November 5, 2018

Randall Walker, District Ranger
North Kaibab Ranger District
430 South Main Street
Fredonia, AZ 86022

Submitted via email to: comments-southwestern-kaibab-north-kaibab@fs.fed.us

RE: Kaibab Plateau Ecological Restoration Project

Dear Mr. Walker,

This letter supplies comments from the Center for Biological Diversity (the "Center") on the proposed Kaibab Plateau Ecological Restoration Project ("KPERP", the "proposed action", or the "project") on the North Kaibab Ranger District, Kaibab National Forest, Arizona. The legal public notice was published on October 5, 2018 in the Arizona Daily Sun, making these comments timely. The Center is a public-interest wildlife conservation organization with more than one million members and supporters who support our mission of protecting the lands, waters and climate that species need to survive. We support restoration efforts to ensure the protection, recovery, and conservation of natural habitats for a wide range of native species to support the long term viability of these species on the Kaibab Plateau and Grand Canyon bioregion. We support carefully planned efforts to restore habitats, reduce the threat of habitat loss from uncharacteristic fires, and protect critical infrastructure from such fires. We consider this project to be potentially beneficial to native wildlife and ecosystems insofar as it is based upon the science-based considerations and recommendations that we present here.

The Center has long worked to protect and restore the old growth forests and woodlands that so define the Kaibab Plateau and set the Plateau apart from so much of the southwest where most old growth forest has already been virtually entirely destroyed. Among other things, our staff participated in the Kaibab Forest Health Focus ("KFHF") meetings that gave rise to this project, as well as appealing past "restoration" projects that resulted in widespread logging of old growth ponderosa pine and degradation of northern goshawk habitat. We are pleased to see the proposed action appears to be a "fire-centric" approach to restoration of a variety of vegetation types, and we support the use of fire as the primary management tool to achieve forest resiliency in the face of climate change. However, we have a number of concerns based on the recent history of old growth and large tree logging on the Kaibab Plateau promulgated in the name of forest restoration, and we wish to impart a serious consideration of the risks of pursuing an aggressive landscape scale fire-based restoration project without meaningful public participation, substantial analysis, and strategic planning. First and foremost, we appreciate the up-front intent to proceed with "non-commercial" mechanical treatments, but this term needs to be defined clearly and unambiguously. Justifying old and large tree removal as a non-commercial action because there is no payment changing hands would be disingenuous and inflame stakeholder angst surrounding the history of old growth logging on the Kaibab Plateau. The definition of this term should be shaped by stakeholders and not defined in such a way as to permit unlimited flexibility to pursue agency agendas under the guise of restoration.

These comments provide scientific, legal, and historical justification for our primary requests for the KPERP project moving forward:

• KPERP requires a full EIS with range of alternatives for comparison
• KPERP would benefit greatly from an inclusive collaborative process
• Non-commercial mechanical and fire treatments should be implemented within an optimized treatment design, which we propose as a *Strategic Treatments for Fire Use Alternative*, for consideration and analysis as a reasonable alternative within the EIS
• Old and large trees must be preserved without exception in all wooded vegetation communities
• Desired conditions must be tailored to the Kaibab Plateaus unique ecological characteristics
• The Burnt Corral proposed action and analysis should be abandoned and folded into KPERP and the plateau-wide strategic treatments analysis and modelling
• Livestock grazing on the KPERP area should be retired forever to ensure restoration success and progress towards desired conditions

**Project requires an EIS and meaningful stakeholder collaboration**

NEPA is designed to foster informed and transparent decision-making.[1,2] It requires federal agencies to "[e]*ncourage and facilitate public involvement in decisions which affect the quality of the human environment*,"[3] and to use high quality information because "[a]*ccurate scientific analysis…and public scrutiny are essential to implementing NEPA*."[4] To these ends, courts have held that environmental review documents must be written in plain, clear language and "*supported by evidence that the agency has made the necessary environmental analyses*."[5]

In your cover letter sent along with the proposed action, you state that you "*do not anticipate providing an additional opportunity to submit written comments other than during this comment period*." We interpret that to mean that your next step after reviewing comments solicited during this scoping period will be to issue a Decision. Is this correct, that you do not intend to even prepare a draft EA for this treatment of 511,000 acres? If so, that is an unprecedented move that seems to intentionally shut out public comment and review, and foreclose on the benefits of shaping the project to meet the expectations of the public and stakeholders with decades of experience working on this landscape, this author included. More so, such an approach short-

[1] 40 C.F.R.. § 1500.1
[2] See also: *Robertson v. Methow Valley Citizens Council*, 490 U.S. 322, 349 (1989)
[3] 40 C.F.R.. § 1500.2(d)
[4] 40 C.F.R.. § 1500.1(b)
[5] See, e.g., *Earth Island Inst. v. U.S. Forest Service*, 442 F.3d 1147, 1160 (9th Cir. 2006)

changes the potential contributions that could be made by interested Native American tribes who have called this landscape home for thousands of years. The level of involvement and leadership by Native American tribes in the effort to create a new Grand Canyon Heritage National Monument encompassing the KPERP landscape should be reason enough to seek to actively engage this critical partner in landscape restoration. The Center already feels shut out of this process and limiting public involvement to one comment period and a few token meetings does little to garner a sense of inclusion that should be the cornerstone of such a high-profile landscape scale project. Agencies must take a "*hard look*" at the environmental consequences of their actions before these actions occur[6]; and agencies must make the relevant information available to the public so that it may also play a role in both the decision-making process and the implementation of that decision.[7] A collaborative and inclusive process open to conservation organizations, academics, partner agencies, Native American tribes, and interested citizens will yield a more durable and successful project for years to come.

NEPA outlines several requirements, including a purpose and need statement to provide the guideposts for the analysis of the proposed action, alternatives, and environmental effects.[8] NEPA also requires federal agencies to "*study, develop, and describe appropriate alternatives to recommend courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources.*"[9] This includes preparation of an environmental impact statement (EIS) for all "*major Federal actions significantly affecting the quality of the human environment*."[10]

Contrary to the apparent direction this project is currently taking, the Center believes that this project should proceed in a formal collaborative setting and result in an EIS -- both of which are absolutely required for a project of this scale and scope encompassing such valued public lands. A reasonable range of alternatives need to be developed that address the ecological concerns, economic constraints, and effects uncertainties that are inherent with a project of such immense geographic breadth and with such potential for cumulative effects. The statement in the cover letter that you "*do not anticipate development of any alternatives to the proposed action*" shortcuts the value of the public NEPA process, and potentially limits the acceptance of the project by key stakeholders. The Center requests that you decide early-on that a collaboratively driven EIS be your objective in analyzing this major federal action.

To accomplish NEPA's purposes, all agencies of the federal government must prepare a "*detailed statement*" that discusses the environmental impacts of, and reasonable alternatives to, all "*major Federal actions significantly affecting the quality of the human environment*."[11] This

[6] *Natural Resources Defense Council v. Morton*, 458 F.2d 827, 838 (D.C. Cir. 1972).
[7] *See* 40 C.F.R. § 1500.1.
[8] 40 C.F.R.. § 1502.13
[9] 42 U.S.C. § 4332(2)(E)
[10] 42 U.S.C. § 4332(2)(C)
[11] 42 U.S.C. § 4332(2)(C).

statement is commonly known as an environmental impact statement ("EIS").[12] "*NEPA requires that a federal agency consider every significant aspect of the environmental impact of a proposed action and inform the public that it has indeed considered environmental concerns in its decision making process*."[13] "*Significantly* as used in NEPA requires considerations of both context and intensity."[14]

The factors that should be considered in evaluating intensity[15], and the Centers appeal for consideration of such factors (*italics*), are:

1. Impacts that may be both beneficial and adverse. A significant effect may exist even if the Federal agency believes that on balance the effect will be beneficial.

   • *The geographic and temporal scale of this project is immense and will have both beneficial and adverse effects.*

2. The degree to which the proposed action affects public health or safety.

   • *The implementation of 20,000-50,000 acres of burning annually poses tremendous public health and safety risks and demands an intelligent and strategic plan for safely and effectively accomplishing objectives.*

3. Unique characteristics of the geographic area such as proximity to historic or cultural resources, park lands, prime farmlands, wetlands, wild and scenic rivers, or ecologically critical areas.

   • *At minimum, the proximity to Grand Canyon National Park, Marble Canyon ACEC, Kanab Creek, Paria Canyon-Vermillion Cliffs and Saddle Mountain Wilderness Areas, Vermillion Cliffs National Monument, Grand Canyon-Parashant National Monument, Grand Staircase-Escalante National Monument, Kaibab Squirrel National Natural Landmark, the historic Grand Canyon Game Preserve, Pipe Springs National Monument, The Kaibab-Paiute and Navajo Indian Reservations, Glen Canyon National Recreation Area, the historic Kane and Two-Mile Ranches, the concentration of northern goshawk territories, the abundance of relict old growth forest, and cultural significance for Native American, Mormon, Hispanic, and Anglo communities sets this project area apart from much of this Nation in its ecological, cultural, and historical significance*.

4. The degree to which the effects on the quality of the human environment are likely to be highly controversial.

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[12] *See* 40 C.F.R. Part 1502.
[13] *Pit River Tribe v. U.S. Forest Serv.*, 469 F.3d 768, 781 (9th Cir. 2006).
[14] 40 C.F.R. § 1508.27(b).
[15] 40 C.F.R. § 1508.27.

*• The geographic and temporal scope of this project, encompassing a publicly owned ecosystem of tremendous diversity and history, and the ongoing logging of old growth forest under the guise of restoration, supports our position that substantial controversy is likely to exist surrounding any landscape-scale vegetation management project on the North Kaibab Ranger District.*

5. The degree to which the action may establish a precedent for future actions with significant effects or represents a decision in principle about a future consideration.

   *• We are aware of no other project in the Southwest where over a half-million acres were slated for mechanical and fire treatments that has not been analyzed in an EIS. Thus, to proceed with only an EA would establish a precedent of overgeneralization and under-consideration of a suite of relevant cultural and ecological effects.*

6. Whether the action is related to other actions with individually insignificant but cumulatively significant impacts. Significance exists if it is reasonable to anticipate a cumulatively significant impact on the environment. Significance cannot be avoided by terming an action temporary or by breaking it down into small component parts.

   *• Significant cumulative effects are reasonably predictable in combination with ongoing fire management activities in the adjacent Grand Canyon National Park, the proposed vegetation management actions in the Burnt Corral analysis area, livestock, vegetation, and wildlife management activities on adjacent Bureau of Land Management areas (including the Shuttleworth-Suicide Habitat Management Project, the House Rock Valley Bison Management Project, and others), and continued implementation of previously decided vegetation management including but not limited to the Jacob-Ryan project. Landscape-scale fire and vegetation management, as proposed, must incorporate all of these actions into a comprehensive analysis.*

7. The degree to which the action may adversely affect districts, sites, highways, structures, or objects listed in or eligible for listing in the National Register of Historic Places or may cause loss or destruction of significant scientific, cultural or historical resources.

   *• At least twelve places listed on the National Register of Historic Places are within the perimeter of the KPERP project area[16], any and all of which may be affected by possible escape of managed or prescribed fire.*

8. The degree to which the action may adversely affect an endangered or threatened species or its habitat that has been determined to be critical under the Endangered Species Act of 1973.

[16] https://www.nps.gov/maps/full.html?mapId=7ad17cc9-b808-4ff8-a2f9-a99909164466 accessed on 11/3/2018

> • *Virtually the entire forested portion of the Kaibab Plateau has been designated as Critical Habitat for the Mexican Spotted Owl, which may be adversely affected by mechanical thinning and/or fire operations implemented under the proposed action. Additionally, there is a risk that managed or prescribed fires may escape and adversely affect the Fickeisen plains cactus and it's Critical Habitat in House Rock Valley*.

The proposed action cites the Western Governors' National Forest and Rangeland Management Initiative Special Report as a guiding document. This document repeatedly identifies collaboration as a keystone part of successful restoration projects, specifically that "*Solutions born from bipartisan cooperation among diverse interests always yield the most durable returns*." We hope that you will consider the long-term investment of project stakeholders in this landscape as suitable justification for meaningful collaborative project design and implementation. If funding is your concern, we suggest seeking partnership with the National Forest Foundation, as this project is of national environmental and cultural significance due to the unique nature and global ecological significance of the Kaibab Plateau and greater Grand Canyon ecosystem.

**Best available science and project purpose and need**

The proposed action document establishes these purposes for the project:

- Reduce the threat of uncharacteristic high-intensity wildfire
- Restore the structure, species composition, and function of ecosystems
- Increase resiliency and overall health of vegetation and watersheds
- Address the longer term need to restore low-intensity wildfire to the fire-adapted ecosystems of the Kaibab Plateau

These purposes are sufficiently broad to demand a dramatic expansion of the proposed actions to be undertaken if these desired outcomes are to be accomplished. A comprehensive restoration plan that includes removal of domestic livestock, reduction in road density, protection of old growth forest and woodland, treatment of invasive plants, and strategies for using naturally occurring fires for resource benefit, is needed to address the stated purposes.

Federal law ensures that all agencies shall "*initiate and utilize ecological information in the planning and development of resource-oriented projects*."[17] *NEPA procedures must insure that environmental information is available to public officials and citizens before decisions are made and before actions are taken. The information must be of high quality. Accurate scientific analysis, expert agency comments, and public scrutiny are essential to implementing NEPA*."[18] The comments here represent a wealth of high quality, scientific analysis, expert agency-

[17] 42 U.S.C. § 4332(H)
[18] 40 C.F.R. § 1500.1(b)

produced reports, and a high level of public scrutiny provided by our organization. As stewards of our public lands, we expect the Kaibab National Forest to utilize the best available science, public participation, and ecological management principles to move the vegetative communities of the project area towards a state of higher ecological integrity and resilience, consistent with law and agency regulation.

**Baseline conditions must be documented in detail**

Conditions that underlay the need for ecological restoration in the project area result from high-grade logging, fire suppression, livestock grazing,[19] encroachment of human civilization into fire-adapted ecosystems,[20] and effects of climate change to fire regime.[21] A proactive landscape-scale restoration approach must deal with fundamental ecological problems. This project does not stand alone, as many past and foreseeable actions, including unplanned fire events, affect potential fire behavior effects in the project area. The analysis should consider these factors in the discussion of the affected environment and effects of the action.

It is unclear to us as we read the proposed action whether the Forest Service fully recognizes certain past land uses (other than fire suppression) as the primary drivers of habitat loss, erosion, diminished ecosystem productivity, loss of biodiversity, uncharacteristic fire behavior/severity, invasive weed spread, and simplified forest composition, structure and function. These past land uses include livestock grazing, chaining/other aggressive woodland treatments, unregulated firewood cutting, livestock grazing infrastructure, predator-removal, old growth logging, Integrated Stand Management, road building, and other heavy-handed vegetation management practices. The time is now for the Forest Service to reverse course on these antiquated and failed practices and take a holistic and low-impact approach to habitat and ecosystem restoration.

The Forest Service must accurately describe the baseline conditions in the project area. "*In analyzing the affected environment, NEPA requires the agency to set forth the baseline conditions.*"[22] "*The concept of a baseline against which to compare predictions of the effects of the proposed action and reasonable alternatives is critical to the NEPA process…Once a project begins, the pre-project environment becomes a thing of the past and evaluation of the project's effect becomes simply impossible.*"[23] *"[W]ithout [baseline] data, an agency cannot carefully*

[19] Covington, W.W., and M.M. Moore. 1994. Southwestern ponderosa forest structure: Changes since Euro-American settlement. *Journal of Forestry* 92: 39-47.
[20] Radeloff, V.C., R.B Hammer, S.I. Stewart, J.S. Fried, S.S. Holcomb, and J.F. McKeefry. 2005. The wildland-urban interface in the United States. *Ecological Applications* 15: 799-805.
[21] Flannigan, M.D., B.J. Stocks, and B.M. Wotton. 2000. Climate change and forest fires. *The Science of the Total Environment* 262: 221-29.
[22] Western Watersheds Project v. Forest Service, 552 F.Supp.2d 1113, 1126 (D. Nev. 2008)
[23] Northern Plains v. Surf. Transp. Brd., 668 F.3d 1067, 1083 (9th Cir. 2011)

*consider information about significant environment impacts. Thus, the agency fails to consider an important aspect of the problem, resulting in an arbitrary and capricious decision.*"[24]

Important baseline information needed to make an informed decision includes:

- Historic climax plant communities and reasons for their decline
- Current location and extent of all old growth forest and woodland
- Location and condition of northern goshawk and Mexican spotted owl habitats
- Ecological Site Description, soils, and associated potential vegetation types
- Occupied and potential habitat for sagebrush-obligate species
- Soils with potential to develop biological soil crust cover of at least 20%
- Current cover of biological soil crust (distinguishing light cyanobacteria, dark cyanobacteria, moss, and lichen)
- Current size and density distributions of major tree species
- Size/density/species of sagebrush present
- Exotic and invasive species presence and factors leading to current conditions
- Current authorized system roads and user-created motorized vehicle routes
- Sources of water for wildlife by season of use in the proposed treatment area
- Fences and water transport, storage, and intensity of use within and near the proposed treatment areas
- Incised channels, areas of severe erosion, and soils with severe erosion hazard

[*Note*: These data should be summarized and mapped in the EIS for the average reader, but the underlying data will need to be publicly available for independent data analysis by interested stakeholders.]

NEPA also requires federal agencies to take a "*hard look*" at the environmental consequences of proposed actions, including their direct, indirect, and cumulative effects.[25,26] The Forest Service must consider all direct, indirect, and cumulative environmental impacts of the proposed action, including the interactions between livestock grazing and vegetation or habitat management.[27] Direct effects are caused by the action and occur at the same time and place as the proposed project.[28] Indirect effects are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable.[29] Both types of impacts include "*effects on natural resources and on the components, structures, and functioning of affected ecosystems*," as well as "*aesthetic, historic, cultural, economic, social or health [effects].*"[30] For example, if herbicides may be used for fuel or invasive grass/forb treatment under the proposed action, then the Forest

[24] *Ibis* at 10850
[25] Robertson v. Methow Valley Citizens Council, 490 U.S. 332, 348 (1989)
[26] 42 U.S.C. § 4332(2)(C); 40 C.F.R.. §§ 1502.16, 1508.7, 1508.8
[27] 40 C.F.R. §§ 1502.16, 1508.8, 1508.25(c)
[28] 40 C.F.R. § 1508.8(a)
[29] 40 C.F.R. § 1508.8(b)
[30] *Ibid*

Service must consider all direct, indirect, and cumulative impacts of such herbicide use on the environment including on water and air quality and impacts to native species and downstream communities.

Identification of cumulative impacts must be robust. The NEPA obligation to consider cumulative impacts extends to all "*past*," "*present*," and "*reasonably foreseeable*" future projects.[31] Past cumulative effects analyses have violated NEPA because they failed to provide "*adequate data of the time, place, and scale*" and did not explain in detail "*how different project plans and harvest methods affected the environment*."[32] When considering the effects of past actions as part of a cumulative effects analysis, the Responsible Official must analyze the effects in accordance with 40 CFR 1508.7 and in accordance with relevant guidance issued by the Council on Environmental Quality.[33] Past effects should include livestock grazing, fire suppression, chaining and herbicide use, past logging practices, road network, and other past and ongoing vegetation treatments.

The Forest Service must evaluate all potential impacts to native wildlife and plants whether detrimental or beneficial. The EIS should establish a robust monitoring and adaptive management framework to better understand the impacts of treatments to wildlife as these effects are largely unknown for many species. Significant cumulative effects to numerous environmental resources may result from the proposed action in combination with past, ongoing and foreseeable management activities within and in close proximity to the project area. The Forest Service is required to take a hard look at such impacts rather than merely list potential causes or mention that some risk may result from a catalogue of activities.

**The *Strategic Treatments for Fire Use Alternative* framework**

The origin of the contemporary health crisis affecting Southwestern forests such as the North Kaibab Ranger District lies squarely on past attempts to bring order to wild, natural ecosystems. Fire suppression, old-growth liquidation, excessive livestock grazing, and application of silvicultural systems designed to maximize sawtimber production are primary factors that led to degraded forest health, diminished ecological integrity, and reduced resilience to climate change and other perturbations. Recognizing the need for comprehensive ecological restoration of degraded fire-adapted forests, watersheds, and endangered species habitats, a diverse group of stakeholders united in search of solutions, in what later became the Four Forest Restoration Initiative ("4FRI"). Many of the 4FRI Stakeholders are the same entities and individuals who

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[31] Oregon Natural Resources Council Fund v. Brong, 492 F.3d 1120, 1133 (9th Cir. 2007); Lands Council v. Powell, 395 F.3d 1019, 1028 (9th Cir.2005)

[32] *Ibid*

[33] 43 C.F.R. § 46.115; and see "The Council on Environmental Quality Guidance Memorandum on Consideration of Past Actions in Cumulative Effects Analysis" dated June 24, 2005, or any superseding Council on Environmental Quality guidance.

consider themselves stakeholders in the KPERP project. The Centers positions and interests as they relate to KPERP are consistent with our history as a key member of 4FRI.

As a founding member of 4FRI, the Center has been at the philosophical forefront of forest restoration activities in the southwest for decades. The Center believes that 4FRI, and many of the Forest Service's recent actions relating to forest restoration planning, are now moving in the wrong direction, with excessive emphasis on structural manipulation and insufficient attention to fire-driven ecological processes. As an example, the Apache-Sitgreaves National Forest has recently ramped up old growth logging to a level not seen in 25 years because of perceived threats to forest sustainability due to dwarf mistletoe. Another example is the recently abandoned effort to increase the intensity of thinning treatments in 4FRI under the guise of "Extended Duration Restoration". We are pleased to see the KPERP does not thus far seem to continue this unfortunate trajectory of misguided decision making.

In response to the pattern of drifting away from core restoration principles, the Center has prepared the *Strategic Treatments for Fire Use Alternative* as a change of course to accomplish 4FRI's goals in a more effective and efficient manner, and we are now requesting that this model is incorporated into the KPERP EIS as well, including the entire Burnt Corral project area which should be included entirely in the KPERP. Fundamental to nearly all guiding forest restoration documents (including the 4FRI project record) is the need for strategically prioritizing and placing mechanical thinning treatments that facilitate safe application of prescribed and wildland fire. This need is consistent throughout the entire history and evolution of southwestern and national level forest restoration literature.

At the core of the *Strategic Treatments for Fire Use Alternative* is our position that the current direction in planning, analysis and implementation of southwestern forest restoration is overly reliant on meeting structural and compositional targets, representing what is in effect a non-viable silvicultural solution to a complex ecological problem. The quest to create the ideal vegetative state across every operable acre has marginalized the overriding importance of fire-driven ecological processes. The Center rejects a framework which assumes that complex ecosystems can be wrangled into fixed proportions of tree ages and sizes that must be repeatedly tinkered with at 30-year rotations to maintain "desired conditions." In areas where strategically located mechanical intervention is implemented, fire alone can and should be the primary future maintenance tool.[34] Measuring the health of the forest on the basis of density-metrics represents a worn-out allegiance to a past industrial paradigm. This regulated-forest model defines successful restoration as growing large, defect-free trees as quickly as possible and ignores the complexity of process-centered ecosystem function. Restoring a forest is not an exercise in

[34] North, M., B.M. Collins, and S. Stephens. 2012. Using Fire to Increase the Scale, Benefits, and Future Maintenance of Fuels Treatments. *Journal of Forestry* 110(7): 392-401.
Reinhardt, E.D., R.E. Keane, D.E. Calkin, and J.D. Cohen. 2008. Objectives and considerations for wildland fuel treatment in forested ecosystems of the interior western United States. *Forest Ecology and Management* 256:1997-2006.

manipulating every quantifiable metric into a neat category, or alleviating any form of stress that might lead to unexpected mortality. Renowned fire ecologist Dr. Pete Fulé stated that "*The fire-related adaptations of pine forests are associated with fire's role as a selective force going far back in evolutionary time,*"[35] suggesting that restoration of fire adapted dry forests is inseparable from the influence of recurrent fire as a primary selective force. Applying a new form of growth and density regulation, as articulated in GTR-310[36], cannot by itself accomplish restoration at meaningful landscape scale; only the additive effects of frequent fire can fully restore these ecosystems. We are hopeful that because the KPERP is a "non-commercial" project that our vision for strategically designed and implemented small-scale treatments fits well into the Forest Service's proposed action.

USFS research scientists have long worked to develop decision support, risk management, and prioritization tools for use in applications like KPERP. Their work has been fundamental in establishing the science of optimization that is increasingly being explored and implemented in the western United States. Important considerations for utilizing wildland fire use have been identified by fire management professionals[37,38] and agency-developed risk management and decision support systems, such as Fire Effects Planning Framework,[39] provide systematic geospatial techniques for managing fire for resource benefit.

Prominent fire scientists and managers are increasingly calling for strategically placed treatments on portions of the landscape in order to safely facilitate the use of prescribed and managed wildfire to achieve restoration of frequent fire adapted ecosystem processes, composition, and structure. In a sweeping review of federal fire policy, Stephens and others recommended that the number one improvement that could be made in planning and implementing forest and fire management is to "*mandate evaluation of opportunities for ecologically beneficial fire in land management planning*."[40] Forest Service researchers have established that any science-based planning should ask "*Which locations provide the greatest strategic opportunity for fuel treatments that would facilitate attainment of desired conditions*?"[41] The *Strategic Treatments for Fire Use Alternative* asks this important question. One of the Nation's foremost forest restorationists has stated that "*restoration of surface fire in most sites and thinning in strategic sites will increase resistance to severe wildfire at the stand and landscape scales, insect*

[35] p. 528 in Fulé 2008. Does it make sense to restore wildland fire in changing climate? *Restoration Ecology* 16(4): 526-531.

