E	2-High	SR		S2	S2	G3	G3	Upland	Animal
355	22670	26497	Carex purpurifera	13	Purple Sedge	1996-07-11	1996-07-11	1996-07-11	Current	E	2-High	SC-V		S3	S3	G4?	G4	Upland	Plant
356	22711	36128	Perimyotis subflavus	43	Tricolored Bat	2011-08-01	2011-08-01	2011-08-01	Current	E	2-High	SR		S3	S3	G2G3	G2	Upland	Animal
357	22786	25756	Rhododendron cumberlandense	7	Cumberland Az	2007-07-05	2007-07-05	2007-07-05	Current	C	2-High	SR-P		S1	S1	G4?	G4	Upland	Plant
358	22983	10801	Packera millefolium	3	Divided-leaf Ra	2001-09	2001-09	1975-05-31	Current	B	2-High	T		S2	S2	G3	G3	Upland	Plant
359	23073	34635	Plagiochila sullivantii var. sullivantii	25	A Liverwort	2014-08-16	2014-08-16	2014-08-07	Current	E	2-High	SR-T		S2	S2	G2T2	T2	Wetlan	Plant
360	23122	36068	Myotis lucifugus	82	Little Brown Ba	2004-08-09	2004-08-09	2004-08-09	Current	E	5-Very Low	SR		S2	S2	G3	G3	Upland	Animal
361	23162	30341	Symphyotrichum shortii	3	Short's Aster	2011-09-13	2011-09-13	2011-05-17	Current	B?	2-High	SR-P		S2	S2	G5	G5	Upland	Plant
362	23185	30155	Carex purpurifera	24	Purple Sedge	2011-09-14	2011-09-14	2011-09-14	Current	B	2-High	SC-V		S3	S3	G4?	G4	Upland	Plant
363	23201	29242	Lonicera canadensis	44	American Fly-h	2009-09-30	2009-09-30	1991	Current	BC	2-High	SR-P		S2	S2	G5	G5	Wetlan	Plant
364	23298	30154	Carex purpurifera	23	Purple Sedge	2012-09-13	2011-09-23	2011-09-23	Current	A	2-High	SC-V		S3	S3	G4?	G4	Upland	Plant
365	23303	29257	Packera millefolium	49	Divided-leaf Ra	2009-04-29	2009-04-29	2009-04-23	Current	CD	2-High	T		S2	S2	G3	G3	Upland	Plant
366	23436	33941	Thaspium pinnatifidum	10	Mountain Thas	2014-09-24	2014-09-24	2014-09-24	Current	B?	2-High	T		S1	S1	G2G3	G2	Upland	Plant
367	23504	19558	Cardamine rotundifolia	8	Mountain Wate	2012-04-10	2012-04-10	1994-06	Current	B?	2-High	T		S2	S2	G4	G4	Wetlan	Plant
368	23590	36139	Perimyotis subflavus	52	Tricolored Bat	2014-07-07	2014-07-07	2008-07-02	Current	E	2-High	SR		S3	S3	G2G3	G2	Upland	Animal
369	23670	37755	Desmognathus wrighti	49	Southern Pygm	2011-07	2011-07	2011-07	Current	E	2-High	SR		S2S3	S2	G3	G3	Upland	Animal
370	23806	29243	Lonicera canadensis	45	American Fly-h	2018-06-14	2018-06-14	1991	Current	C	2-High	SR-P		S2	S2	G5	G5	Wetlan	Plant
371	23828	12400	Lysimachia fraseri	10	Fraser's Loose	2013-05-16	2013-05-16	1987-07-17	Current	BC	2-High	E		S3	S3	G3	G3	Upland	Plant

372	23862	37750	Desmognathus wrighti	47	Southern Pygm	2017-07-12	2017-07-12	1955-10-07	Current	E	3-Medium	SR		S2S3	S2
373	23865	37748	Desmognathus wrighti	45	Southern Pygm	2003-10-12	2003-10-12	1967-07-24	Current	E	3-Medium	SR		S2S3	S2
374	23869	37954	Desmognathus wrighti	61	Southern Pygm	2018-05-15	2018-05-15	1979-07-02	Current	E	3-Medium	SR		S2S3	S2
375	23878	34005	Myotis leibii	52	Eastern Small-f	2016-07-20	2016-07-20	2004-05-21	Current	E	2-High	SC		S2	S2
376	23960	26340	Rhododendron vaseyi	72	Pink-shell Azale	2007-08-20	2007-08-20	2007-07-16	Current	CD	2-High	SR-L		S3	S3
377	23991	5263	Sorex palustris punctulatus	1	Southern Wate	2006-03-27	2006-03-27	1974-04-20	Current	E	3-Medium	SR		S3	S3
378	23996	27359	Viola appalachiensis	13	Appalachian Vio	2008-06-30	2008-06-30	2004-04-29	Current	CD	2-High	SC-V		S2	S2
379	24027	30343	Symphyotrichum shortii	5	Short's Aster	2011-06-14	2011-06-14	2011-06-14	Current	BC	2-High	SR-P		S2	S2
380	24066	15861	Liatris squarrulosa	32	Earle's Blazing-	1998-09-08	1998-09-08	1997-09-19	Current	C	2-High	SR-P		S2	S2
381	24119	27183	Packera millefolium	44	Divided-leaf Ra	2009-08-11	2009-08-11	2008-05-09	Current	C	2-High	T		S2	S2
382	24120	31670	Carex purpurifera	26	Purple Sedge	2012-08-07	2012-08-07	2012-08-07	Current	B	2-High	SC-V		S3	S3
383	24142	30153	Carex purpurifera	22	Purple Sedge	2011-09-13	2011-09-13	2011-09-13	Current	B	2-High	SC-V		S3	S3
384	24147	37743	Myotis leibii	108	Eastern Small-f	2015-07-15	2015-07-15	2015-07-12	Current	E	2-High	SC		S2	S2
385	24162	27354	Viola appalachiensis	8	Appalachian Vio	2008-07-23	2008-07-23	2008-07-23	Current	C	2-High	SC-V		S2	S2
386	24214	24839	Neotoma magister	20	Allegheny Woo	2007-05-30	2007-05-30	2007-04	Current	E	3-Medium	SC		S2S3	S2
387	24249	36084	Myotis lucifugus	98	Little Brown Ba	2013-08-20	2013-08-20	2003-07-29	Current	E	1-Very High	SR		S2	S2
388	24350	35814	Buchnera americana	10	American Blueh	2015-08-13	2015-08-13	2015-08-13	Current	A?	2-High	E		S1	S1
389	24619	35182	Myotis lucifugus	25	Little Brown Ba	2002-08-08	2002-08-08	2002-08-06	Current	E	2-High	SR		S2	S2
390	24848	35241	Perimyotis subflavus	29	Tricolored Bat	2016-06-22	2016-06-22	2002-07-29	Current	E	2-High	SR		S3	S3
391	24888	36142	Perimyotis subflavus	54	Tricolored Bat	2011-07-10	2011-07-10	2010-06-26	Current	E	3-Medium	SR		S3	S3
392	24891	27921	Silene ovata	55	Mountain Catch	2005-09-28	2005-09-07	2005-09-07	Current	F	2-High	SC-V		S3	S3
393	24930	35815	Euphorbia purpurea	36	Glade Spurge	2014-08-07	2014-08-07	2014-08-07	Current	C	2-High	SR-T		S3	S3
394	24977	25072	Corynorhinus rafinesquii rafinesquii	24	Rafinesque's B	2018-08-14	2018-08-14	2010-07-22	Current	E	2-High	T		S2	S2
395	25042	29288	Plethodon chattahoochee	1	Chattahoochee	2014-04-05	2014-04-05	2007-07-16	Current	B	2-High	SR		S1	S1
396	25064	22091	Tortula ammonsiana	5	Ammons's Tort	1995-10-14	1995-10-14	1995-10-14	Current	BD	2-High	SR-O		S1	S1
397	25118	36777	Orbexilum pedunculatum	1	Sampson's Sna	2015-08-13	2015-08-13	2015-08-13	Current	B?	1-Very High	SR-P		S1	S1
398	25157	23965	Sphagnum angustifolium	5	Narrowleaf Pea	2006-03-15	2006-03-15	2006-03-15	Current	E	2-High	SR-D		S1	S1
399	25168	30157	Celastrus scandens	27	American Bitter	2012-09-13	2011-09-23	2011-09-23	Current	BC	2-High	E		S2?	S2
400	25209	27310	Solidago simulans	29	Granite Dome G	2008-06-05	2008-06-05	2008-06-05	Current	B	2-High	SR-L		S2	S2
401	25305	34070	Myotis leibii	71	Eastern Small-f	2017-06-08	2017-06-08	2010-06-22	Current	E	2-High	SC		S2	S2
402	25399	31713	Silene ovata	63	Mountain Catch	2012-09-20	2012-09-20	2012-09-20	Current	AB	2-High	SC-V		S3	S3
403	25424	34021	Myotis leibii	59	Eastern Small-f	2018-06-28	2018-06-28	2010-08-02	Current	E	2-High	SC		S2	S2
404	25490	29226	Carex purpurifera	20	Purple Sedge	2009-05-04	2009-05-04	2009-05-04	Current	D	2-High	SC-V		S3	S3
405	25539	34114	Myotis leibii	84	Eastern Small-f	2017-07-20	2017-07-20	2011-08-02	Current	E	2-High	SC		S2	S2
406	25595	31671	Carex purpurifera	27	Purple Sedge	2013-07-10	2013-07-10	2013-07-10	Current	D	2-High	SC-V		S3	S3
407	25625	30165	Echinacea purpurea	14	Purple Coneflow	2011-08-24	2011-08-24	2010-Pre	Current	B	2-High	SC-V		S1	S1
408	25664	26343	Rhododendron vaseyi	74	Pink-shell Azale	2007-04-30	2007-04-30	2007-04-30	Current	D	2-High	SR-L		S3	S3
409	25704	29341	Viola appalachiensis	20	Appalachian Vio	2009-06-08	2009-06-08	2009-06-08	Current	CD	2-High	SC-V		S2	S2
410	25712	36674	Myotis lucifugus	136	Little Brown Ba	2012-07-14	2012-07-14	2012-07-14	Current	E	2-High	SR		S2	S2
411	25731	37773	Plethodon chattahoochee	4	Chattahoochee	2014-04-04	2014-04-04	2014-04-04	Current	BC	2-High	SR		S1	S1
412	25923	36008	Myotis lucifugus	39	Little Brown Ba	2008-08-01	2008-08-01	2008-08-01	Current	E	1-Very High	SR		S2	S2
413	25945	33025	Haliaeetus leucocephalus	211	Bald Eagle	2013-09-26	2013-early	2013-early	Current	E	2-High	T	BGPA	S3B,S3N	S3B,S3N
414	25969	37742	Myotis leibii	107	Eastern Small-f	2015-07-11	2015-07-11	2015-07-11	Current	E	2-High	SC		S2	S2
415	26017	39072	Haliaeetus leucocephalus	279	Bald Eagle	2019-01	2019-01	2019-01	Current	E	2-High	T	BGPA	S3B,S3N	S3B,S3N
416	26031	20604	Spigelia marilandica	2	Pink-root	1999-09-15	1999-09-15	1999-06-18	Current	E	2-High	T		S1	S1
417	26157	39053	Spiranthes ochroleuca	15	Yellow Ladies'-t	2016-10-02	2016-10-02	2016-10-02	Current	E	2-High	T		S1	S1
418	26180	28051	Euphorbia purpurea	30	Glade Spurge	2009-06-24	2009-06-24	2009-06-24	Current	C	2-High	SR-T		S3	S3
419	26191	24833	Woodsia appalachiana	13	Appalachian Cli	2007-04-30	2007-04-30	2006-10-02	Current	B	2-High	SR-P		S2	S2
420	26210	1980	Plethodon welleri	10	Weller's Salama	2001-11-08	2001-11-08	2001-11-08	Current	C?	2-High	SC		S2	S2
421	26288	21796	Myotis leibii	25	Eastern Small-f	2006-07-11	2006-07-11	1994-Post	Current	E	2-High	SC		S2	S2
422	26348	35999	Myotis lucifugus	33	Little Brown Ba	2011-08-02	2011-08-02	2011-08-02	Current	E	1-Very High	SR		S2	S2
423	26356	25205	Neotoma magister	22	Allegheny Woo	2007-07-23	2007-07-23	2007-07-23	Current	E	3-Medium	SC		S2S3	S2
424	26407	22090	Tortula ammonsiana	4	Ammons's Tort	1995-10-14	1995-10-14	1995-10-14	Current	BD	2-High	SR-O		S1	S1
425	26492	30158	Celastrus scandens	28	American Bitter	2011-06-13	2011-06-13	2011-06-13	Current	CD	2-High	E		S2?	S2
426	26523	28065	Silene ovata	57	Mountain Catch	2009-09-09	2009-09-09	2009-09-09	Current	CD	2-High	SC-V		S3	S3
427	26582	22088	Tortula ammonsiana	3	Ammons's Tort	1995-10-14	1995-10-14	1995-10-01	Current	BD	2-High	SR-O		S1	S1
428	26589	27904	Caulophyllum giganteum	6	Northern Blue C	2005-05-06	2005-05-06	2004-05	Current	E	2-High	SR-P		S1	S1
429	26626	27360	Viola appalachiensis	14	Appalachian Vio	2008-05-01	2008-05-01	2008-05-01	Current	E	2-High	SC-V		S2	S2
430	26669	27127	Lonicera canadensis	39	American Fly-h	2008-08-01	2008-08-01	2008-08-01	Current	C	2-High	SR-P		S2	S2
431	26674	28052	Euphorbia purpurea	31	Glade Spurge	2009-07-09	2009-07-09	2009-07-09	Current	CD	2-High	SR-T		S3	S3
432	26688	29236	Carex cherokeensis	7	Cherokee Sedg	2010-05-10	2010-05-10	2010-05-10	Current	A	2-High	E		S1	S1
433	26706	29310	Solidago simulans	40	Granite Dome G	2009-08-11	2009-08-11	2009-08-11	Current	BC	2-High	SR-L		S2	S2
434	26707	30342	Symphyotrichum shortii	4	Short's Aster	2011-09-14	2011-09-14	2011-09-14	Current	C	2-High	SR-P		S2	S2
435	26767	38356	Sorex palustris punctulatus	28	Southern Wate	2008-09-09	2008-09-09	2008-09-09	Current	E	2-High	SR		S3	S3
436	26773	30326	Solidago simulans	44	Granite Dome G	2011-05-24	2011-05-24	2011-05-24	Current	BC	2-High	SR-L		S2	S2
437	26789	30144	Adlumia fungosa	46	Climbing Fumit	2011-10-11	2011-10-11	2011-10-11	Current	C	2-High	SC-V		S2	S2
438	26826	36002	Myotis lucifugus	36	Little Brown Ba	2005-06-14	2005-06-14	2005-06-14	Current	E	2-High	SR		S2	S2
439	26867	29160	Asplenium pinnatifidum	17	Lobed Spleenw	2009-11-12	2009-11-12	2009-11-12	Current	C	2-High	SR-P		S2	S2
440	26875	37308	Myotis leibii	103	Eastern Small-f	2016-08-01	2016-08-01	2014-07-27	Current	E	2-High	SC		S2	S2

