Lynx Habitat Ecology in Beetle-Impacted Forests

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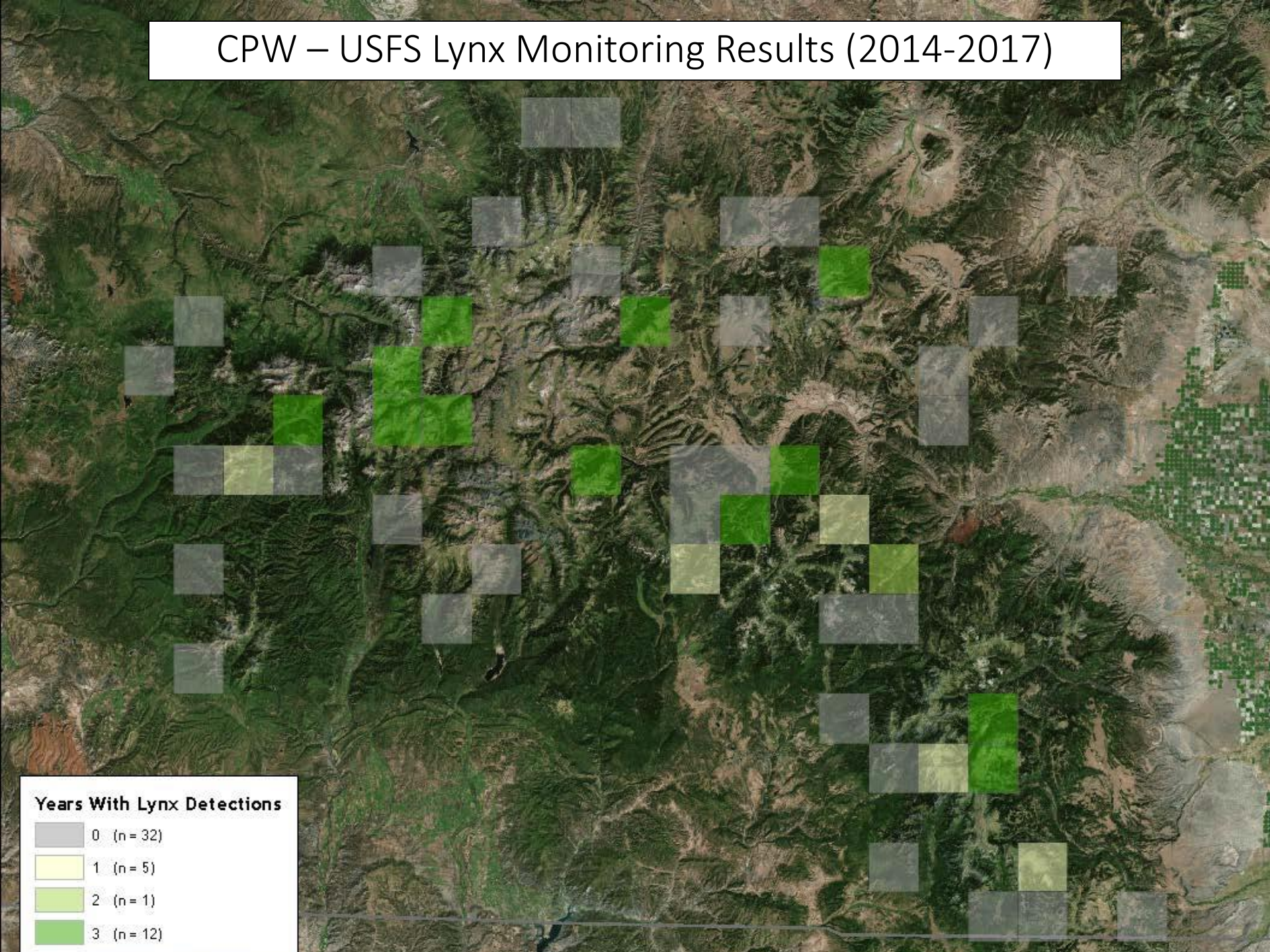
RGNF Meeting

17 May 2018

CPW – USFS Lynx Monitoring Results (2014-2017)