[36] Reynolds *et al.* 2013. Restoring composition and structure in Southwestern frequent-fire forests: A science-based framework for improving ecosystem resiliency. RMRS-GTR-310.

[37] Black *et al.* 2008. Wildland Fire Use Barriers and Facilitators. *Fire Management Today* 68(1): 10-14.

[38] Doane, D., J. O'Laughlin, P. Morgan, and C. Miller. 2006. Barriers to wildland fire use: A preliminary problem analysis. *International Journal of Wilderness* 12(1): 36-38.

[39] Black and Opperman 2005. Fire Effects Planning Framework: a user's guide. RMRS-GTR-163.

[40] p. 4 in Stephens, S.L., B.M. Collins, E. Biber, and P.Z. Fule. 2016. U.S. federal fire and forest policy: emphasizing resilience in dry forests. *Ecosphere* 7(11): 1-19.

[41] Peterson and Johnson 2007. Science-based strategic planning for hazardous fuel treatments. *Fire Management Today* 67(3): 13-18.

*pathogens, and invasive non-native species.*"[42] The Center agrees with that assertion and believes that the Forest Service should approach the KPERP analysis within such a framework, wherein project objectives relax the focus on strict structural parameters and instead utilize cost-effective means that emphasize fire-based ecological process to establish landscape mosaics and maintain ecological integrity. If this is indeed your objective, please state that clearly and convincingly in future documents.

Ager and colleagues stated in a 2013 article that "*Meeting the long-term goals of dry forest restoration will require dramatic increases in prescribed and managed fire that burn under conditions that pose minimal ecological and social risk. Optimization models can facilitate the attainment of these goals by prioritizing management activities and identifying investment tradeoffs.*"[43] That 2013 work, located in ponderosa pine forests on the Deschutes National Forest in Oregon, studied an optimization model "…*to locate project areas to most efficiently reduce potential wildfire loss of fire resilient old growth ponderosa pine while creating contiguous areas within which prescribed and managed fire can be effectively used...*"[44] The complex modelling and algorithms used by the researchers ultimately identified locations where strategically deployed mechanical treatments would reduce flame length and thus save old growth ponderosa pine while killing small diameter ladder fuels.

One common fundamental similarity between all optimization models is that they seek to reduce fire-severity or minimize wildfire risk, balancing tradeoffs between the size of treatment units, the placement of treatments, and the proportion of the landscape treated.[45,46,47] Collins and colleagues[48] also reviewed fuel treatment strategies, including much of Finney and Ager's work, and arrived at some basic parameters for optimizing fuel reduction treatments at the landscape scale that provide some guidance for those evaluating tradeoffs and can be used as guidelines in the *Strategic Treatments for Fire Use Alternative*:

> • Treating 10% of the landscape provides notable reductions in modeled fire size, flame length, and spread rate across the landscape relative to untreated scenarios, but treating 20% provides the most consistent reductions in modeled fire size and behavior across multiple landscapes and scenarios.

[42] p. 529 in Fule, P.Z. 2008. Does it make sense to restore wildland fire in changing climate? *Restoration Ecology* 16(4):526-531.

[43] p. 11 in Ager, A.A., N.M. Vaillant, and A. McMahan. 2013. Restoration of fire in managed forests: a model to prioritize landscapes and analyze tradeoffs. *Ecosphere* 4(2): 1-19.

[44] p. 3 in Ager *et al.* 2013

[45] Collins *et al.* 2010. Challenges and approaches in planning fuel treatments across fire-excluded forested landscapes. *Journal of Forestry* Jan/Feb 2010: 24-31.

[46] Chung 2015. Optimizing fuel treatments to reduce wildland fire risk. *Current Forestry Reports* 1: 44-51.

[47] Krofcheck, D.J., M.D. Hurteau, R.M. Scheller, and E.L. Loudermilk. 2017a. Prioritizing forest fuels treatments based on the probability of high-severity fire restores adaptive capacity in Sierran forests. *Global Change Biology DOI: 10.1111/gcb.13913.*

[48] Collins *et al.* 2010

• Increasing the proportion of area treated generally resulted in further reduction in fire size and behavior, however, the rate of reduction diminishes more rapidly beyond 20% of the landscape treated.

• Random placement of treatments requires substantially greater proportions of the landscape treated compared with optimized or regular treatment placement.

• The improvements offered by optimized treatments are reduced when 40-50% of the landscape is unavailable for treatment due to land management constraints.

• Treatment rates beyond 2% of the landscape per year yield little added benefit.

The EIS should identify strategic treatment priorities incorporating new scientific information relevant to landscape-scale restoration within the KPERP landscape. These include:

(1) Strategically placed treatments to support fire use in the long-term, utilizing anchor points such as natural fuel breaks, previously treated or burned areas, roads, and waterways

(2) Reasons why the location, timing and intensity of proposed mechanical actions will support a coherent restoration strategy

(3) Landscape scale assessment of opportunities to manage unplanned natural ignitions for resource benefits

(4) An analysis of fire-risk at multiple spatial scales using broader criteria[49]

(a) surface fuel density and arrangement
(b) canopy base height
(c) crown bulk density
(d) local topography
(e) prevailing weather patterns

Without active fuels management and fire use for resource benefits on relatively short rotations compared to the era of total fire suppression, the Forest Service generally manages landscapes for large-scale, high-intensity fires that outrun suppression resources in extreme weather and create unnecessary management expense and unacceptable risks to human life and resource values. We appreciate that the KPERP intends to use prescribed fires to accomplish a range of objectives. In addition, we urge the Forest Service to the design the project to promote use of

[49] These criteria have long-been identified as fundamental factors in effective fire and fuels-management planning, for example see:

Agee, J.K., and C.N. Skinner. 2005. Basic principles of forest fuel reduction treatments. *Forest Ecology and Management* 211(1): 83-96.

Reinhardt, E. D., R.E. Keane, D. E. Calkin, and J. D. Cohen. 2008. Objectives and considerations for wildland fuel treatment in forested ecosystems of the interior western United States. *Forest Ecology and Management* 256:1997-2006.

unplanned wildland fires while providing for public safety. The EIS should provide meaningful analysis of how, where, and when unplanned ignitions could be used to accomplish resource management objectives, and what the range of effects of fire-use could be. Adverse effects of fire control practices to the environment[50] should be analyzed and disclosed where proposed treatments are designed to increase the effectiveness of fire suppression.

Ultimately, forest structure and fire regime must be restored in an integrated way.[51] In ponderosa pine forest and mixed-conifer forest, this means emphasizing landscape-scale use of wildland fire as the primary self-sustaining disturbance process that will naturally promote ecosystem adaptation and resilience—and then scaling down to coordinated project-level actions including fuel treatments that accomplish landscape-level objectives.[52] The project analysis should demonstrate that the proposed action fits into the coordinated management strategy possible through the *Strategic Treatments for Fire Use Alternative* that moves towards allowing natural ignition fires to burn.

Considering the fire modeling that we assume is already underway by the Forest Service for the KPERP landscape, and the key takeaways reviewed here, the Center believes that a modified version of the methodology developed by the Hurteau lab and used by Krofcheck and colleagues[53,54] is completely appropriate for the KPERP analysis. Their research[55] has developed "*prioritization strategies for implementing fuel treatments… with the goal to maximize treatment efficacy using optimal placement and prescription options under typical and extreme fire weather conditions*."[56] Their optimization model, which mechanically treats only the operable areas with a high probability of mixed- and high-severity fire, was shown in multiple fire simulations to be as effective as thinning all operable acres at reducing wildfire burn severity and facilitating landscape scale low-severity fire restoration. This approach could inform landscape-scale restoration planning nationwide, as "*Testing of strategic placement of treatments by resource managers will add data in the years ahead and provide information that can be shared and applied in other locations*."[57] The authors summarize their methods here:

> "*We developed three scenarios: no-management, naive placement, and optimized placement. Both management scenarios employed combinations of mechanical*

[50] Backer, D.M, S.A. Jensen, and G.R. McPherson. 2004. Impacts of fire suppression activities on natural communities. *Conservation Biology* 18: 937-46.

[51] DellaSala, D.A., J.E. Williams, C.D. Williams and J.F. Franklin. 2004. Beyond smoke and mirrors: a synthesis of fire policy and science. *Conservation Biology* 18: 976-86.

[52] Peterson, D.L. and M.C. Johnson. 2007. Science-based strategic planning for hazardous fuel treatment. *Fire Management Today* 67(3):13-18.

[53] Krofcheck *et al*. 2017a.

[54] Krofcheck, D.J., M.D. Hurteau, R.M. Scheller, and E.L. Loudermilk. 2017. Restoring surface fire stabilizes forest carbon under extreme fire weather in the Sierra Nevada. *Ecosphere* 8(1): 1-18.

[55] Krofcheck *et al*. 2017a; Krofcheck *et al*. 2017b.

[56] http://www.hurteaulab.org/

[57] p. 15 in Peterson, D. L. and M.C. Johnson. 2007. Science-based strategic planning for hazardous fuel treatment. *Fire Management Today* 67(3):13-18.

> *thinning and prescribed burning. The naive placement scenario aimed to simulate mechanical thinning from below and prescribed fire to all forest types that have experienced a fuels load departure from their historic condition due to fire exclusion. Within each forest type that received mechanical thinning, thinning was constrained based on operational limits (slope>30%, which totaled 22,436 ha available for mechanical thinning). The optimized placement scenario further constrained the area that received mechanical thinning by limiting thinning to areas that also had a high probability of mixed- and high-severity wildfire…In both treatment scenarios, stands identified for mechanical treatment were thinned from below, removing roughly one-third of the live tree biomass over the first decade of the simulation. Stands selected for mechanical thinning were only thinned once in the simulations, and all thinning was completed within the first decade*."[58]

Their results suggested that thinning the most optimum 33% of the operable acres could achieve the same effect as thinning all operable acres. The study was simulated in the Sierra Nevada of California, but the authors asserted that their approach was *"broadly applicable to historically frequent-fire ecosystems, or systems which have transitioned away from a low severity and fuel limited fire regime to one characterized by high-severity fires*."[59] The authors have recently completed similar optimization simulations in the Santa Fe Fireshed, which is likely to provide additional direction for utilizing such an approach in Southwestern ponderosa pine and mixed conifer forests (findings are to be published soon). We strongly believe that it is possible and beneficial to integrate the existing Grand Canyon National Park and Kaibab National Forest fire behavior and risk assessment modelling into an optimization simulation based on that work. We recommend that the Hurteau Lab is contacted immediately to begin dialogue with KPERP Stakeholders as to how an optimization process can incorporate optimized fire modelling to achieve a high level of strategic utility for the benefit of the entire northern greater Grand Canyon ecosystem.

Optimizing spatial prioritization of non-commercial mechanical treatments reflects an evolution of fire management, placing emphasis on restoring fire as a natural process, rather than simply disrupting fire spread and protecting areas from burning.[60] The result of a strategic approach is to move away from managing for short-term outcomes and towards achievement of long-term restoration goals and objectives, consistent with calls from the scientific community to increase the use of prescribed and managed wildfires for resource benefit.[61] In a review of optimization strategies, Collins and colleagues stated that "*The basic idea is that an informed deployment of treatment areas, a deployment that covers only part of the landscape, can modify fire behavior*

[58] p. 2 in Krofcheck *et al*. 2017a
[59] p. 6 in Krofcheck *et al*. 2017a
[60] Ager *et al.* 2013
[61] Stephens *et al.* 2016

*for the entire landscape*."[62] As an example, researchers have observed that thinned stands within the Rodeo-Chediski Fire affected fire behavior in neighboring untreated stands, leading to more complex heterogeneity, reduced fire severity, and increased ponderosa pine regeneration following the fire.[63]

The Center believes that an *informed deployment* of the non-commercial mechanical and fire treatments can more effectively and efficiently restore ponderosa pine and mixed conifer forests of the Rim Country landscape than the current 4FRI direction, and the *Strategic Treatments for Fire Use Alternative* is the way to get there. The NEPA implementing regulations refer to the selection and review of alternatives as "*the heart*" of the environmental review.[64] The National Environmental Policy Act requires the Forest Service to "*study, develop, and describe appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources*."[65] Regulations implementing NEPA require that the agency "[r]*igorously explore and objectively evaluate all reasonable alternatives, and for alternatives which were eliminated from detailed study, briefly discuss the reasons for their having been eliminated*." [66] Even as it considers and analyzes impacts of the proposed action, the Forest Service also must "[r]*igorously explore and objectively evaluate all reasonable alternatives*."[67] The NEPA process must "*identify and assess the reasonable alternatives to proposed actions that will avoid or minimize adverse effects of these actions upon the quality of the human environment*."[68] The analysis of this additional alternative is critical as it ensures that the Forest Service does not "*prematurely foreclose options that might protect, restore, and enhance the environment.*"[69]

**Current policy and guidance calls for strategic treatment implementation**

The dramatic deficit of annual acreage burned in frequent-fire adapted forests has led senior Forest Service scientists to call for increasing the scale and rate of fuels treatments following three key strategies:[70] 1) Increasing the extent of fuel treatments if resources permit; 2) Designing treatments to create conditions conducive to naturally ignited fires burning under desired conditions while fulfilling an ecological role; and 3) Placing treatments to reduce hazard while providing options for firefighting when highly valued resources and assets are present.

[62] p. 25 in Collins *et al.* 2010
[63] Shive, K.L., C.H. Seig, and P.Z. Fule. 2013. Pre-wildfire management treatments interact with fire severity to have lasting effects on post-wildfire vegetation response. *Forest Ecology and Management* 297: 75-83.
[64] 40 C.F.R.. § 1502.14
[65] 42 U.S.C. § 4332(2)(E)
[66] 40 C.F.R.. § 1502.14(a)
[67] *Ibid*
[68] 40 C.F.R. § 1500.2(f)
[69] FSH 1905.15 Ch. 20 § 14
[70] p. 301in Vaillant and Reinhardt 2017. An evaluation of the Forest Service hazardous fuels treatment program—are we treating enough to promote resiliency or reduce hazard? *Journal of Forestry* 115(4): 300-308.

These strategies are becoming widely accepted by fire scientists and managers, but intransigence remains firmly rooted in certain elements of Forest Service culture.[71]

The *Strategic Treatments for Fire Use Alternative* is rooted in these strategies and demonstrative of the approach promoted in the *National Cohesive Wildland Fire Management Strategy* ("National Strategy").

The National Strategy identifies this general guidance for Vegetation and Fuels Management:[72]

> i. **Design and prioritize fuel treatments.** Where wildfires are unwanted or threaten communities and homes, design and prioritize fuel treatments to reduce fire intensity, structure ignition, and wildfire extent.
> ii. **Strategically place fuel treatments.** Where feasible, implement strategically placed fuel treatments to interrupt fire spread across landscapes.
> iii. **Increase the use of wildland fire for meeting resource objectives.** Where allowed and feasible, manage wildfire for resource objectives and ecological purposes to restore and maintain fire-adapted ecosystems and achieve fire-resilient landscapes.
> iv. **Continuing and expanding the use of all methods to improve forest and range resiliency.** Continue and expand the use of prescribed fire to meet landscape objectives, improve ecological conditions, and reduce the potential for high-intensity wildfires. Use and expand fuel treatments involving mechanical, biological, or chemical methods where economically feasible and sustainable, and where they align with landowner objectives.

By focusing limited resources on specific key locations, expanded wildland fire use for resource benefit can be utilized to achieve fuels reduction and ecological restoration objectives. The National Strategy clearly asserts that "*Prescribed fire and managing wildfire for resource objectives have the greatest potential for treating large areas at lower cost than mechanical treatments.*"[73] Researchers have long asserted that "*Prioritizing restoration efforts is essential because resources are limited. An initial focus on areas most likely to provide benefits and that present a low risk of degradation of ecological values will build experience and credibility.*"[74] Prominent fire scientists have recently affirmed that "*Strategically placing fuel treatments to*

[71] Doane *et al.* 2006. Barriers to wildland fire use a preliminary problem analysis. *International Journal of Wilderness* 12(1): 36-38.
North *et al.* 2015b. Reform forest fire management – agency incentives undermine policy effectiveness. *Science* 349(6254): 1280–1281.
Stephens *et al*. 2009. Fire treatment effects on vegetation structure, fuels, and potential fire severity in western U.S. forests. *Ecological Applications* 19(2): 305-320.
[72] pp. 1 and 58 in National Strategy 2014: https://www.forestsandrangelands.gov/strategy/thestrategy.shtml
[73] p. 58 in National Strategy 2014
[74] Brown *et al.* 2004. Forest restoration and fire: principles in the context of place. *Conservation Biology* 18(4): 903-912.

*create conditions where wildland fire can occur without negative consequences and leveraging low-risk opportunities to manage wildland fire will remain critical factors to successful implementation of the* [National] *Strategy*."[75] This approach is further called for in the 2012 Mexican Spotted Owl Recovery Plan, which suggests that restoration projects "*Conduct a landscape-level risk assessment to strategically locate and prioritize mechanical treatment units to mitigate the risk of large wildland fires while minimizing impact to PACs*."[76] The *Strategic Treatments for Fire Use Alternative* considers these fundamental principles, and prioritizes mechanical thinning where it would be most effective to ensure community protection, preserve recreational opportunities, and restore predominantly low-intensity fire regimes where they are appropriate, and facilitate use of mixed severity fire where it is appropriate.

**Forest thinning treatments must focus on small diameter, young-aged ladder fuels**

The intensity of wildland fire behavior and the severity of its physical and biological effects depend, in part, on fuel properties and their spatial arrangement. Fuel bed structure is a key determinant of fire ignition and spread potential and a central consideration in developing an effective management strategy.[77] The bulk density (weight within a given volume) of ground fuels (*e.g.*, grasses, shrubs, litter, duff, and down woody material) influences frontal surface fire behavior (heat output and spread rate) more than fuel loading (weight per unit area).[78,79] In turn, surface fireline intensity dictates the likelihood of tree crown ignition and torching behavior.[80]

The density, composition and structure of intermediate fuel strata consisting of tall shrubs and small trees also affect crown fire ignition potential because they can support surface fireline intensity and serve as "ladders" that facilitate vertical fire spread from the ground surface into overstory tree canopies. The size of the spatial gap in between ground fuel beds and tree canopies strongly influences the crown ignition potential of a surface fire.[81] Van Wagner[82] quantified crown fire ignition rates when surface fires exceed critical fireline intensity relative to

[75] p. 8 in Barnett *et al.* 2016. Beyond fuel treatment effectiveness: characterizing interactions between fire and treatments in the US. *Forests* 7(237): 1-12.

[76] p. 262 in USFWS 2012 Mexican Spotted Owl Recovery Plan, First Revision (*Strix occidentalis lucida*). Southwest Region U.S. Fish and Wildlife Service Albuquerque, New Mexico.

[77] Graham, R.T. (Ed.). 2003. *Hayman Fire Case Study*. USDA For. Serv. Rocky Mtn. Res. Sta. Gen. Tech. Rep. RMRS-GTR-114. Ogden, UT.

[78] Agee, J.K. 1996. The influence of forest structure on fire behavior. Pp. 52-68 in: J.W. Sherlock (chair). *Proc. 17th Forest Vegetation Management Conference.* 1996 Jan. 16-18: Redding, CA. Calif. Dept. Forestry and Fire Protection: Sacramento.

[79] Sandberg, D.V., R.D. Ottmar, and G.H. Cushon. 2001. Characterizing fuels in the 21st century. *International Journal of Wildland Fire* 10: 381-87.

[80] Scott, J.H., and E.D. Reinhardt. 2001. *Assessing Crown Fire Potential by Linking Models of Surface and Crown Fire Behavior*. USDA For. Serv. Rocky Mtn. Res. Sta. Res. Pap. RMRS-RP-29. Fort Collins, CO.

[81] Graham, R.T. (Ed.). 2003. *Hayman Fire Case Study*. USDA For. Serv. Rocky Mtn. Res. Sta. Gen. Tech. Rep. RMRS-GTR-114. Ogden, UT.

[82] Van Wagner, C.E. 1977. Conditions for the start and spread of crown fire. *Canadian Journal of Forest Research* 7: 23-24.

the height of the base of aerial fuels in tree crowns. Torching crowns (*i.e.*, "passive crown fire") can develop into running canopy fires (*i.e.*, "active crown fire" that spreads independent of surface fire behavior) if the spread rate surpasses a crown fuel density threshold that varies with slope angle and wind speed. Predictions about the relationship of forest structure to crown fire hazard depend, in part, on the validity of crown bulk density calculations and estimates.[83] The project analysis should ensure integrity with site-specific information based on field observations.

Active management of the arrangement and density of surface fuels and "ladder fuels" is effective at minimizing potential fire intensity in most circumstances.[84] Some have advocated removing large or dominant trees to reduce crown bulk density and contended that doing so will lessen fire resistance-to-control in extreme weather.[85] However, fire weather can overwhelm any effect of fuel treatments on fire behavior.[86] To accurately assess fuel treatment effects on the likelihood of crown fire initiation and spread, it is necessary to consider: (1) surface fuel density and arrangement; (2) canopy base height; (3) local topography; and (4) weather patterns.[87] The former two factors can be actively managed in conifer forest to significantly decrease the likelihood of crown fire initiation and spread without resort to large tree removal in most cases.[88,89,90,91]

[83] Perry, D.A., H. Jing, A. Youngblood, and D.R. Oetter. 2004. Forest structure and fire susceptibility in volcanic landscapes of the eastern high Cascades, Oregon. *Conservation Biology* 18: 913-26.

[84] Graham, R.T., S. McCaffrey, and T.B. Jain (Tech. Eds.). 2004. *Science Basis for Changing Forest Structure to Modify Wildfire Behavior and Severity*. USDA For. Serv. Rocky Mtn. Res. Sta. Gen. Tech. Rep. RMRS-120. Ft. Collins, CO.

Graham, R.T., A.E. Harvey, T.B. Jain, and J.R. Tonn. 1999. *The Effects of Thinning and Similar Stand Treatments on Fire Behavior in Western Forests.* USDA For. Serv. Pac. Nor. Res. Sta. Gen. Tech. Rep. PNW-GTR-463. Portland, OR.

[85] Abella, S.R., P.Z. Fulé and W.W. Covington. 2006. Diameter caps for thinning southwestern ponderosa pine forests: viewpoints, effects, and tradeoffs. *Journal of Forestry* (December): 407-14.

[86] Pollett, J. and P.N. Omi. 2002. Effect of thinning and prescribed burning on crown fire severity in ponderosa pine forests. *International Journal of Wildland Fire* 11: 1-10.

[87] Hunter, M.E., W.D. Shepperd, J.E. Lentile, J.E. Lundquist, M.G. Andreu, J.L. Butler, and F.W. Smith. 2007. *A Comprehensive Guide to Fuels Treatment Practices for Ponderosa Pine in the Black Hills, Colorado Front Range, and Southwest*. USDA For. Serv. Rocky Mtn. Res. Sta. Gen. Tech. Rep. RMRS-GTR-198. Fort Collins, CO.

[88] Fiedler, C.E., and C.E. Keegan. 2003. Reducing crown fire hazard in fire-adapted forests of New Mexico. Pp. 29-38 in: P.N. Omi and L.A. Joyce (tech. eds.). *Fire, Fuel Treatments, and Ecological Restoration: Conference Proceedings*. 2002 April 16-18: Fort Collins, CO. USDA For. Serv. Rocky Mtn. Res. Sta. Proc. RMRS-P-29. Fort Collins, CO.

[89] Keyes, C.R. and K.L. O'Hara. 2002. Quantifying stand targets for silvicultural prevention of crown fires. *Western Journal of Applied Forestry* 17: 101-09.

[90] Omi, P.N., and E.J. Martinson. 2002. *Effect of Fuels Treatment on Wildfire Severity*. Unpubl. report to Joint Fire Science Program. Fort Collins: Colorado State Univ. Western Forest Fire Research Ctr. March 25. 36 pp.

[91] Perry, D.A., H. Jing, A. Youngblood, and D.R. Oetter. 2004. Forest structure and fire susceptibility in volcanic landscapes of the eastern high Cascades, Oregon. *Conservation Biology* 18: 913-26.

Omi and Martinson[92] measured the effect of fuel treatments on fire severity in highly stratified study areas and reported a strong correlation of crown base height with "stand damage" by fire. Importantly, crown bulk density did not strongly correlate with observed fire effects:

> *"[H]eight to live crown, the variable that determines crown fire initiation rather than propagation, had the strongest correlation to fire severity in the areas we sampled... [W]e also found the more common stand descriptors of stand density and basal area to be important factors. But especially crucial are variables that determine tree resistance to fire damage, such as diameter and height. Thus, "fuel treatments" that reduce basal area or density from above (i.e., removal of the largest stems) will be ineffective within the context of wildfire management"* (Omi and Martinson 2002: 22).

That research was retroactive and the scale of observed fire events confounds replication. However, its observation that large trees promote fire resistance is supported by Forest Service research.[93] A key implication is the importance of treating fuels "from below" in order to prevent widespread occurrence of stand-replacing fires. Keyes and O'Hara (2002: 107) agreed that raising canopy base height is an important factor in reducing fire hazard and noted, "[P]*runing lower dead and live branches* [of large trees] *yields the most direct and effective impact.*" They also noted the incompatibility of open forest conditions created by "heavy" thinning treatments designed to maximize horizontal discontinuity of forest canopies with other management objectives that include conservation of threatened wildlife populations and prevention of rapid understory initiation and ladder fuel development. Understory growth following treatments that create open forest conditions may undermine their long-term effectiveness without commitments to maintenance treatments (*e.g.*, prescribed fire).

Mechanical logging generates large quantities of activity-created slash fuels by relocating tree stems, branches and needles from the overstory canopy to the ground surface.[94] Logging slash produces higher flame lengths and more intense surface fires that can increase the probability of

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[92] Omi, P.N., and E.J. Martinson. 2002. *Effect of Fuels Treatment on Wildfire Severity*. Unpubl. report to Joint Fire Science Program. Fort Collins: Colorado State Univ. Western Forest Fire Research Ctr. March 25. 36 pp.