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF
441	26902	25738	Carex purpurifera		10	Purple Sedge	2007-04-27	2007-04-27	2007-04-27	Current	D	2-High	SC-V	S3	S3	G4?	G4	Upland	Plant	Vascular Plant	M: low elevation, rich forests over limestone or marble	21008	N	N	0.48	3700	3700	Nantahala National Forest, Thunderstruck Branch	Nantahala National Forest, Thunderstruck Branch: Approximately 16 km northeast of Hayesville, NC; growing in the bed of an old woods road running along the top of the ridge, at approximately 3700 feet (Rankin 2008).	Rankin observed a single clump of vegetative stems on 27 March 2007 (Rankin 2008).	W.T. "Duke" Rankin, USFS	Oak-Hickory forest (Rankin 2008).
442	27094	26700	Lysimachia fraseri		50	Fraser's Loose	2007-11-08	2007-11-08	2007-11-08	Current	CD	2-High	E	S3	S3	G3	G3	Upland	Plant	Vascular Plant	M: wet forest borders, roadsides, alluvial meadows	18303	N	N	0.48	3560	3600	Windy Gap	On Forest Service Road, 0.3 km from Windy Gap at Upper Whitewater Church Road (SR 1152). This is a sub EO of 051.	18-20 plants. Approximately 1/2 in fruit observed by Schwartzman on 11/08/07 (Schwartzman 2008).	Ed Schwartzman (NCNHP)	On Forest Service road in cut-over Montane Oak-Hickory Forest.
443	27104	37777	Plethodon chattahoochee		7	Chattahoochee	2014-04-04	2014-04-04	2014-04-04	Current	BC	2-High	SR	S1	S1	G3	G3	Upland	Animal	Amphibian	M: moist forests in the southwestern counties, close to the Georgia border	17087	N	N	0.48	-1	-1	McClure Road vicinity	McClure Road vicinity: This occurrence is located in Cherokee County, NC and consists of habitat along the west side of McClure Road, 5.75 km southwest of Murphy, NC.	2014: Dr. David Beamer collected 1 specimen on 04 April 2014.		
444	27112	36482	Myotis lucifugus		133	Little Brown Ba	2008-06-03	2008-06-03	2008-06-03	Current	E	3-Medium	SR	S2	S2	G3	G3	Upland	Animal	Mammal	MPC: roosts in buildings (summer), in caves and mines (winter)	15533	N	N	0.48	-1	-1	Santeetlah Creek, FSR-81	Santeetlah Creek, FSR-81. Mist net site along FSR-81, between Wright Creek and Indian Creek [this is where coordinates map to but description indicates site may be closer to NC-143 (Mason 2016)].	1 adult female mist netted by Gatens et al. on 03 June 2008 at FS-81 #1 site (NCWRC 2014).	Lisa Gatens, NCSM	
445	27245	34840	Chelone obliqua var. erwiniae		27	Erwin's Turtlehe	2014-09-17	2014-09-17	2014-09-17	Current	B	2-High	SR-T	S2	S2	G4T2T4Q	T3	Wetland	Plant	Vascular Plant	M: streambanks, swamp forests	406407	N	N	0.48	4600	5000	Charley Bald	Headwaters of a tributary to Rough Butt Creek, 0.7 km north-northwest of Rich Mountain Bald. Seepage area mid-slope, approaching the crest towards Rich Mountain Bald (Punsalan 2015).	Punsalan and Smith observed 40+ stems in a 75'x75' area. 75% of individuals were in flower (Punsalan 2014).	April Punsalan, USFS; Le'Andra Smith	High Elevation Seep. Associated species include Diphylleia cymosa, Chelone obliqua, Micranthes micranthidifolia, Houstonia serpyllifolia, and Vibrunum lantanoides. The canopy is partially open due to hydrology and dying hemlocks (Punsalan
446	27429	35906	Carex hitchcockiana		7	Hitchcock's Se	1995-07-11	1995-07-11	1995-07-11	Current	E	2-High	SC-V	S1	S1	G5	G5	Upland	Plant	Vascular Plant	M: moist to dryish forests over calcareous or mafic rocks	17332	N	N	0.48	884	884	Linville Mountain Dolomite Areas	Linville Mountain Dolomite Areas. Specimen collected from Carolina Vegetation Survey plot 005-04-0305 (1995). [Based on the GPS coordinates provided by CVS, this plot is 350 meters east of the Catawba River and 1.5 kilometers southwest of Linville Falls,	Covering less than 10 square meters in a 1000 square meter Carolina Vegetation Survey plot surveyed 11 July 1995; extent of population outside of survey plot is unknown (Peet et al. 2007). Specimen collected by Bob Peet, Marshall Ellis, and Jame Amoros	Carolina Vegetation Survey	Calcareous Rich Cove Forest dominated by Acer saccharum and Aesculus flava with herb layer dominated by Laportea canadensis (Peet, Ellis, and Amoroso 1995).
447	27457	37758	Perimyotis subflavus		184	Tricolored Bat	2016-03-23	2016-03-23	2016-03-23	Current	E	2-High	SR	S3	S3	G2G3	G2	Upland	Animal	Mammal	MPSC: roosts in clumps of leaves (mainly in summer), caves, rock crevices, and other dark and sheltered	18194	N	N	0.48	-1	-1	Pisgah NF: Hurricane Creek Site	Pisgah NF: Hurricane Creek Site. Small site on FS 233, about 0.4 mile north of highway 40, on west side of road, right next to road (NCWRC 2016b).	2016: 1 individual observed roosting by Caldwell et al. on 23 March 2016 (NCWRC 2016b).	Katherine Caldwell, NCWRC	
448	27526	12344	Carex utriculata		6	Beaked Sedge	2015-06-05	2015-06-05	1993-Pre	Current	B	2-High	SR-P	S1	S1	G5	G5	Wetland	Plant	Vascular Plant	M: wet meadows	37884	N	N	0.45	2200	2240	Foster Creek Bog	Foster Creek Bog: Along Foster Creek, between Caney and Bryson Mountains. Access by forest road north from the end of SR 1347, 1.5 miles north of North Mills River Road (SR 1345).	Extensive in the Southern Appalachian Bog and the largest openings in the Swamp Forest--Bog Complex. Probably hundreds of plants. Identity was confirmed by Gary Kauffman (Schafale, et al. 2015). 100'S OF PLANTS, GOOD GLADES OF C. SCHWEINITZII (GADDY		COMPLEX OF SMALL OPEN SPHAGNUM BOGS INTERSPERSED WITH WET FLATS DOMINATED BY ACER RUBRUM AND PINUS STROBUS. FLORISTIC DIVERSITY IS MODERATELY HIGH WITH GOOD GLADES OF
449	27668	35160	Myotis lucifugus		19	Little Brown Ba	2014-07-03	2014-07-03	2002-06-30	Current	E	2-High	SR	S2	S2	G3	G3	Upland	Animal	Mammal	MPC: roosts in buildings (summer), in caves and mines (winter)	15533	N	N	0.35	-1	-1	NCDOT TIP No. B-4287 ; Nantahala River: Nantahala to Beechertown	Nantahala River: Nantahala to Beechertown. Mist net sites along the Nantahala River from Winding Stairs Road bridge south to near Beechertown.	2014: 2 individuals (1 adult male, 1 adult female) captured by Libby on 03 July 2014 on the Nantahala River Bike Path (NCWRC 2016). 2011: 12 individuals (5 adult females, 3 adult males, 1 juvenile female, 2 juvenile males, 1 unspecified) captured by Libb	BHE Environmental; Chris McGrath, NCWRC; Dottie Brown, NCWRC; Gary Libby	
450	28055	34567	Silene ovata		66	Mountain Catch	2013-09-13	2013-09-13	2013-09-13	Current	C	2-High	SC-V	S3	S3	G3	G3	Upland	Plant	Vascular Plant	M: rich slopes, cove forests, montane oak-hickory forests	17844	N	N	0.18	4400	4400	Charley Bald/Buck Knob	Nantahala National Forest, Charley Bald/Buck Knob natural area. Along the east side of the road bank of USFS 4665, approximately 1.78 miles north of SR 1755 (Charleys Creek Road), along USFS road, individuals are growing along east side of road bank.	April Punsalan observed 11 individuals (approximately 60% in flower) scattered across 0.2 acres on 13 September 2013 (Punsalan 2015).	April Punsalan, USFS	This population occurs within a Montane Oak-Hickory forest grading into High elevation Red Oak forest. The canopy was partially open due to its proximity to the road. No invasive species noted
451	28169	35119	Perimyotis subflavus		27	Tricolored Bat	2008-08-13	2008-08-13	2008-08-05	Current	BC	2-High	SR	S3	S3	G2G3	G2	Upland	Animal	Mammal	MPSC: roosts in clumps of leaves (mainly in summer), caves, rock crevices, and other dark and sheltered	18194	N	N	0.15	-1	-1	Burrell Mountain Road	Burrell Mountain Road. Mist net site along Burrell Mountain Road (SR-1325) at powerline corridor (NCDOT 2015) [directions derived from coordinate location].	6 invididuals total captured in 2008 at Site B by NCDOT biologists in conjunction with a Division 14 road project: 2 juvenile males, 1 adult male, 1 adult female, 1 unspecified on 13 August 2008; 1 adult male on 05 August 2008 (NCDOT 2015).		
452	28191	29409	Euphorbia purpurea		35	Glade Spurge	2008-07-01	2008-07-01	2008-07-01	Current	C	2-High	SR-T	S3	S3	G3	G3	Upland	Plant	Vascular Plant	M: forests, especially over mafic rock	18229	N	N	0.14	2360	2360	Bald Mountains: unnamed spur ridge 0.7 mile east of High Ridge	Bald Mountains: unnamed spur ridge 0.7 air mile east of High Ridge.	50+ stems in bud on 1 July with forbs on dry roadbank (Oakley and Rossell 2008).	S. Oakley and R. Rossell, NC NHP	Dry south-facing bank of dirt logging road, full sun. Area above on slope burned in recent years. The species with Lespedeza, other forbs, Hypericum stragalum, Philadelphus hirsutus (Oakley and Rossell 2008).
453	28216	5908	Hymenophyllum tayloriae		7	Gorge Filmy F	1998-06-01	1998-06-01		Current	C	2-High	SR-O	S1S2	S1	G2	G2	Upland	Plant	Vascular Plant	M: moist grottoes and spray cliffs in escarpment gorges with high rainfall	19476	N	N	0.13	3000	3000	BROOKS COVE	BROOKS CREEK WATERFALL IMMEDIATELY UPSLOPE OF FOREST SERVICE ROAD 367. POPULATION BEGINNING APPROXIMATELY 30 METERS UPSLOPE OF THE ROAD ON THE EAST SIDE OF THE WATERFALL. (DAVISON AND KAUFFMAN 1998). [NANTAHALA NF, HIGHLANDS RD, COMPARTMENT 16].	ROBUST POPULATION WITH BROAD COVERAGE COVERING CLOSE TO 5 SQUARE CENTIMETERS. (DAVISON & KAUFFMAN 1998).		ON GROTTO WALL WITHIN 5 METERS OF WATERFALL SPRAY. ASSOCIATED SPECIES INCLUDES FLAKEA PAPILLATA, TRICHOMANES INTRICATUM AND VITTARIA