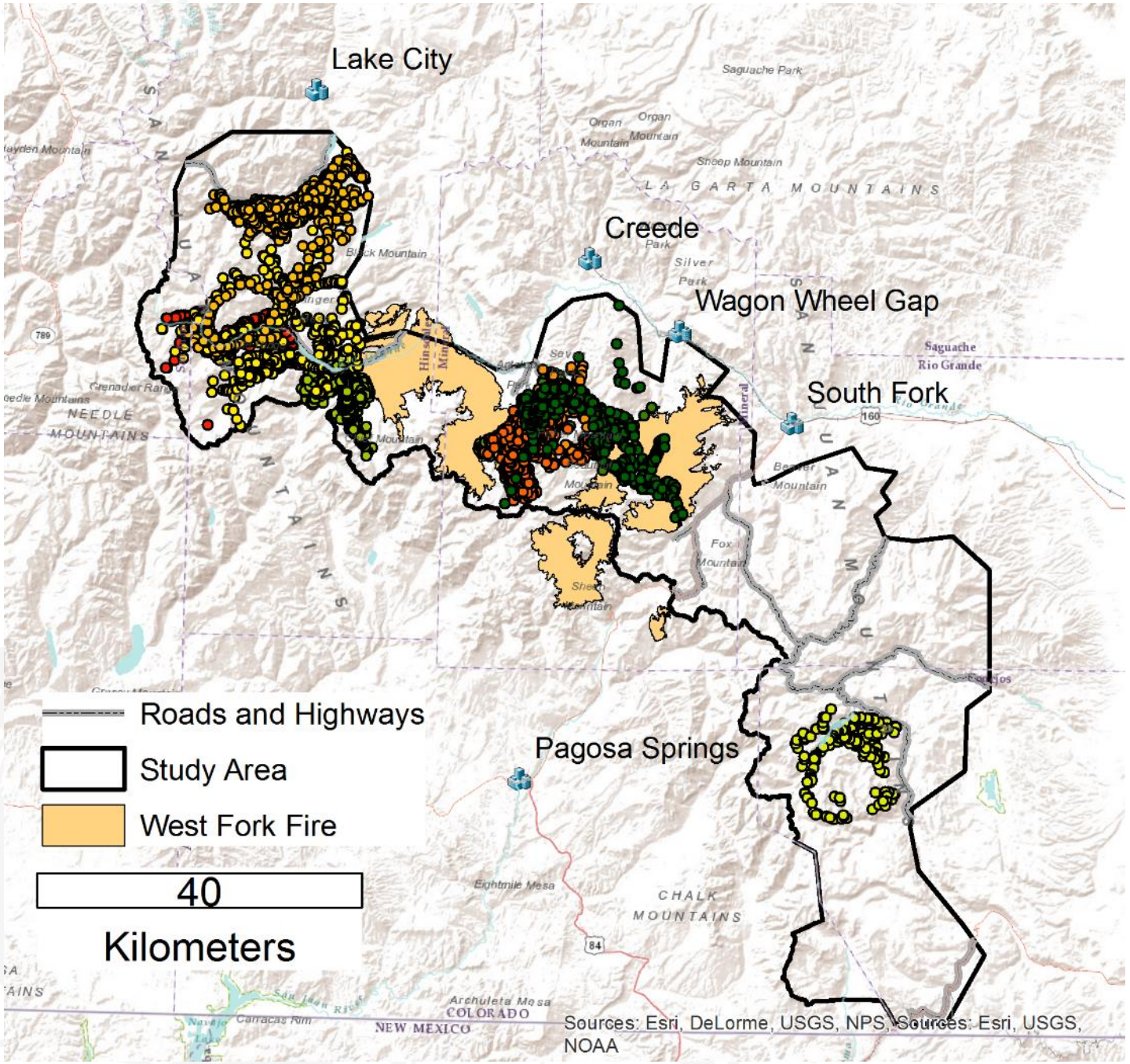
Outline

1. Landscape-level analyses
   - Characterize resource use and predict lynx habitat

2. Stand-level analyses
   - Characterize forest attributes used by lynx

Landscape Analyses

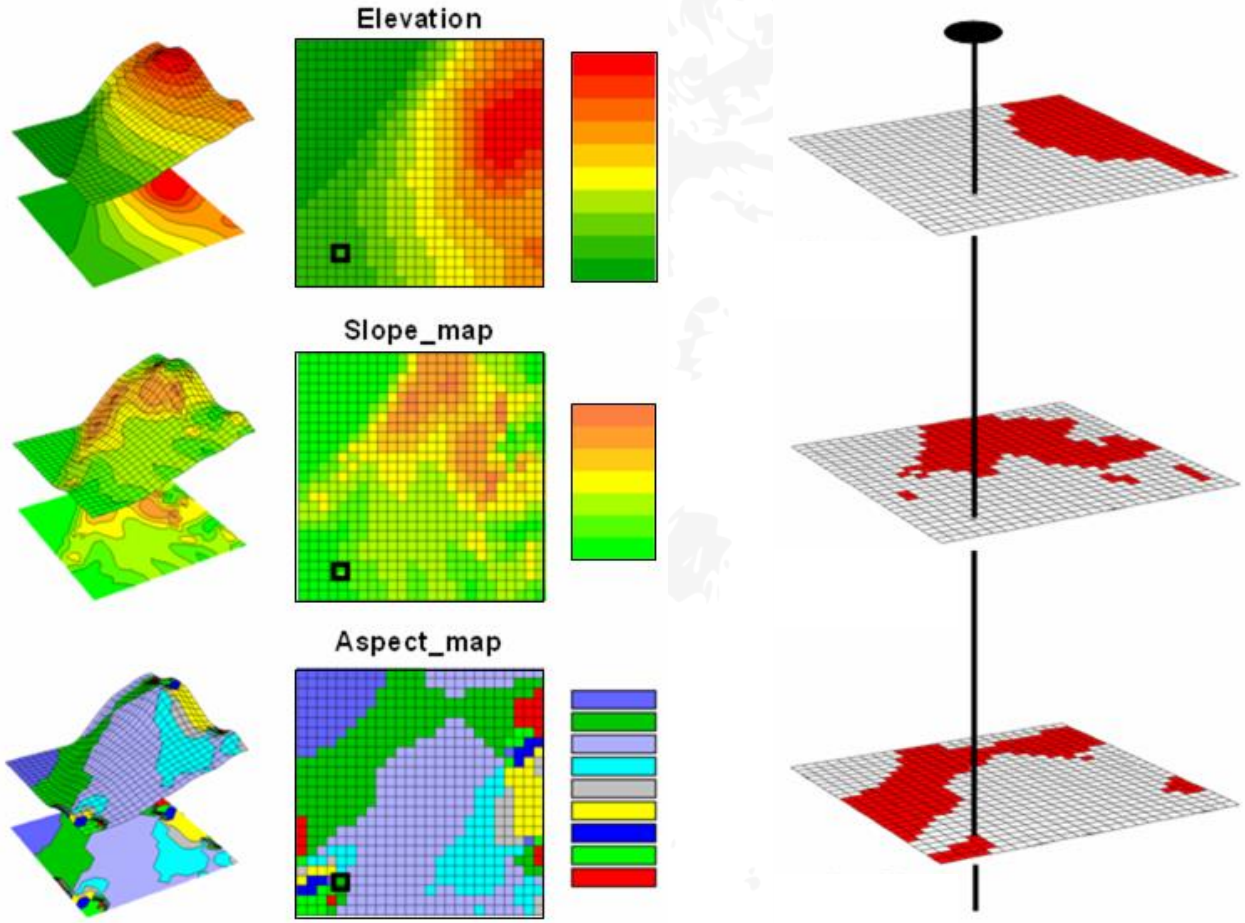
- 19,349 GPS locations in study area
  - Fix success 88%
- Winter (Jan-April)
  - 10 lynx (6 males, 4 females) with 11,628 locations
- Summer (May-August)
  - 7 lynx (3 males and 4 females) with 7,721 locations


Lake City
Creede
Wagon Wheel Gap
South Fork
Pagosa Springs
Saguache Park
Organ Mountain
Sheep Mountain
LA GARTA MOUNTAINS
Silver Park
Saguache
Rio Grande
Beaver Mountain
Fox Mountain
Eightmile Mesa
CHALK MOUNTAINS
NEEDLE MOUNTAINS
Archuleta Mesa
COLORADO
NEW MEXICO
Carracas Rim
Roads and Highways
Study Area
West Fork Fire
40
Kilometers
Sources: Esri, DeLorme, USGS, NPS, Sources: Esri, USGS, NOAA

Landscape Analyses

- Sample of lynx use
  - 90% of GPS locations, withheld 10% for testing maps
  - Winter test = 1,109, Summer test = 780
- Sample of study area (i.e., “availability”)
  - Density of 1 location/500 m^2
  - Approximately 7,000 locations for each lynx
    - Had to be ≥100 m apart
  - Use:availability ratio of ≥1/4
- Build resource selection functions (RSF)

RSF – Landscape analyses



Landscape Covariates

- Canopy
  - Live PIEN, ABLA, PIEN-ABLA, POTR
  - Total % mortality
- Live sub-canopy
  - ABLA, PIEN, PIEN-ABLA, PSME
- Precipitation
  - Mean annual precipitation over 1981-2010
- Topographic
  - Head load, topographic position index
- Anthropogenic
  - Density of major roads and highways, density of FS roads