[93] Arno, S.F. 2000. Fire in western ecosystems. Pp. 97-120 in: J.K. Brown and J.K. Smith (eds.). *Wildland Fire in Ecosystems, Vol. 2: Effects of Fire on Flora*. USDA For. Serv. Gen. Tech. Rep. RMRS-42-vol.2. Ogden, UT.

[94] Graham, R.T. (Ed.). 2003. *Hayman Fire Case Study*. USDA For. Serv. Rocky Mtn. Res. Sta. Gen. Tech. Rep. RMRS-GTR-114. Ogden, UT.

Stephens, S.L. 1998. Evaluation of the effects of silvicultural and fuels treatments on potential fire behavior in Sierra Nevada mixed-conifer forests. *Forest Ecology and Management* 105: 21-35.

van Wagtendonk, J.W. 1996. Use of a deterministic fire growth model to test fuel treatments. Ch. 43 in: *Status of the Sierra Nevada: Sierra Nevada Ecosystem Project, Final Report to Congress, Vol. 1, Assessment Summaries and Management Strategies*. Davis: Univ. Calif. Ctr. for Wildland and Water Resources.

Weatherspoon, C.P. and C.N. Skinner. 1995. An assessment of factors associated with damage to tree crowns from the 1987 wildfires in northern California. *Forest Science* 41: 430-51.

crown fire initiation compared to fuels that pre-exist logging operations.[95] According to the Congressional Research Service:

> "*Timber harvesting removes the relatively large diameter wood that can be converted into wood products, but leaves behind the small material, especially twigs and needles. The concentration of these "fine fuels" on the forest floor increases the rate of spread of wildfires. Thus, one might expect acres burned to be positively correlated with timber harvest volume*."[96]

The proposed action may immediately increase volume of fine surface fuels up to 15 tons per acre, or more depending on pre-treatment forest structure, which will increase fire resistance-to-control and make wildfires more dangerous and severe where activity fuels are not effectively managed. Van Wagtendonk (1996) modeled the effectiveness of low thinning combined with a pile-and-burn slash treatment on flat ground, which yielded nearly identical post-treatment fire behavior as thinning without any slash treatment because pre-existing surface fuels were not significantly reduced. Lop-and-scattering of logging slash "*significantly increased subsequent fire behavior*" (van Wagtendonk 1996: 1160). Activity fuels may persist for decades in xeric forest environments (Stephens and Moghaddas 2005: 377):

> "*In both even aged and un-even aged treatments, it is often assumed that harvest related slash will decompose over time thereby reducing fire hazards. In reality, logging slash may persist for long periods, and therefore, will influence fire hazards for extended periods. Rates of woody fuel decay are highly variable. The rates of decomposition of understory fuels are primarily dependant upon several factors including temperature, soil moisture, insect activity, and material size. Decaying conifer activity fuels have been reported to persist for 30 years in xeric forest environments.*"

Prescribed burning is the only treatment that effectively reduces activity fuels and fire hazard below pre-logging conditions (Stephens 1998, van Wagtendonk 1996). "*Periodic underburns and programs for restoring natural fire are critical to maintain these post-harvest stands*"

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[95] Dodge, M. 1972. Forest fuel accumulation: a growing problem. *Science* 177: 139–42.
Naficy, C., A. Sala, E.G. Keeling, J. Graham and T.H. DeLuca. 2010. Interactive effects of historical logging and fire exclusion on ponderosa pine forest structure in the northern Rockies. *Ecological Applications* 20: 1851-64.
Stephens, S.L. and J.J. Moghaddas. 2005. Silvicultural and reserve impacts on potential fire behavior and forest conservation: Twenty-five years of experience from Sierra Nevada mixed conifer forests. *Biological Conservation* 125: 369-79.
[96] Gorte, R.W. 2000. *Memorandum on Timber Harvesting and Forest Fires*. Congressional Research Service, Library of Congress: Washington, D.C. August 22.

(Pollett and Omi 2002: 9). Burning is uniquely effective because fire consumes the finest and most ignitable activity fuels that pose the greatest hazard.[97]

The Forest Service is required to disclose potentially significant effects of the project on public health and safety, including wildland fire control efforts. It should take a hard look at post-logging fuel profiles and fire hazard at a unit-scale, particularly on steep slopes where prescribed fire may not be used, rather than generalizing them across the project area. Site-specific field data collection and reporting is a fundamental professional standard for fuel management in this project:

> *"Mapping should utilize the best sampling strategies combining remote sensing imagery (perhaps at several scales) and ground truthing. The reliability of existing vegetation maps should be verified before they are incorporated into the database. Fire-relevant attributes of vegetation (including understory composition and structure, and vertical and horizontal continuity) need to be characterized adequately. Similarly, surface fuels should be described, utilizing field-verified vegetation/fuels correlations to the extent feasible. The analysis should disclose how much slash would remain on the ground after logging is completed and take a hard look at the timing, sequence and effectiveness of different activity fuel treatments at sites where mechanical logging is proposed"* (Weatherspoon and Skinner 1996: 1488).

The analysis should disclose how much slash would remain on the ground after non-commercial logging is completed and take a hard look at the timing, sequence and effectiveness of different activity fuel treatments at sites where mechanical logging is proposed.

The direction of potential fire spread (backing, flanking, heading) is an important consideration in treatment design because fire interacts with weather, topography and vegetation to "back" and "flank" around certain conditions, or "head" through others as it spreads. Steep slopes can facilitate wind-driven convection currents that drive radiant heat upward and bring flames nearer to adjacent, unburned vegetation, thus pre-heating fuels and amplifying fire intensity as it spreads upslope.[98] As a result, severe fire effects often are observed to concentrate at upper slope positions and on ridges, whereas such effects are relatively rare on the lee side of slopes that do not directly receive frontal wind.[99] Therefore, fuel treatments should be oriented in concert with prevailing spatial patterns of fire spread in the project area. Overlapping fuel treatments that reduce fuel continuity can fragment extreme fire effects into smaller patches if they disrupt

[97] Deeming, J.E. 1990. Effects of prescribed fire on wildfire occurrence and severity. Pp. 95-104 in: J.D. Walstad, S.R. Radosevich, and D.V. Sandberg (eds.). *Natural and Prescribed Fire in Pacific Northwest Forests*. Corvallis: Oregon State Univ. Press.

[98] Whelan, R.J. 1995. *The Ecology of Fire*. Cambridge Univ. Press: New York.

[99] Finney, M.A. 2001. Design of regular landscape fuel treatment pattern for modifying fire growth and behavior. *Forest Science* 47: 219-28.

heading fire behavior and increase the area burned by flanking and backing fires[100]. Slope aspects facing away from frontal or diurnal winds are a lesser treatment priority because backing fires are the most likely to exhibit mild intensity and effects. The Forest Service should analyze these factors and demonstrate that proposed treatment locations and intensities will meet the purpose and need. The analysis will be most helpful to the decision-maker and the public if it includes detailed study and development of action alternatives that propose different treatment locations and intensities to compare project effects on potential fire behavior and effects under modeled conditions that include extreme and moderate weather scenarios.

An additional approach to the strategic location of fuel treatments is to identify landscape features that are currently resistant to severe fire effects and use them as anchor points for a compartmentalized landscape fire management strategy. Such features may include natural openings, meadows, relatively open ridges, moist riparian areas, mature forest patches with shaded and cool microclimates and little or no history of past logging (*see* Naficy et al. 2010), and areas where fuel treatments already have been completed. Those features can support the strategic use of fire for resource benefits, application of confinement and containment strategies as alternatives to full control of unplanned fires, and provide safe areas for workers to ignite prescribed fires for hazard reduction and ecological process restoration. The analysis should consider such factors.

Finally, in our view, the Forest Service should prioritize fuel treatments at locations where relatively little resource investment may create fire resistant conditions in the shortest amount of time. Targeting initial work in this way will maximize the area treated with available funds and personnel, and provide the greatest opportunity to quickly reduce fuels and restore ecosystem function at larger spatial scales. These factors can all be included in an optimization model.

## Large and old trees must be protected with a clearly-defined and enforced plan

Most old growth forests that historically existed in the Southwestern Region were eliminated by logging.[101] The ecological significance of old growth habitat and large trees that comprise their structure is amply documented[102]. Large tree removal is not necessary or beneficial to restoration of fire-adapted forest ecosystems.[103] Live conifer stems larger than 16-inches diameter are rare at

[100] *Ibid*

[101] Covington, W.W., and M.M. Moore. 1994. Southwestern ponderosa forest structure: Changes since Euro-American settlement. *Journal of Forestry* 92: 39-47.

[102] Friederici, P. (Ed.). 2003. *Ecological Restoration of Southwestern Ponderosa Pine Forests*. Island Press: Washington, DC.

[103] Arno, S.F. 2000. Fire in western ecosystems. Pp. 97-120 in: J.K. Brown and J.K. Smith (eds.). *Wildland Fire in Ecosystems, Vol. 2: Effects of Fire on Flora*. USDA For. Serv. Gen. Tech. Rep. RMRS-42-vol.2. Ogden, UT.

a landscape scale in forests of the Southwestern Region. The Center encourages the Forest Service to study, develop and describe action alternatives in detail that generally retain existing large trees outside of a wildland-urban interface ("WUI") zone that includes forest lands located one-quarter (¼) mile distant from established residential and other essential community infrastructure.

The Forest Service is in possession of the collaboratively-designed Old Growth Protection and Large Tree Retention Strategy ("Strategy") developed by public stakeholders, including the Center, for implementation in 4FRI forest treatment projects. The Strategy is an agreement-based outcome and product developed in recognition that translation of such agreement greatly enhances chances for success, and reduces the risk of conflict. Given the enormous commitment of stakeholder time and energy to collaborative development of the Strategy, as well as its clear relevance and applicability to the KPERP area, it is reasonable to study, develop and describe in detail (rather than mention and dismiss) a stand-alone action alternative based on the entire Strategy as it was originally designed. Implementation of a similar collaboratively designed retention strategy is a reasonable alternative in this project for three reasons. First, it could meet the purpose and need by actively managing hazardous fuels and forest structure.[104] Second, such a strategy strategy avoids significant cumulative impacts that may result from excessive and unnecessary removal of large, fire-resistant trees, which are deficient in the Southwestern Region compared to historic conditions.[105/106/107] Finally, it mitigates adverse effects to threatened and sensitive wildlife species that require closed canopy forest habitat for essential life behaviors. The 4FRI Strategy is attached to these comments. Support for the use of the such a strategy is given in further detail below.

*Large tree retention meets the purpose and need*

Retention of large trees is fundamentally important to fire resistance of treated stands.[108] Large ponderosa pine trees possess autecological characteristics such as relatively thick bark and insulated buds that promote resistance to heat injury. Self-pruning, mature conifers feature high

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Allen, C.D. M.A. Savage, D.A. Falk, K.F. Suckling, T.W. Swetnam, T. Schulke, P.B. Stacey, P. Morgan, M. Hoffman, and J.T. Klingle. 2002. Ecological restoration of southwestern ponderosa pine ecosystems: A broad perspective. *Ecological Applications* 12: 1418-33.

Brown, R.T., J.K. Agee, and J.F. Franklin. 2004. Forest restoration and fire: principles in the context of place. *Conservation Biology* 18: 903-12.

[104] The 4FRI stakeholders expressly developed the Strategy to avoid reliance on strict diameter-limits while addressing the significant issues of old growth protection and large tree retention in ponderosa pine and mixed conifer forest restoration treatments. The Strategy identifies circumstances, ecological objectives and selection criteria for cutting large trees under site-specific conditions.

[105] Covington and Moore 1994

[106] Fulé, P.Z., W.W. Covington, and M.M. Moore. 1997. Determining reference conditions for ecosystem management of Southwestern ponderosa pine forests. *Ecological Applications* 7: 895-908.

[107] USDA 1999, USDA 2007

[108] DellaSala, D.A., J.E. Williams, C.D. Williams and J.F. Franklin. 2004. Beyond smoke and mirrors: a synthesis of fire policy and science. *Conservation Biology* 18: 976-86.

branch structure, which discourage torching behavior.[109] Finally, mature conifers have a high capacity to survive and recover from crown scorch.[110] Thus, large tree structure enhances forest resilience to severe fire effects[111,112,113] whereas removing them may undermine fire resilience.[114,115]

Research demonstrates no advantage in fire hazard mitigation resulting from mechanical forest treatments that remove large trees compared to treatments that retain them. Modeled treatments that removed only trees smaller than 16-inches diameter were marginally more effective at reducing long-term fire hazard than so-called "comprehensive" treatments that removed trees in all size classes.[116] Thinning small trees and pruning branches of large trees to increase canopy base height significantly decreases the likelihood of crown fire initiation,[117,118,119,120] which is a precondition to active crown fire behavior.[121,122] Therefore, low thinning and underburning to reduce surface fuels and increase canopy base height at strategic locations effectively reduces fire hazard at a landscape scale and meets the purpose and need.

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[109] Keeley, J.E. and P.H. Zedler. 1998. Evolution of life histories in *Pinus*. Pp. 219-250 in: D.M. Richardson (ed.). *Ecology and Biogeography of* Pinus. Univ. Cambridge: U.K.

[110] McCune, Bruce. "Ecological diversity in North American pines." American Journal of Botany (1988): 353-368.

[111] Arno, S.F. 2000. Fire in western ecosystems. Pp. 97-120 in: J.K. Brown and J.K. Smith (eds.). *Wildland Fire in Ecosystems, Vol. 2: Effects of Fire on Flora*. USDA For. Serv. Gen. Tech. Rep. RMRS-42-vol.2. Ogden, UT.

[112] Omi, P.N., and E.J. Martinson. 2002. *Effect of Fuels Treatment on Wildfire Severity*. Unpubl. report to Joint Fire Science Program. Fort Collins: Colorado State Univ. Western Forest Fire Research Ctr. March 25. 36 pp.

[113] Pollett, J. and P.N. Omi. 2002. Effect of thinning and prescribed burning on crown fire severity in ponderosa pine forests. *International Journal of Wildland Fire* 11: 1-10.

[114] Brown, R.T., J.K. Agee, and J.F. Franklin. 2004. Forest restoration and fire: principles in the context of place. *Conservation Biology* 18: 903-12.

[115] Naficy, C., A. Sala, E.G. Keeling, J. Graham and T.H. DeLuca. 2010. Interactive effects of historical logging and fire exclusion on ponderosa pine forest structure in the northern Rockies. *Ecological Applications* 20: 1851-64.

[116] Fiedler, C.E., and C.E. Keegan. 2003. Reducing crown fire hazard in fire-adapted forests of New Mexico. Pp. 29-38 in: P.N. Omi and L.A. Joyce (tech. eds.). *Fire, Fuel Treatments, and Ecological Restoration: Conference Proceedings*. 2002 April 16-18: Fort Collins, CO. USDA For. Serv. Rocky Mtn. Res. Sta. Proc. RMRS-P-29. Fort Collins, CO.

[117] Graham, R.T., S. McCaffrey, and T.B. Jain (Tech. Eds.). 2004. *Science Basis for Changing Forest Structure to Modify Wildfire Behavior and Severity*. USDA For. Serv. Rocky Mtn. Res. Sta. Gen. Tech. Rep. RMRS-120. Ft. Collins, CO.

[118] Keyes, C.R. and K.L. O'Hara. 2002. Quantifying stand targets for silvicultural prevention of crown fires. *Western Journal of Applied Forestry* 17: 101-09.

[119] Perry, D.A., H. Jing, A. Youngblood, and D.R. Oetter. 2004. Forest structure and fire susceptibility in volcanic landscapes of the eastern high Cascades, Oregon. *Conservation Biology* 18: 913-26.

[120] Omi and Martinson 2002, Pollett and Omi 2002

[121] Agee, J.K. 1996. The influence of forest structure on fire behavior. Pp. 52-68 in: J.W. Sherlock (chair). *Proc. 17th Forest Vegetation Management Conference.* 1996 Jan. 16-18: Redding, CA. Calif. Dept. Forestry and Fire Protection: Sacramento.

[122] Van Wagner, C.E. 1977. Conditions for the start and spread of crown fire. *Canadian Journal of Forest Research* 7: 23-24.

*Large tree retention avoids significant cumulative impacts*

Large trees are not abundant at any scale in Southwestern ponderosa pine forest and they are the most difficult of all elements of forest structure to replace once removed.[123] The ecological significance of old growth forest habitat and large trees comprising it is widely recognized.[124,125] There is no agreed-upon scientific basis for removing large trees to promote fire resistance in southwestern forests.[126,127] In addition to their rarity, a variety of factors other than logging threatens the persistence of the remaining large trees in Southwestern conifer forests. Prescribed fire can injure exposed tree roots that have migrated into accumulated duff layers and cause high levels of post-treatment mortality among large trees.[128] Burning of pine stands with high surface fuel loading also can produce high fireline intensities and result in large tree mortality due to cambial injury by heat.[129] Prescribed fire also may render large trees susceptible to delayed bark beetle infestation.[130] In addition, large tree mortality has indirectly resulted from mechanical thinning activities too.[131] Large standing dead trees ("snags") and downed logs supply critical habitat for primary and secondary cavity-nesting species and may be destroyed by fuel treatments.[132] Prescribed fire may create coarse woody habitat by killing live trees, but gains generally do not offset losses, as existing coarse wood is irretrievably.[133] Recruitment of large trees, snags and large woody debris will become more limiting over time as climate change imposes chronic drought, reduced tree growth rates, and more widespread tree

[123] Agee, J.K. and C.N. Skinner. 2005. Basic principles of forest fuel reduction treatments. *Forest Ecology and Management* 211: 83-96.

[124] Friederici, P. (Ed.). 2003. *Ecological Restoration of Southwestern Ponderosa Pine Forests*. Island Press: Washington, DC.

[125] Kaufmann, M.R., W.H. Moir, and W.W. Covington. 1992. Old-growth forests: what do we know about their ecology and management in the Southwest and Rocky Mountain regions? Pp. 1-10 in: M.R. Kaufmann, W.H. Moir, and R.L. Bassett (eds.). *Old-Growth Forests in the Southwest and Rocky Mountain Regions: Proceedings from a Workshop* (1992). Portal, AZ. USDA For. Serv. Gen. Tech. Rep. RM-213. Fort Collins, CO.

[126] Allen, C.D. M.A. Savage, D.A. Falk, K.F. Suckling, T.W. Swetnam, T. Schulke, P.B. Stacey, P. Morgan, M. Hoffman, and J.T. Klingle. 2002. Ecological restoration of southwestern ponderosa pine ecosystems: A broad perspective. *Ecological Applications* 12: 1418-33.

[127] Brown et al. 2004, Dellasala et al. 2004

[128] Sackett, S.S., S.M. Hasse, and M.G. Harrington. 1996. Lessons learned from fire use for restoring Southwestern ponderosa pine ecosystems. In: W.W. Covington and M.R. Wagner (eds.). *Conference on Adaptive Ecosystem Restoration and Management: Restoration of Cordilleran Conifer Landscapes of Northern America*. USDA For. Serv. Rocky Mtn. Res. Sta. Gen. Tech. Rep. RM-GTR-278. Fort Collins, CO.

[129] Hunter, M.E., W.D. Shepperd, J.E. Lentile, J.E. Lundquist, M.G. Andreu, J.L. Butler, and F.W. Smith. 2007. *A Comprehensive Guide to Fuels Treatment Practices for Ponderosa Pine in the Black Hills, Colorado Front Range, and Southwest*. USDA For. Serv. Rocky Mtn. Res. Sta. Gen. Tech. Rep. RMRS-GTR-198. Fort Collins, CO.

[130] Wallin, K.F., T.E. Kolb, K.R. Skov, and M.R. Wagner. 2003. Effects of crown scorch on ponderosa pine resistance to bark beetles in northern Arizona. *Environmental Entomology* 32: 652-61.

[131] Hunter et al. 2007

[132] *Ibid*

[133] Randall-Parker, T., and R. Miller. 2002. Effects of prescribed fire in ponderosa pine on key wildlife habitat components: preliminary results and a method for monitoring. Pp. 823-34 in: W.F. Laudenslayer, et al. (coord.). *Proc. Symp. Ecology and Management of Dead Wood in Western Forests*. 1999 November 2-4; Reno, NV. USDA For. Serv. Pac. So. Res. Sta. Gen. Tech. Rep. PSW-GTR-181. Albany, CA.

mortality.[134,135,136,137,138] A large tree retention alternative would maintain trees that are most likely to survive fire injury and supply recruitment structure that will support the recovery of old growth forest habitat in the future.

*Large tree retention mitigates adverse effects to wildlife*

Large tree removal reduces forest canopy and diminishes recruitment of large snags and downed logs, which in turn affects long-term forest dynamics, stand development and wildlife habitat suitability.[139,140,141] If significant reductions of crown bulk density are deemed necessary to meet the purpose and need then it is highly unlikely that the project will maintain habitat for threatened and sensitive wildlife species associated with closed-canopy forest.[142,143] A large tree retention alternative would maintain wildlife habitat in the short-term and mitigate adverse effects of proposed treatments.

**Old growth must be protected from cutting without exception**

Old growth forests differ in structure and function from younger forests, providing the preferred habitat of many sensitive wildlife species as well as a host of ecological services including watershed function, water purification, soil retention, and storage of greenhouse gasses.[144,145] Old growth habitat consists of large trees with fire-resistant "plated" bark structure and tall canopies, snags with nesting cavities and broken tops valuable to wildlife, as well as vertical and horizontal structural diversity within stands. As noted above, most of the former old growth forests throughout the ponderosa pine and mixed conifer formations in the Southwest already have been destroyed by logging. This practice continues to this day, currently under the authority

[134] Diggins, C., P.Z. Fulé, J.P. Kaye and W.W. Covington. 2010. Future climate affects management strategies for maintaining forest restoration treatments. *International Journal of Wildland Fire* 19: 903-13.
[135] Savage, M. P.M. Brown, and J. Feddema. 1996. The role of climate in a pine forest regeneration pulse in the southwestern United States. *Ecoscience* 3: 310-18.
[136] Seager, R., M. Ting, Y. Kushnir, J. Lu, G. Vecchi, H. Huang, N. Harnik, A. Leetmaa, N. Lau, C. Li, J. Velez and N. Naik. 2007. Model projections of an imminent transition to a more arid climate in southwestern North America. *Science* 316: 1181-84.
[137] van Mantgem, P.J., N.L. Stephenson, J.C. Byrne, L.D. Daniels, J.F. Franklin, P.Z. Fulé, M.E. Harmon, A.J. Larson, J.M. Smith, A.H. Taylor and T.T. Veblen. 2009. Widespread increase of tree mortality rates in the western United States. *Science* 323: 521-24.
[138] Williams, A.P., C.D. Allen, C.I Millar, T.W. Swetnam, J. Michaelsen, C.J. Still and S.W. Leavitt. 2010. Forest responses to increasing aridity and warmth in the southwestern United States. *PNAS* 107: 21289-94.
[139] Quigley, T.M., R.W. Haynes and R.T. Graham. 1996. *Disturbance and Forest Health in Oregon and Washington*. USDA For. Serv. Pac. Nor. Res. Sta. Gen. Tech. Rep. PNW-GTR-382. Portland, OR.
[140] Spies, T.A. 2004. Ecological concepts and diversity of old-growth forests. *Journal of Forestry* 102: 14-20.
[141] van Mantgem et al. 2009
[142] Beier, P., and J. Maschinski. 2003. Threatened, endangered, and sensitive species. Pp. 206-327 in: P. Friederici (ed.). *Ecological Restoration of Southwestern Ponderosa Pine Forests*. Island Press: Washington, D.C.
[143] Keyes and O'Hara 2002
[144] Kaufmann et al. 1992
[145] Luyssaert, S., E.D. Schulze, A. Börner, A. Knohl, D. Hessenmöller, B.E. Law, P. Ciais and J. Grace. 2008. Old-growth forests as global carbon sinks. *Nature* 455: 213-15.

of the Jacob-Ryan Timber Sale that you have authorized. Indeed, numerous analyses by the Forest Service and others demonstrate that logging significantly affects long-term recruitment of coarse wood and the availability of old growth habitat.[146]

Past timber management destroyed nearly all ponderosa pine and mixed conifer old growth forest in Arizona and New Mexico, including on much of the Kaibab National Forest. Even-aged forest is now common in the project area and throughout the landscape.[147,148] Old growth forests differ functionally from younger forests in the habitat they offer to wildlife, carbon storage, water filtration and flow regulation, and nutrient cycling.[149] The ecological significance of old growth forest is amply documented, whereas a scientific basis for logging large trees in pursuit of forest health or fire management objectives is lacking.[150]

The Center expects the Forest Service to include an unambiguous restriction on any form of cutting of any old growth tree of any species for any reason. We are not confident that you will do so willingly, however, given that your proposed action allows large (and therefore old) trees to be cut "*to obtain desired species composition and structure or for other forest health-related reasons in a group of trees that need to be thinned*." The Center previously caught your district marking to cut old growth trees smaller than 18-inches diameter at breast height (<18" dbh), including many with tell-tale orange and yellow plated bark and flat tops occurring within clumps and groups that properly constitute "old growth," per Forest Plan definition.[151] We hope that the KPERP sets the North Kaibab Ranger District on a new path of sincere commitment to protect old growth.

We have attached the 2006 Grand Canyon Trust report titled "An Environmental History of the Kane and Two-Mile Ranches in Arizona," which provides a comprehensive review of important historical accounts of the Kaibab Plateau Including early Forest Service inventories), which should be thoroughly understood and addressed in this analysis, as well as a chapter reviewing Kaibab Plateau fire history studies, which is directly relevant to this project. As with all sources cited and discussed in this letter, we anticipate a thoughtful assessment and incorporation of this information into future documents and analyses.