454	28231	37038	Perimyotis subflavus		154	Tricolored Bat	2010-07-04	2010-07-04	2010-07-04	Current	E	6-Unknown	SR	S3	S3	G2G3	G2	Upland	Animal	Mammal	MPSC: roosts in clumps of leaves (mainly in summer), caves, rock crevices, and other dark and sheltered	18194	N	N	0.12	-1	-1	Nantahala National Forest: Miller Branch - mist net area	Nantahala National Forest: Miller Branch. Mist net site located along Miller Branch (Upper Copper Creek), at the trail crossing (NCWRC 2016) [derived from coordinate location].	2010: 1 adult male captured in a mist net by McClanahan et al. on 04 July 2010 (NCWRC 2016).	Rod McClanahan	
455	28248	37000	Myotis leibii		102	Eastern Small-f	2010-07-04	2010-07-04	2010-07-04	Current	E	2-High	SC	S2	S2	G4	G4	Upland	Animal	Mammal	M: roosts in hollow trees and in rock crevices (warmer months), in caves and mines	19689	N	N	0.12	-1	-1	Nantahala National Forest: Miller Branch - mist net area	Nantahala National Forest: Miller Branch. Mist net site located along Miller Branch (Upper Copper Creek), at the trail crossing (NCWRC 2016) [derived from coordinate location].	2010: 1 adult male captured in a mist net by McClanahan et al. on 04 July 2010 (NCWRC 2016).	Rod McClanahan	
456	28356	31644	Setophaga cerulea		58	Cerulean Warbl	2011-06-03	2011-06-03	2011-06-03	Current	E	2-High	SC	S2B	S2B	G4	G4	Upland	Animal	Bird	MC: mature hardwood forests; steep slopes and coves in mountains, natural levees in Coastal Plain [breeding evidence only]	17322	N	N	0.08	3500	3600	Bert Creek	Bert Creek -- near the upper end of the drainage of this creek, about 2.25 air-mile ENE of where Bert Creek meets US 129. GPS coordinates: 35.30336N, -83.7333W	2011: Kelly noted one bird, on June 3.	Chris Kelly (WRC) - 2011	
457	28382	33595	Trillium simile		45	Sweet White T	1997-07-18	1997-07-18	1997-07-18	Current	E	2-High	T	S2	S2	G3	G3	Upland	Plant	Vascular Plant	MP: rich coves	19583	N	N	0.08	-1	-1	Brown Mountain/Hench Knob	Includes NCVS Plot 022-03-0388, located near 35.30633897 N, -83.05322643 W (Peet et al. 2007).	Present, occupying trace amounts in a 1000 sq meter plot, located on 18 July 1997 by Carolina Vegetation Survey (Peet et al. 2007).		See Peet et al. 2007 for complete list of related species
458	28412	33675	Cardamine clematitis		38	Mountain Bitter	2010-06-19	2010-06-19	2010-06-19	Current	E	2-High	SR-T	S2S3	S2	G3	G3	Wetland	Plant	Vascular Plant	M: high elevation seeps, shaded outcrops, and streambanks	19516	N	N	0.08	-1	-1	Along southern slopes of Fires Creek, approximately 500 meters west of Mule Flats Bend	Includes NCVS plot 121-04-1459 located near 35.1246592127809 N, -83.7944582471572 W (Peet et al. 2013; directions derived from coordinates).	Present, occupying less than 1% cover (cover class 2) in a 1000 sq-meter plot, located by Peet, Bond, Brown, Hart, and Hart on 19 June 2010 (Peet et al. 2013; unknown if population exists outside of plot boundaries).	Anne Bond; Barbara Hart; David Brown ; Jesse Hart; Robert Peet	Associated species include Liriodendron tulipifera, Aesculus flava, Fraxinus americana, Tilia americana, Actaea racemosa, Laportea canadensis
459	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.08	-1	-1	Nantahala National Forest	Population found "along lower side of Forest Service road crossing unnamed tributary of Cornsilk Branch..approximately 4.2 miles southwest of Robbinsville" located near 35.29455 N, -83.87238 W (DuMond 2011).	Mixed mat observed in 2 sq. foot area on 21 June 2011 (DuMond 2011).	David M. DuMond; Kevin Markham, ESI	Mesic, mixed hardwood forest with circumneutral soils (Hemlock dead or dying) Associated species include Thuidium delicatulum, Anomodon rostratus, Anomodon attenuatus, Eurhynchium hians, Plagiomnium cuspidatum, Hypnum imponens, Dicranum fuscescens, Le
460	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.08	-1	-1	near Hot Springs, NC	EO located along N roadside of Lookout Mountain Rd. near 35.9316028504533 N, -82.78143475080378 W (LeGrand 2012).	1 individual stem located at margin of dirt road and forestland by LeGrand on 28 July 2012 (LeGrand 2012).	Deb Carter; Harry LeGrand Jr., NCNHP; Merrill Lynch; Will Cook	
461	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.08	-1	-1	Nantahala National Forest	Population located "in flowing water near crossing of unnamed tributary of Cornsilk Branch below Forest Service gravel road about 4.2 miles southwest of Robbinsville" near 35.29284 N, -83.87154 W (DuMond 2011).	Population occuring as a mixed mat at the water's edge, noted in vegetative growth by DuMond on 21 June 2011 (DuMond 2011).	David M. DuMond; Kevin Markham, ESI	"Mesic, mixed hardwood forest with circumneutral soils (Hemlock dead or dying)" Associated species include Jubula pennsylvanica, Eurynchium pulchellum, Lejeunea ulicina, Riccardia palmata.
462	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.08	-1	-1	Nantahala National Forest	Population observed in "moist wood and bark near flowering water at upper crossing of unnamed tributary of Cornsilk Branch below Forest Service gravel road, approximately 4 miles southwest of Robbinsville" located near 35.29344 N, -83.86176 W (DuMond 201	Population occurring as a mixed mat observed in vegetative growth on 21 June 2011 (DuMond 2011).	David M. DuMond; Kevin Markham, ESI	"Mesic, mixed hardwood forest with circumneutral soils (Hemlock dead or dying) near stream" Associated species include Leucolejeunea clypiata, Lejeunea ulicina, Ulota crispa
463	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.08	-1	-1	Upper Cornsilk Branch - mist net site	Upper Cornsilk Branch - mist net site. Mist net site along Cornsilk Branch between Cornsilk Branch Road and the creek, about about 0.35 roadmiles south of the Ike Jackson Road intersection [derived from coordinate location].	2016: 1 adult female mist netted by Libby et al. on 27 May 2016 (NCWRC 2018).	Gary Libby	
464	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.04	-1	-1	Rocky Knob; approximately 900 meters southwest from Rocky Knob summit	Includes CVS plot 121-05-1452, located near 35.2238412286176 N, -84.0646115083771 W (Peet et al. 2013).	Present, occupying less than 1% cover (cover class 2) in a 1000 sq-meter plot, located by Dellinger, Morris, Gale, and Lee on 18 June 2010 (Peet et al. 2013; unknown if populations exist beyond plot boundaries).		Related species include Betula alleghaniensis, Tilia americana var. herophylla, Acer spicatum, Ribes cynosbati, Dryopteris marginalis (Peet, et al. 2013).
465	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.04	3800	3800		Northeast of town of Swannanoa, the Blue Ridge Parkway delineates the northern (upper) boundary, and it is joined by the North Fork Watershed on east, and High Swan-Bull Mountain on the west.	12 plants seen at two locations. Many more plants likely to be found here as the time of year was very late for survey work and some plants had nearly all perygynea shattered from plants. Plants found in more wooded areas of site (Knapp 2018).	Gary Kauffman, USFS; Josh Kelly, Mountain True; Sue Fruchey, USFS; Wesley Knapp, NCNHP	
466	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.01	-1	-1	Nantahala National Forest: Locust Tree Gap	Nantahala National Forest: Locust Tree Gap. FSR-713, headwaters area of Pol Miller Hollow (NCWRC 2014) [directions derived from coordinate location].	2006: 1 adult female captured by O'Keefe on 27 June 2006 (NCWRC 2014). 2005: 2 bats (1 adult female and 1 juvenile male) captured by O'Keefe on 24 July 2005 (NCWRC 2014).	Joy O'Keefe, Indiana State Univ.	
467	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.01	-1	-1	Nantahala National Forest: Trimont Ridge Spur	Nantahala National Forest: Trimont Ridge Spur. Top of spur of Trimont Ridge located between Arrowwood Creek and Shingletree Branch, off FSR-7154 (NWRC 2014) [directions derived from coordinate location].	1 adult male captured by O'Keefe on 24 May 2007 (O'Keefe 2012, NCWRC 2014).	Joy O'Keefe, Indiana State Univ.	
468	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.01	-1	-1	Nantahala National Forest: Rattler Ford Campground	Nantahala National Forest, Rattler Ford Campground. Northeast of Santeetlah Gap, between SR-1127 (Rattler Ford Rd) and Santeetlah Creek, at campground (NCWRC 2014) [directions derived from coordinate location].	1 adult female capture by O'Keefe on 25 July 2006 (NCWRC 2014).	Joy O'Keefe, Indiana State Univ.	
469	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.01	-1	-1	Little Buck Creek	Little Buck Creek. Capture location between Little Buck Creek and FSR-71, about 1 road mile from US-64 (NCWRC 2014) [directions derived from coordinate location].	Three bats total captured by O'Keefe and Brown on 30 July 2008: 1 adult female, 1 juvenile female, 1 juvenile male (NCWRC 2014).	Dottie Brown; Joy O'Keefe, Indiana State University	
470	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.01	-1	-1	Harmon Den/Hurricane Creek Area	Harmon Den/Hurricane Creek Area. Mist-net location in Pisgah National Forest but the exact location is unknown; GPS point is exit of I-40 to the area (NCWRC 2014).	17 individuals captured in a mist-net by USFS and NCWRC staff (NCWRC 2014).		
471	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	-1	-1	Nantahala National Forest, Brooks Cove powerline	Nantahala National Forest, Brooks Cove powerline. In powerline corridor that is just north of the end of Copper Drive, about 125m east of the house (Kauffman 2014) [directions derived from feature location].	Presence only; Kauffman reported the location and indicated that it is a new site that was found in 2012 (Kauffman 2014).	Gary Kauffman, USFS	Maintained open powerline corridor (Kauffman 2014).