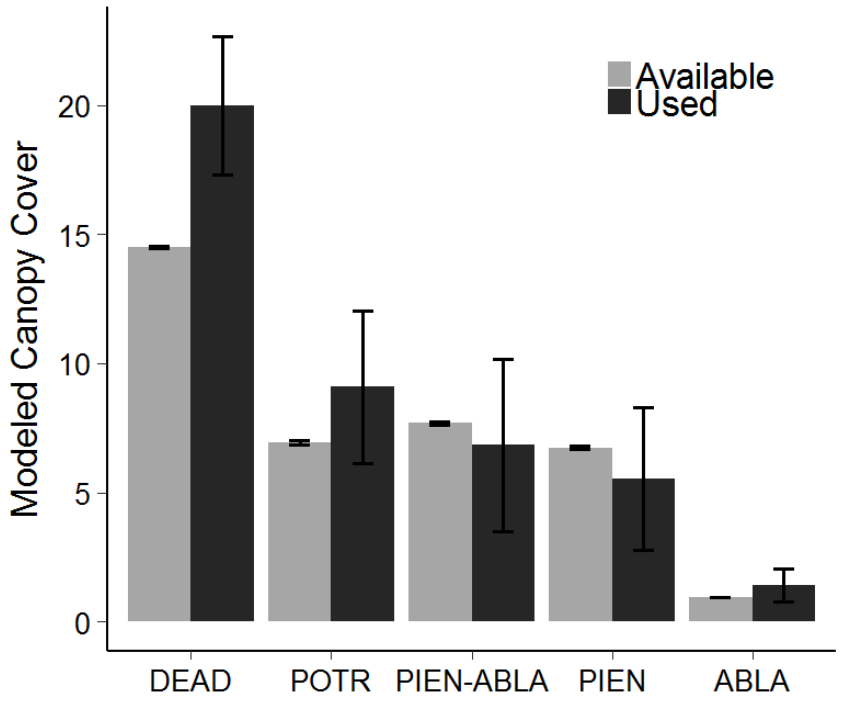
Landscape Covariates

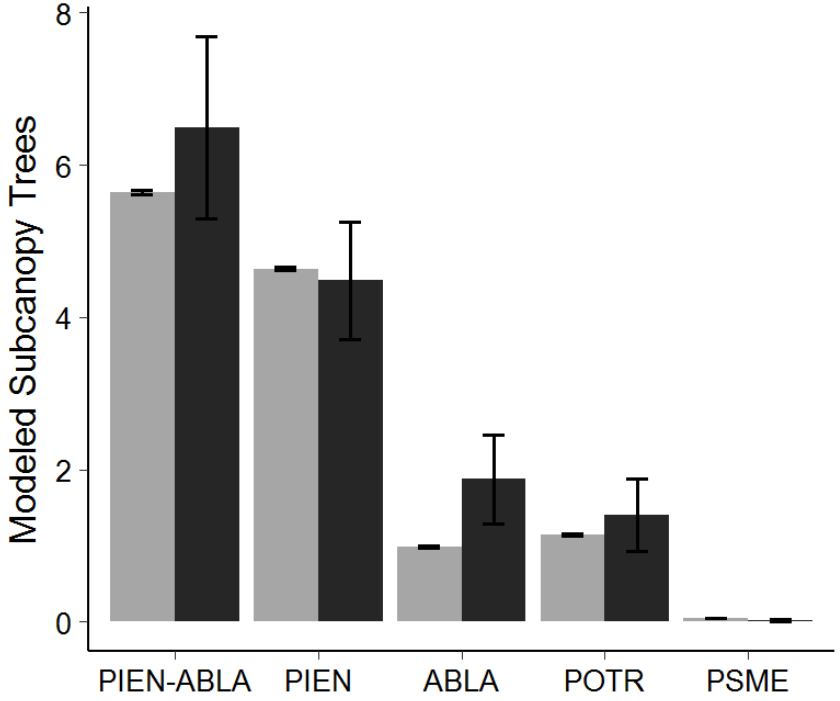
- Calculated all at 3 resolutions
  - 100, 250, and 500 m^2
- Identified the most supported scale and function with AIC
- Removed correlated variables

Landscape Analyses

- We first found the “best” model of the abiotic covariates
- We then evaluated a set of hypotheses concerning how lynx selected canopy cover and sub-canopy density
- Used RSF in the form of a GLMM

Winter Results





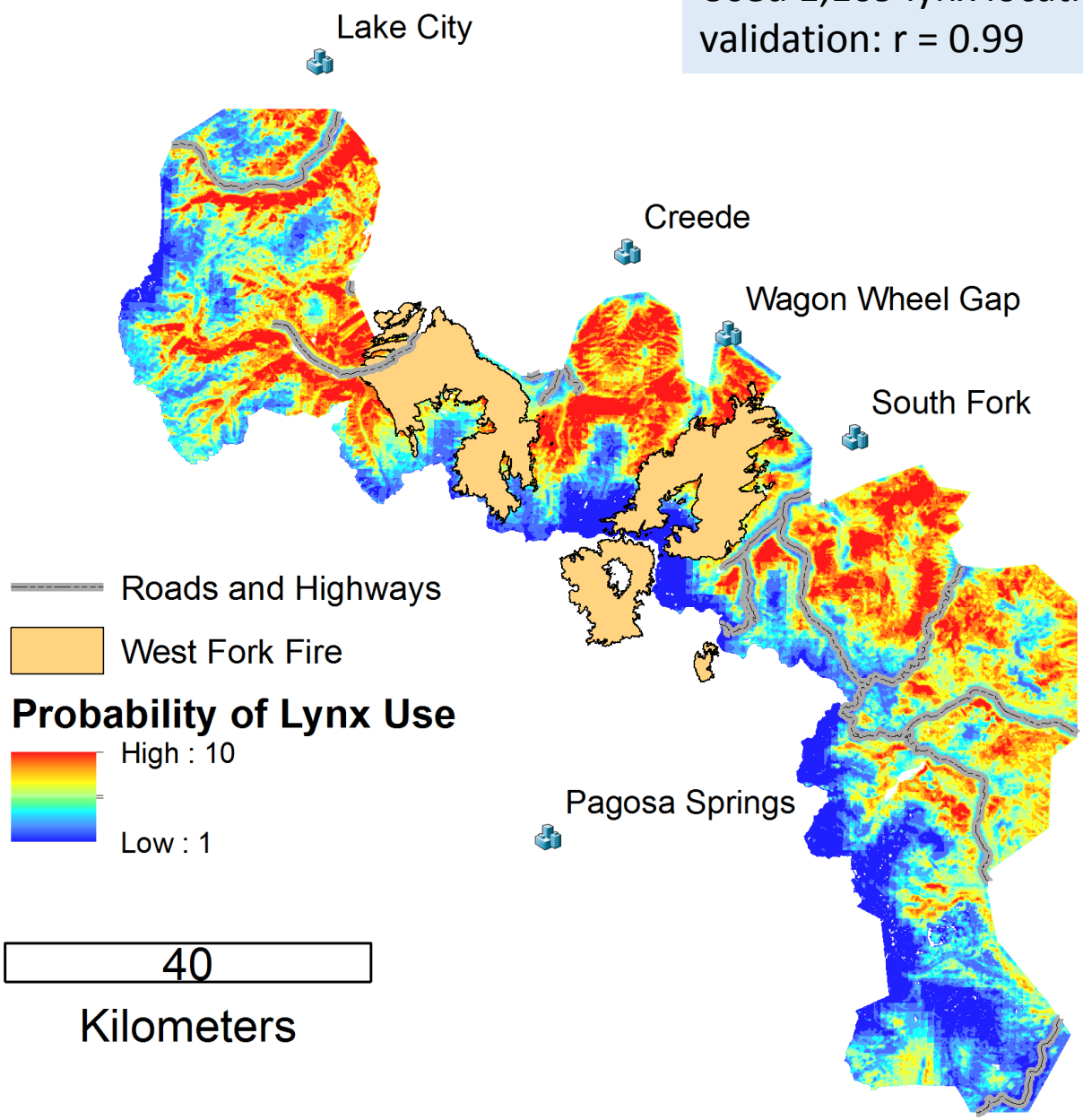
Winter Results

- Top model
  - ABIOTIC + Dead canopy + POTR canopy + PIEN-ABLA subcanopy + PSME subcanopy
    - See Table 2 on page #6 for additional details
  - Validated using a leave-lynx-out cross-validation
    - Assess predicted use versus real lynx use
    - Mean r = 0.90