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[146] Quigley et al. 1996; Spies 2004; van Mantgem et al. 2009
[147] Covington and Moore 1994
[148] Sesnie, S. and J. Bailey. 2003. Using history to plan the future of old-growth ponderosa pine. *Journal of Forestry* 99(7) (Oct/Nov): 40-47.
[149] Kaufmann et al. 1992
[150] Friederici 2003
[151] See May 8, 2009 CBD letter to District Ranger Timothy Short

**Desired conditions for conifer forests must be tailored to Kaibab Plateau reference sites**

The Center has considerable concerns with General Technical Report 310[152] which we have addressed in previous correspondence with the Kaibab National Forest. This is the Forest Service's own self-published desired conditions for dry conifer forest in the southwest and its relevance to the KPERP should be questioned. Much of the information used in this report to identify desired conditions for ponderosa pine and mixed conifer forest is derived mainly from studies accomplished far from the KPERP landscape. We reviewed the 111 studies cited in GTR-310 as sources of information for reference conditions, disturbance histories, disturbance effects, stand structure and composition, and canopy openness. These studies are listed by location in a table and a map on the following pages. Of these 111 published studies, a few are directly relevant to the proposed action, and those should be given preference in determining how to meet desired conditions for the KPERP. As the table later in this letter clearly shows, the sources consulted for the formulation of desired conditions for the southwest cover an extensive geographic range, especially the Flagstaff area, but other than those specific to the Kaibab Plateau, most provide very little guidance for the unique forests of the Kaibab Plateau.

Reynolds and others (p. 12) admit uncertainty in their recommendation of desired conditions for dry conifer forest resulting from a paucity of supporting information and geographic imbalance of accessible data:

> "*There is a clear need for additional reference condition data sets, including sites from a wider spectrum across environmental gradients (e.g., soils, moisture, elevations, slopes, aspects) occupied by frequent-fire forests in the Southwest, especially in dry mixed-conifer. While the quantity of reference data sets is increasing, existing data represent a largely unbalanced sampling across gradients (e.g., most data sets are from basaltic soils and on dry to typic plant associations), and there have been few studies quantitatively*."

We request that the Kaibab National Forest will recognize, based on this basic analysis, that the GTR-310 framework is not suited for immediate adoption for meeting ecological needs, formulation of desired conditions, or development of restoration and ecosystem management projects and prescriptions for KPERP. The GTR-310 approach to uncertainty is to blur site-specific forest variation across a vast geographic area and *scale up* desired conditions to broad landscapes with a generic "pooled natural range of variability" (Reynolds et al. 2103: p. 11):

> "*The natural range of variability can be estimated by pooling reference conditions across sites within a forest type. Reference conditions for a forest type typically vary from site to site due to differences in factors such as soil, elevation,*

[152] Reynolds, R.T., A.J. Sánchez Meador, J.A. Youtz, T. Nicolet, M.S. Matonis, P.L. Jackson, D.G. DeLorenzo and A.D. Graves. 2013. *Restoring Composition and Structure in Southwestern Frequent-Fire Forests: A Science-Based Framework for Improving Ecosystem Resiliency*. USDA For. Serv. Rocky Mtn. Res. Sta. Gen. Tech. Rep. RMRS-GTR-310. Fort Collins, CO.

> *slope, aspect, and micro-climate and manifests as differences in fire effects, tree densities, patterns of tree establishment and persistence, and numbers and dispersion of snags and logs. When pooled, these sources of variability comprise the natural range of variability of a site or forest type*."

Much of GTR-310 is based on reconstruction studies of "Woolsey Plots." In 1909, T.S. Woolsey, Jr., Assistant District Forester and Chief of the Office of Silviculture (Southwestern District now Southwest Region 3), and G. A. Pearson, Director, Fort Valley Forest Experiment Station (Flagstaff, AZ), drafted instructions that led to establishment of a network of permanent plots in ponderosa pine, mixed conifer, and spruce-fir forests of the Southwest. Between 1909 and 1941 Woolsey and team established 140 plots in AZ and NM, of which 98 were in ponderosa pine. Of the pine plots, 30% are located southwest of Flagstaff at the Coulter Ranch site. Of the 140 plots, 44 were in the Coconino NF.

> "*So-called sample plots were established on logged over areas in order to ascertain how fast residual stands would grow, whether they could produce merchantable timber, and whether natural restocking would take place*" (Pearson, 1933, p. 272).

Bell and others[153] compared current conditions of 14 Woolsey plots to 98 AZCFI and 58 FSFIA plots in the Flagstaff/western Mogollon Rim area. The metrics under comparison were Trees/Hectare, BA/Hectare, QMD, and frequency of DBH classes/hectare. Comparisons of forest structural data applied a distance-based multivariate nonparametric permutation method. All analyses indicated dissimilarity between the FIA and CFI plots compared to the Woolsey plots across the study area, and across TEU's. Within TEU's, the Woolsey plots were not statistically dissimilar, but current conditions were consistently denser in all metrics. Bell and others' results suggest that Woolsey plots are only representative of the TEU to which the plot belongs.

> "*The selection of [Woolsey] plot locations in the early 1900s followed a subjective nonrandom approach. [Our] results indicated that the Woolsey plots (1) were neither historically nor contemporarily representative of the entire study area because of environmental and current forest structural differences with respect to the FSFIA and AZCFI and (2) may be considered historically representative of their corresponding TEUs. Our study supports the use of TEUs for defining the applicability of information obtained from the Woolsey plots….Subjective plot selection, together with the small sample size of this rare dataset, raises questions about the inference space with regard to the larger, heterogeneous landscape of ponderosa pine forests in northern Arizona*"

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[153] Bell, D.M., P.F. Parysow, and M.M. Moore. 2009. Assessing the representativeness of the oldest permanent inventory plots in northern Arizona ponderosa pine forests. *Restoration Ecology* 17(3): 369-377.

Disturbance patterns are driven by spatial and temporal variation in climate, vegetation growth habitats, and management history. These are place-specific and cannot reliably be generalized over broad landscapes or timeframes.[154,155] Ecologists stress definition of locally specific reference conditions to justify restoration goals and outcomes due to scale dependence of ecological pattern.[156,157,158] For example, Korb and others[159] stated this about their study results from the San Juan Mountains of southern Colorado:

> "*Our findings demonstrate the need to develop site-specific reference conditions and for managers to exercise caution when extrapolating fire regimes and forest structure from one geographic locality to another given a projected warmer climate making conditions more favorable to frequent, large wildfires*."

Desired conditions for dry conifer forests suggested by Reynolds and others (2013) are clearly not specific to the Kaibab Plateau, and should be critically reviewed prior to assuming their usefulness. They fail to address uncertainty and qualified disagreement among experts about forest ecology and management in the Southwestern Region. Close inspection of place-specific information reveals that Reynolds and others selectively interpreted literature to make a poorly supported case for sustained mechanical intervention as a surrogate for restoration of natural fire regimes. Reynolds and others (p. 48-49) state:

> "*The re-establishment of frequent, low-severity fire is critical to the success of our restoration framework. However, because of limitations such as proximity to human developments, air quality restrictions, and workforce capacity, the use of fire will probably continue to be limited. Therefore, mechanical-only treatments, or perhaps combinations of fire and mechanical treatments, are likely to be the restoration tools of choice in much of the Southwestern landscape*."

That statement is the sole basis presented by the authors for their recommendation of landscape-scale mechanical treatments of vegetation in ponderosa pine and mixed conifer forest. Furthermore, we would argue that workforce limitations will affect mechanical thinning operations more than fire management crews. The "implementation recommendations" of

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154 Agee, J.K. 1996. The influence of forest structure on fire behavior. Pp. 52-68 in: J.W. Sherlock (chair). *Proc. 17th Forest Vegetation Management Conference.* 1996 Jan. 16-18: Redding, CA. Calif. Dept. Forestry and Fire Protection: Sacramento.

155 DellaSala, D.A., J.E. Williams, C.D. Williams and J.F. Franklin. 2004. Beyond smoke and mirrors: a synthesis of fire policy and science. *Conservation Biology* 18: 976-86.

156 Noss, R., P. Beier, W. W. Covington, R. E. Grumbine, D. B. Lindenmayer, J. W. Prather, F. Schmiegelow, T. D. Sisk, and D. J. Vosick. 2006. Recommendations for integrating restoration ecology and conservation biology in ponderosa pine forests of the Southwestern United States. *Restoration Ecology* 14: 4-10.

157 Swetnam, T.W., C.D. Allen and J.L. Betancourt. 1999. Applied historical ecology: Using the past to manage the future. *Ecological Applications* 9(4):1189-1206.

158 White, P.S. and J.L. Walker. 1997. Approximating nature's variation: selecting and using reference information in restoration ecology. *Restoration Ecology* 5: 338-349.

159 Korb, J.E., P.Z. Fule, P.Z. and R. Wu. 2013. Variability of warm/dry mixed conifer forests in southwestern Colorado, USA: Implications for ecological restoration. *Forest Ecology and Management* 304:182-191.

Reynolds and others (p. 35-37) do not present a compelling fact-based case for the efficacy of mechanical treatments to manage structure or composition in fire-adapted forest, other than to allude that such treatments may be desirable for unstated reasons.

It is true that Reynolds and colleagues synthesized a wide array of literature, but, the studies used to substantiate the GTR-310 structural framework are disproportionately clustered around northern Arizona, including a number of studies at the same sites (Gus Pearson Natural Area and Fort Valley Experimental Forest), and including a reliance on re-measures of the historic "Woolsey plots", which are not representative of the surrounding landscape.[160] Furthermore, some suitable reference sites were notably excluded from GTR-310, such as the Long Valley Experimental Forest, which was established in 1936 as a comparison site to the much-studied Fort Valley unit. Long Valley "*contained some of the best stands of ponderosa pine on the Coconino and Sitgreaves National Forests,*[161]" but for an unknown reason it does not appear in GTR-310.

The regional desired conditions document does mention this site (DC's, p. 14), noting that

> "*On the Long Valley Experimental Forest (sedimentary soils on the Mogollon Rim, central Arizona), the sampled trees per acre (1938) ranged up to 99 trees per acre, with an estimated 75 trees per acre being present prior to the cessation of frequent fire (circa 1880-1900, USDA Forest Service, unpublished data from Long Valley Experimental Forest).*"

If the pre-settlement trees per acre value (~75TPA) was included in GTR-310, it would have been more dense than any other ponderosa pine reference site cited in Arizona, with the exception of the four Grand Canyon sites studied by Fule and others (2002[162]; based on ranges provided in GTR-310), and would have been essentially equal to Williams and Bakers studies along the Mogollon Rim which have been widely criticized by the restoration community.[163] The only site cited in GTR-310 that Long Valley would have been less dense than is Malay Gap, studied by Cooper (1960[164]), and this site was in fact not even as dense as Coopers Maverick study site that was not included in GTR-310. Also, Long Valley may have been even denser, assuming that not all of the remaining 24 post-fire suppression trees would have been killed by fire.

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[160] The reconstructions by ERI scientists on Woolsey plots have established a high bar for scientific integrity, but the plots were subjectively located by Woolsey and team as part of early silvicultural experiments, calling the usefulness of the results to be interpreted carefully and within a broader collection of multiple lines of evidence on representative sites.

[161] https://www.fs.usda.gov/main/longvalley/home

[162] Fulé, P.Z., W.W. Covington, M.M. Moore, T.A. Heinlein, and A.E.M. Waltz. 2002. Natural variability in forests of the Grand Canyon, USA. *Journal of Biogeography* 29:31-47.

[163] See Fule et al., 2014. "Unsupported inferences of high-severity fire in historical dry forests of the western United States: a response to Williams and Baker." *Global Ecology and Biogeography* 23:825-830.

[164] Cooper, C.F. 1960. Changes in vegetation, structure and growth of southwestern pine forests since white settlement. *Ecological Monographs* 30: 129-64.

Cooper studied three sites on the White Mountain and San Carlos Apache Reservations in 1957. His paper is one of the most oft-cited sources of reference conditions data and descriptions for southwestern ponderosa pine, including by Reynolds et al (2014), and it is particularly valuable to consider. His Bog Creek site was selectively logged in the 1930's, but his Maverick and Malay Gap sites were unlogged, the latter also having never experienced fire suppression nor livestock grazing. Of the Malay Gap site, Cooper (p. 139) wrote "*this is perhaps the closest approach to a truly primeval forest left in the Southwest*." Prior to 1910, the Malay Gap site had experienced wildfire on average every 7 years, and then burnt again in 1910, 1919, 1935, and lastly in 1943. By the time of his field work, in 1957, the fire regime was effectively uninterrupted. Cooper's extensive report is indeed one of the most essential studies to read and comprehend, and it is important to fully examine the breadth and depth of his analyses, as well as the photographs included therein, in order to responsibly reference this detailed work. It is a step backwards for restoration ecologists to dilute his work to a few numbers, such as his determination that mean basal area at Malay Gap, where a visitor "*is immediately struck by the open nature of the forest*", was 70 ft$^2$/acre[165] (photo at right).

The figure at right, taken directly from Cooper (1960: p. 150), shows an image that does not support most contemporary notions of an "open" forest, and in fact might be considered overly dense by many land managers.

In addition to simple density metrics, Cooper reported on spatial arrangement, age/size distributions, regeneration patterns in time and space, fire effects on stand development, and many other important ecological processes that are still being debated. Of particular

FOREST CONDITIONS AT MAVERICK AND AT MALAY GAP

Although similar in basic composition and structure, the forests at Maverick and at Malay Gap are quite different in appearance. A visitor to Malay Gap, conditioned by acquaintance with the over-dense thickets characteristic of most of the Southwestern pine region, is immediately struck by the open nature of the forest (Fig. 20). The forest floor is carpeted with a deep layer of grass, and small discrete patches of young trees are dispersed among groups of stately pines. The pure beauty of the Malay Gap region more than compensates for its difficulty of access.

FIG. 20. Typical view of the ponderosa pine forest in the primitive area at Malay Gap.

[165] Interestingly, Reynolds et al. (2013) cite Malay Gap as a reference site, but ignore the results from the Maverick study location, which had a mean basal area of 102 ft$^2$/acre, to which Cooper (1960: p. 150) remarked: *"Although similar in basic composition and structure, the forests at Maverick and Malay Gap are quite different in appearance… The site at Malay Gap is clearly not as good as that at Maverick. The average height of mature dominants at Malay Gap is 95 ft, while those at Maverick average about 110 ft…The difference reflects inherent differences in site productivity*." The basal area of old growth at Maverick exceeds the range reported in Reynolds et al. (2013) and is outside of the basal area range given in Table 2 in the regional desired conditions document.

relevance to the current debate in ponderosa pine restoration are his observations on the grouping habits of this species.

The figure on the next page (Cooper, 1960: p. 148) is a typical example of the "*conspicuous… grouped arrangement of the trees*." Similarly to the figure provided on the previous page, this image again contradicts the widespread contemporary notion of what constitutes a "*distinct group*". Nowhere in his report does Cooper specify how he determined what a "group" was, but it would seem apparent that his definition is markedly different than many offered today.

The concept of "interspaces" is a central tenet in the formulation of desired conditions by some within the U.S. Forest Service, wherein these "interspaces" are areas not occupied by trees and serve to define somewhat even-aged groups. The entire basis of the model promulgated in Reynolds and others is built around this notion. However, Cooper's analysis of Malay Gap might suggest that this model is not applicable to all areas. In discussing structural patterns in the virgin pine forest, he remarked (at p. 158):

"*The relatively small size of the even-aged groups in the southwestern forest is due to the small size of the openings in which the groups can become established*."[166]

PATTERN

A conspicuous feature of the ponderosa pine forest is the grouped arrangement of the trees. It is obvious that the forest is composed of distinct groups, each made up of several trees similar in size and apparent age (Fig. 17). This fact has long been recognized, but surprisingly little attention has been given to the structure of these groups or to their mode of origin.

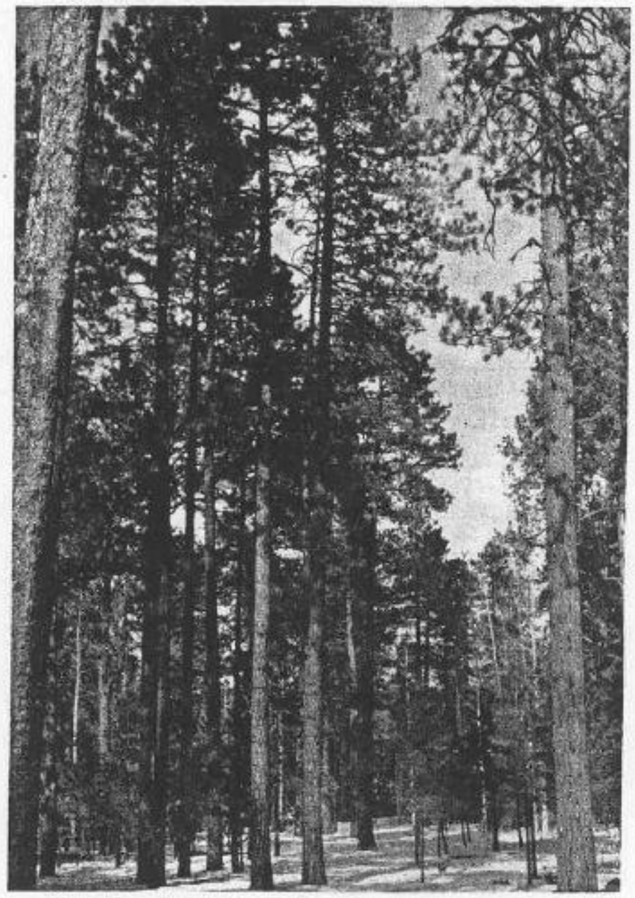

FIG. 17. Typical stand of mature ponderosa pine, showing grouped distribution of trees.

[166] Cooper's report does not specifically provide data as to how many trees occur per group, but he does state (at p. 149) that "*analysis indicates that the mature stands at both Maverick and Malay Gap are aggregated into groups with an area of .16 to .32* [acres]", within the range described by Reynolds et al. (2013). However, the definition of a "group" would seem to differ greatly between the two sources based on comparison of Cooper's example photos and observations at the Bluewater demonstration site and other contemporary treatments.

If the KPERP is to base its desired conditions on GTR-310, then the project is lacking some significant guidance provided by these other neglected reference sites, as well as the thoroughly studied sites on the Kaibab Plateau discussed and reference here, and reviewed in the attached 2006 Grand Canyon Trust Environmental History report, which we incorporate as comment substance by reference. The KPERP is not proceeding under the direction of science if it ignores the wealth of site-specific information in favor of diluted Regional Forest Service direction.

LONG VALLEY EXPERIMENTAL FOREST: 2 TO 3 TIMES DENSER THAN FORT VALLEY, BUT IGNORED BY GTR-310
Photo: Joe Trudeau, 10.11.2017 (compare to Cooper's photo on the previous page)

## TYPICAL CONDITIONS AT POWELL PLATEAU, GRAND CANYON NATIONAL PARK

*"To some extent, these sites may be rare representatives of nearly-natural conditions due to the relatively undisrupted fire regimes in a never-harvested forest setting"* (Fule et al., 2003: p. 129).

Powell Plateau experienced fires in 1855, 1879, 1892, 1895, 1924, 1950, 1953, 1962, 1986, 1987, 1988, & 2003.

67% of trees at Powell Plateau predate 1800, and 22% predate 1700 (Fule et al., 2003)

Reconstructed 1879 forest structure at Powell Plateau (trees >2.5cm dbh; Fule et al., 2002):
63 TPA (mean), ranging from 8 to 261 TPA
17.9 $m^2$/ha BA, ranging from 4.7 to 77.3 (78 BAF, ranging from 20 to 335 BAF)

*"A central theme of this paper is that Powell Plateau, Rainbow Point, and the western third of Fire Point, are currently in conditions similar to those which prevailed prior to European settlement, so contemporary characteristics of these sites can be used as points of reference of natural variability... Contemporary reference sites are unusually important because they show the variability in ecological conditions under today's climate"* (Fule et al., 2002: p. 44)

*"The patchy distribution of forest structure observed from the forests in the Sierra San Pedro Matir, Grand Canyon, and elsewhere argues against the application of uniform targets for snag retention, fuels, and live trees across similar forest landscapes. An improvement in management guidelines would be to manage for forest structures over moderate spatial scales (hundreds to thousands of acres) instead of on a stand basis"* (Stephens & Fule, 2005: p. 361).

Powell Plateau Photos taken July 5, 2017

**TYPICAL CONDITIONS AT FIRE POINT, GRAND CANYON NATIONAL PARK**

*"Fire sizes prior to European settlement reached at least hundreds of hectares, for fires scarring 25% or more of the samples distributed across the study areas, and probably reached many thousands to tens of thousands of hectares… These relatively uninterrupted fire regimes are highly unusual in the Southwest, even in comparison with the other large unharvested forest area, the Gila Wilderness…These sites may still be the best existing representatives of natural ponderosa pine forest landscapes in the Southwest"* (Fule et al., 2003: pp. 142-143).

This forest isn't overly dense due to fire suppression: 93% of trees at Fire Point predate 1800; 20% predate 1700 (Fule et al., 2003)

Reconstructed 1879 forest structure at Fire Point (trees >2.5cm dbh; Fule et al., 2002):
61 TPA (mean), ranging from 16 to 125 TPA
20.5 $m^2$/ha BA, ranging from 6.5 to 30.2 (88 BAF/acre, ranging from 28 to 131.6)

Comparing Lang & Stewarts (1910) inventory to contemporary data *and* 1879 reconstruction, Fule et al (2002: p.40) concluded that at North Rim sites, *"there has been nearly no change in pine density over c. 120 years"* for trees over 6" dbh.

Fulé, P.Z., W.W. Covington, M.M. Moore, T.A. Heinlein, and A.E.M. Waltz. 2002. Natural variability in forests of the Grand Canyon, USA. *Journal of Biogeography* 29:31-47.

Fulé, P.Z., T.A. Heinlein, W.W. Covington, and M.M. Moore. 2003. Assessing fire regimes on Grand Canyon landscapes with fire-scar and fire-record data. *International Journal of Wildland Fire* 12: 129-145.

Stephens, S.L. and P.Z. Fule. 2005. Western pine forests with continuing frequent fire regimes: possible reference sites for management. *Journal of Forestry* October/November 2005: 357-362.

Fire Point Photos taken July 3, 2017

**FIGURE 1: LOCATIONS OF CERTAIN REFERENCE SITES* USED IN GTR-310 (REYNOLDS ET AL., 2013)**

*Specifically Tables 3, 6 and 9


Sites referenced by Reynolds et al (2013) are biased towards conditions at the Grand Canyon and Mogollon Plateau around Flagstaff. All sites shown for New Mexico are limited to original inventory by Woolsey (1909-1913) and subsequent re-measures of those sites (Moore et al. 2004). Polygons represent work by Abella and Denton (2009; square around Flagstaff) and Williams and Baker (2012; two polygons along Mogollon Rim). None of the studies assessed in GTR-310 include sites with ponderosa pine-evergreen oak or ponderosa pine-shrub types.

"*The minimum diameters reported in Table 6 may also result in a source of error that can lead to small underestimates of historical tree densities reported in studies. Additional error may result from missing fully decomposed structures at time of measurement and reconstruction*" (Reynolds et al., 2013: p.17).

"*To date, only six studies report tree spatial reference conditions in the Southwestern ponderosa pine forests*" (Reynolds et al., 2013: p.17).

"*Management informed by reference conditions and natural ranges of variability (the range of ecological and evolutionary conditions* ***appropriate for an area****) allow for the restoration of the characteristic composition, structure, spatial pattern, processes, and functions of ecosystems*" (Reynolds et al., 2013: p.2, emphasis added).