<u>Attachment 13</u>

Quantifying the National Significance of Local Areas for Regional Conservation Planning: North Carolina's Mountain Treasures

land

MDPI

Article

Quantifying the National Significance of Local Areas for Regional Conservation Planning: North Carolina's Mountain Treasures

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Abstract: Conservation scientists recognize that additional protected areas are needed to maintain biological diversity and ecological processes. As regional conservation planners embark on recommending additional areas for protection in formal ecological reserves, it is important to evaluate candidate lands for their role in building a resilient protected areas system of the future. Here, we evaluate North Carolina's Mountain Treasures with respect to their (1) ecological integrity, (2) role in connecting existing core protected areas, (3) potential to diversify the ecosystem representation of reserves, and (4) role in maintaining hotspots of biologically-rich areas that are not well protected. Mountain Treasures represent a citizen inventory of roadless areas and serve as candidates for elevated levels of conservation protection on U.S. federal lands. We compared Mountain Treasures to other candidate lands throughout the country to evaluate their potential national significance. While the Mountain Treasures tended to be more impacted by human modifications than other roadless areas, they are as important as other roadless areas with respect to their role in connecting existing protected areas and diversifying representation of ecosystems in conservation reserves. However, Mountain Treasures tended to have a much higher biodiversity priority index than other roadless areas leading to an overall higher composite score compared to other roadless areas. Our analysis serves as an example of how using broad-scale datasets can help conservation planners assess the national significance of local areas.

Keywords: biodiversity; connectivity; ecological integrity; Mountain Treasures; protected areas; Southern Appalachian Mountains

1. Introduction

For over a century, conservation efforts have led to the establishment of hundreds of protected areas covering millions of hectares in the United States. These protected areas form the foundation for strategies to protect biological diversity and ecological processes upon which people and other species depend [1]. Nevertheless, there is growing recognition that existing protected areas may be insufficient to sustain biodiversity as climate change and land development continue to impact natural ecosystems [2]. In fact, referencing the Convention on Biological Diversity [3], Aycrigg et al. (2016) [4] recognized that "as significant as conservation areas are ... they fall short of meeting recommended policy goals of each nation having established by 2020 an ecologically representative and well-connected system of protected areas."

Recent calls have been made to add to the system of protected areas by establishing an ecologically connected network that is more inclusive of ecosystems and species currently under-represented in protected areas [3,4]. In response to these calls, Belote et al. (2017) [5] conducted a national assessment of wildland values and priorities for expanding the U.S. protected area system to include the most ecologically intact and wildest lands [6], establish a national connected network [7], and better represent ecosystem diversity [8] and hotspots of range-limited species [9]. Establishing a system of conservation reserves that is more resilient to climate change may require adding intact lands that connect existing protected areas and adding ecosystem and species representation to the existing system [1,10,11].

At the same time, protecting what is left of the remaining wildlands (areas where human land use does not dominate ecological systems) has been recognized as a key conservation strategy [12,13]. Watson et al. (2016) suggest that "protecting the world's last wilderness areas is ... our best prospect for ensuring that intact ecosystems and ... evolutionary processes persist for the benefit of future generations." Similarly, Ibisch et al. (2016) [14] recently mapped Earth's remaining roadless lands and described the global importance of these areas for additional conservation protection.

Marshall and Dobbins (1936) [15] made similar calls for the protection of large tracts of wildlands after evaluating roadless areas over 80 years ago using paper maps to identify national conservation priorities. Today, national and global high resolution data on human impacts allow conservation scientists to better evaluate human land use changes [16,17], identify roadless and wildland areas [12,14], and map biodiversity [9,18]. These datasets provide important opportunities for assessing the global or national importance of regions or local areas in conservation planning [2]. Without such evaluations, local assessments and management recommendations may fail to consider the full conservation value of lands [2].

In this paper, we used data compiled by Belote et al. (2017) [4] to evaluate the national wildland conservation significance of the "Mountain Treasures" of western North Carolina for their value in completing a national network of conservation reserves. Ranging in size from 80 to 11,810 hectares, the Mountain Treasures are 53 units of land in the Southern Appalachian Mountains first identified in 1992 by citizens via spatial analysis of roadless areas and field verification [19]. The citizen inventory and identification of Mountain Treasures was originally conducted in conjunction with the development of a management plan by the United States Forest Service. This inventory has been updated and refined in anticipation of the Forest Plan revision for the Nantahala and Pisgah National Forests that began in 2014 (see Appendix A for the list of Mountain Treasures).

The Nantahala and Pisgah National Forests are primarily managed for multiple uses by the U.S. Forest Service, which administers over 78 million hectares throughout the United States [20]. National Forests are managed under federal direction through the National Forest Management Act, which requires that management plans be updated on a regular basis (every 10–15 years). During management plan revisions, the Forest Service evaluates candidates of land units to be recommended to the U.S. Congress for additional conservation protections, including formal wilderness designation. Here, we use national data to assess the relative value of the Mountain Treasures, which are candidates for elevated levels of conservation protection, compared to other similar units on all other Forest Service lands of the contiguous U.S.

We evaluated the relative importance of adding the Mountain Treasures to the national system of conservation reserves by assessing their: (1) ecological integrity, (2) importance for connecting existing protected areas, (3) whether the composition of their ecosystems are national priorities for expanding representation, and (4) their importance as habitats for range-restricted and unprotected hotspots of biodiversity. These qualities derive from conservation principles to maintain biological diversity under the increasing pressures of climate change and land development. Protecting intact lands (areas of high ecological integrity) that connect protected areas and diversify the ecological representation of conservation reserves are among the highest conservation priorities. Here, we quantified these qualities and compared the Mountain Treasures to other similar candidates for elevated levels of protection occurring on Forest Service lands (Figure 1). In so doing, we demonstrate a relatively straightforward method for evaluating the national significance of local areas during regional land use and conservation planning.