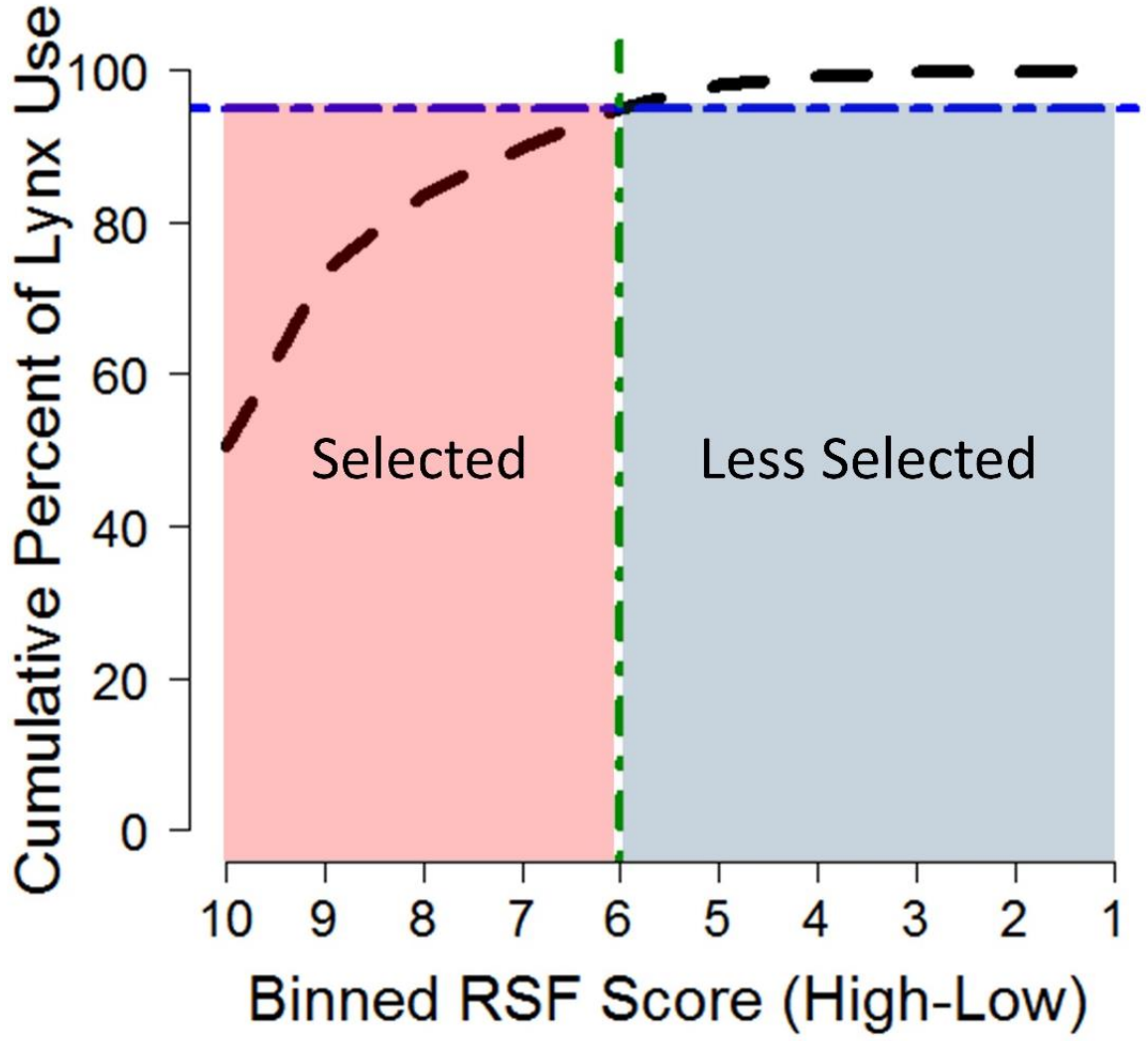
Winter Top Model

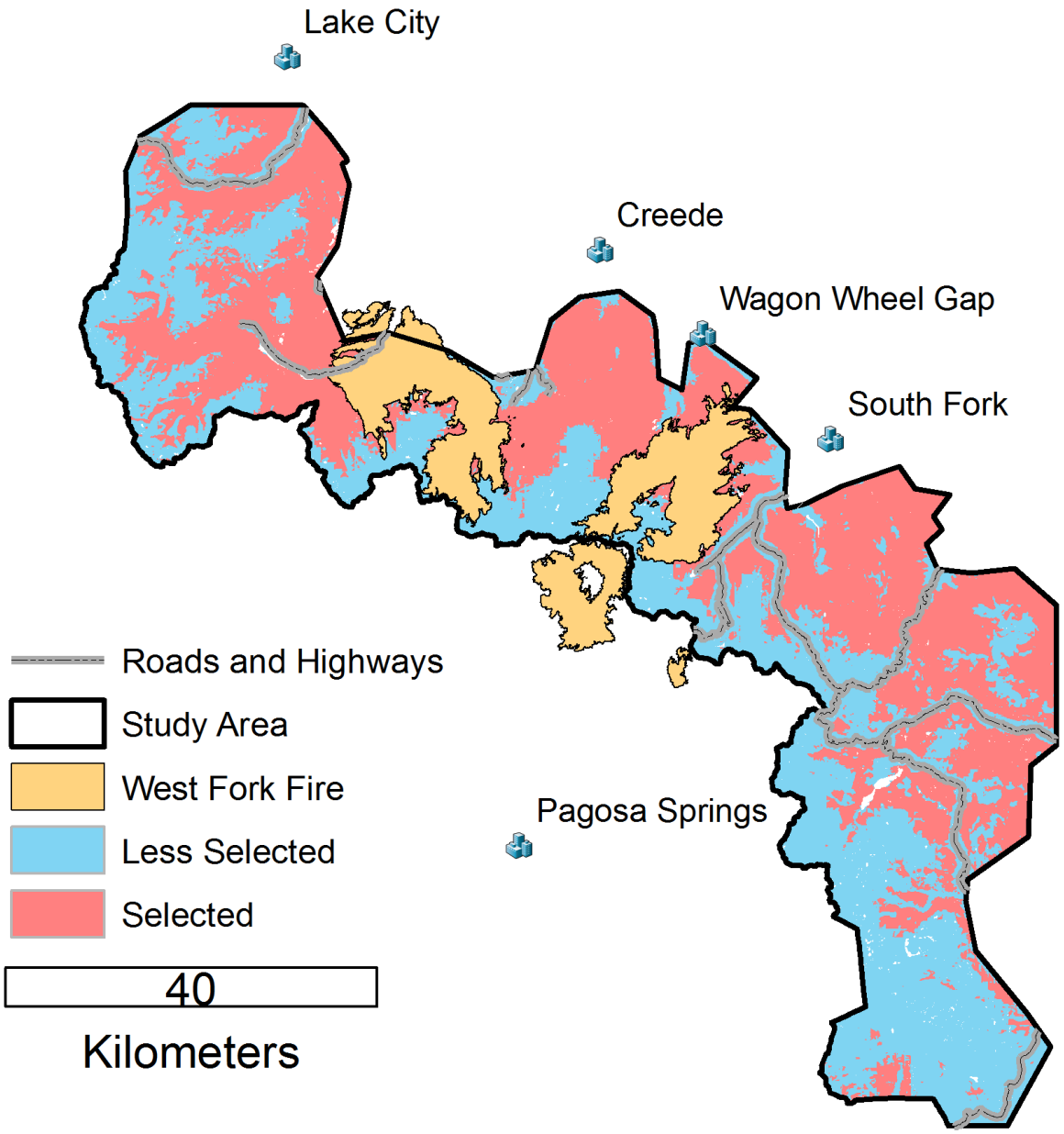
Theme	Covariate	β	SE	p
Abiotic	Roughness	-0.183	0.012	<0.001
	Heat load index	0.195	0.013	<0.001
	Topographic position index	-0.078	0.012	<0.001
	Mean annual precipitation over 1981-2010	-1.682	0.031	<0.001
	Mean annual precipitation over 1981-2010 ^{2}	-0.499	0.020	<0.001
	Density of major roads and highways	-0.449	0.022	<0.001
	Density of USFS roads	0.457	0.012	<0.001
Forest	Dead canopy	0.672	0.015	<0.001
	POTR canopy	0.129	0.013	<0.001
	PIEN-ABLA subcanopy	0.247	0.014	<0.001
	PSME subcanopy	-0.391	0.022	<0.001

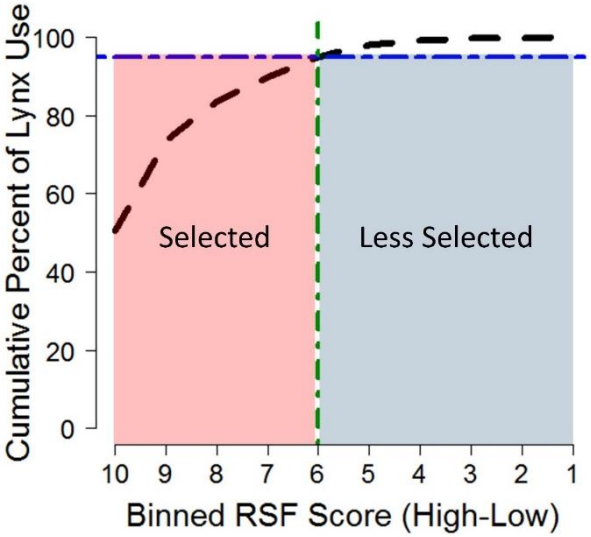
Used 1,109 lynx locations for validation: r = 0.99