"Some dry mixed-conifer forests and ponderosa pine-shrub communities experienced mixed-severity fires, which included combinations of surface and crown fires, sometimes resulting in larger patches of tree aggregation" (Reynolds et al., 2013: p.1).

| **Figure 2: Locations Of Studies Cited In Reynolds et el. (2013)**<br>*see GTR-310 for full citations | |
|---|---|
| **General Location of Referenced Literature** | **Literature cited for that location in GTR-310**<br>**Bold** denotes measurements at historic Woolsey plots<br>Underline denotes study specific to Gus Pearson Natural Area, Coconino NF |
| New Mexico | **Moore et al., 1994 (Gila & Zuni Mtns Woolsey remeasures); Woolsey, 1911 (Carson, Zuni, Gila, Alamo, Jemez sites);** Allen, 2007 (northern NM); Brown et al., 2001 (Sacramento Mountains); Conklin & Geils, 2008 (Jemez & Manzano Mountains); Kaye & Swetnam, 1999 (Sacramento Mountains); Negron, 1997 (Sacramento Mountains); Romme et al., 1999 (Carson & Santa Fe NF's); Swetnam & Dieterich, 1985 (Gila Wilderness); Touchan et al., 1996 (Jemez Mountains) |
| North Rim Grand Canyon/Kaibab Plateau/Uinkaret Plateau | Covington & Moore, 1994; Fule et al., 2002; Fule et al., 2003; Fule & Laughlin, 2007; Heinlein et al., 1999; Lang & Stewart, 1910; Rasmussen, 1941; Roccaforte et al., 2010; Waltz & Fule, 1998; White & Vankat, 1993 |
| South Rim Grand Canyon | Fule et al., 2002; Harrington & Hawksworth, 1980; **Woolsey, 1911** |
| Mogollon Plateau (Flagstaff Area) | Abella & Denton, 2009; Abella et al., 2011; Biondi et al., 1994; Biondi, 1996; Cocke et al., 2005; Covington & Sacket, 1986; Covington & Moore, 1994a&b; Covington et al., 1997; Dieterich, 1980; Fule et al., 1997; Heinlein et al., 2005; Hoffman et al., 2007; Mast et al., 1999; Menzel & Covington, 1997; Pearson, 1950; White, 1985; **Sanchez Meador et al., 2011; Sanchez Meador & Moore, 2010; Woolsey, 1911;** Schneider, 2012; Williams & Baker, 2012 |
| Mogollon Rim (Apache-Sitgreaves NF, White Mtn. Apache Reservation) | Cooper, 1960, 1961; Greenamyre, 1913; Lynch et al., 2010; Williams & Baker, 2012; **Woolsey, 1911** |
| Colorado | Binkley et al., 2008 (Uncompahgre Plateau); Boyden et al., 2005 (Front Range); Brown & Wu, 2005 (SW of Pagosa Springs); Ehle & Baker, 2003 (RMNP); Fornwalt et al., 2002 (Front Range); Fule et al., 2009 (San Juan Mountains); Grissino-Mayer et al., 2004 (San Juan Mountains); Korb et al., 2012 (San Juan Mountains); Mast et al., 1998 (Front Range); Mast & Veblen, 1999 (Front Range); Romme et al., 1999 (SW Colorado) |
| Southwestern Utah | Madany & West (Zion National Park) |
| Pacific and Inland Northwest/Northern Rocky Mountains/Black Hills (South Dakota) | Agee, 2003; Arno et al., 1995; DeLuca & Sala, 2006; Franklin et al., 2002 (incorrectly cited as 2012); Harrod et al., 1999; Hessberg et al., 1994, 2004, 2005; Lundquist, 1995; Nacify et al., 2010; Taylor, 2010; Taylor & Skinner, 2003; Von Schrenck, 1903; West, 1969; Wickman, 1963; Youngblood et al., 2004 |
| Mexico/Baja California | Minnisch et al., 2000; Stephens et al., 2008 |
| California | Fettig, 2012; Parsons & DeBenedetti, 1979 (Sequoia & Kings Canyon NP); Scholl & Taylor, 2010 (Yosemite NP) |
| Sky Islands Region | Barton, 2002; Grissino-Mayer et al., 1995 |
| Illinois | Dhillon & Anderson, 1993 |
| Macro-scale studies (west-wide/regional)<br>* denotes utilization of Gila NF data | Bentz et al., 2010; Drummond, 1982; Littell et al., 2009; Maffei & Beatty, 1988; Moeck et al., 1981; Negron et al., 2009; Swetnam & Baison, 1996*; Savage & Mast, 2005*; Swetnam & Betancourt, 1990*; Wood, 1983 |
| Review Reports, books, or general literature inappropriately cited as reference-site studies or original research | Abella, 2008; Abella, 2009; Castello et al., 1995; Edmunds et al., 2000; Ferry et al., 1995; Fitzgerald, 2005; Friederici, 2004; Goheen & Hansen, 1993; Hart et al., 2005; Hawksworth & Weins, 1996; Jenkins et al., 2008; Larson & Churchill, 2012; Miller & Keen, 1960; Miller, 2000; Rippy et al., 2005; Smith, 2006a,b,c; Stevens & Hawksworth, 1984; Tainter & Baker, 1996; Weaver, 1950 |

**Successful Implementation of KPERP Requires Expanding the Use of Fire**

Abundant evidence points to the success of fuels reduction treatments including thinning, burning, and combinations of the two at restoring natural fire behavior,[167] even though restoration treatments may not produce significant changes in mean diameter, canopy base height, surface fuels, spatial aggregation, or vertical heterogeneity.[168] Despite the benefits accrued from thinning treatments, restoration of fire-adapted natural and human communities in the KPERP landscape will require a substantial increase in the area burned annually. Fortunately, the KPERP landscape is ideally positioned to accomplish this, as current management direction is strongly supportive of enhanced fire use, and the neighboring Grand Canyon National Park has successfully been using managed wildfire for decades. Two data points support the successful implementation of fire in this KPERP region so far:

1) Barnett and colleagues assessed nearly 4,000 wildland fires, more than 136,000 individual fuel treatments, and their interactions across ecoregions of the continental United States[169]. While less than 7% of fuels treatments nationwide were later encountered by a wildfire, the rate rose to more than 30% for the Mogollon Rim Ecoregion (encompassing the Kaibab Plateau in this analysis) where there were >720 instances across >21,000 hectares where a wildfire encountered an area treated by thinning, burning, or combination thereof.

2) Among USFS Regions, Vaillant and Reinhardt found that the Southwest (Region 3) is far ahead of the rest of the country in returning fire to the landscape[170]. Their analysis showed that Region 3, compared to the 6 other western Regions, has proportionally the most acres burned by characteristic severity wildfire, the smallest deficit of land area needing treatment to match historical acreage-burned, and the least amount of area being mechanically treated

These robust macro-scale analyses and real data confirm that the Southwest Region - and the Kaibab National Forest in particular - are ahead of the rest of the nation in returning fire to the landscape, often with beneficial outcomes as determined by proportion of the area burning at characteristic historic fire-severity. The *Strategic Treatments for Fire Use Alternative* would position KPERP to build upon this trend.

[167] Fule, P.Z., J.E. Crouse, J.P. Roccaforte, and E.L. Kalies. 2012. Do thinning and/or burning treatments in western USA ponderosa or Jeffrey pine dominated forests help restore natural fire behavior? *Forest Ecology and Management* 269: 68-81.

[168] Ziegler *et al.* 2017. Spatially explicit measurements of forest structure and fire behavior following restoration treatments in dry forests. *Forest Ecology and Management* 386: 1-12.

[169] Barnett, K., S.A. Parks, C. Miller, and H.T. Naughton. 2016. Beyond fuel treatment effectiveness: characterizing interactions between fire and treatments in the US. *Forests* 7(237): 1-12.

[170] Vaillant, N.M., and E.D. Reinhardt. 2017. An evaluation of the forest service hazardous fuels treatment program—are we treating enough to promote resiliency or reduce hazard? *Journal of Forestry* 115(4): 300-308.

Resource benefit fires tend to cover far more acres than do thinning and prescribed fire treatments.[171] Large treatments can be more effective at moderating fire behavior relative to smaller treatments because they contain more interior area and less edge and are more likely to be encountered by a wildfire.[172] Large fire footprints are more effective at modifying future fire activity than small fires and generally reduce the size of subsequent overlapping burns that occur within ten years of the initial fire, which increases manageability and benefits of subsequent fires.[173] Strategically placed treatments that facilitate the management of wildfire for resource benefit can lead to the required increases in annual wildfire acres burned.[174] Breaking the typical cycle of management reaction and suppression response by increasing the scale and frequency of large prescribed and resource benefit fire use will support sustainable feedback mechanisms whereby future suppression efforts, even in severe fire-weather events, become less necessary.[175] Because the Southwest has entered an era of longer, hotter, drier, and unpredictable fire seasons, it is critical that fire use is accelerated in order to reduce fuels, restore ecosystem process, create landscape heterogeneity, and reduce the impact and severity of the next big blaze beyond the horizon.

**Evidence of Mixed Fire Severities in Southwestern Frequent-Fire Forests**

Multiple lines of evidence support the occurrence of fire effects outside the traditionally accepted notion that low-severity fire was characteristic of southwestern middle elevation forest types. This is particularly relevant to the KPERP project as the project area includes a range of elevations spanning all fire regimes imaginable for the southwestern United States. Generalizing desired conditions to suggest that all fires should be low-intensity surface fires ignores the bulk of scientific evidence to support that pinyon-juniper, mixed conifer, and spruce fire ecosystems commonly burned at high severity, and occasionally ponderosa pine did as well.

This section discusses this growing body of evidence and is specifically focused on southwestern ponderosa pine and ponderosa pine dominated dry mixed-conifer ecosystems, and includes a number of studies that are specific to the Kaibab Plateau. These studies should form the basis of your decision making. Because the occurrence of mixed-severity fire is now recognized as within the historical range of variability for these forests, and there are noteworthy advantages of such effects, there is valid scientific support for utilizing it as a restoration tool *where appropriate and*

[171] Hunter, M.E., J.M. Iniguez, and L.B. Lentile. 2011. Short- and long-term effects on fuels, forest structure, and wildfire potential from prescribed fire and resource benefit fire in southwestern forests, USA. *Fire Ecology* 7)3): 108-121. *doi: 10.4996/fireecology.0703108*
[172] Barnett *et al.* 2016
[173] Teske *et al.* 2012. Characterizing fire-on-fire interactions in three large wilderness areas. *Fire Ecology* 8(2): 82-106.
[174] Vaillant and Reinhardt 2017
[175] Calkin *et al*. 2015. Negative consequences of positive feedbacks in US wildfire management. *Forest Ecosystems* 2:9.
North *et al.* 2015b

*feasible in a manner that does not put communities, infrastructure, and other key values at risk*. The Kaibab Plateau is the prime venue for putting such an approach to work, given the dominance of federal land ownership, the minimal Wildland Urban Interface concerns, and the ongoing track record of successful fire use at Grand Canyon National Park.

Traditionally, the extensive body of literature surrounding restoration of ponderosa pine and dry mixed-conifer ecosystems has supported the notion that fires burned almost exclusively at low-severities. In a seminal paper on the subject, Moore and colleagues stated that "*low-frequency, high intensity stand replacement fires were very rare or nonexistent.*"[176] However, a growing body of research during intervening years, described here, suggests that a mix of severities have historically occurred across landscapes similar to or including the KPERP area. For example, Owen and colleagues stated frankly that "*ponderosa pines evolved under fire regimes dominated by low- to moderate-severity wildfire*"[177] which is a substantial philosophical departure from Moore and colleagues' statement. Additionally, Fulé and colleagues, in their noteworthy response to Williams and Bakers[178] claims of widespread high-severity fires in northern Arizona's forests, stated that "*historical fires in relatively dry forests dominated by ponderosa pine included a range of fire severities*."[179]

The historical phenomenon of stand-replacing fire and attendant debris flows in ponderosa pine dominated mixed-conifer forests have been recorded at Kendrick Mountain on the Kaibab National Forest, Missionary Ridge in the San Juan Mountains of Colorado, The Jemez Mountains of New Mexico, at Rio Puerco in northern New Mexico, the Sacramento Mountains of New Mexico, and elsewhere throughout the West.[180] While the methods used to age severe

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[176] p. 1269 in Moore *et al.* 1999. Reference conditions and ecological restoration: a southwestern ponderosa pine perspective. *Ecological Applications* 9(4): 1266-1277.

[177] p. 134 in Owen *et al.* 2017. Spatial patterns of ponderosa pine regeneration in high-severity burn patches. *Forest Ecology and Management* 405: 134-149.

[178] Williams, M.A. and W.L. Baker. 2012. Spatially extensive reconstructions show variable severity fire and heterogeneous structure in historical western United States dry forests. *Global Ecology and Biogeography* 21(10): 1042-1052.

[179] p. 827-828 in Fulé, P.Z., T.W. Swetnam, P.M. Brown, D.A. Falk, D.L. Peterson, C.D. Allen, G.H. Aplet, M.A. Battaglia, D. Binkley, C. Farris, R.E. Keane, E.Q. Margolis, H. Grissino-Mayer, C. Miller, C.H. Seig, C. Skinner, S.L. Stephens, and A. Taylor. 2014. Unsupported inferences of high-severity fire in historical dry forests of the western United States: response to Williams and Baker. *Global Ecology and Biogeography* 23: 825-830.

[180] Jenkins *et al.* 2011. Late Holocene geomorphic record of fire in ponderosa pine and mixed-conifer forests, Kendrick Mountain, northern Arizona, USA. *International Journal of Wildland Fire* 20: 125-14

Bigio *et al.* 2010. A comparison and integration of tree-ring and alluvial records of fire history at the Missionary Ridge Fire, Durango, Colorado, USA. *The Holocene* 20(7): 1047-1061.

Fitch 2013. Holocene fire-related alluvial chronology and geomorphic implications in the Jemez Mountains, New Mexico. M.S Thesis, University of New Mexico, Albuquerque, NM.

Meyer and Frechette 2010. The Holocene record of fire and erosion in the southern Sacramento Mountains and its relation to climate. *New Mexico Geology* 32(1): 19-21.

French *et al.* 2009. Holocene alluvial sequences, cumulic soils and fire signatures in the middle Rio Puerco basin at Guadalupe Ruin, New Mexico. *Geoarchaeology* 24(5): 638-676.

Pierce and Meyer 2008. Late Holocene records of fire in alluvial fan sediments: fire-climate relationships and implications for management of Rocky Mountain forests. *International Journal of Wildland Fire* 17*:* 84-95.

fire events cannot suggest the size of such events, these studies uniformly conclude that fire behavior is highly sensitive to relatively modest climatic change and that it is important to include mixed-severity fire at centennial to millennial scales as a component of the natural range of variability. Roos and Swetnam reported that the combined effects of a century long fire-free period (1360 to 1455) punctuated by two unusually wet periods and followed by a hemispheric mega-drought may have led to conditions that supported widespread crown fires in southwestern ponderosa pine forests. They also suggested that similar periods of reduced fire frequency in the eighth, ninth, and sixteenth centuries may have "*led to altered forest structures that were more vulnerable to increased fire severity.*"[181] The likelihood of the past occurrence of similar large scale stand replacing fires on the Kaibab Plateau should not be discounted.

Fire history research has provided additional support for mixed fire severities in more recent centuries. Hunter and colleagues reported that high-severity burn patches within moderate severity burn matrixes in ponderosa pine and pinyon-juniper ecosystems on the Gila National Forest were generally smaller than, but up to, 120 hectares.[182] Those findings corroborate Abolt's determinations that historical stand-replacing patches in the Mogollon Mountains ranged from 6 to 103 hectares along an elevational gradient, based off of aged aspen stands.[183] In a fire history study in the Black Mesa Ranger District of the Apache-Sitgreaves National Forest, Huffman and colleagues determined that their 1,300 hectare study site (7,600-7,900 ft.) was dominated by frequent, low-severity fires that maintained a ponderosa pine-dominated mixed conifer plant community. However, they did suggest that fire-induced even-aged regeneration events up to 25 hectares in size did occur historically, based off of spatial patterns of large trees and stumps.[184] Williams and Baker concluded that around 30% of trees survived high-severity fires along the Mogollon Rim,[185] which was not refuted by Fule and Colleagues, although it led to a robust discussion of what the definition of 'high-severity' really is.[186]

Studies at Grand Canyon, the Mogollon Rim, and the Gila Wilderness are also consistent with research coming from the Sierra Nevada of California. For example, a study at Illilouette Creek Basin in Yosemite National Park (4,600-9,900 ft.) determined that in Jeffrey pine and mixed conifer forests that have seen a return to near-normal fire regimes, high-severity patch sizes

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181 p. 288 in Roos and Swetnam 2011. A 1416-year reconstruction of annual, multidecadal, and centennial variability in area burned for ponderosa pine forests of the southern Colorado Plateau region, Southwest USA. *The Holocene* 22(3): 281-291.

182 Hunter *et al.* 2011.

183 Abolt 1997. Fire histories of upper elevation forests in the Gila Wilderness, New Mexico via fire scar and age structure analysis. MS Thesis, University of Arizona, Tucson, AZ.

184 Huffman *et al.* 2015. Fire history of a mixed conifer forest on the Mogollon Rim, northern Arizona, USA. *International Journal of Wildland Fire http://dx.doi.org/10.1071/WF14005*

185 Williams and Baker 2012.

186 Fulé *et al.* 2014.

made up 15% of burned areas, and were typically less than 4 hectares, with occasional patches up to 60 hectares.[187]

Yocum-Kent and colleagues utilized three sampling and analysis approaches to estimate historical high-severity fire patches in a high-elevation (~8,000-9,000 ft.) mixed conifer forest at Grand Canyon National Park. By aging aspen stands, aging even-aged patches of fire-sensitive trees, and by interpolating patch-size based off the oldest fire-sensitive tree in each plot area, and comparing to existing fire chronologies, the authors were able to estimate minimum, maximum, and mean patch size for high-severity mortality events. They concluded that in those high-elevation forests high-severity patches of fire were historically common and that "*Patch size of high-severity fire during the 1800s likely ranged from small patches that allowed a few trees to establish to large patches that initiated multiple stands across the landscape, on the order of* [10 to 100 hectares]."[188]

Recent fire activity at Grand Canyon is apparently not overly departed from this historical pattern. Based off National Park Service records, during a twelve year period (2000-2012) at the North Rim, twenty-five mixed-severity fires burned 2,294 individual high-severity fire patches across 6,221 hectares. The majority of patches were small (95% were <5 hectares) but three patches were between 500 and 1,300 hectares, accounting for 44% of total high-severity fire area. Furthermore, because of the overall young age of the 1,400 hectare study are and the relative infrequency of very old trees, they couldn't "*rule out a large stand-replacing fire in* [our] *study region in 1685, or even later, in the mid-1700s,*" causing them to speculate that perhaps modern patch sizes at the North Rim were not necessarily unprecedented at the centuries-scale.[189] Margolis and colleagues reported that stand-replacing patch sizes in mixed-conifer forests above 8,500 ft. on the Mogollon Plateau were historically up to nearly 300 hectares in size, with some individual fires contributing multiple patches of 100 hectares or more.[190]

The restoration of functional natural fire processes in the future is likely to regulate ecosystem structure and composition[191] and re-establish a new dynamic equilibrium that tracks climate effects on vegetation and landscape pattern in real time.[192] Cutting-edge research has concluded that these small patches of near or total mortality contribute to spatial heterogeneity, and may be

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[187] Collins and Stephens 2010. Stand-replacing patches within a 'mixed-severity' fire regime: quantitative characterization using recent fires in a long-established natural fire area. *Landscape Ecology* 25: 927-939.

[188] Yocum-Kent, L.L., P.Z. Fule, W.A. Bunn, and E.G. Gdula. 2015. Historical high-severity fire patches in mixed-conifer forests. *Canadian Journal of Forest Research* 45: 1587-1596.

[189] *Ibid* at page 1594

[190] Margolis, E. Q., and J. Balmat. 2009. Fire history and fire-climate relationships along a fire regime gradient in the Santa Fe Municipal Watershed, NM, USA. *Forest Ecology and Management* 258: 2416-2430.

[191] Parks, S.A., L.M. Holsinger, C. Miller, and C.R. Nelson. 2015. Wildland fire as a self-regulating mechanism: the role of previous burns and weather in limiting fire progression. *Ecological Applications* 25(6): 1478-1492.

[192] Falk 2006. Process-centered restoration in a fire-adapted ponderosa pine forest. *Journal for Nature Conservation* 14: 140-151.

consistent with historical spatial patterns.[193] After observing the effects of numerous resource benefit fires in the Gila Wilderness, Holden and colleagues concluded that fire-caused openings ranged in size from 0.25 to 20 hectares and that "*most of the risks, in terms of mortality to medium- and large-diameter trees are associated with the first fire after long periods of fire exclusion.*"[194]

Increased frequency, extent, and severity of wildland fires may attend climate warming and increasing drought.[195] Numerous research approaches using a range of modelling techniques suggest that widespread conifer mortality, diminished recruitment opportunities, and high-severity fire feedbacks will reduce the range and sustainability of southwestern forested ecosystems.[196] Ponderosa pine forests have survived past mega-droughts and protracted mortality events, however,[197] suggesting that resilience-to and recovery-from extreme perturbations may be driven by complex multidirectional relationships between disturbance and abiotic and biotic factors.[198] Extreme droughts driving widespread mortality events can be followed by profoundly wet periods where fire frequency declines and tree recruitment increases.[199] Extensive bark beetle outbreaks, such as those which repeatedly occurred on the Kaibab Plateau up to the period of fire-suppression initiation,[200] can create large openings within the forest canopy, which may have increased fire severity at the patch scale as downed logs were consumed.

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[193] Iniguez *et al.* 2009. Spatially and temporally variable fire regime on Rincon Peak, Arizona, USA. *Fire Ecology* 5: 3-21.

Margolis and Balmat 2009. Fire history and fire-climate relationships along a fire regime gradient in the Santa Fe Municipal Watershed, NM, USA. *Forest Ecology and Management* 258: 2416-2430.

Sensibaugh and Huffman 2014. Managing naturally ignited wildland fire to meet fuel reduction and restoration goals in frequent-fire forests. Ecological Restoration Institute Fact Sheet.

[194] p. 28 in Holden, Z.A., P. Morgan, M.G. Rollins, and K. Kavanaugh. 2007. Effects of multiple wildland fires on ponderosa pine structure in two southwestern wilderness areas, USA. *Fire Ecology* 3(2):18-33.

[195] Seager and Vecchi 2010. Greenhouse warming and the 21st century hydroclimate of southwestern North America. *Proceedings of the National Academy of Sciences* 107(50): 21277-21282.

Williams *et al.* 2010

[196] Savage *et al.* 2013. Double whammy: high-severity fire and drought in ponderosa pine forests of the southwest. *Canadian Journal of Forest Research* 43: 570-583.

McDowell *et al.* 2015. Multi-scale predictions of massive conifer mortality due to chronic temperature rise. *Nature Climate Change*

Petrie, M.D., J.B. Bradford, R.M. Hubbard, W.K. Lauenroth, C.M. Andrews, and D.R. Schlaepfer. 2017. Climate change may restrict dryland forest regeneration in the 21st century. *Ecology* 98(6): 1548-1559.

Williams, A.P., C.D. Allen, C.I. Millar, T.W. Swetnam, J. Michaelsen, C.J. Still, and S.W. Leavitt. 2010. Forest responses to increasing aridity and warmth in the southwestern United States. *Proceedings of the National Academy of Sciences* 107(50): 21289-21294.

[197] Brown and Wu 2005. Climate and disturbance forcing of episodic tree recruitment in a southwestern ponderosa pine landscape. *Ecology* 86(11): 3030-3038.

[198] Puhlick *et al.* 2012. Factors influencing ponderosa pine regeneration in the southwestern USA. *Forest Ecology and Management* 264: 10-19.

[199] Brown, P.M., and R. Wu. 2005. Climate and disturbance forcing of episodic tree recruitment in a southwestern ponderosa pine landscape. *Ecology* 86(11): 3030-3038.

[200] Lang and Stewart 1910. Reconnaissance of the Kaibab National Forest. Available on-line at www.nau.edu/library/speccoll/manuscript/kaibab_recon.

Craighead 1924. The black hills beetle practicing forestry on the Kaibab. *Forest Worker*, November, 1924: 74.

This evolution of our understanding of drought, insects and diseases, and occasional mixed-severity fire occurring at limited scales within the natural range of variability, as well as the utility of such fires in restoring forest structure, provides needed justification for concerns that arise from expanding the use of fire to achieve beneficial outcomes. Based on these studies, prescribed and resource benefit fires could mimic historical fire behavior by accepting higher levels of mortality in patches of up to 100 hectares in ponderosa pine, and perhaps up to several hundred or more in mixed-conifer forests during the initial fire entry, *and only in areas where such fires can be managed to protect communities, infrastructure, and other key values*.

**Benefits of Mixed-Severity Fires in Southwestern Frequent-Fire Forests**

Implementing a strategic approach to facilitate the expanded use of prescribed and resource benefit wildfire includes a greater acceptance of mixed-severity fire across all vegetation types in the KPERP landscape. In this section, we review the state of our understanding of how mixed-severity fire can be a useful tool to achieve beneficial ecological outcomes. The diversity of fire effects is driven by factors that are common on the KPERP landscape, such as topographic variation, disturbance history, vegetation characteristics, and proximity to values-at-risk. Because wildland fire use has been increasingly used throughout the west, research on its ecological and practical benefits has multiplied. An extensive body of science now points towards a wide range of fire intensities and severities as a critical driver of ecological restoration and fuels reduction success.

*Reducing fuels and restoring historic structure.*

Agee and Skinner suggested that prescribed fire is generally effective at reducing surface fuels and raising canopy base height, but because of undesirable "severity thresholds" reductions in crown density were less easy to achieve.[201] Implementing a *Strategic Treatments for Fire Use Alternative* requires reconsideration of acceptable severity thresholds. A growing body of research from dry, frequent-fire adapted forests supports the use of moderate-severity prescribed and/or natural-ignition fire in a mosaic of severities to achieve fuels reduction objectives, as well as restoring historic structure and pattern. Patchy-mosaics resulting from mixed-severity fire provide timely opportunities to conduct additional prescribed burns while fuel continuity and density have been reduced.[202] Often, subsequent fires burn at lower severity and result in fewer changes to the forest.[203]

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Craighead 1925. The *Dendroctonus* problem. *Journal of Forestry* 23: 340-354.

[201] Agee and Skinner 2005. Basic principles of forest fuel reduction treatments. *Forest Ecology and Management* 211(1): 83-96.

[202] Williams *et al.* 2010

[203] Holden *et al.* 2007.

Low severity prescribed fire alone may not always reduce canopy density sufficient to meet fuels reduction or ecological restoration objectives.[204] On the Gila National Forest (outside of the Gila Wilderness) moderate-severity resource benefit fire more effectively reduced basal area, tree density, seedling density, crown bulk density, canopy base height, and surface fuel loads than did low-severity prescribed or resource benefit fires in ponderosa pine and pinyon-juniper ecosystems.[205] Because of reductions in crown bulk density and crown base height, moderate-severity resource benefit fires in ponderosa pine and pinyon-juniper ecosystem can be more effective at reducing predicted crown fire potential than low-severity prescribed fires, even under very severe fire weather conditions.[206]

Studying the effects of a mixed-severity fire in ponderosa pine and dry mixed-conifer forest on Kendrick Peak, Kaibab National Forest, Stevens-Rumann and colleagues observed that areas of moderate-severity burn effects with mortality rates generally ranging between 40%-80% had met target basal area thresholds the highest amount of ponderosa pine regeneration, optimum coarse woody debris loadings, adequate fine woody debris to carry a surface fire, and met minimum requirements for snags. The authors concluded that areas where 40-80% tree mortality occurred should be managed with reintroduction of frequent low-severity surface fires to maintain stand structure, and pointed out that these moderate-severity burned areas would be more resilient to future disturbance and would be easier to maintain than thinning overly dense ponderosa pine forests.[207] Similarly, Huffman and colleagues found that across ten single-entry resource benefit fires in northern Arizona, most structural and fuels targets were only met when fire-induced mortality exceeded 31%.[208] Hunter and colleagues compared prescribed and resource benefit fires on the Gila National Forest and their "*results show that a single fire of moderate severity alone can result in stand densities that more closely resemble pre-settlement conditions.*"[209]

Pulses of dead trees resulting from patches of high-severity fire have led to speculation that increased fuel loadings may lead to amplified reburn severity. In the Southwest, patches of fire-killed trees can be expected to have fallen and substantially decomposed within one decade,[210] and even in areas of very high mortality coarse woody debris is unlikely to exceed management

[204] Stephens, S.L., J.J. Moghaddas, C. Edminster, C.E. Fiedler, S. Haase, M. Harrington, J.E. Keeley, E.E. Knapp, J.D. McIver, K. Metlen, C.N. Skinner, and A. Youngblood. 2009. Fire treatment effects on vegetation structure, fuels, and potential fire severity in western U.S. forests. *Ecological Applications* 19(2): 305-320.