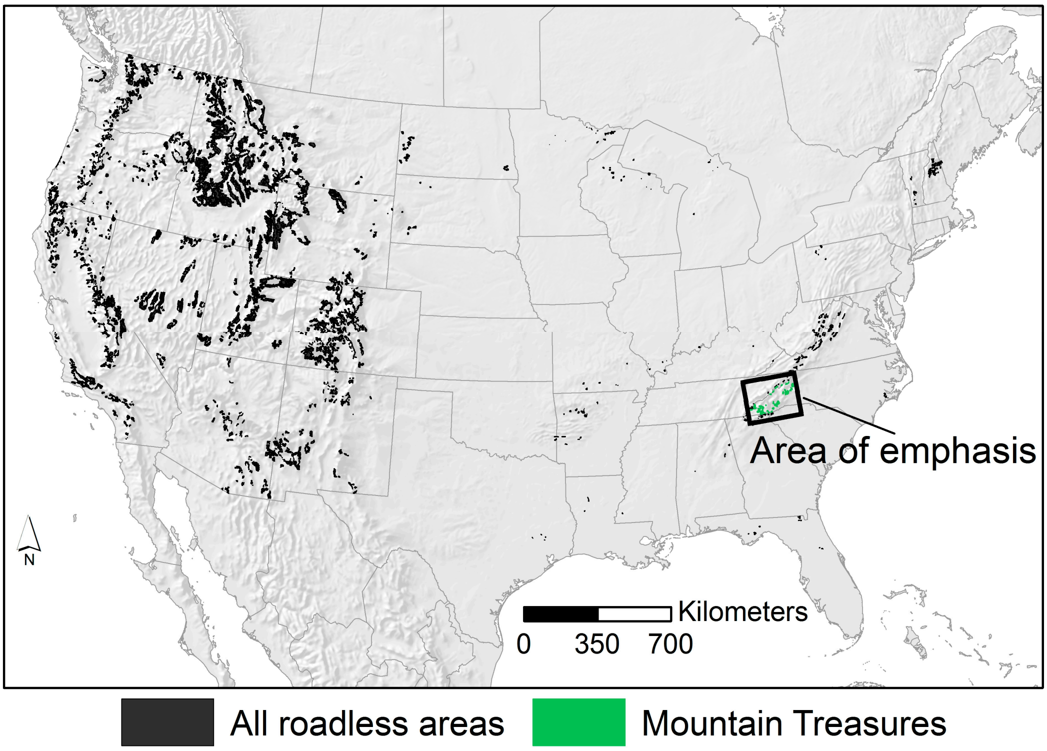

Figure 1. The location of Mountain Treasures (green) and all other roadless areas (grey) in the contiguous United States. The maps in Figures 3–7 represent the "area of emphasis" highlighted here.

2. Materials and Methods

2.1. Study Area Region

The Mountain Treasures of North Carolina are located in the Nantahala and Pisgah National Forests of the Southern Appalachian Mountains (Figure 1). The Southern Appalachians contain one of the most biologically diverse temperate forests in the world [9]. The topography includes sheltered valleys at relatively low elevations up to the highest mountains of the eastern U.S. This topographic richness provides a very broad range of different habitat niches. In addition, a wide variety of geologic substrates also contributes to a range of soil types. The geological history is also very ancient, with continuous vegetation likely extending back to the last mass extinction 65 million years ago. The diverse microclimatic conditions, the relatively moderated climate over long periods, and a long geological history without major disturbances, such as direct glaciation or submersion under water, contribute to the high biological diversity of the region. Mountain Treasures range in elevation from 604–1623 meters above sea level, with metamorphic and metasedimentary rock characterizing the parent material. The vegetation cover of the Mountain Treasures is diverse, but characterized by species of oak (*Quercus* spp.) and mixed deciduous trees with areas dominated by conifers (*Pinus* spp. and *Tsuga canadensis*), as well as Appalachian mountain balds.

2.2. Quantifying Conservation Value

To quantify ecological integrity, we used Theobald's map of human modification [6]. This is a composite map developed from spatial data representing land cover, human population density, roads, structures, and other stressors to the ecosystems. Lands that maintain a high degree of ecological integrity or low degree of human modification have been referred to as "wildlands" [21], and protecting the remaining wildlands is considered by many to be among the highest of conservation priorities [12,13,22].

To quantify the value of land units for maintaining or establishing connections between protected areas, we used a mapped connectivity index from Belote et al. (2016) [7]. The index was developed to identify the least human-modified corridors between existing large protected areas, which were defined as all wilderness areas regardless of size and all other Gap Analysis Program (GAP) status 1 and 2 lands $\geq$4046.9 hectares (10,000 acres). GAP 1 and 2 lands are classified as such because laws, policies, or their land management plans mandate that biodiversity be a central conservation goal and that land conversion, commercial development, and resource extraction is prohibited or limited [23]. Lands with a high connectivity index receive a higher wildland conservation value, as they may help to maintain ecological linkages between protected areas [7].

To quantify ecosystems currently under-represented in the existing protected area system, we used an assessment of ecological representation in highly protected lands. Ecosystem representation has recently been calculated using a number of different methods, including those based on the proportion of ecosystem area within different GAP status lands [8], wilderness areas [24], and roadless lands [25]. We recalculated the analyses of Aycrigg et al. (2013) using the latest protected areas database (PAD) to map the proportion of total area of each ecosystem occurring in GAP status 1 or 2 areas (Figure 2C) [23]. The ecosystem classification we used was based on the National Vegetation Classification System (NVCS) ecological "group" level and is mapped at 30-meter resolution throughout the contiguous U.S. These data are made available from the GAP land cover data (http://gapanalysis.usgs.gov/gaplandcover). Lands composed of ecosystems that are less well-represented in protected areas are assigned a higher value than lands with ecosystems that are already highly protected.

To quantify the value of land for hosting species currently under-represented in protected areas, we used the conservation priority index of Jenkins et al. (2015) [9] (Figure 2D). This index was developed by overlaying maps of mammal, bird, reptile, amphibian, freshwater fish, and tree species distributions and weighting the rarity of species (calculated based on the size of each species' geographic distribution) and the proportion of its distribution that is protected based on the International Union for Conservation of Nature (IUCN) protected area categories I to VI [9]. Lands classified in categories I–VI overlap those considered as GAP 1 and 2 (http://gapanalysis.usgs.gov/blog/iucn-definitions). Areas rich in endemic species with limited geographic distributions that are currently not well-represented in protected areas receive a higher value in our index than areas with few such species. Rarity-weighted richness values, such as the index we use here, perform well at identifying conservation priorities when compared with more complex conservation design algorithms (e.g., Zonation, [26]).

Finally, we derived an index of composite wildland conservation values, which was produced by summing the normalized indices of each quality described above [5]. This index map shows important priorities for adding lands to the national system of conservation reserves. Lands that currently serve as candidates of elevated levels of protection and with higher composite values may be considered high priorities for added conservation protections. Pairwise complementarity [27] of the four values were mapped across the contiguous U.S. in Belote et al. (2017) [5], and the Southern Appalachian region was found to possess high degrees of many of the value combinations.

For each quality, we compared the distribution of Mountain Treasures to all other inventoried roadless areas (IRAs) within the entire National Forest System of the contiguous United States. To do this, we calculated the mean value of each index for every Mountain Treasure (N = 53) and IRAs (N = 2408). We plotted kernel density distributions (analogous to smoothed histograms) of each index to compare Mountain Treasures and IRAs. We used this method of plotting over alternatives (e.g., box and whisker, bar graphs) to better evaluate the distribution of data within Mountain Treasures and IRAs. Because our data represent a census of all values within units of interest, we were not interested in conducting inferential statistics to compare distributions. We also rank ordered each Mountain Treasure with respect to the four indices, as well as their final composite wildland conservation value. In addition to comparing values among Mountain Treasures, we also plotted 75th, 90th, 95th, and 99th percentiles of each index calculated from all IRAs to quantify the relative importance of individual Mountain Treasures compared to national IRAs.

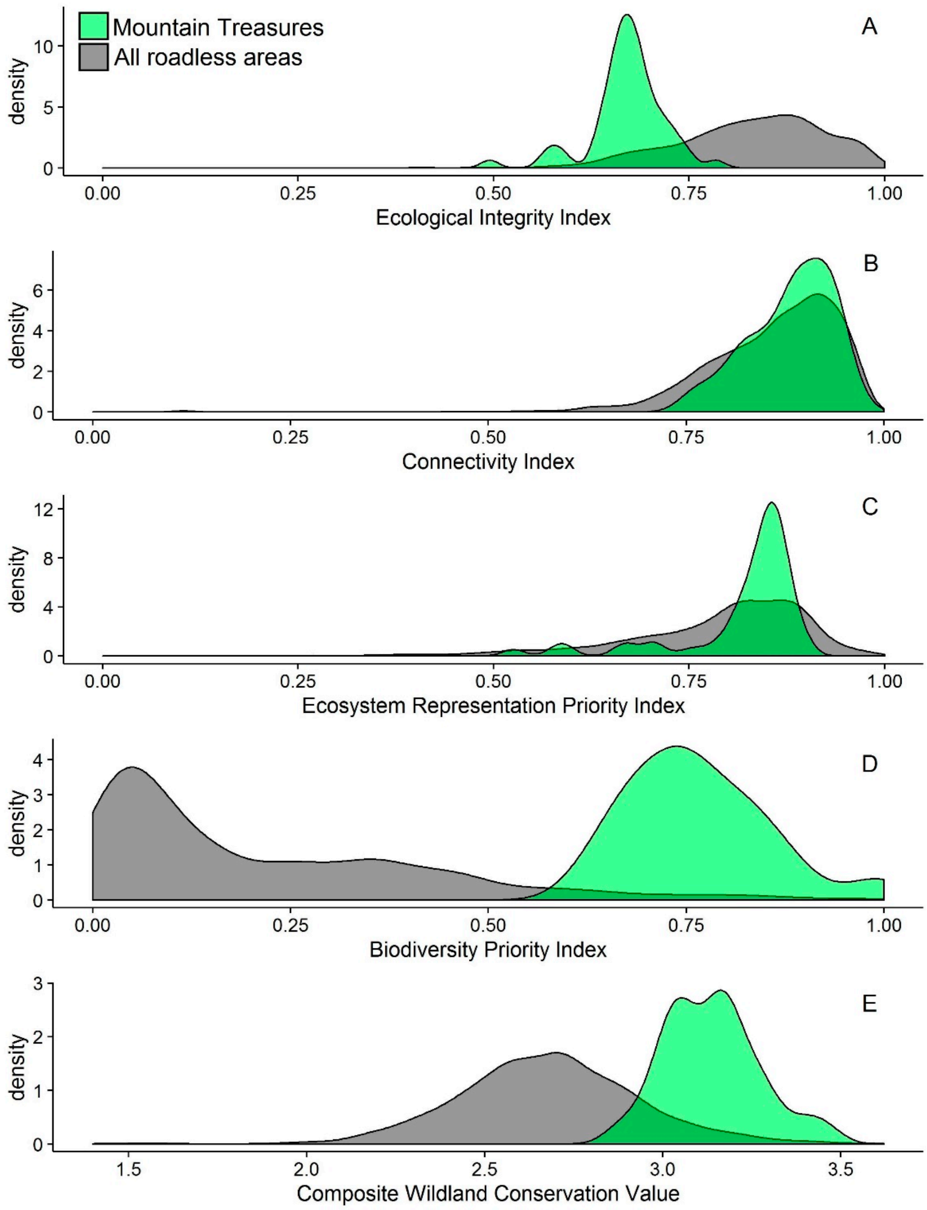

Figure 2. The distribution of conservation priorities for Mountain Treasures (green) and all other roadless areas in the lower 48 United States (grey) based on data from Belote et al. (2017). The values for the top four indices range from 0 (low) to 1 (high) nationally. These indices were combined into a composite Wildland Conservation Value index (bottom panel). (**A**) Ecological integrity; (**B**) Connectivity; (**C**) Ecosystem representation priority; (**D**) Biodiversity priority index; (**E**) Composite wildland conservation value.