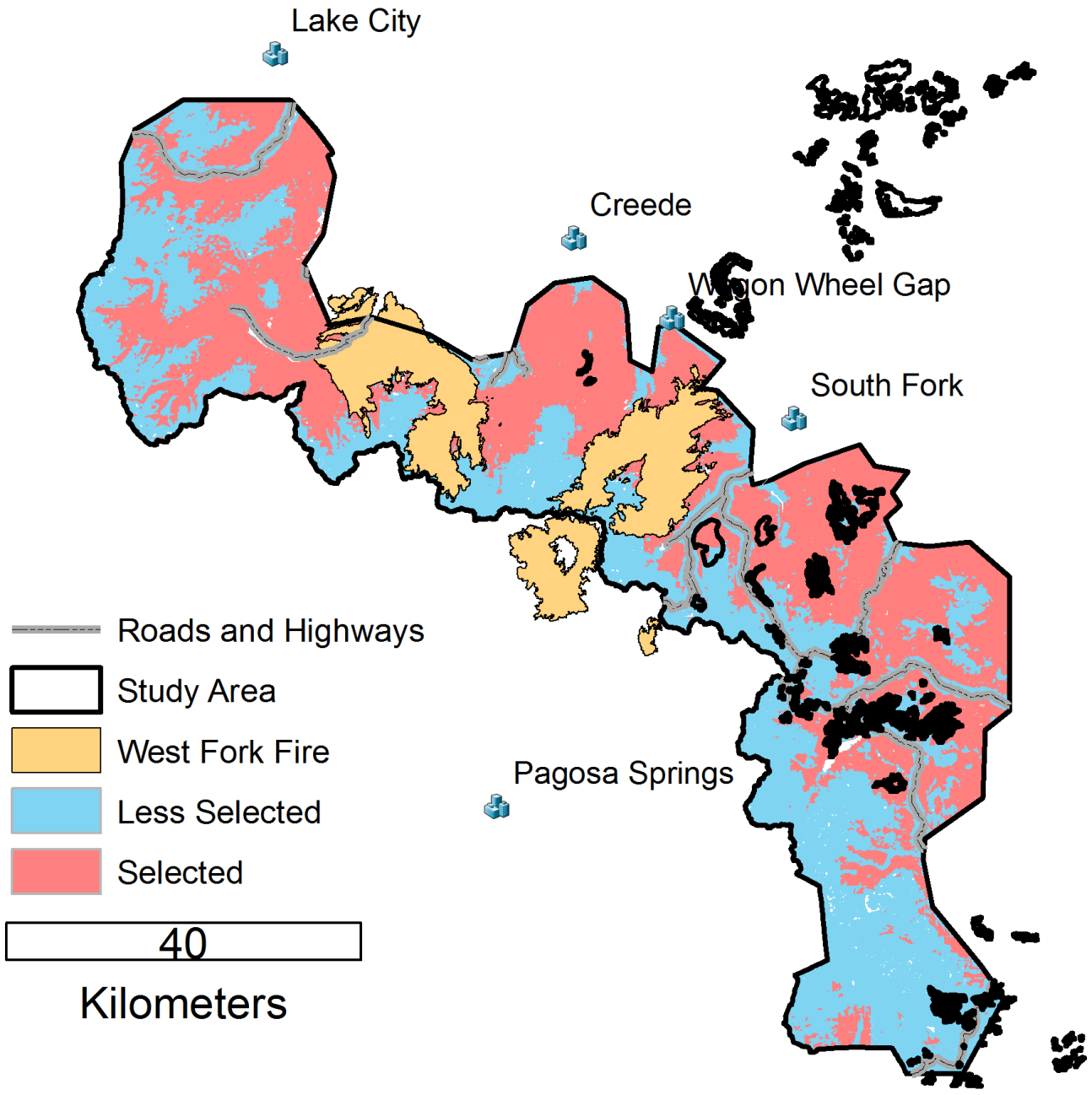
Binary Cutpoint

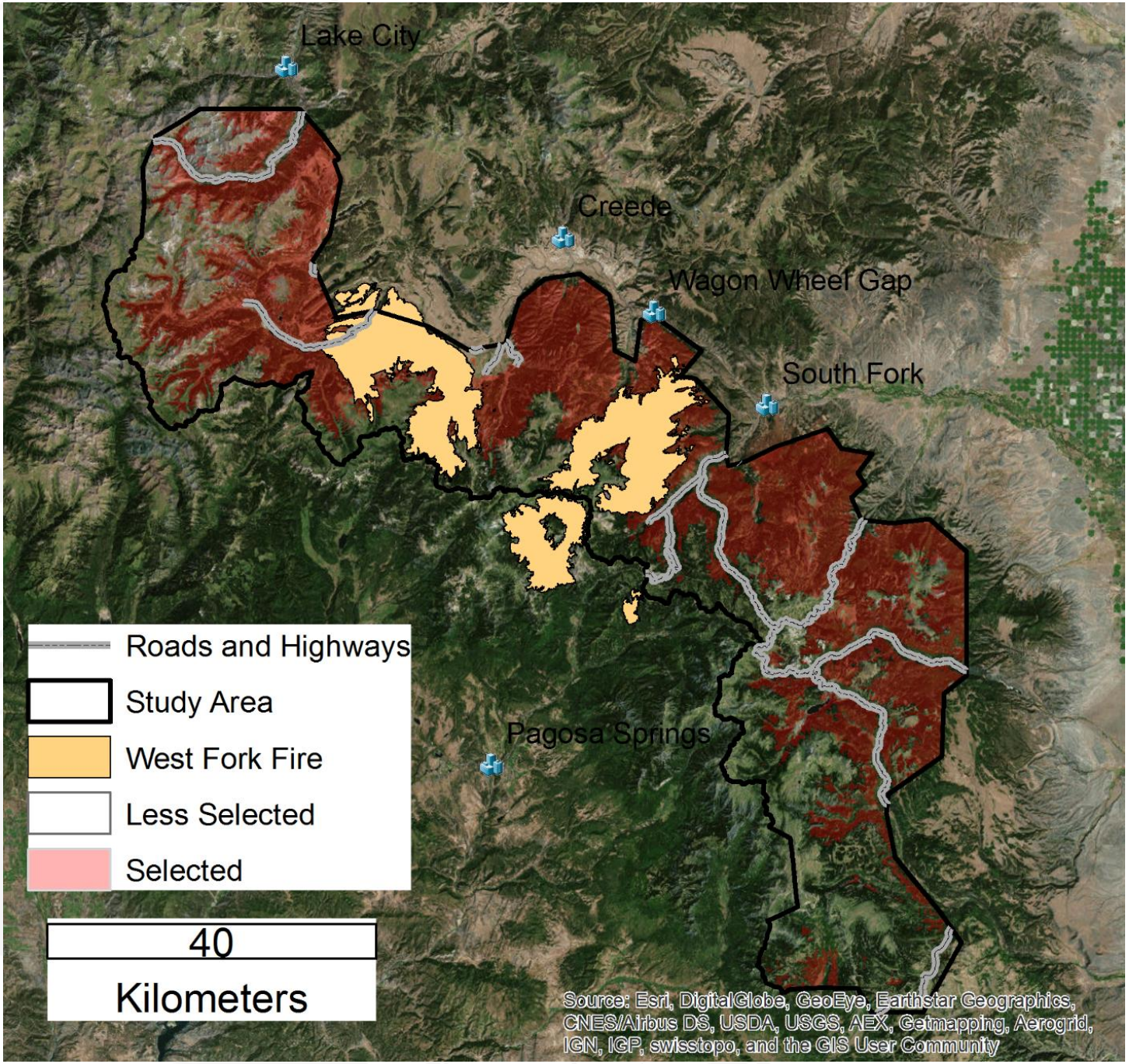


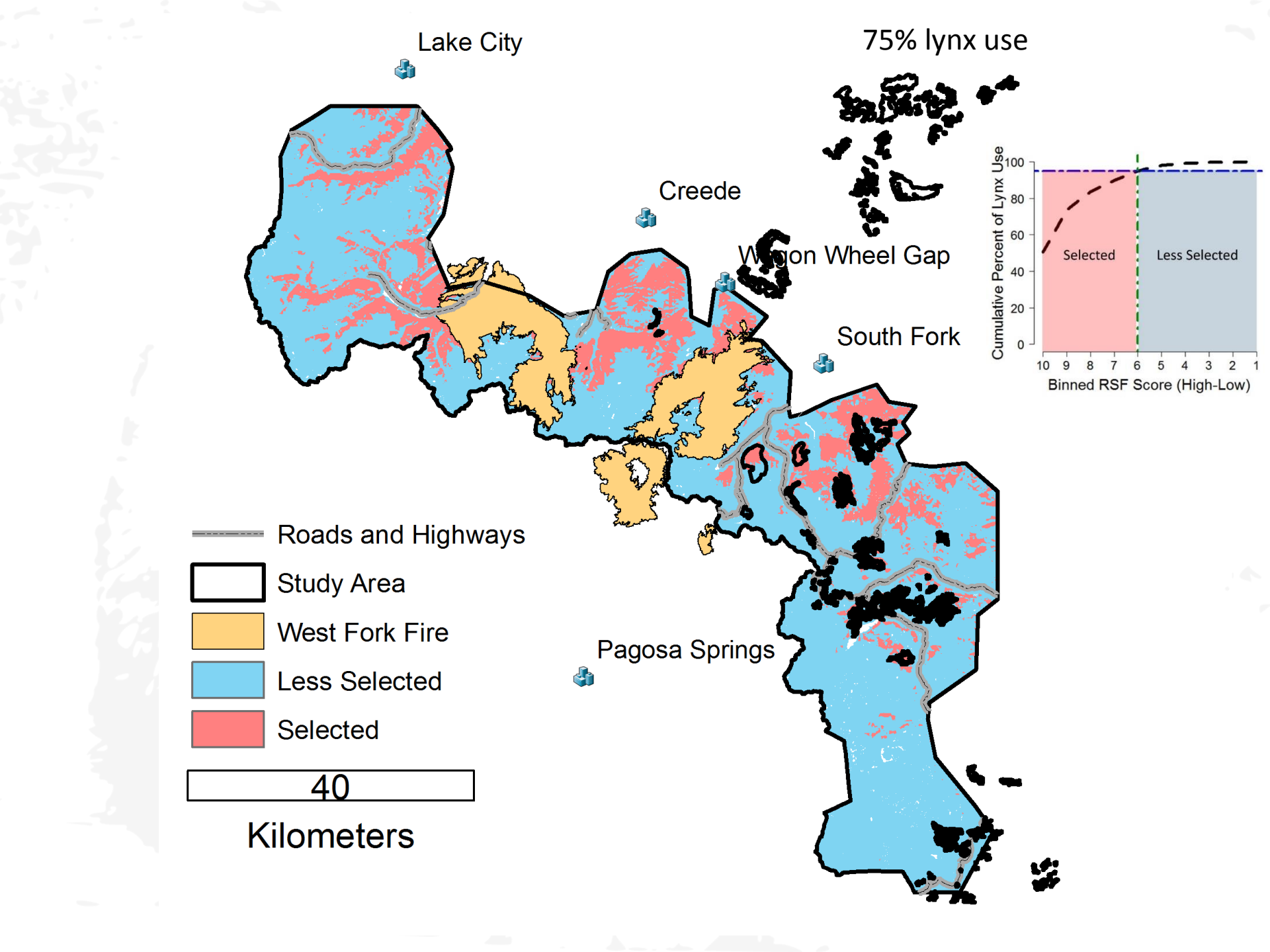