[205] Hunter *et al.* 2011

[206] Hunter *et al.* 2011

[207] Stevens-Rumann *et al.* 2012. Ten years after wildfires: How does varying tree mortality impact fire hazard and forest resiliency? *Forest Ecology and Management* 267: 199-208.

[208] Huffman *et al.* 2017a. Efficacy of resource objective wildfires for restoration of ponderosa pine (*Pinus ponderosa*) forests in northern Arizona. *Forest Ecology and Management* 389: 395-403.

[209] p. 117 in Hunter *et al.* 2011

[210] Roccaforte *et al.* 2012. Woody debris and tree regeneration dynamics following severe wildfires in Arizona ponderosa pine forests. *Canadian Journal of Forest Research* 42: 593-604.
Passovoy and Fulé 2006. Snag and woody debris dynamics following severe wildfires in northern Arizona ponderosa pine forests. *Forest Ecology and Management* 223: 237–246.
Savage and Mast 2005. How resilient are southwestern ponderosa pine forests after crown fire? *Canadian Journal of Forest Research* 35: 967-977.

recommendations for fuel loadings.[211] Studies from the dry forests of the Pacific Northwest have shown that standing dead and dead/down woody debris actually experienced lower severity subsequent fires than salvage logged and replanted sites.[212] Similarly, Meigs and colleagues discovered after analyzing several hundred fires in the Pacific Northwest that burn severity was generally lower in forests with higher cumulative bark beetle damage, and that burn severity continued to decrease with time.[213]

A number of studies have reported inadequate post-fire ponderosa pine regeneration and type-conversion to shrub or grassland habitats with decades-long legacy effects.[214] However, this is not a universal phenomenon. Despite the size of high-severity burn patches in the Rodeo-Chediski fire, ponderosa pine appears to be regenerating in abundance, spatial pattern, and uneven-agedness along a trajectory that is similar to historical structural characteristics, albeit with a higher abundance of sprouting oak and juniper species. [215] Also on the Rodeo-Chediski Fire, Shive and colleagues reported significantly more ponderosa pine regeneration in high severity burn patches than in low-severity patches.[216]

In spite of the tremendous size of the Rodeo-Chediski Fire – which the Center agrees is dramatically beyond the scale of characteristic fire behavior in the southwestern ponderosa pine forest – the situation today is not as grim as it appeared in the fires immediate aftermath. Leveraging the reduced fuels across the Rodeo-Chediski fire area to return low-intensity prescribed fire would be useful for limiting the degree to which sprouting woody species dominate the post-fire community, breaking up fuel continuity in future fires, and restoring natural frequent fire processes. The same can be said about the Warm Fire, and possibly others on the Kaibab Plateau.

*Increasing spatial and temporal heterogeneity.*

Fire and forest structure interact such that the variability in stand structures present within a landscape influences the distribution of fire behaviors and severities, which in turn influence

[211] Stevens-Rumann *et al.* 2013. Pre-wildfire fuel reduction treatments result in more resilient forest structure a decade after wildfire. *International Journal of Wildland Fire* 22: 1108-1117.

[212] Thompson *et al.* 2007. Reburn severity in managed and unmanaged vegetation in a large wildfire. *Proceedings of the National Academy of Sciences* 104(25): 10743-10748.

[213] Meigs *et al.* 2016. Do insect outbreaks reduce the severity of subsequent forest fires? *Environmental Research Letters* 11.

[214] Haire and McGarigal 2008. Inhabitants of landscape scars: succession of woody plants after large, severe forest fires in Arizona and New Mexico. *The Southwestern Naturalist* 53(2): 146-161
Savage and Mast 2005

[215] Owen, S.M., C.H. Seig, A.J. Sanchez-Meador, P.Z. Fule, J.M. Iniguez, L.S. Baggett, P.J. Fornwalt, and M.A. Battaglia. 2017. Spatial patterns of ponderosa pine regeneration in high-severity burn patches. *Forest Ecology and Management* 405: 134-149.

[216] Shive *et al.* 2013. Pre-wildfire management treatments interact with fire severity to have lasting effects on post-wildfire vegetation response. *Forest Ecology and Management* 297: 75-83.

successional trajectories of post-fire environments.[217] The patchy mosaic patterns attributed to historic forest ecosystems were influenced by a range of fires and other disturbances through time and space – including patches of high-severity fire – that "*create coarse-grained, high-contrast heterogeneity…*[and]… *a complex mosaic of seral stages at the landscape and local scales*."[218] Fine scale, site-specific factors can produce dissimilar spatial patterns between sites in close proximity[219] in response to site characteristics, disturbance, successional pathways, and management history.[220]

Fire can create heterogeneity in ways that mechanical approaches simply cannot. A study of eleven mixed-severity Arizona fires across a sixteen year chronosequence described dramatic variability between fires in residual structure, regeneration response, snag and coarse woody debris dynamics, and future trajectories.[221] On the Rodeo-Chediski Fire in Arizona, Shive and colleagues observed that pre-fire treatments combined with mixed fire-severities to produce landscape heterogeneity that defied simple classification by burn severity.[222] On the same fire Owen and colleagues observed unexpected and paradoxical regeneration characteristics that included the highest documented rates of ponderosa pine regeneration occurring intermixed with the highest density of re-sprouting species in a plot far from the nearest pine seed-source.[223] These types of complex spatial arrangements of vegetative successional stages with variations in patch size and shape enhance biological diversity and influence future fire spread and behavior.[224] Diverse understory communities across a spectrum of disturbance histories and successional trajectories may provide additional resilience to future climate-induced changes.[225]

High-severity burn patches in the Rodeo-Chediski Fire on the White Mountain Apache Reservation in Arizona have been found to have significantly higher forb species richness, total understory plant cover, and ponderosa pine regeneration compared to low-severity areas.[226] A

217 Ziegler, J.P., C. Hoffman, M. Battaglia, and W. Mell. 2017. Spatially explicit measurements of forest structure and fire behavior following restoration treatments in dry forests. *Forest Ecology and Management* 386: 1-12.

218 p. 310 in DellaSala *et al*. 2014. Complex early seral forests of the Sierra Nevada: what are they and how can they be managed for ecological integrity? *Natural Areas Journal* 34(3): 310-324.

219 Rodman *et al.* 2016. Reference conditions and historical fine-scale spatial dynamics in a dry mixed-conifer forest, Arizona, USA. *Forest Science* 62: 268–280.

220 Hessburg *et al.* 2015. Restoring fire-prone Inland Pacific landscapes: seven core principles. *Landscape Ecology* 30: 1805-1835.

221 Roccaforte, J.P., P.Z. Fule, W.W. Chancellor, and D.C. Laughlin. 2012. Woody debris and tree regeneration dynamics following severe wildfires in Arizona ponderosa pine forests. *Canadian Journal of Forest Research* 42: 593-604.

222 Shive *et al.* 2013

223 Owen *et al.* 2017

224 Teske, C.C., C.A. Seielstad, and L.P. Queen. 2012. Characterizing fire-on-fire interactions in three large wilderness areas. *Fire Ecology* 8(2): 82-106.

225 Halofsky *et al.* 2011. Mixed- severity fire regimes: lessons and hypotheses from Klamath-Siskiyou Ecoregion. *Ecosphere* 2(4): art40.

Hurteau *et al.* 2014. Climate change, fire management, and ecological services in the southwestern US. *Forest Ecology and Management* 327: 280-289.

226 Shive *et al.* 2013

high-intensity escaped prescribed fire in a ponderosa pine dominated mixed-conifer forest at Grand Canyon National Park led to a dramatic increase in understory native plant cover, species richness, and composition.[227] Naturally recovering high-severity burn patches within mixed-severity mosaics have increased plant diversity and may be more resilient to future climate stress.[228] As an example, consider the extensive aspen stands that have established in the Warm Fire scar. The contemporary fire crisis is not so much predicated on high-severity fire being inherently "bad," but that the scale of patches exceeds what would have historically occurred. Determining the appropriate scale and frequency of fire-induced patch disturbance is an important step towards harnessing the efficacy of fire to achieve restoration objectives.

*Promoting complex early-successional ecosystems*

Early-successional forest ecosystems possess high structural complexity, spatio-temporal heterogeneity, and biological/foodweb diversity resulting from variability in disturbance severity, environmental conditions, and surviving trees.[229] Patches of moderate to high-severity fire can produce highly spatially variable forest structures as a response to uneven burn effects and patchy mortality dynamics.[230] Tree regeneration patterns in early-successional habitats reflect favorable environmental conditions[231] and variable thinning by fire and other disturbance.[232] These areas of localized disturbances create valuable wildlife habitat[233] and provide opportunities to apply additional fire treatments which promote further spatial diversity.[234]

The common attributes of complex early seral forests include:[235]

- Abundant and widely distributed large trees, snags and downed logs
- Varied and rich understory flora
- Varied and rich floral invertebrate, avian and mammalian species composition
- Highly complex structural complexity with many biological legacies
- Complex and functional below-ground biological processes
- Complex and varied genetic diversity
- Rich ecosystem processes including pollination and predation
- Low susceptibility to invasive species

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227 Huisinga *et al.* 2005. Effects of an intense prescribed fire on understory vegetation in a mixed conifer forest. *Journal of the Torrey Botanical Society* 32(4): 590-601.
228 Hunter *et al.* 2011; Owen *et al.* 2017
229 Swanson *et al.* 2011. The forgotten stage of forest succession: early-successional ecosystems on forest sites. *Frontiers in Ecology and the Environment* 9(2): 117-125.
230 Fulé *et al.* 2004. Effects of an intense prescribed forest fire: is it ecological restoration? *Restoration Ecology* 12(2): 220–230.
231 Savage *et al.* 1996. The role of climate in a pine forest regeneration pulse in the southwestern United States. *Ecoscience* 3(3): 310-318.
232 Holden *et al.* 2007
233 Halofsky *et al.* 2011; Hunter *et al.* 2011
234 Williams *et al.* 2010
235 p. 314 in DellaSala *et al.* 2014

•Varied and complex disturbance frequency
•High landscape integrity with shifting mosaics and disturbance dynamics
•High resilience and resistance to climate change due to varied and complex genomes

Haire and McGarigal studied high-severity burn patches at Saddle Mountain (Kaibab Plateau, Arizona; burned in 1960) which is directly relevant to the KPERP landscape, and La Mesa (Pajarito Plateau, New Mexico; burned in 1977), which shares similar soils, topography, and vegetative communities as the former. The purpose of their research was to "*better understand plant succession after severe fire events in the southwestern United States, given the possibility that these landscapes occupy an important place in long-term variability of ecosystems.*"[236] Fifty-two species of native trees and shrubs, arranged along dynamic spatially and temporally influenced gradients, were documented at the two sites. Distance from edge-of-burn was strongly correlated to prevalence of resprouting species (generally shrubs, including oaks) over off-site seeders (generally coniferous trees), and was influenced by conditions in the pre-fire landscape. However, evidence of continued tree establishment and succession was evident decades post-fire as environmental conditions permitted tree establishment.

The early-successional habitats encountered by Haire and McGarigal led to their conclusion that:

> *"Areas burned in severe fire at Saddle Mountain and La Mesa included communities that might diversify function of landscapes through creation of early successional habitats for wildlife. In addition, woody species at the study sites have a wide range of traditional and current uses; basketry and other building material important food sources, a plethora of medicinal remedies, and ceremonial uses in contrast to studies that emphasize undesirable effects when forests transition to openings and alternative habitats, our research elucidates the need for further consideration of both young forest communities, and the persistent species and communities described as landscape scars, in conservation plans for forest systems of the southwestern United States.*"[237]

Recent work by Owen and colleagues at the Rodeo-Chediski and Pumpkin Fires confirmed ponderosa pine establishment > 300m from nearest seed source in spatial arrangements that were indistinguishable from forest-edge locations regardless of presence of sprouting woody species, suggesting forest recovery was in fact occurring.[238] Unfortunately, complex early seral forests are poorly understood in southwestern dry forests as reference site studies and stand reconstructions characteristically cannot account for small diameter trees and other small vegetation. In order to maintain biodiversity and support landscape heterogeneity it is imperative that scientists initiate more research on these ephemeral habitats in dry southwestern forests in

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[236] p. 147 in Haire, S.L. and K. McGarigal. 2008. Inhabitants of landscape scars: succession of woody plants after large, severe forest fires in Arizona and New Mexico. *The Southwestern Naturalist* 53(2):146–161.
[237] p. 159 in Haire and McGarigal 2008
[238] Owen *et al.* 2017

order to account for their contribution in ecosystem management.[239] Meaningfully increasing the use of prescribed and wildland fire for ecological restoration requires recognition of the benefits of mixed fire severities in shrub, woodland and forested ecosystems. Based on the information presented above, small patches of high-severity fire effects interspersed within a matrix of low and moderate-severity can meet restoration objectives, create important ephemeral habitats, and reduce the risk of uncharacteristic reburn potential.

**Repeated fire application in prescribed and managed wildfire settings is needed and reflects the best available science**

The objective of ecological restoration in southwestern fire-adapted forests is to restore resilience to the inevitable future fires that will come, regardless of climate, environmental or human influences.[240] A number of fires have occurred across the KPERP landscape that can be leveraged for additional gains in fuels reduction and ecosystem restoration. It's a lost opportunity to not follow recent prescribed, resource benefit, and uncontrolled wildfires with additional fire, knowing that past fires act as fuel breaks and that effect diminishes with time.[241] It is critical to remember that "*historical ponderosa pine forest structure was a product of not one but of a series of fires over time*."[242] The compounding effect of recurring fire through centuries was selection for functional traits that incur ecophysiological adaptive benefits for drought and fire tolerance.[243] Overlapping fire mosaics promote development of differential tree recruitment, increase structural diversity and successional pathways, and break up fuel beds, facilitating more beneficial fires in the future.[244]

Holden and colleagues, in an analysis of thirteen fires in the Gila and Aldo Leopold Wilderness areas found evidence that initial wildfire severity slightly influenced severity of subsequent fires. In that study, which did not provide information for the size or distribution of burn patches, initial high-severity burns frequently reburned at high-severities, but most often in moist, high-elevation sites. The authors ultimately concluded that satellite imagery must be interpreted carefully and that field verification of their sites was needed.[245] Later work provided a

[239] Swanson *et al.* 2011

[240] Allen, C.D. M.A. Savage, D.A. Falk, K.F. Suckling, T.W. Swetnam, T. Schulke, P.B. Stacey, P. Morgan, M. Hoffman, and J.T. Klingle. 2002. Ecological restoration of southwestern ponderosa pine ecosystems: A broad perspective. *Ecological Applications* 12(5): 1418-1433.
Schoennagel *et al.* 2017. Adapt to more wildfire in western North American as climate changes. *PNAS* doi/10.1073/pnas.1617464114.

[241] Parks *et al.* 2015.

[242] p. 118 in Hunter *et al.* 2011

[243] Strahan *et al*. 2016. Shifts in community-level traits and functional diversity in a mixed conifer forest: a legacy of land-use change. *Journal of Applied Ecology*, doi: 10.1111/1365-2664.12737.

[244] Teske *et al.* 2012

[245] Holden *et al*. 2010. Burn severity of areas reburned by wildfires in the Gila National Forest, USA. *Fire Ecology* 6(3): 77-85.

contrasting conclusion, that previous wildfires do in fact moderate the severity of subsequent fires and lead to proportionally more area burned at low-severity.[246]

Returning frequent fire to the landscape will continue to alter forest structure and composition in ways that are not yet fully known, especially for wildlife that utilize snags and coarse woody debris.[247] Consistently, however, research from throughout the western United States alludes to the efficacy of returning fire in a mixed-severity approach, and following up with repeated low-severity burning for restoring historical structure, pattern, and process.[248] Modelling by Shive and colleagues showed that under milder climate scenarios, prescribed fire combined with climate-induced growth reductions resulted in ponderosa pine basal areas within the HRV[249], consistent with field observations of fire-based restoration at Grand Canyon and the Gila Wilderness, described below.

Repeated summer wildfires since 1946 at in the Gila and Saguaro Wilderness areas have successfully reduced density of small-diameter trees while not affecting large tree density, effectively shifting towards a larger tree distribution while reducing risk of crown fire, increasing resilience, and creating desired structural heterogeneity.[250] Similar effects have been documented on the Hualapai Indian Reservation, where more than fifty years of frequent prescribed fires have increased resilience to crown fire and climate change near the lower elevational limit of ponderosa pine.[251]

Repeated mixed-severity prescribed and natural-ignition fires in ponderosa pine dominated forests at Grand Canyon National Park have been shown to limit large tree mortality, reduce density of conifer seedlings and shade tolerant understory saplings, and reduce surface fuels consistent with restoration objectives and managing for climate resilience.[252] Initial mortality pulses resulting from initial fire entry create numerous snags, but many are consumed upon fire reentry as snag recruitment and persistence reaches a possible equilibrium.[253]

Studying the effects of prescribed fires on burn severity in the Rodeo-Chediski Fire, Finney and colleagues found that areas which were repeatedly burned significantly reduced subsequent burn

[246] Parks *et al.* 2014. Previous fires moderate burn severity of subsequent wildland fires in two large western US wilderness areas. *Ecosystems* 17: 29-42.

[247] Holden *et al*. 2006. Ponderosa pine snag densities following multiple fires in the Gila Wilderness, New Mexico. *Forest Ecology and Management* 221: 140–146.

[248] Hunter *et al.* 2011

[249] Shive *et al*. 2014. Managing burned landscapes: evaluating future management strategies for resilient forests under a warming climate. *International Journal of Wildland Fire* 23: 915–928

[250] Holden *et al.* 2007

[251] Stan *et al*. 2014. Modern fire regime resembles historical fire regime in a ponderosa pine forest on Native American lands. *International Journal of Wildland Fire* 23: 686-697.

[252] Fulé *et al*. 2002. Natural variability in forests of the Grand Canyon, USA. *Journal of Biogeography* 29: 31-47.
Fulé and Laughlin 2007. Wildland fire effects on forest structure over an altitudinal gradient, Grand Canyon National Park, USA. *Journal of Applied Ecology* 44: 136-146.
Laughlin *et al*. 2011. Effects of a second-entry prescribed fire in a mixed conifer forest. *Western North American Naturalist* 71(4): 557-562; and Fulé *et al.* 2004

[253] Holden *et al.* 2006; Laughlin *et al.* 2011

severity, but the beneficial effects diminished with time since fire. Their observations of fire progression, captured via satellite, provided evidence "*consistent with model predictions that suggest wildland fire size and severity can be mitigated by strategic placement of treatments.*"[254] Researchers observed the same effect studying fires in New Mexico and Idaho, where the "*severity of reburns increases with time since the previous fire, likely due to biomass accumulation associated with longer fire-free intervals.*"[255] Although their data showed that previous fires did have an effect up to 22 years later, further study concluded that initial fires ability to act as a fuel break was as little as 6 years in warm/dry climates such as southwestern ponderosa pine forests.[256]

Repeated resource objective fires on the Kaibab National Forest were recently reported to be more effective at restoring desired structure when they burned at moderate-severity under active fire-weather conditions.[257] Collins and Stephens found that in two Sierra Nevada wilderness areas where fire use policies were adopted, contemporary low-severity fires had allowed forests to become more resistant to insects, drought, and disease despite not having been thinned to historical densities. They concluded that "*what may be more important than restoring structure is restoring the process of fire*…[which] *could be important in allowing these forests to cope with projected changes in climate.*"[258]

Collins and colleagues studied mixed conifer forests in Yosemite National Park (4,800 - 7,000 ft.) where up to seven management and lightning started fires burned between 1983 and 2009, following an approximately 80-year fire-free period. They found that recent low severity fires reduced surface fuels and understory trees but did not kill enough intermediate sized trees to move towards desired structural characteristics. Their findings indicated "*no significant differences between current forest structure in areas that burned recently with moderate severity and forest structure in 1911*"[259] which was the year that historical inventory data was available for, and that only moderate fire-severity could substantially alter the ratio of fir to pine trees.

Taylor reported that two late twentieth century fires in an old growth ponderosa pine-Kellogg oak forest in California's Ishi Wilderness were effective at restoring pre-fire-exclusion structural characteristics, including composition, density, basal area and spatial pattern.[260] Similar effects were reported by Larson and colleagues, where reintroduction of natural-ignition fire in the Bob

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[254] p. 1714 in Finney *et al*. 2005. Stand- and landscape-level effects of prescribed burning on two Arizona wildfires. *Canadian Journal of Forest Research* 35: 1714-1722.

[255] p. 38 in Parks *et al.* 2014

[256] Parks *et al.* 2015

[257] Huffman *et al*. 2017b. Restoration benefits of re-entry with resource objective wildfire on a ponderosa pine landscape in northern Arizona, USA. *Forest Ecology and Management* 408: 16-24.

[258] pp. 526-527 in Collins and Stephens 2007. Managing natural wildfires in Sierra Nevada wilderness areas. *Frontiers in Ecology and the Environment* 5(10): 523–527.

[259] p. 10 in Collins *et al*. 2011. Impacts of fire exclusion and recent managed fire on forest structure in old growth Sierra Nevada mixed-conifer forests. *Ecosphere* 2(4): 1-14.

[260] Taylor 2010. Fire disturbance and forest structure in an old-growth Pinus ponderosa forest, southern Cascades, USA. *Journal of Vegetation Science* 21: 561-570.

Marshall Wilderness of Montana has restored low-density mixed conifer forest dominated by large, old ponderosa pine by consuming surface fuels and thinning shade-tolerant species from the forest understory and mid-canopy.[261]

These studies support the concept that repeated fires will move ponderosa pine and dry mixed-conifer systems towards predominantly low-severity fire equilibrium, consistent with the body of work focused on frequent fire systems achieving a self-regulating state.[262] The consistent theme is that a mixed-severity initial fire entry creates conditions conducive to repeat burning at low and moderate severities within the historical fire regime.[263] By allowing for moderate sized patches of high mortality that do not generally exceed 100 to 200 hectares (where determined appropriate by optimization analysis), there is relatively little risk of high-severity re-burning, inadequate regeneration, excessive coarse woody debris loadings, or transition to non-forest types.

**Nexus with livestock grazing effects is unavoidable and demands allotment retirement**

We are concerned that the analysis will not candidly describe and assess the inextricable cause-effect relationship between ongoing livestock management activities and this proposed management action. There is, unequivocally, no distinction between the destructive impacts of the industrial livestock grazing program supported by the Forest Service and the degraded condition of our public lands. To pursue this project without significantly modifying livestock grazing is surely to result in increasingly diminished ecosystem productivity, integrity, and resilience, and efforts to return fire to its natural role will be hampered by insufficient fine fuels. It is imperative that you thoroughly analyze the cumulative impact of cattle grazing (and associated “range management” practices) with proposed vegetation and fire treatments, in addition to drought and higher temperatures that are increasing as a result of climate change. The Forest Service has a responsibility to steward the public’s natural resources and protect the taxpayer’s investment so as not to require unnecessary remedial vegetation treatments in the future. Can the Forest Service ensure that post-treatment grazing practices will not continue to impact resources and lead to a need for retreatment?

The Center requests that part of this analysis is the permanent retirement of the grazing allotments contained within the project area. While grazing practices have improved on the North Rim Ranches under the stewardship of the Grand Canyon Trust, the practice as a whole is

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[261] Larson *et al*. 2013. Latent resilience in ponderosa pine forest: effects of resumed frequent fire. *Ecological Applications* 23(6): 1243–1249.

[262] Miller and Aplet 2015. Progress in Wilderness Fire Science: Embracing Complexity. *Journal of Forestry* 113: 1-11; and Parks *et al.* 2014; Parks *et al.* 2015

[263] Laughlin and Fule 2006. Meeting forest ecosystem objectives with wildland fire use. *Fire Management Today* 66(4): 21-24.

not sustainable and is a chronic and persistent stress on ecosystems that are being amply stressed by climate change.

Cattle grazing selectively removes desired plant species, facilitates the establishment and spread of invasive species, tramples biological soil crust, removes fine fuels needed to carry low-intensity fire, and exacerbates channel incision/erosion. Cattle grazing within the project area is not compatible with support of sagebrush and woodland dependent species, reduction of channel incision, support and restoration of biological soil crust to prevent further erosion, prevention of dust generation, growth of fine fuels for carrying surface fire, and support of robust native understory vegetation.