3. Results

3.1. Ecological Integrity and Connectivity Priority

The mean ecological integrity of the Mountain Treasures was 23% lower than the mean integrity of other US Forest Service IRAs (Table 1; Figure S1; Figures 2A and 3). Despite the lower degree of ecological integrity, Mountain Treasures fall between existing protected areas and maintain an overall connectivity value similar to other IRAs (Figures 2B and 4). The connectivity values of Siler Bald and Bald Mountain are above 90% of all U.S. roadless lands in the lower 48 United States, and sixteen

Mountain Treasures possess connectivity values greater than 75% of all designated roadless areas (Figure S2).

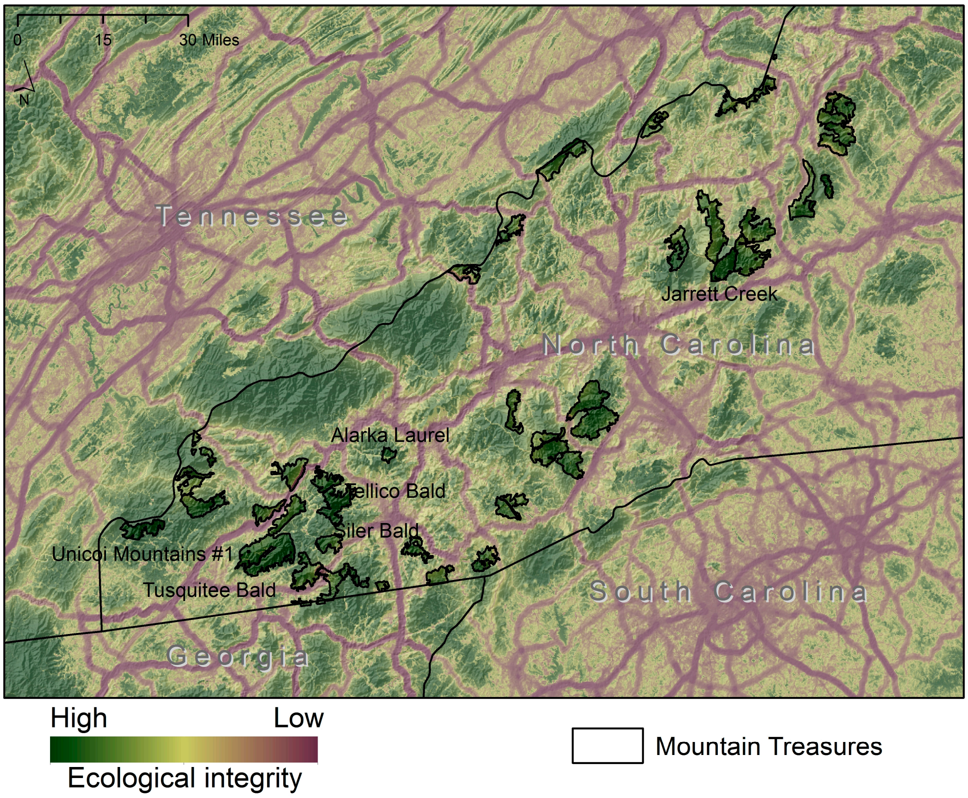

Figure 3. Map of ecological integrity for the Southern Appalachian Mountains highlighting the Mountain Treasures. While the Mountain Treasures have on average lower ecological integrity scores compared to all other roadless areas, it is important to note their regional significance for sustaining relatively intact and wild, some of the wildest places in the Southeastern U.S.

Table 1. Summary statistics for each index used to compare North Carolina's Mountain Treasures with other US Forest Service (USFS) candidates for additional protection. All indices are based on data compiled by Belote et al. (2017) and range from 0 to 1, except for the composite wildland conservation value which had a maximum possible value of 4.

Index	Mountain Treasures			All Other USFS Inventoried Roadless Areas					
	Median	Mean	SD	Median	Mean	SD	75%	90%	95%
Ecological integrity	0.67	0.67	0.05	0.84	0.83	0.26	0.90	0.95	0.97
Connectivity priority	0.89	0.88	0.05	0.88	0.86	0.09	0.92	0.95	0.96
Ecosystem representation priority	0.85	0.82	0.08	0.82	0.79	0.12	0.87	0.90	0.92
Biodiversity priority	0.75	0.77	0.09	0.13	0.21	0.20	0.34	0.48	0.61
Wildland conservation value	3.15	3.14	0.13	2.68	2.68	0.26	2.83	2.99	3.11

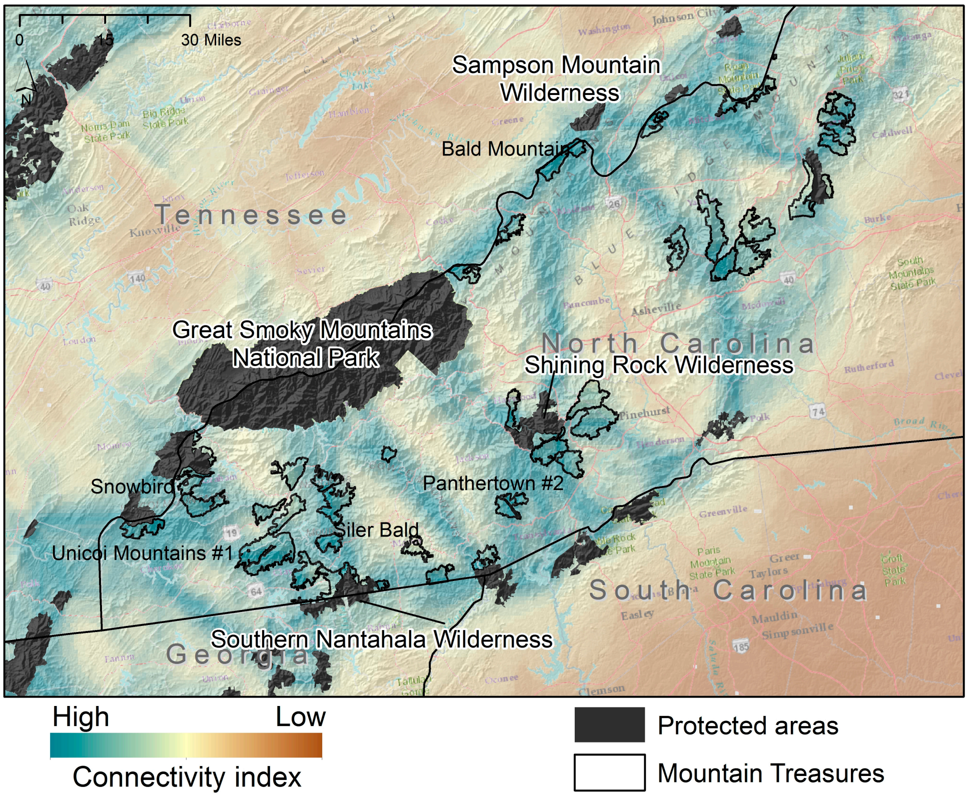

Figure 4. Map of the connectivity priority value between protected areas for the Southern Appalachian Mountains, highlighting the Mountain Treasures based on data from Belote et al. (2016). Many of the Mountain Treasures lie between existing protected areas and therefore represent important priorities for maintaining connections between existing conservation reserves including the Great Smoky Mountains National Park and wilderness areas on the Nantahala and Pisgah National Forests.

3.2. Ecosystem Representation

The ecosystem representation priority of the Mountain Treasures was also comparable to IRAs (Figure 2C). Panther Town #1 and #3, Dobson Knob, Linville Gorge Extension A, Sugar Knob, Nolichucky Gorge, and Southern Nantahala Extension D are composed and dominated by ecosystems poorly represented in protected areas (Figure 5), making these areas a higher priority than 75% of other roadless areas in the U.S. (Figure S3).

3.3. Biodiversity Priority Index

The biodiversity priority index was on average 73% higher than other IRAs (Table 1; Figure 2D). Santeetlah Bluffs, Snowbird, Joyce Kilmer-Slickrock Extension #1, Lower Snowbird Creek, Southern Nantahala Extensions A1 and A2, Wesser Bald, and Unicoi Mountains #1 have a higher biodiversity priority index than 99% of all other roadless lands in the lower 48 United States (Figure 6). Nearly all Mountain Treasures have a higher biodiversity priority index than 95% of all other roadless areas (Figure S4).

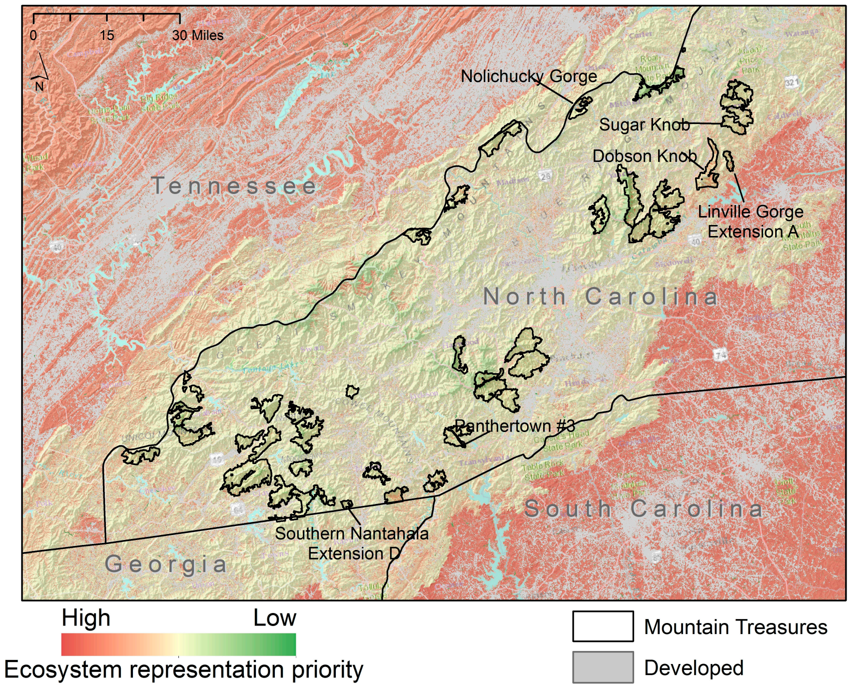

Figure 5. Map of the ecosystem representation priorities in the Southern Appalachian Mountains highlighting the Mountain Treasures. Many of the Mountain Treasures are home to ecosystems that are not well-protected based on recent evaluations of how well the existing system of protected areas represents the nation's ecosystem diversity.