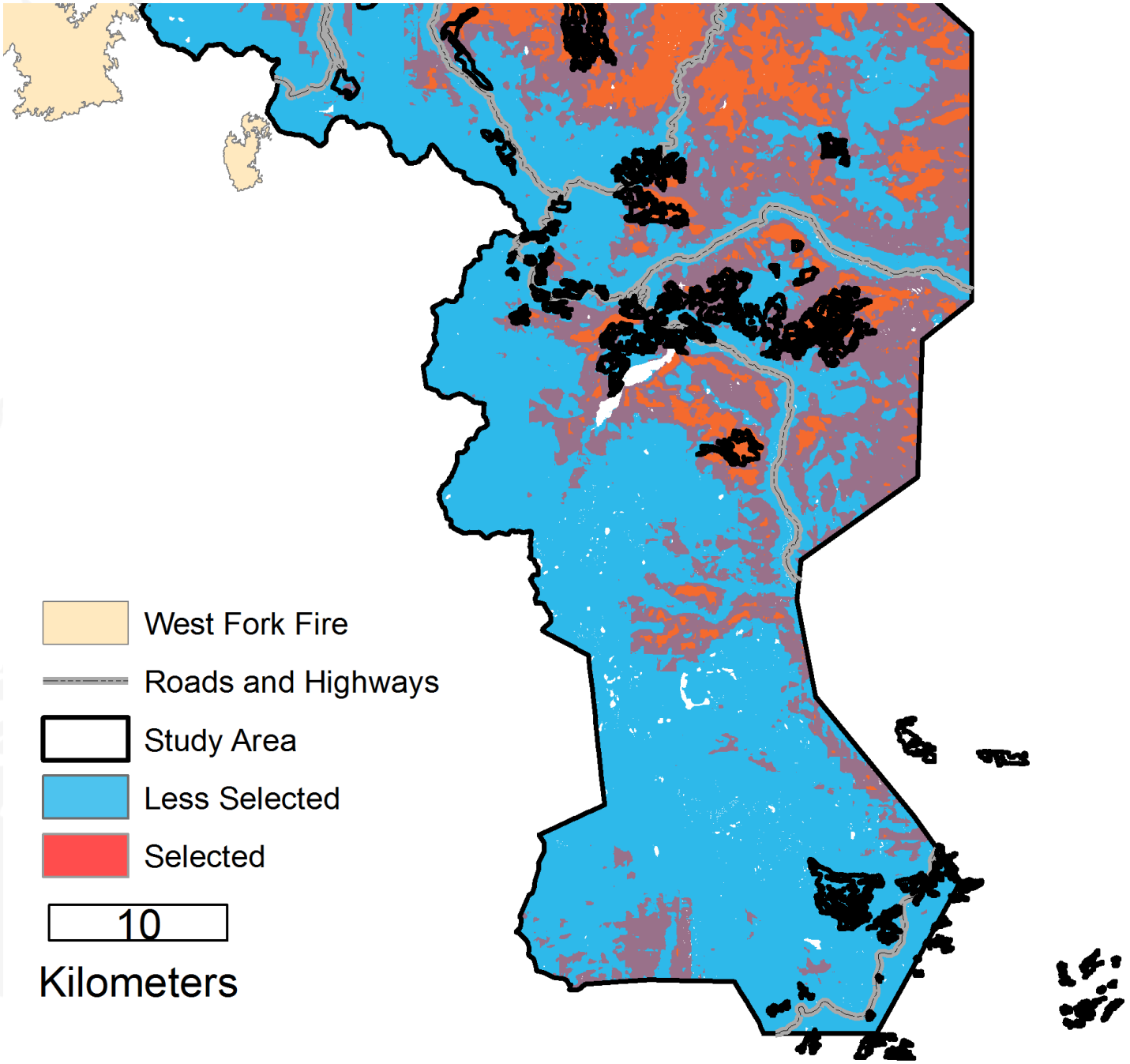


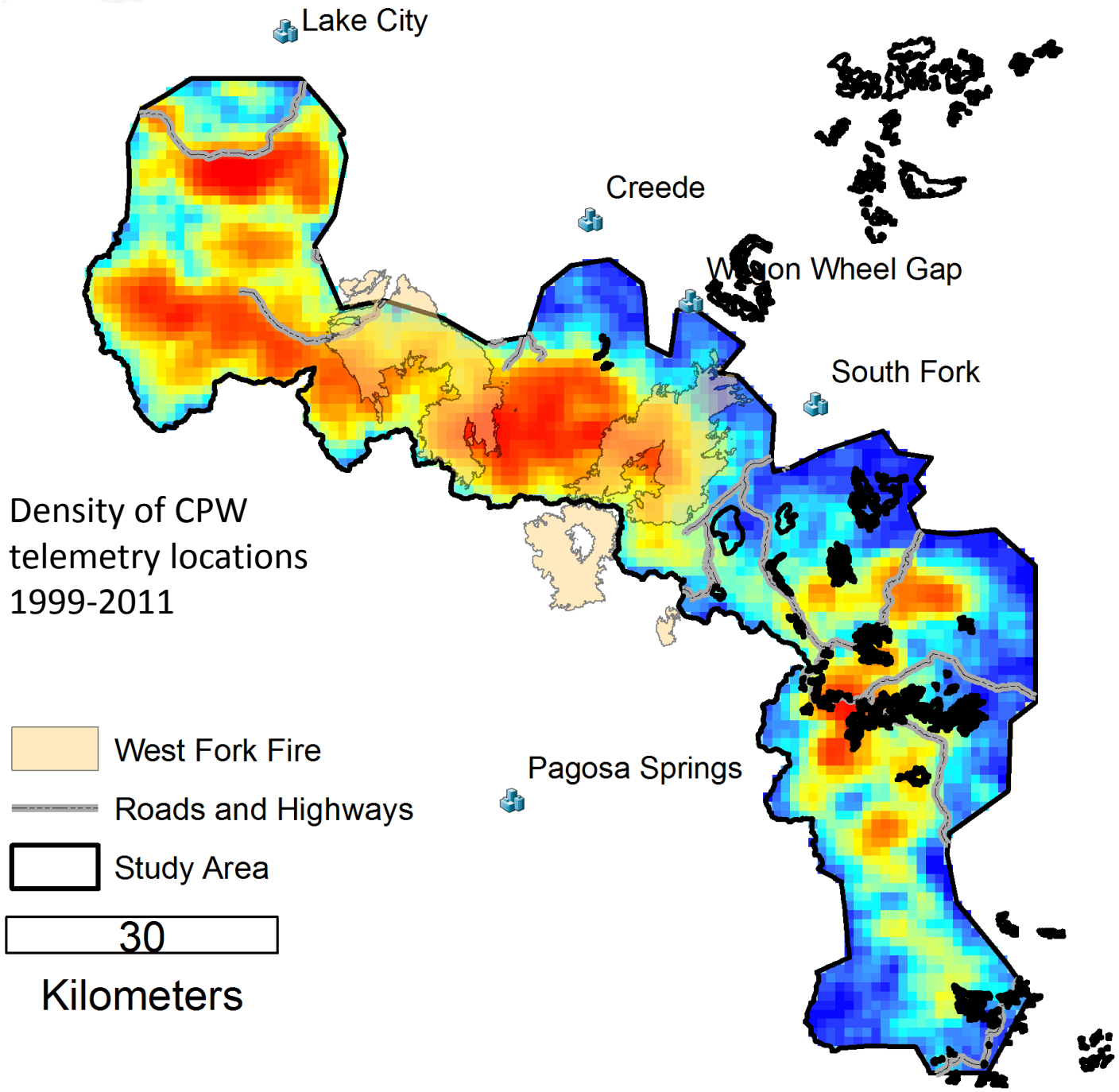
Selected = 377,513 acres
Less Selected = 378,877 acres

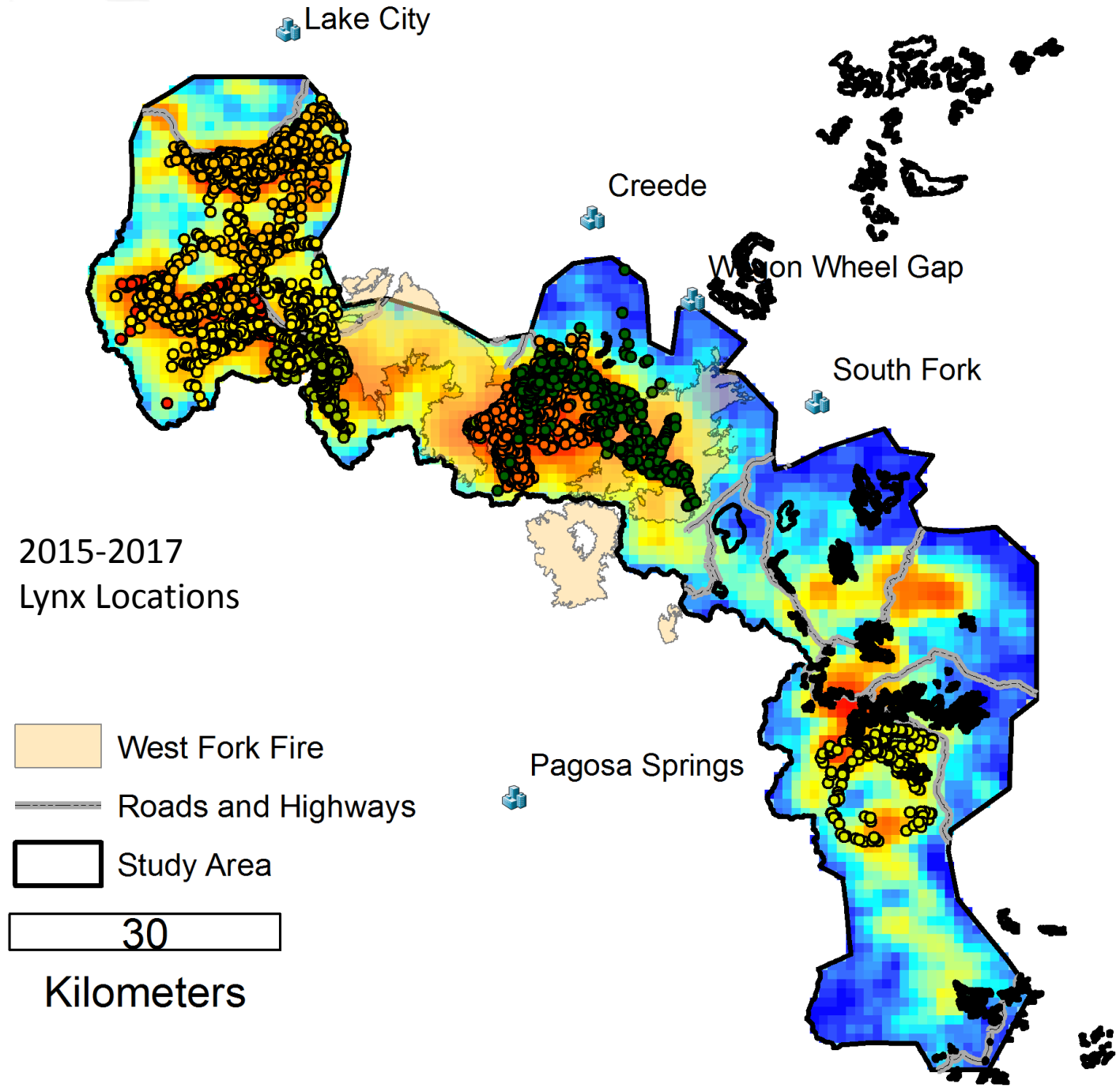

Lake City
Creede
Wagon Wheel Gap
South Fork
Pagosa Springs
Roads and Highways
Study Area
West Fork Fire
Less Selected
Selected
40
Kilometers