A critical long-term influence on restoration treatment success is subsequent livestock management. This stressor is almost never addressed in management plans beyond a general prescription to rest the area up to two years. Some even regard livestock grazing as necessary for maintaining healthy vegetation, although no credible data exist to support this contention. In fact, most objective studies of this subject indicate the opposite is true. Overgrazing removes fine fuels, reducing fire frequency and competition and facilitating expansion of woody species. Livestock and wildlife tend to concentrate in seeded areas, which leads to soil compaction, soil surface disturbance and erosion, and overuse of vegetation. In sagebrush habitats, the USDA recommends removing grazing for *at least* 3 to 5 years after restoring sage habitats, and inoculating seed or soil with microorganisms and fungal mycorrhizae that are missing from the soil when seeding with native plants.[264] Because soils across much of the Arizona Strip are already largely depleted of soil crusts and bunchgrass cover, the Forest Service should remove livestock for more than just 3 to 5 years; livestock should be permanently removed from this treasured landscape.

A nearby example of livestock destroying public investments in reseeding can be seen on Grand Staircase-Escalante National Monument. Many seeded areas on the Monument have been degraded due to trespass by livestock (e.g., Mollies Nipple, Vermilion, Circle Cliffs, and Upper Paria allotments). The ability of seeded areas to withstand perturbations such as drought is weakened by illegal grazing, and then the projects fail. When this happens, the agencies strategy is to replant the forage species and begin the cycle again. A better, less expensive approach, and one more in keeping with the purpose of habitat restoration, would be to manage livestock (i.e., remove them completely) so as to not require expensive seeding or restoration projects.

Livestock grazing is one important factor to consider that may adversely impact woodland health and fire regime. It directly contributes to fire hazard in the project area by impairing soil productivity and altering vegetation communities, which indirectly contribute to delayed fire rotations, increased woody vegetation density, and reduced forage opportunities for herbivorous

[264] USDA. 2005. Seeding considerations in restoring big sagebrush habitat. *by* Scott M. Lambert. USDA Forest Service Proceedings RMRS-P-38.

species and predators. Potentially significant cumulative effects to soil productivity, plant communities, fire regime and wildlife may result from fuel management in combination with livestock grazing and other activities, such as road building and motorized vehicle use, which disturb soils and spread exotic plant species. Livestock disturb soil, introduce and enable seeds of exotic species to spread, and reduce the competitive and reproductive capacities of native species. Exotic plant species, once established, can displace native species, in part, because native grasses are not adapted to frequent and close grazing alone or in combination with fire disturbance.

Exotic plant spread is a guaranteed significant cumulative impact of the proposed action. Treatments similar to the proposed action elsewhere in northern Arizona left forested sites overrun with cheatgrass (*Bromus tectorum*).[265] Because it is already extensively established in the project area today, exotic grass invasion is foreseeable and has important long-term implications for native plant communities, ecosystems, and wildlife. Melgoza and others[266] studied cheatgrass soil resource acquisition after fire and noted its competitive success owing to its ability suppress the water uptake and productivity of native species for extended periods of time. They further showed that cheatgrass dominance is enhanced by its high tolerance to grazing. Its annual life-form coupled with the abilities to germinate readily over a wide range of moisture and temperature conditions, to quickly establish an extensive root system, and to grow early in the spring contribute to its successful colonization. In addition, Melgoza and others showed that cheatgrass successfully competes with the native species that survive fire, despite these plants being well-established adult individuals able to reach deeper levels in the soil. This competitive ability of cheatgrass contributes to its dominance when lands experience synergistic disturbances from grazing, mechanical treatments, and fire.

The most important factors for preventing cheatgrass invasions are biological soil crust and bunchgrass community structure, abundance, and composition. Bunchgrasses provide groundcover and impede connectivity of gaps where cheatgrass establishes. Cattle grazing increases susceptibility by decreasing bunchgrass abundance and altering bunchgrass composition, as well as trampling soil crusts and other plants, thereby connecting gaps and increasing open ground. In order to prevent cheatgrass invasions, managers must restore bunchgrass cover and diversity, and allow biological soil crusts to establish. Removing cattle grazing is the best passive method of protecting an area from cheatgrass infestation.[267] The Forest Service should exert extreme caution in removing vegetative cover where cheatgrass is present. Instead, remove grazing from areas considered susceptible to cheatgrass invasion, or

[265] McGlone, Chris M., Judith D. Springer, and William W. Covington. 2009. Cheatgrass encroachment on a ponderosa pine forest ecological restoration project in northern Arizona. *Ecological Restoration* 27:37-46.
[266] Melgoza, G., R.S. Nowak and R.J. Tausch. 1990. Soil water exploitation after fire: competition *between Bromus tectorum* (cheatgrass) and two native species. *Oecologica* 83:7-13.
[267] Reisner, M.D., J.B. Grace, D.A. Pyke, and P.S. Doescher. 2013. Conditions favouring *Bromus tectorum* dominance of endangered sagebrush steppe ecosystems. *Journal of Applied Ecology* 50:1039-1049.

where a resource can be lost if cheatgrass invades (this includes the entire project area). Also, avoid ground disturbing activities in areas with cheatgrass, such as mastication.

Persistent livestock grazing is a component of the compromised ecological condition of the Southwest's forests and woodlands, including the Kaibab and Kanab Plateaus. The Forest Service must analyze the effects of livestock grazing on the success of the proposed vegetation treatments in achieving and maintaining desired future conditions as they relate to fire use, migratory birds, northern goshawk, Mexican spotted owl, native reptiles and amphibians, and other sensitive species populations and habitats. Livestock grazing has had numerous, long-lasting negative impacts to arid western ecosystems.[268] Some major effects of livestock grazing that are relevant to accomplishing the project purpose are given here:

• Livestock grazing decreases understory biomass and density, reducing competition with conifer seedlings and reducing the ability of the understory to carry low-intensity fire, contributing to dense forests and woodlands with altered species composition.[269]

• Grazing significantly reduces water infiltration into the soil, and rest from grazing allows infiltration rates to recover. USDA research has found that excluding cattle from a landscape for five growing seasons "*significantly increased: (1) total vegetative cover, (2) native perennial forb cover, (3) grass stature, (4) grass flowering stem density, and (5) the cover of some shrub species and functional groups.*"[270]

• Livestock grazing degrades water quality by increasing water temperatures in several ways. It widens channels due to bank damage from trampling and sedimentation, leading to elevated water temperature via the loss and suppression of riparian vegetation that provides stream shade.[271,272] Trampling impacts are substantial even in the absence of shade loss.[273] This is a serious impact because elevated water temperature adversely affects numerous aquatic species, including those which may occur near this project area.

[268] Fleischner, T.L. 1994. Ecological costs of livestock grazing in western North America. *Conservation Biology* 8(3):629-644.

[269] Belsky A.J. and D.M. Blumenthal. 1997. Effects of livestock grazing on stand dynamics and soils in upland forests of the Interior West. *Conservation Biology* 11:316-27.

[270] Kerns, Becky K., Michelle Buonopane, Walter G. Thies, and Christine Niwa. 2011. Reintroducing fire into a ponderosa pine forest with and without cattle grazing: understory vegetation response. *Ecosphere* 2(5):1-23.

[271] Kondolf, G. Mathias, Richard Kattelmann, Michael Embury, and Don C. Erman. 1996. Status of riparian habitat. Sierra Nevada Ecosystem Project: Final report to Congress, Volume 2

[272] Beschta, R.L., D.L. Donahue, D.A. DellaSala, J.J. Rhodes, J.R. Karr, M.H. O'Brien, T.L. Fleischner and C.D. Williams. 2013. Adapting to climate change on western public lands: addressing the ecological effects of domestic, wild, and feral ungulates. *Environmental Management* 51: 474-91.

[273] Rhodes, J.J., D.A. McCullough, and F.A Espinosa, Jr. 1994. A coarse screening process of the effects of land management on salmon spawning and rearing habitat in ESA consultations. Technical Report 94-4. Columbia River Inter-Tribal Fish Commission. Portland, Oregon. Report prepared for National Marine Fisheries Service.

• Removal of livestock grazing pressure from riparian areas has been found to have a positive effect on growth, distribution, and vigor of riparian communities which are very limited on the Kaibab Plateau and require immediate protection and restoration.[274]

• Grazing of the most nutritious plants by livestock results in a loss of forage for native species and can alter habitat or insect prey base.[275,276] A decrease in prey base inevitably leads to a decrease in carnivores in the area, which are also eliminated by the government at the request of the livestock community.

• Livestock facilitate the spread of exotic species, particularly in combination with fire, and reduce the competitive and reproductive capacities of native species.[277] Exotic plant species, once established, can displace native species, in part, because native grasses are not adapted to frequent and close grazing in combination with fire disturbance.[278,279,280] "*The productivity, diversity, and species richness of native grasslands are threatened by competition from noxious and invasive weeds/grasses. Productivity is threatened by other factors including drought, soil erosion, fire suppression, and improper livestock management practices.*"[281]

• Grazing also has negative effects on songbirds, reptiles and other mammals especially if their habitat is close to the ground.[282]

• A critical and often overlooked consideration in effective vegetation treatments is the necessity for resting a treated area from domestic livestock grazing to allow establishment of fine fuels such that low-intensity ground fire can be applied to the ground surface, and aligning allotment management plans such that future livestock grazing does not deplete the fine fuels that are required to maintain a prescribed fire schedule. The Ecological Restoration Institute reviewed the research and perspectives on resting from grazing, and concluded that:

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[274] Schulz, Terri Tucker, and Wayne C. Leininger. 1990. Differences in riparian vegetation structure between grazed areas and exclosures. Journal of Range Management 43(4):295-299.

[275] Donahue, D. 1999. The Western Range Revisited: Removing Livestock from Public Lands to Conserve Native Biodiversity. Norman, OK: University of Oklahoma Press. 338 pages.

[276] Kie, John G., Charles J. Evans, Eric R. Loft, and John W. Menke. 1991. Foraging behavior by mule deer: the influence of cattle grazing. *The Journal of Wildlife Management* 55(4):665-674.

[277] Brooks, M.L., C.M. D'Antonio, D.M. Richardson, J. B. Grace, J.E. Keeley, J. M. DiTomaso, R.J. Hobbs, M. Pellant and D.Pyke. 2004. Effects of invasive alien plants on fire regimes. *BioScience* 54(7):677-688.

[278] Mack, R. N., and J. N. Thompson. 1982. Evolution in steppe with few large, hooved mammals. *American Naturalist* 119:757-72.

[279] Melgoza, G., R.S. Nowak and R.J. TaU.S.C.h. 1990. Soil water exploitation after fire: competition *between Bromus tectorum* (cheatgrass) and two native species. *Oecologica* 83:7-13.

[280] Belsky, A.J., and J.L. Gelbard. 2000. Livestock Grazing and Weed Invasions in the Arid West. Oregon Natural Desert Association: Portland, OR. April. 31 pp.

[281] Central Arizona Grasslands Conservation Strategy, page 21

[282] Finch, D.M., and W. Block, technical editors. 1997. Songbird ecology in southwestern ponderosa pine forests: a literature review. Gen. Tech. Rep. RM-GTR-292. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 152 p.

"*These research findings, although limited, suggest that federal agencies should be prepared to wait more than two years before allowing domestic grazing on restored allotments lest they jeopardize two important goals of restoration treatments—restoring the understory and returning low-intensity prescribed fire as an ecosystem process.*"[283]

Recent studies into livestock grazing management[284,285] have identified ways to reduce negative impacts, primarily through changes in agency management of forage resources and grazing to reflect best available science. These changes would contribute significantly to improving the habitat for a range of species in the KPERP project area. Recommended management changes include:

(1) Eliminating areas with sensitive or high-erosion soils from capacity, suitability, or stocking rate calculations;

(2) Updating stocking rates based on conservative forage utilization rates (25-30 percent);

(3) Managing livestock by herding rather than fencing or water developments;

(4) Provide for rest, in some cases, several years, to allow for recovery of vegetation within allotments following vegetation treatments, fire or other disturbances;

(5) Closure of areas with degraded soil or plant communities.

The Forest Service should identify areas with degraded soils or plant communities, areas with sensitive or high-erosion soils, and areas in need of recovery, and reduce or eliminate grazing in those pastures altogether to contribute to the success of the proposed restoration treatments. Utilization rates should never exceed 30%.[286]

As an appendix to these comments, we have attached the 2006 "Environmental History of the Kane and Two-Mile Ranches in Arizona," in which one chapter provides the most comprehensive review of livestock use of the Kaibab Plateau and Arizona Strip ever completed. This document will be a helpful starting point for understanding the legacy of grazing in the area.

[283] Egan, D. 2011. Integrating Domestic and Wild Ungulate Grazing into Forest Restoration Plans at the Landscape Level. Issues in Forest Restoration, ERI White papers. Ecological Restoration Institute, Flagstaff, AZ. 14p.
[284] Carter, J., J. Chard, and B. Chard. 2011. Moderating Livestock Grazing Effects on Plant Productivity, Nitrogen and Carbon Storage. *In* Monaco, T.A. *et al.*, 2011. Proceedings – Threats to Shrubland Ecosystem Integrity; May 18-20, 2010, Logan, UT. *Natural Resources and Environmental Issues* 17.
[285] Carter, J., J.C. Catlin, N. Hurwitz, A.L. Jones, and J. Ratner. 2017. Upland water and deferred rotation effects on cattle use in riparian and upland areas. *Rangelands* 39(3-4): 112-118.
[286] Holecheck, J.L, H. Gomez, F. Molinar, and D. Galt. 1999. Grazing Studies: What we've learned. *Rangelands* 21(2): 12-16.

**Pinyon-juniper woodlands**

Range management scientists have stated that, "*Current conservation…could be improved by incorporating more direct linkages to…ecologically based technical literature, more up-to-date information on adaptive management strategies in highly variable rangeland systems…*"[287] In the EIS, please produce the evidence linking removal of pinyon and juniper to improved biodiversity, sagebrush community health, improvement in watershed conditions, and other reasons for the proposed action. Treatments in pinyon-juniper woodlands and savannas must retain all old growth and mature characteristics, mimic natural patch disturbances, be designed according to site-specific natural range of variability, and fit into a broader strategic treatment optimization for allowing natural fire to play its role as the dominant driver in ecosystem structure and composition. Well-research reviews, cited here, provided ample technical basis for decision making. We anticipate the Forest Service will base treatment decision on science, rather than ideology, but the Kaibab Forest Plan's desired conditions for pinyon-juniper communities does not inspire much confidence that this will happen.

Fire is a naturally occurring disturbance process in the Colorado Plateau pinyon-juniper/sagebrush/grassland ecosystem, but it is not well-understood compared to other ecosystems such as ponderosa pine forest. It is extremely important that the results from well-studied forested environments are not inappropriately applied to Colorado Plateau pinyon-juniper or sagebrush ecosystems. At a broad scale, the pinyon-juniper ecosystem has evolved under the influence of predominantly high severity fires occurring at multi-century scales.[288,289] Sagebrush too, is likely to have evolved under an infrequent fire regime, although the lack of trees to record fire scars makes it very difficult to determine fire history,[290] and site-specific studies have not been completed. Long fire-free intervals can lead to the development of extensive old growth pinyon-juniper stands[291] which must be identified and deferred from mechanical thinning in this project. In some cases, protection of old growth stands can be accomplished through low-impact removal of young ladder fuels by hand-thinning crews.

Decadal, centurial, and millennial-scale climatic variation has influenced fire size, severity, and frequency in the Great Basin and southern Colorado Plateau, leading to periods of increased and

[287] Hardegree, S.P., T.A. Jones, B.A. Roundy, N.L. Shaw, and T.A. Monaco. 2016. Assessment of range planting as a conservation practice. *Rangeland Ecology and Management* 69: 237-247.

[288] Baker, W.L., and D.J. Shinneman. 2004. Fire and restoration of pinon-juniper woodlands in the western United States: a review. *Forest Ecology and Management* 189: 1-21.

[289] Floyd, M.L., W.H. Romme, D.P. Hanna, and D.D. Hanna. 2017. Historical and modern fire regimes in pinon-juniper woodlands, Dinosaur National Monument, United States. *Rangeland Ecology & Management* 70: 348-355.

[290] Mensing, S., S. Livingston, and P. Barker. 2006. Long-term fire history in Great Basin sagebrush reconstructed from macroscopic charcoal in spring sediments, Newark Valley, Nevada. *Western North American Naturalist* 66(1): 64-77.

[291] Shinneman, D.J., and W.L. Baker. 2009. Historical fire and multidecadal drought as context for pinon–juniper woodland restoration in western Colorado. *Ecological Applications* 19(5): 1231–1245.

decreased fire activity in a range of vegetation types.[292,293,294] A coalition of the 15 leading researchers in western pinyon-juniper woodland ecology have argued that

> "*given the very long fire rotations that naturally characterize persistent piñon-juniper woodlands, we cannot yet determine whether the recent increase in frequency of large fires occurring in this vegetation type represents genuine directional change related to changing climate or fuel conditions, or is simply a temporary episode of increased fire activity, comparable to similar episodes in the past.*"[295] In addition, in pinyon-juniper woodlands "*climatic variability influences key ecological processes such as masting behavior, recruitment, and mortality to produce vegetation change across a wide range of temporal and spatial scales.*"[296]

"Encroachment" of juniper into shrublands is often used as a justification for a wide array of highly intensive mechanical treatments. But there is considerable controversy over whether the increase in these species is really an expansion at all. It may be a reversion back to a more natural "pre-contact state", or natural ecological succession in response to climate change, or succession in response to uses such as livestock grazing. A study conducted for the Cedar City BLM Planning Area found that while pinyon-juniper woodlands increased in range since the early 20th century most of this growth was recovery from deforestation that occurred in the late 19th century.[297] New information on expected fire frequency[298] suggests that removal of these woodlands to replicate historic fire intervals is not justified.[299] Rosenstock and Van Riper reported that "*Livestock grazing and fire suppression commonly are cited as causes of woodland*

[292] Mensing et al. 2006
[293] Shinneman and Baker 2009
[294] Weppner, K.N., J.L. Pierce, and J.L. Betancourt. 2013. Holocene fire occurrence and alluvial responses at the leading edge of pinyon–juniper migration in the Northern Great Basin, USA. *Quaternary Research* http://dx.doi.org/10.1016/j.yqres.2013.06.004.
[295] Page 212 in: Romme, W.H., C.D. Allen, J.D. Bailey, W.L. Baker, B.T. Bestelmeyer, P.M. Brown, K.S. Eisenhart, L. Floyd-Hanna, D.W. Huffman, B.F. Jacobs, R.F. Miller, E.H. Muldavin, T.W. Swetnam, R.J. TaU.S.C.h, P.J. Weisberg. 2009. Historical and Modern Disturbance Regimes, Stand Structures, and Landscape Dynamics in Piñon-Juniper Vegetation of the Western U.S. Rangeland Ecology & Management 62(3): 203-222.
[296] Betancourt, J.L., E.A. Person, K.A. Rylander, J.A. Fairchild-Parks, and J.S. Dean. 1993. Influence of History and Climate on New Mexico Pinion-Juniper Woodlands. In: Aldon, E.F., and D.W. Shaw, technical coordinators. 1993. Managing Pinion-Juniper Ecosystems for Sustainability and Social Needs; proceedings of the symposium 1993 April 26-30; Sante Fe, New Mexico. Gen. Tech. Rep. RM-236. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 169 p.
[297] Catlin, J, E. Vesquez, A. Jones. 2012. Piñon-juniper forest and the sagebrush steppe, Cedar City Resource Management Plan. Unpublished comments on the Cedar City RMP. Wild Utah Project.
[298] Baker and Shinneman 2004
[299] Bukowski, B.E. and W.L. Baker. 2013. Historical fire regimes, reconstructed from land-survey data, led to complexity and fluctuation in sagebrush landscapes. *Ecological Applications* 23(3):546-564.

*expansion.*"[300] Removal of livestock and reintroduction of appropriate levels of fire are necessary steps to restore function to degrade pinyon-juniper communities.

Other studies are casting doubt on the efficacy of vegetation treatments in pinyon-juniper communities, at least as they are currently conducted.[301] One study of particular relevance to the proposed action is in nearby Grand Staircase-Escalante National Monument. Analysis of several 20-40 year old chained areas in pinyon-juniper woodland showed that while herbaceous understory increased after treatment (mainly crested wheatgrass), so did soil bare ground. Biological soil crust was still reduced decades after the treatments were put in place.[302] Both of these indicators lead to increased soil erosion. In addition, rangeland health assessments conducted on the adjacent Grand Staircase-Escalante National Monument show that seeded areas in sagebrush vegetation types had much higher rates of non-functioning and functioning at risk rangeland health sites than their unseeded counterparts.[303] Soil and hydrologic functions at 57% of these sites were either non-functioning or functioning at risk. Biotic integrity at 28% of sites was either non-functioning or functioning at risk.

In similar ecosystems in the Great Basin, in areas away from the woodland-steppe ecotone where fires may have historically been more frequent and lower severity,[304] contemporary density and stand structure may not be overly dense compared to pre-settlement conditions.[305,306] The perceived 'invasion' of shrublands by woodland species is something that the Forest Service must study with a critical eye on past land use history, especially the vast areas of forest and woodland that were cleared during the Mormon settlement period. The contemporary expansion of woodland types into shrub and grass communities may in some cases be a reestablishment of areas that were destroyed by past land use practices, stressing the importance of locally-formulated understandings of ecosystem history and human land use interactions.

> "*Similarly, many areas that were chained in the 1950s and 1960s now support dense stands of young piñons and/or junipers that may give the appearance of expansion into grasslands or shrublands [and] the presence of young piñon and juniper trees near the species' current geographical range limits may represent*

300 Rosenstock, S. S. and Van Riper III, C. (2001) Breeding Bird Responses to Juniper Woodland Expansion. *Journal of Range Management*, 54:226-232.

301 Davies, K.W., J.D. Bates, and A.M. Nafus. 2012. Mowing Wyoming big sagebrush communities with degraded herbaceous understories: has a threshold been crossed? *Rangeland Ecology and Management* 65:498-505.

302 Redmond, M, Cobb, N, Miller, M, and Barger, N. 2013. Long-term effects of chaining treatments on vegetation structure of piňon-juniper woodlands of the Colorado Plateau. Forest Ecology and Management 305:120-128.

303 Miller, M. 2008. Broad-scale assessment of rangeland health, Grand Staircase-Escalante National Monument, USA. Rangeland Ecology and Management 61 (3): 249-262.

304 Mensing et al. 2006

305 Bauer, J.M., and P.J. Weisberg. 2009. Fire history of a central Nevada pinyon-juniper woodland. Canadian Journal of Forest Research 39: 1589–1599.

306 Tausch, R.J., N.E. West, and A.A. Nabi. 1981. Tree Age and Dominance Patterns in Great Basin Pinyon-Juniper Woodlands. Journal of Range Management 34(4): 259-264.

> *natural, long-term change in biogeographical extent rather than unnatural expansion into non-woodland habitats*."[307]

The increase in modern fires, due largely to the cheatgrass-positive feedback cycle, has in some areas led to a reduction in the extent of woodlands compared to historical distribution. Contrary to the assumptions of resource managers, Floyd and colleagues[308] documented that the extent of pinyon-juniper woodlands at Dinosaur National Monument had actually decreased, and woodlands had not spread into adjacent grasslands and shrublands. The KPERP analysis must complete a robust site-specific review of landscape-scale patterns of shift and transition in vegetation extent to ensure that treatments are designed in a manner that is in line with ecological trends, and that proposed treatments do not increase the spread of cheatgrass.

The Forest Service must consider the wide disparity between sites in natural range of variability, historic conditions, and disturbance processes, and develop site-specific management approaches. The pinyon-juniper and sagebrush ecosystems occur across a tremendous gradient of floristic, hydrologic, climatic, geographic, and cultural conditions. Management strategies used in one area will not necessarily translate to success in another area with different soils, land use history, and precipitation regimes, "*thus two identical management strategies may differ drastically in their effects.*"[309] It is important that the proposed project approaches ecosystem management by fully appreciating the diversity inherent to these vegetative communities. Regarding the pinyon-juniper ecosystem, Romme and colleagues[310] stated that:

> "*Uncertainties about historical stand structures and disturbance regimes in piñon-juniper vegetation create a serious conundrum for land managers and policy-makers who are charged with overseeing the semi-arid landscapes of the West. Vegetation treatments often are justified in part by asserting that a particular treatment (e.g., tree thinning or prescribed burning) will contribute to restoration of historical conditions, i.e., those that prevailed before the changes wrought by Euro-American settlers. However, in the absence of site-specific information about historical disturbance regimes and landscape dynamics, there is danger that well-meaning "restoration" efforts actually may move piñon-juniper ecosystems farther from their historical condition. Some kinds of vegetation treatments may even reorganize ecosystems in such a way that restoration of historical patterns and processes becomes more difficult. Of course, ecological restoration is not the only appropriate goal in land management; but*

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[307] Page 215 in: Romme et al. 2009

[308] Floyd et al. 2017

[309] Page 89 in: Williamson, Matthew A. 2008. Variation among pinyon-juniper woodlands: A cautionary note. In: Gottfried, Gerald J.; Shaw, John D.; Ford, Paulette L., compilers. 2008. Ecology, management, and restoration of pinon-juniper and ponderosa pine ecosystems: combined proceedings of the 2005 St. George, Utah and 2006 Albuquerque, New Mexico workshops. Proceedings RMRS-P-51. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. p. 89

[310] Page 204 in: Romme et al. 2009

*even where the actual goal is wildfire mitigation or forage enhancement, treatments are more likely to be effective if designed with an understanding of the historical ecological dynamics of the system being manipulated*."

Ultimately several convergent factors have influenced contemporary woodland extent and density, including a wet period in the latter half of the 1800's, overgrazing by domestic livestock, tree harvesting during the settlement era, and prior periods of extensive fires.[311] The EIS must stress that locally-derived, site specific conditions should be the basis for decision making, not generalized simplifications of complex interactions across space and time. Anywhere that old growth pinyon and juniper is present should be immediately identified as an area that should not be cleared of woodlands species. Hand thinning treatments of young woodland species should be the primary treatment approach.