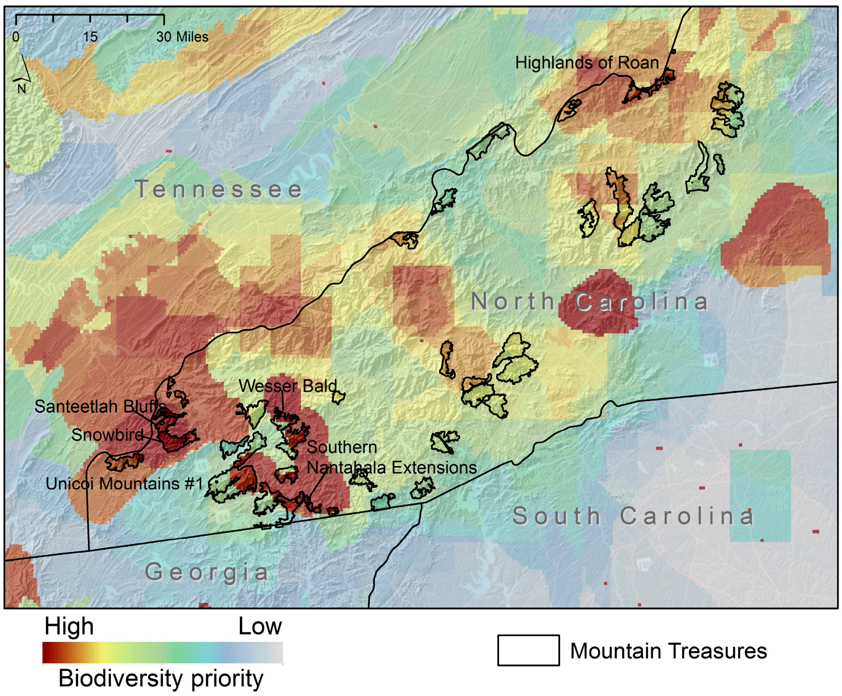

Figure 6. Map of the biodiversity priority index of Jenkins et al. (2015), which identifies key areas containing many range-limited species that are poorly represented in protected areas.

3.4. Composite Wildland Conservation Value

Combined these qualities resulted in a composite wildland conservation priority of the Mountain Treasures that was on average ~15% higher than IRAs (Table 1; Figures 2E and 7). On average, the Mountain Treasures exceed the wildland conservation value of other roadless areas and over half of the Mountain Treasures have a higher value than 95% of all other roadless areas (Figure S5).

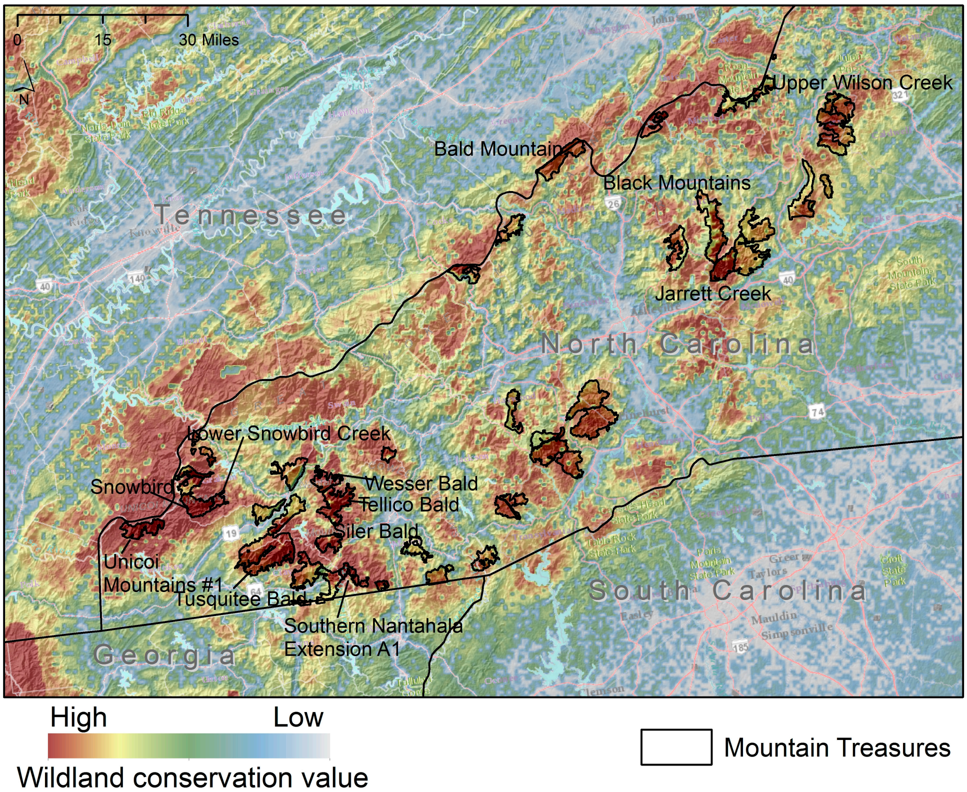

Figure 7. The composite wildland conservation value of Belote et al. (2017) that combined the indices of ecological integrity, connectivity, ecosystem representation, and biodiversity priorities into one map.

4. Discussion

The Mountain Treasures represent some of the most important lands in the U.S. to establish a protected areas system that is intact, connected, and representative of ecological diversity and hotspots of range-limited species. Our assessment is based on a number of widely accepted principles from conservation science that provide guidance on how to construct a system of protected areas to maintain biodiversity and ecological processes in the face of habitat fragmentation and climate change [3,4,10,28–30]. A conservation reserve system that is ecologically intact, connected in a network of protected areas, and representative of ecosystem and species diversity may provide the greatest degree of adaptive capacity in the face of a global change [10,31]. Unprotected lands that possess these qualities may be considered high priorities for adding to the existing system of conservation reserves [5]. The Mountain Treasures are not currently designated as highly protected lands.

In their valuable new paper, Aycrigg et al. (2016) state their intent to "start the conversation" about completing a national protected area system that is more representative of ecosystem and species diversity. Our objective here is to use a recent national assessment of wildland conservation values to assess the significance of North Carolina's Mountain Treasures in helping to achieve a resilient protected area system of the future. The Mountain Treasures are among the most valuable roadless areas in the country for the qualities they currently maintain. It may be critical to consider their national significance in land management and conservation decisions. Without such broad-scale analyses, local decisions and actions may fail to appreciate important national [5] or global [2] conservation priorities.

The Mountain Treasures are less intact and wild compared to all roadless areas, many of which are in the western U.S. (Figure 2A). This is not surprising given the higher density of human population, roads, and other disturbances experienced by ecosystems of the eastern U.S. Interestingly, at a global scale, biologically-rich areas tend to experience more intensive human modification [17]. Thus, patterns of biodiversity and human modification of the Southern Appalachians represent an example of this global phenomenon [32]. It is worth noting, however, that the Mountain Treasures represent some of the most intact and wildest places in the Southeastern U.S.

Despite the overall higher degree of human modification and lower degree of ecological integrity of the Mountain Treasures, on average their importance for establishing and maintaining a nationwide and regional connected network of protected areas is nearly identical to all other roadless areas in the U.S. [7]. Many of the Mountain Treasures lie between existing protected areas and therefore represent important priorities for maintaining connections between existing conservation reserves including the Great Smoky Mountains National Park and wilderness areas in the Nantahala and Pisgah National Forests (Figure 4). Creating a connected network of protected areas is among the highest recommended adaptation strategies to maintain biodiversity under a changing climate [7,10,33,34].

The Mountain Treasures are also equally important compared to the other roadless areas with respect to expanding the representation of ecosystem diversity in protected areas (Figure 2C). These roadless areas may be considered as reasonable candidates for future wilderness designation [25], and protecting roadless areas composed of ecosystems poorly represented in wilderness and other highly protected areas should be considered high priorities for additional protections [24]. Designating lands composed of poorly represented ecosystems will ensure that our protected areas system of the future includes all of nature's diversity, and can be used as part of important climate adaptation planning [35].

Compared to other roadless areas—the likely candidates for inclusion in an expanded conservation reserve system—the Mountain Treasures are some of the most biologically rich areas (Figure 2D) and represent important conservation priorities [9]. The richness of range-limited and endemic species in the Appalachians compared to other roadless lands is the result of paleo-ecological history [36], the diverse climatic and edaphic gradients [37,38], and the evolutionary history of the species in the region, e.g., [39]. A number of species occur nowhere else on Earth or are geographically restricted, but remain without formal conservation protection [9].

When combined, the four indices described above provide important insights into the national conservation significance of the Mountain Treasures. These roadless lands are among the nation's most important if we are to construct a protected area system of the future that has the best chance of passing our natural heritage on to future generations. The Southern Appalachian Mountains have been identified as a critical region for historical [36,40] and projected future [41,42] climate change-driven species migrations. Minimizing or eliminated non-climate stressors to species and ecosystems through elevated levels of conservation protection may be regarded as a 'no regrets' climate adaptation conservation strategy [43].

Our analysis is based on data representing the qualities of land important for constructing an ecologically representative and connected system of protected areas. Our goal was to provide a simple means of comparing local candidates for elevated levels of conservation protection to other candidates throughout the contiguous U.S. based on the recommendations of Aycrigg et al. (2016) [4] and the assessment of Belote et al. (2017) [5]. However, other ecosystem values or tools of conservation planning—not considered here—would enrich our evaluation. For instance, measuring ecosystem services [44] and recreational or other economic values [45] could provide additional insights into the relative value of the Mountain Treasures.

Other conservation optimization or prioritization tools may also provide important insights into the value and rank of the Mountain Treasures [27]. Because Mountain Treasures are in the federal estate and are already publicly owned and managed, the cost of land will not need to be factored in, as in other conservation prioritizations [46]. However, we recognize that our evaluation is but one resource used in a more complex approach to conservation planning [47]. Our main goal was to provide insights into the potential national significance of the Mountain Treasures, because such insights might be easily overlooked by regional conservation planners.

In fact, other global or continental data could also be used to provide additional insights into conservation values of local areas, such as the Mountain Treasures. For instance, Pouzols et al.'s (2014) [2] global evaluation of priorities for protected area expansion to meet international targets [3] using over 24,000 terrestrial vertebrate species' range maps reveals the Southern Appalachian Mountains to be in the top 20% of the highest priorities on Earth. In fact, several of the Mountain Treasures (Tellico Bald, Wesser Bald, Joyce Kilmer-Slickrock Extension #2-4, Dobson Knob, Linville Gorge Extension A, Sugar Knob, and Harper Creek) represent the top 10% of the highest global priorities for terrestrial protected area expansion on the planet (data available for download here: https://avaa.tdata.fi/web/cbig/gpan).

5. Conclusions

Our analysis provides a case study for using national geospatial data that represent individual or combined conservation values to assess the significance of local areas in regional conservation plans. Implementing conservation protections will require work with local communities, federal agencies, and potentially congressional review and legislation. However, we believe it is important to place conservation evaluations into a broader spatial context than is typically considered in decision making (e.g., [48]). The local abundance of values can sometimes conceal the national or global rarity or significance of lands to local conservation planners.

While we believe that local land use decisions should be placed into this global or national context, we also recognize that local evaluations of data on conservation values not reflected in national datasets will remain a critical part of conservation planning. However, a well-known adage of conservation is "think globally, act locally." As global and national data become increasingly available, local conservation planners or land managers can evaluate the broader significance of local areas. These efforts provide important opportunities to not only think globally (or nationally), but also to quantify the global or national significance of lands.

Supplementary Materials: The following are available online at www.mdpi.com/2073-445X/6/2/35/s1, Figure S1: Mean value of the ecological integrity index used in Belote et al. (2017) with each Mountain Treasure rank ordered from highest to lowest; Figure S2: Mean value of the corridor index from Belote et al. (2016) and used in Belote et al. (2017) with each Mountain Treasure rank ordered from highest to lowest; Figure S3: Mean value of the ecosystem representation priority index used in Belote et al. (2017) with each Mountain Treasure rank ordered from highest to lowest; Figure S4. Mean value of the biodiversity priority index used in Belote et al. (2017) with each Mountain Treasure rank ordered from highest to lowest; Figure S5: The mean composite Wildland Conservation Value for all Mountain Treasures rank ordered from highest to lowest.

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Author Contributions: R.T.B. and G.H.I conceived and designed the project; R.T.B performed the analysis and analyzed the data; R.T.B. and G.H.I wrote the paper.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. List of North Carolina's Mountain Treasures, area, mean elevation (meters above sea level), and mean indices (± standard deviation) based on the national data of Belote et al. (2017).

Mountain Treasure Name	Hectares	Elevation (m)	Ecological Integrity	Biodiversity Priority Index	Connectivity Index	Ecosystem Representation Index	Composite Wildland Conservation Value
Alarka Laurel	1006	1273	0.73 ± 0.05	0.74 ± 0.03	0.93 ± 0.01	0.83 ± 0.14	3.2 ± 0.14
Ash Cove	2382	940	0.57 ± 0.22	0.62 ± 0.05	0.85 ± 0.04	0.86 ± 0.04	2.88 ± 0.3
Bald Mountain	4696	1010	0.68 ± 0.05	0.66 ± 0.01	0.95 ± 0.02	0.86 ± 0.06	3.16 ± 0.06
Big Ivy #1	4297	1253	0.7 ± 0.05	0.75 ± 0.02	0.87 ± 0.03	0.78 ± 0.16	3.06 ± 0.17
Black Mountains	7248	1386	0.66 ± 0.03	0.79 ± 0.02	0.88 ± 0.04	0.73 ± 0.18	3.06 ± 0.17
Bluff Mountain	2373	837	0.64 ± 0.11	0.64 ± 0.02	0.87 ± 0.05	0.87 ± 0.08	3.02 ± 0.17
Boteler Peak	4320	1023	0.65 ± 0.13	0.72 ± 0.1	0.89 ± 0.06	0.85 ± 0.09	3.11 ± 0.2
Cedar Rock Mountain	3513	934	0.69 ± 0.04	0.73 ± 0.01	0.9 ± 0.04	0.86 ± 0.1	3.14 ± 0.2
Cheoah Bald	3826	1057	0.56 ± 0.23	0.76 ± 0.07	0.83 ± 0.05	0.84 ± 0.11	2.99 ± 0.28
Daniel Ridge	4782	1195	0.68 ± 0.04	0.73 ± 0.01	0.93 ± 0.02	0.81 ± 0.14	3.15 ± 0.18
Dobson Knob	4771	776	0.67 ± 0.06	0.68 ± 0.01	0.81 ± 0.06	0.89 ± 0.08	3.05 ± 0.11
Fishhawk Mountain	2294	1050	0.68 ± 0.03	0.7 ± 0.01	0.76 ± 0.03	0.85 ± 0.1	2.95 ± 0.19
Harper Creek	3008	710	0.68 ± 0.02	0.69 ± 0.06	0.89 ± 0.05	0.87 ± 0.09	3.14 ± 0.13
Highlands of Roan #1	1643	1551	0.67 ± 0.04	0.83 ± 0.01	0.93 ± 0.02	0.6 ± 0.19	3.04 ± 0.2
Highlands of Roan #2	2145	1482	0.65 ± 0.05	0.83 ± 0.02	0.86 ± 0.03	0.62 ± 0.18	2.97 ± 0.18
Jarrett Creek	3633	964	0.72 ± 0.03	0.75 ± 0.02	0.94 ± 0.03	0.85 ± 0.1	3.23 ± 0.17
Joyce Kilmer—Slickrock Extension #1	1444	1223	0.66 ± 0.04	0.98 ± 0.03	0.89 ± 0.04	0.79 ± 0.16	3.24 ± 0.24
Joyce Kilmer—Slickrock Extension #2	936	927	0.69 ± 0.02	0.84 ± 0	0.79 ± 0.03	0.85 ± 0.12	3.17 ± 0.06
Joyce Kilmer—Slickrock Extension #3	489	604	0.64 ± 0.06	0.84 ± 0	0.83 ± 0.04	0.88 ± 0.05	3.19 ± 0.09
Joyce Kilmer—Slickrock Extension #4	132	997	0.71 ± 0.01	0.84 ± 0	0.8 ± 0	0.86 ± 0.06	3.18 ± 0.02
Laurel Mountain	5411	1053	0.67 ± 0.1	0.74 ± 0.01	0.81 ± 0.04	0.85 ± 0.1	3.06 ± 0.18
Linville Gorge Extension A	1151	653	0.71 ± 0.03	0.68 ± 0	0.76 ± 0.02	0.87 ± 0.11	3.04 ± 0.03
Linville Gorge Extension B	251	654	0.68 ± 0.03	0.68 ± 0	0.89 ± 0	0.87 ± 0.09	3.01 ± 0.28
Lost Cove	2392	824	0.67 ± 0.04	0.76 ± 0.04	0.89 ± 0.05	0.86 ± 0.09	3.16 ± 0.16
Lower Snowbird Creek	1097	868	0.73 ± 0.02	0.9 ± 0.07	0.91 ± 0.02	0.87 ± 0.04	3.41 ± 0.08
Mackey Mountain	6110	790	0.68 ± 0.04	0.69 ± 0.01	0.84 ± 0.04	0.86 ± 0.05	3.04 ± 0.14
Middle Prong Extension	2708	1330	0.67 ± 0.02	0.78 ± 0.01	0.85 ± 0.08	0.75 ± 0.17	2.99 ± 0.13
Nolichucky Gorge	2285	893	0.66 ± 0.03	0.79 ± 0.01	0.92 ± 0.05	0.86 ± 0.11	3.26 ± 0.06
Overflow	2432	950	0.65 ± 0.04	0.62 ± 0	0.92 ± 0.04	0.87 ± 0.11	3.04 ± 0.21
Panthertown #1	1890	1207	0.68 ± 0.05	0.7 ± 0.01	0.93 ± 0.03	0.85 ± 0.14	3.19 ± 0.07
Panthertown #2	1529	1117	0.66 ± 0.02	0.7 ± 0.01	0.94 ± 0.03	0.86 ± 0.07	3.16 ± 0.11
Panthertown #3	127	1268	0.66 ± 0.03	0.67 ± 0.02	0.93 ± 0.04	0.86 ± 0.1	3.17 ± 0.05

Table A1. *Cont.*

Mountain Treasure Name	Hectares	Elevation (m)	Ecological Integrity	Biodiversity Priority Index	Connectivity Index	Ecosystem Representation Index	Composite Wildland Conservation Value
Piercy Mountain Range	3686	1046	0.66 ± 0.11	0.73 ± 0.09	0.82 ± 0.04	0.86 ± 0.05	3.07 ± 0.21
Pigeon River Gorge	2473	868	0.5 ± 0.21	0.78 ± 0.01	0.88 ± 0.06	0.85 ± 0.11	2.97 ± 0.4
Santeetlah Bluffs	1800	1327	0.63 ± 0.03	1 ± 0	0.9 ± 0.02	0.73 ± 0.18	3.19 ± 0.19
Shining Rock Extension	1968	1623	0.64 ± 0.05	0.78 ± 0.02	0.89 ± 0.03	0.6 ± 0.19	2.88 ± 0.17
Siler Bald	2542	1231	0.68 ± 0.07	0.83 ± 0.08	0.96 ± 0.01	0.83 ± 0.11	3.28 ± 0.17
Slide Hollow NC	80	933	0.69 ± 0.01	0.8 ± 0.02	0.77 ± 0	0.86 ± 0.11	3.17 ± 0.03
Snowbird	3630	1214	0.7 ± 0.04	1 ± 0.01	0.93 ± 0.02	0.83 ± 0.12	3.47 ± 0.13
South Mills River	6929	937	0.7 ± 0.05	0.74 ± 0.01	0.88 ± 0.04	0.86 ± 0.05	3.18 ± 0.08
Southern Nantahala Extension A1	1014	1187	0.7 ± 0.03	0.88 ± 0.01	0.93 ± 0.05	0.87 ± 0.05	3.38 ± 0.09
Southern Nantahala Extension A2	703	1244	0.74 ± 0.02	0.88 ± 0	0.84 ± 0.04	0.86 ± 0.05	3.29 ± 0.09
Southern Nantahala Extension B	3174	1140	0.58 ± 0.23	0.76 ± 0.15	0.85 ± 0.04	0.83 ± 0.13	3.02 ± 0.25
Southern Nantahala Extension D	634	978	0.63 ± 0.05	0.81 ± 0.1	0.93 ± 0.02	0.86 ± 0.04	3.22 ± 0.16
Southern Nantahala Extension E	468	847	0.69 ± 0.01	0.64 ± 0.01	0.94 ± 0.03	0.87 ± 0.03	3.15 ± 0.04
Sugar Knob	2501	786	0.59 ± 0.11	0.73 ± 0.04	0.9 ± 0.06	0.87 ± 0.08	3.09 ± 0.14
Tellico Bald	5068	1133	0.75 ± 0.03	0.81 ± 0.09	0.92 ± 0.06	0.83 ± 0.12	3.29 ± 0.15
Terrapin Mountain	2691	957	0.65 ± 0.08	0.66 ± 0.01	0.9 ± 0.05	0.86 ± 0.13	3.05 ± 0.21
Tusquitee Bald	11,810	1031	0.73 ± 0.03	0.76 ± 0.1	0.92 ± 0.03	0.84 ± 0.1	3.26 ± 0.13
Unicoi Mountains #1	3615	838	0.78 ± 0.02	0.85 ± 0.06	0.94 ± 0.02	0.87 ± 0.05	3.44 ± 0.1
Upper Wilson Creek	3771	817	0.66 ± 0.09	0.73 ± 0.05	0.89 ± 0.05	0.86 ± 0.1	3.11 ± 0.17
Wesser Bald	2693	982	0.69 ± 0.1	0.87 ± 0.15	0.93 ± 0.03	0.86 ± 0.07	3.32 ± 0.17
Woods Mountain	5131	800	0.67 ± 0.04	0.69 ± 0	0.81 ± 0.04	0.87 ± 0.05	3.03 ± 0.1

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