As an appendix to these comments, we have attached the 2006 Grand Canyon Trust report titled "An Environmental History of the Kane and Two-Mile Ranches in Arizona," which provides the most comprehensive review of pinyon-juniper natural range of variability known to exist for the Arizona Strip. This document will be a helpful starting point for developing reasonable alternatives for comparison in the EIS.

**Pinyon Juniper Woodlands Provide Irreplaceable Wildlife Habitat**

Pinyon-juniper woodlands support high avian abundance and diversity, with many obligate and semi-obligate species, and with a low level of avian community similarity to other forest habitats.[312] Sieg[313] found higher bird abundance in pinyon-juniper woodlands in Utah during every season than were found in adjacent grasslands. An estimated 1,000 species of wildlife, plants, and fungi are associated with pinyon pines in the southwest,[314] and pinyon pines hold cultural significance (i.e., pine nut gathering). Slow-growing pinyons are extremely drought sensitive, unlike their juniper counterparts.[315,316] Within the last 20 years, pinyon mortality has

[311] Tausch et al. 1981

[312] USDA. 1999. Forest Service Proceedings RMRS-P-9. Paulin, K.M., J.J. Cook, and S.R. Dewey. Pinyon-juniper woodlands as sources of avian diversity.

[313] Sieg, Carolyn H. 1991. Rocky Mountain juniper woodlands: yearround avian habitat. Research paper RM-296. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 7 p.

[314] Whitham, T.G., M.P. Young, G.D. Martinsen, C.A. Gehring, J.A. Schweitzer, G.M. Wimp, D.G. Fischer, J.K. Bailey, and R.L. Lindroth. 2003. Community and ecosystem genetics: a consequence of the extended phenotype. *Ecology* 84:1171–1178.

[315] Mueller, R.C., C.M. Scudder, M.E. Porter, R.T. Trotter III, C.A. Gehring, and T.G. Whitham. 2005. Differential tree mortality in response to sever drought: evidence for long-term vegetation shifts. *Journal of Ecology* 93:1085-1093.

[316] Breshears, D.D., O.B. Myers, C.W. Meyer, F.J. Barnes, C.B.Zou, C.D. Allen, N.G. McDowell, and W.T. Pockman. 2009. Tree die-off in response to global change-type drought: mortality insights from a decade of plant water potential measurements. *Frontiers in Ecology and Environment* 7:185-189.

occurred throughout the southwest, exceeding 90% in some places.[317] Therefore, even though the two trees often coexist, pinyon and juniper may require separate management strategies to maintain biodiversity. After the massive die-offs of pinyon pine that have occurred over the last 20 years[318] we should not gratuitously remove them from the landscape.[319] In short: pinyon pine should not be intentionally removed from the landscape *en masse* when ecological restoration is a project goal. There are a variety of potential impacts to resources and wildlife foreseeable from the project which would warrant the type of analysis that a full EIS would provide. Some of these include: impacts to raptor populations, based on nest surveys on and adjacent to the project site; impacts to big game, some of which use pinyon-juniper as primary habitat; impacts to riparian areas and vegetation; impacts to surface water, if any is present; and the myriad of other environmental impacts that NEPA documents are intended to disclose and analyze.

According to the Southwest Environmental Information Network,[320] a database of plant collections in herbaria across the southwest, the project area is nearby to populations of and potential habitat for *Astragalus pinonis* var. *atwoodii*. This endemic plant is ranked as G2G3/T1 (Globally imperiled) by the NatureServe database. It occurs in pinyon-juniper woodlands at N36.7536 - W112.3131 and N36.767342 - W112.312181. These occurrences and others yet to be mapped may be impacted by the project. Additionally, there are many native plants in the project area that are restricted from salvage by Arizona Administrative Code 3 A.A.C. 3 Article 11.[321] These species require a permit for removal. Has the Forest Service surveyed the area for rare plants and other native plant species on the list, and have the proper permits for plant destruction and removal been acquired?

### Chaining Has Negative Effects on Wildlife and Doesn't Meet Restoration Objectives

A major goal of vegetation treatments should be restoring the natural disturbance regime and chaining is not a natural disturbance. If one goal of this project is to increase grass cover for grassland species, then fire is a more effective method of grassland restoration than chaining.[322] Areas restored with fire have far more productive understories and avoid a problem created by chaining whereby large old trees are killed but younger, smaller trees remain to resprout.[323]

[317] *Ibid*
[318] *Ibid*
[319] Redmond et al. 2013
[320] SEINet.org
[321] Arizona Native Plants Section RS-3 Appendix B Salvage restricted native plants as prescribed in A.R.S. 3-903(B)(2))
[322] Aro, Richard S. Evaluation of pinyon-juniper conversion to grassland. Journal of Range Management (1971): 188-197.
[323] *Ibid*

It is not clear that chaining is an effective technique for converting pinyon-juniper woodlands to shrubland-grasslands. Bristow and colleagues[324] found that "*chained sites can be rapidly recolonized by trees and achieve pretreatment densities within a few decades*." They further state that such treatments, when not accompanied by regular follow-up treatments, have potential to "*create or amplify landscape-level shifts in tree species composition.*"[325] Tausch and Tueller[326] studied six chaining sites in eastern Nevada and found that understory response was short-lived and in all cases, trees were again dominant within 15 years, while fire had a longer, though still transient, effect. Skousen and colleagues[327] also found only a temporary effect from chaining, where forbs decreased over time, and where shrubs made up 84% of plant cover after 24 years; furthermore, juniper density was not always lowered by treatments. Chaining can also facilitate cheatgrass invasion,[328] and lead to future dominance of juniper at the expense of mast-producing pinyon, such as at Grand Staircase Escalante National Monument.[329]

Chaining can be very detrimental to non-game species, with long-term impacts on wildlife. Chaining reduces abundance and diversity of avian communities. Chained pinyon-juniper woodland in Colorado only supported one third of bird species and half the bird densities found on unchained landscapes, even 8 to 15 years later.[330] Species diversity of small mammals was also reduced in the chained areas.[331] In an exhaustive review of chaining impacts, Jones and colleagues[332] reported that:

> *"…Sedgwick and Ryder (1987) found that while the chaining of trees from a piñon -juniper woodland in Colorado increased herbaceous production, it significantly reduced site utilization by birds. As a result, avifauna diversity was higher in woodlands than in chained sites, with the foliage/timber searching guild, aerial foraging guild, and cavity nesting guild most affected by treatment. Moreover, woodland clearance has generally shown few effects on population sizes of big-game species such as deer and elk (Terrell and Spillett 1975, Skousen*

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[324] Bristow, N. A., Weisberg, P. J., & TaU.S.C.h, R. J. 2014. "A 40-Year Record of Tree Establishment Following Chaining and Prescribed Fire Treatments in Singleleaf Pinyon (Pinus monophylla) and Utah Juniper (Juniperus osteosperma) Woodlands." *Rangeland Ecol Manage* 67, 389-396.

[325] *Ibid*

[326] Tausch, R.J. and P.T. Tueller. 1977. Plant succession following chaining of pinyon-juniper woodlands in eastern Nevada. Journal of Range Management 30:44-48.

[327] Skousen, J.G., J.N. Davis, and J.D. Brotherson. 1989. Pinyon-juniper chaining and seeding for big game in central Utah. Journal of Range Management 42:98-104

[328] Baughman, C., T.A. Forbis, and L. Provencher. 2010. Response of Two Sagebrush Sites to Low-Disturbance, Mechanical Removal of Piñyon and Juniper. Invasive Plant Science and Management: June-August, Vol. 3, No. 2, pp. 122-129.

[329] Redmond, M, Cobb, N, Miller, M, and Barger, N. 2013. Long-term effects of chaining treatments on vegetation structure of piňon-juniper woodlands of the Colorado Plateau. Forest Ecology and Management 305:120-128.

[330] O'Meara, T.E., J.B. Haufler, L.H. Stelter, and J.G. Nagy. 1981. Nongame wildlife responses to chaining of pinyon-juniper woodlands. *The Journal of Wildlife Management* 45:381-389.

[331] *Ibid*

[332] Jones, A., Catlin, J., Vasquez, E. 2013. "Mechanical Treatment of Pinyon-Juniper and Sagebrush Systems in the Intermountain West: A Review of the Literature."

> *et al. 1989 – a study in central Utah, Belsky 1996). One reason it is theorized that deer will not tend to utilize cleared P-J sites above normal use levels for the area is because of their hesitancy to expose themselves in large open areas (Short et al. 1977, Lanner 1981).*"

Examining the long-term impacts of chaining on a suite of wildlife species, Gallo and colleagues[333] state,

> "*We found marked differences in habitat use between historically chained sites and reference woodlands for 5 out of the 8 species for which there was sufficient relative activity data. More than 40 years after chaining, bobcat, mountain lion, American black bear, goldenmantled ground squirrel, and rock squirrel all showed a negative response to historic chaining. These findings suggest that tree removal intended to benefit livestock and economically important wildlife species has long-term effects on a variety of non-target mammal species*."

This result clearly shows that chaining is not compatible with a habitat restoration project. In yet another study, chaining did not increase the use of habitat by big game species.[334] Any treatments in pinyon-juniper woodland should be predominantly hand crews using chainsaws and pile burning of slash, to minimize detrimental effects on soils and minimize risk of cheatgrass spread.

**Cultural Resources Must Be Identified and Protected**

The project area is located in a region rich with cultural sites spanning 10,000 years of human habitation. In the modern era, pinyon-juniper woodlands within the planning area are valued by Native Americans from the Kaibab Paiute, Navajo, Hopi, and other tribes for resources such as medicinal plants, pinyon nuts, and fuelwood. Additionally, tribes may be actively using the planning area for ceremonial purposes. These woodlands are also valued for the recreational and hunting opportunities that they provide for a variety of forest visitors. As an appendix to these comments, we have attached the 2006 Grand Canyon Trust report titled "An Environmental History of the Kane and Two-Mile Ranches in Arizona," which provides a comprehensive review of Native American land use history of the Kane and Two-Mile Ranch area, which encompasses the project area and as such is enormously relevant.

It would be a clear violation of Section 106 of the National Historic Preservation Act to conduct the proposed action without any cultural inventory of the area. The Forest Service is obligated to "*consult, coordinate, and cooperate with relevant State, local, and **tribal governments** and other*

[333] Gallo, T., Stinson, L. T., Pejchar, L. 2016. "Pinyon-juniper removal has long-term effects on mammals." *Forest Ecology and Management*, 377, 93-100.
[334] Skousen et al. 1989

*bureaus and Federal agencies concerning the environmental effects of any Federal action within the jurisdictions or related to the interests of these entities.*"[335] If such an inventory has been conducted, an EIS would be the ideal venue to disclose the results of the inventory, and analyze the impacts to the resources identified therein. Executive Order 13175 (November 6, 2000) requires consultation with Indian Tribal Governments in "*formulating or implementing policies that have tribal implications*." Tribes around the Grand Canyon have expressed reservations or opposition to the widespread removal of pinyon and juniper. Tribes located adjacent to the project area or with historical relationships to the area must be consulted on this project which would affect their historical, cultural, and spiritual resources.

The Forest Service must comply with section 106 of the National Historic Preservation Act (NHPA), which requires federal agencies to "*take into account the effect of [any] undertaking on any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register [of Historic Places]*."[336] Federal courts have described section 106 as a "*stop, look, and listen provision that requires each federal agency to consider the effects of its programs*" on historic properties and cultural resources.[337] For any undertaking, all federal agencies must: (1) "*make a reasonable and good faith effort…to identify historic properties within the area of potential effects*," "*which may include background research, consultation, oral history interviews, sample field investigation, and field survey*;" (2) determine whether identified properties are eligible for listing on the National Register of Historic Places; (3) assess the effects of the undertaking on any eligible properties; and (4) avoid, minimize, or mitigate any adverse effects.[338]

**Biocrusts have been severely damaged by livestock and this project must restore them**

The KPERP analysis needs to seriously consider biological soil crust. The use of heavy equipment on lands below 6,500' without facing the reality that most of the area is already lacking its potential biological soil crust skin (Grand Canyon Trust 2015); and that higher temperatures and drought have been shown to reduce lichen, moss, and dark cyanobacterial crust (Ferrenberg, et al. 2015) is neither ecologically appropriate nor legally defensible. A 2016 Grand Canyon Trust report describes a biocrust survey of 176 nearby sites that were expected to support biological soil crust. At the sites that were vulnerable to erosion, surveyors found that at an overwhelming number of the sites, biocrust presence is largely reduced to early-seral, light cyanobacterial crust, if biocrust is present at all. We suspect that the current project area may be in even worse condition than some of the study sites. The EIS must accurately describe baseline conditions for biocrusts, as well as connect past actions to the current condition of these important soil binding organisms.

[335] 43 C.F.R. § 46.155 (emphasis added)
[336] 54 U.S.C. § 306108
[337] Mont. Wilderness Ass'n v. Connell (MWA), 725 F.3d 988, 1005 (9th Cir. 2013)
[338] 36 C.F.R. §§ 800.1(a), 800.4(b), 800.5, 800.6, 800.8(c)(1)(v) & (c)(4)

There are many potential issues related to the loss of biological soil crusts and increased soil erosion associated with mechanical treatments in areas like the proposed project area. Consider this excerpt from Jones and colleagues[339]:

> "*…the machinery involved with mechanical treatments can be extremely destructive to biological crusts (Gifford et al. 1970, Loope and Gifford 1972, Wilcox 1994, Belnap and Gillette 1998, Belnap and Eldridge 2001). The recovery time for the lichen component of crusts has been estimated at about 45 years (Belnap 1993). At this time the crusts may appear to have regenerated to the untrained eye. However, careful observation will reveal that the 45 year-old crusts will not have recovered their moss component, which will take an additional 200 years to fully mature (Belnap and Gillette 1997). Studies done outside of Blanding, Utah have shown that chaining of P-J led to decreased infiltration rates at the study site, and part of the reason given for this decrease was destruction of biological crusts, resulting from mechanical disturbance associated with chaining activities (Gifford et al. 1970, Loope and Gifford 1972; Gifford 1973). In addition to losses of biological crusts due to mechanical treatments, any sagebrush or P-J mechanical clearing technique that actually uproots the plants leads to the greatest degree of soil disturbance, thus significantly adding to the risk of post-treatment soil erosion (Pyke 2011). With soil losses due to erosion following destructive activities on the soil surface, the soils themselves take 5,000 to 10,000 years to naturally re-form in arid regions such the Colorado Plateau (Webb 1983), so this can be considered an irreversible loss. And, in semi-arid climates of the west, some soil properties take even longer to accumulate, on the order of tens of thousands of years (Gottfried et al. 1995).*"

**Restoration requires closing roads and not building more of them**

While the proposed action states that no new roads are needed to access treatment areas, we are concerned that improving administrative use roads that have revegetated and constructing fifty miles of new dozer line may significantly impact soils, water quality, wildlife habitat, or other ecosystem features, and this is a significant issue for environmental analysis. Roads can permanently impair soil productivity even if their use is temporary.[340] Road-related soil erosion is a chronic source of sediment production that can negatively affect water quality.[341,342] In addition, road construction and fuel treatments may combine to increase overland water flow and runoff by removing vegetation and altering physical and chemical properties of soil, which can

[339] Jones, et al. have an extensive discussion with illustrative examples of increased erosion following pinyon-juniper removal.
[340] Trombulak, S.C. and C.A. Frissell. 2000. Review of ecological effects of roads on terrestrial and aquatic communities. *Conservation Biology* 14: 18-30.
[341] Bowman, S.N. 2001. *Verde River TMDL for Turbidity.* Arizona Dept. Env. Quality: Phoenix. February. 39 pp.
[342] Gucinski, H., M.J. Furniss, R.R. Ziemer and M.H. Brookes (eds.). 2001. *Forest Roads: A Synthesis of Scientific Information.* USDA For. Serv. Gen. Tech. Rep. PNW-GTR-509. Portland, OR.

permanently alter watershed function.[343,344] This has implications for the purpose and need to protect downstream resources from the undesirable effects of flooding and excessive erosion, as well as the need to avoid or minimize project effects to sensitive, candidate and threatened species. The extent and location of road construction/improvement and its effects to soil erosion, runoff channelization and sediment loads merit a hard look in the environmental analysis. This should include detailed study (rather than mere mention and cursory dismissal) of an action alternative that foregoes road building or improvement on steep slopes and sensitive, erodible soils where it may increase erosion or impair ecosystem productivity.

In order to best improve wildlife habitat, the KPERP project should close unnecessary roads and primitive vehicle routes, and abandon the construction of fifty miles of dozer line. The Kaibab Plateau already has among the highest road densities in the National Forest system. Road effects range from direct removal of habitat to accommodate the physical footprint of development infrastructure, fragmentation of once continuous habitat into less functional units[345] and indirect and cumulative disturbance that can temporarily or permanently displace wildlife. There are hundreds of scientific papers assessed in comprehensive literature reviews which illustrate the preponderance of evidence that routes ranging from narrow dirt tracks to paved roads can and do cause adverse effects on wildlife.[346,347,348,349]

In fact, habitat fragmentation from roads and other human infrastructure has been identified as one of the greatest threats to biological diversity worldwide.[350] This volume of science simply cannot be ignored in habitat restoration and vegetation management planning on public lands. Biologists agree that habitat loss and fragmentation is one of the greatest threats to the

[343] Elliot, W.J. 2010. Effects of forest biomass use on watershed processes in the western United States. *Western Journal of Applied Forestry* 25: 12-17.

[344] Robichaud, P.R., L.H. MacDonald and R.B. Foltz. 2010. Fuel management and erosion. Ch. 5 in: W.J. Elliot, I.S. Miller and L. Audin (eds.). *Cumulative Watershed Effects of Fuel Management in the Western United States.* USDA For. Serv. Rocky Mtn. Res. Sta. Gen. Tech. Rep. RMRS-GTR-231. Fort Collins, CO.

[345] Lehmkuhl, J.F., and L.F. Ruggiero. 1991. Forest fragmentation in the Pacific Northwest and its potential effects on wildlife. Pages 35-46 in: Ruggiero, L.F., K.B. Aubry, A.B. Carey, and M.H. Huff (tech. coords.) *Wildlife and Vegetation of Unmanaged Douglas-fir Forests*. General Technical Report 285. USDA Forest Service, Pacific Northwest Research Station, Portland, OR.

[346] Trombulak, S.C., and C.A. Frissell. 2000. Review of ecological effects of roads on terrestrial and aquatic communities. *Conservation Biology*. 4: 18-30.

[347] Gucinski, H., M.J. Furniss, R.R. Ziemer and M.H. Brookes (eds.). 2001. *Forest Roads: A Synthesis of Scientific Information.* USDA For. Serv. Gen. Tech. Rep. PNW-GTR-509. Portland, OR.

[348] Confluence Consulting, Inc. 2005. Annotated bibliography of the potential impacts of gas and oil exploration and development on coldwater fisheries. Report prepared for Trout Unlimited. Confluence Consulting, Inc. Bozeman, MT. 30 p.

[349] Switalski, A. 2017. MasU.S.C.ript prepared for publication: Off-Highway Vehicle Recreation in Drylands: A Literature Review and Recommendations for Best Management Practices. Wildlands CPR.

[350] Wilcove, D.S. et al. 1998. Quantifying threats to imperiled species in the United States. *Bioscience* 48(8): 607-615.

persistence of individual wildlife species and overall biodiversity.[351] These consist of two different processes that simultaneously and negatively affect wildlife species:

(1) *Habitat Loss:* a reduction in the overall habitat available to wildlife species; and

(2) *Habitat fragmentation*: the creation of isolated patches of habitat separated from what was once the contiguous landscape.

Habitat loss and fragmentation can occur because of a variety of human activities on the landscape. On public lands, industrial energy development, logging, mining, ORV trails (both designated and illegally created), and roads used for ranching purposes are land uses that drive fragmentation. These are associated with a complex of stressors that cause further fragmentation such as the introduction of invasive species; disease transmission and other issues related to the presence of pets; noise, light, and water pollution; change in wildfire regimes; power transmission lines; and others. Habitat fragmentation leads to a reduction in landscape connectivity by reducing the occurrence or the effectiveness of natural ecosystem processes and preventing wildlife species from moving across the landscape.[352]

When the total effect of the "human footprint" from all fragmentation is modeled across land ownerships in the West, it cumulatively covers approximately 48% of the landscape.[353] This study defined the human footprint as any human development or activity on private or public land (everything from ORV trails to residential and industrial development); and includes direct habitat loss as well as habitat fragmentation and overall degradation. Fahrig suggested that each species tends to have an "extinction threshold" of minimum habitat necessary, meaning that when available habitat drops below the threshold, the risk of extinction increases.[354] Habitat fragmentation may play an important factor in adjusting this threshold level because as fragmentation increases, the amount of habitat necessary for the species to persist also increases.[355] If habitat is connected, even when drastically reduced, there is a much higher probability of population persistence than if the available habitat is reduced and fragmented.[356]

Addressing habitat fragmentation is critical in any habitat "augmentation" project planning on western public lands. To adequately address habitat fragmentation, the Forest Service must analyze the baseline conditions (the existing route network) and authorized activities (such as

[351] *Ibid*

[352] Crooks, K.R. and Sanjayan, M. 2006. Connectivity conservation: maintaining connections for nature. In: Crooks, K.R. and Sanjayan, M., editors. Connectivity Conservation. Cambridge: Cambridge University Press. p. 1-19.

[353] Leu, M. et al. 2008. The human footprint in the west: a large-scale analysis of anthropogenic impacts. *Ecological Applications* 18(5): 1119-1139.

[354] Fahrig, L. 2002. Effect of habitat fragmentation on the extinction threshold: a synthesis. *Ecological Applications* 12(2): 346-353.

[355] *Ibid*

[356] Travis, J.M.J. 2003. Climate change and habitat destruction: a deadly anthropogenic cocktail. *Proceedings of the Royal Society of Biological Sciences* 270: 467-473.

approved transmission lines, oil and gas infrastructure, ranch roads, water development infrastructure, and other development), in addition to impacts from each alternative. The Forest Service must consider alternatives to minimize and mitigate impacts to habitat fragmentation.

Examples of direct, indirect and cumulative impacts of roads on wildlife and their habitats identified in the biological literature include:[357]

- Fragmentation of connected habitats including the loss of core habitat areas and habitat connectivity for wildlife movements and dispersal
- Adverse genetic effects such as reducing genetic diversity by isolating populations
- Increased potential for extirpation of localized populations or extinction of narrowly distributed species from catastrophic events
- Modifications of animal behavior through reductions in habitat use due to human activity and interference with wildlife functions such as courtship, nesting, and migration
- Disruption of the physical environment in many ways including direct removal of habitat due to route construction, reduction of cover and habitat security, increasing dust and erosion
- Alteration of the chemical environment through vehicle emissions and herbicides
- Changes in habitat composition by direct loss of vegetation from road construction and changes in microclimates in road edge habitats potentially resulting in changes in type and quality of food base and reduction in habitat cover
- Spread of exotic species that may lead to competition with preferred forage species
- Degradation of aquatic habitats through alteration of stream banks and increased sediment loads
- Changes to flows of energy and nutrients such as changes in temperatures in microclimates created at road edges
- Increased alteration and use of habitats by humans through activities including increased unethical hunting practices and increased dispersion of recreation impacts, particularly by off-road vehicles due to a proliferation of roads
- Mortality from construction of roads
- Mortality from collisions with vehicles

As documented by the comprehensive literature reviews cited above, the existence of motorized routes can result in habitat fragmentation and, depending on the use of the route, have impacts extending well into surrounding habitats. Such disturbance from transportation networks is

[357] Trombulak, S.C., and C.A. Frissell. 2000. Review of ecological effects of roads on terrestrial and aquatic communities. *Conservation Biology* 4: 18-30

immediate and can lead to a range of risks to the survival of wildlife. Sound science must be used to evaluate impacts from motorized travel routes on resident wildlife and how the closure and restoration of roads and vehicle routes can meet the project purpose and need.

**Monitoring**

The KPERP should include a monitoring plan that allows for verifiable, repeatable quantified data collection; an untreated control; statistically significant analysis; pre-determined trigger points to determine whether the landscape is moving toward the Desired Conditions; and an adaptive management plan to respond if the Desired Conditions are not being achieved.

Monitoring methods should be explicit, with objective, empirical parameters described in detail in the EIS. The EIS should determine what statistical methods will be used and create a monitoring plan that will produce statistical power prior to initiating any actions. Prior to the resumption of grazing on any area following treatment a vegetation productivity analysis should be conducted to accurately determine the amount of AUMs available for both cattle and wildlife. Untreated controls should be part of the project design. The EIS should identify trigger points to determine whether the landscape is moving toward the Desired Conditions and an adaptive management plan to respond if the Desired Conditions are not being achieved. This monitoring/adaptive management approach should use best available science to design a monitoring system for this project; invest in monitoring experts to create a defensible and transparent system; as part of fundamental project design, secure up front, adequate funding for such monitoring system design and implementation; establish quantified desired treatment outcomes prior to treatment; monitor over a science-based timeline of 5-20 years, depending on the vegetation type and the specific metrics that are being tracked per individual treatment goal; share monitoring results in a collaborative, transparent manner; refer to and consider the Four Forest Restoration Initiative's monitoring and adaptive management framework, some of which could be leveraged here; and finally, monitoring data should be maintained in an easy-to-understand format and made available to the public.

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Thank you for the opportunity to provide constructive comment on the Kaibab Plateau Ecological Restoration Project. We hope that you will have taken note that we have used the acronym KPERP throughout this letter, in contrast to what we have observed with the Forest Service calling this project the KPEP. It is imperative that Restoration, in name and authentic practice according to long-standing principles of this subject[358], should not be dropped from the project name in the pursuit of generic desired conditions. Please do not hesitate to contact me

[358] See Allen et al. 2002

directly with questions, to arrange in-person meetings, and to discuss the truly collaborative framework that will shepherd the EIS to successful implementation.

Sincerely,

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