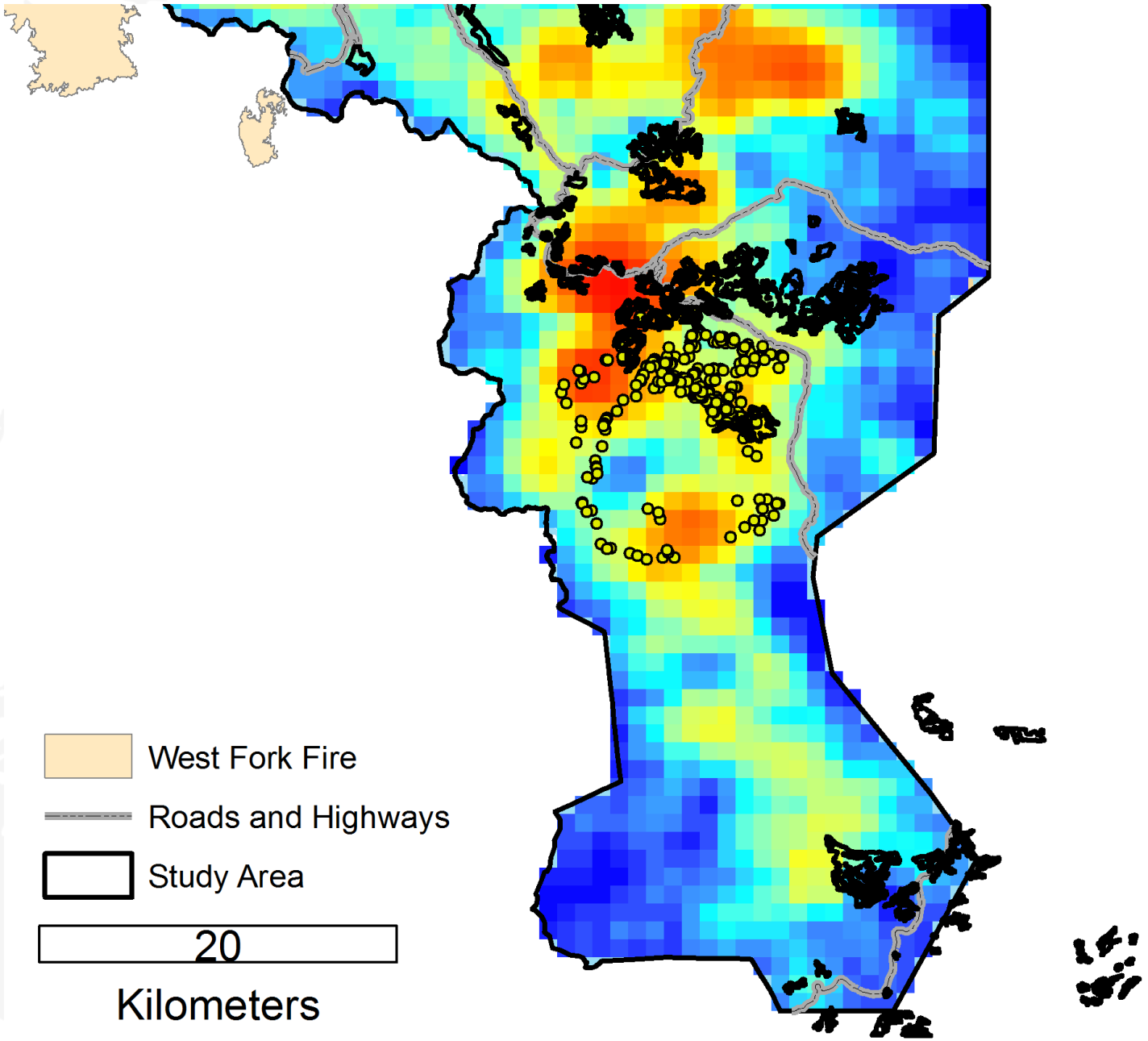

Lake City
Creede
Wagon Wheel Gap
South Fork
Pagosa Springs
Roads and Highways
Study Area
West Fork Fire
Less Selected
Selected
40
Kilometers
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community


Lake City
75% lynx use
Creede
Wagon Wheel Gap
South Fork
Pagosa Springs
Cumulative Percent of Lynx Use
100
80
60
40
20
0
Selected
Less Selected
10 9 8 7 6 5 4 3 2 1
Binned RSF Score (High-Low)
Roads and Highways
Study Area
West Fork Fire
Less Selected
Selected
40
Kilometers

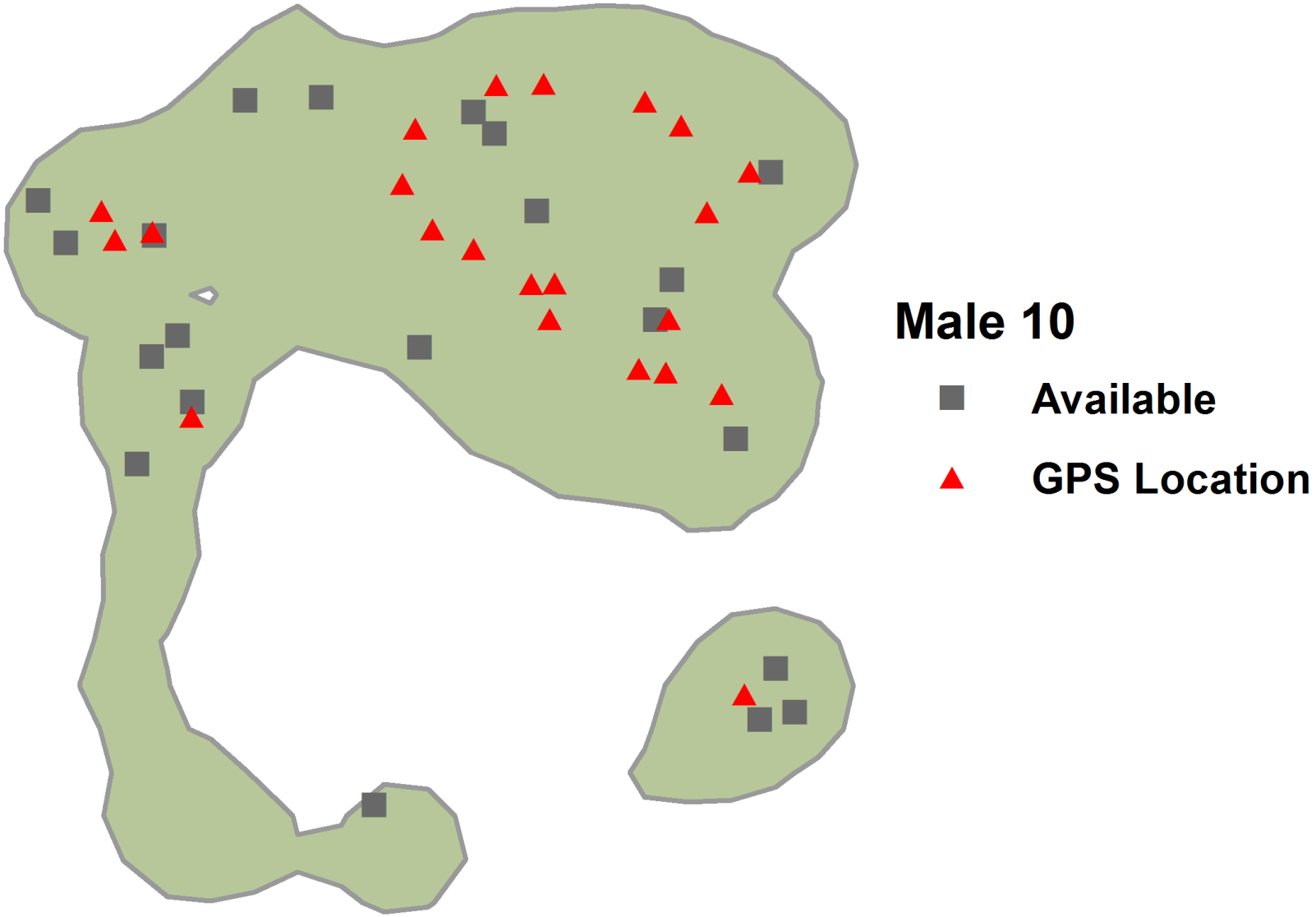

West Fork Fire
Roads and Highways
Study Area
Less Selected
Selected
10
Kilometers

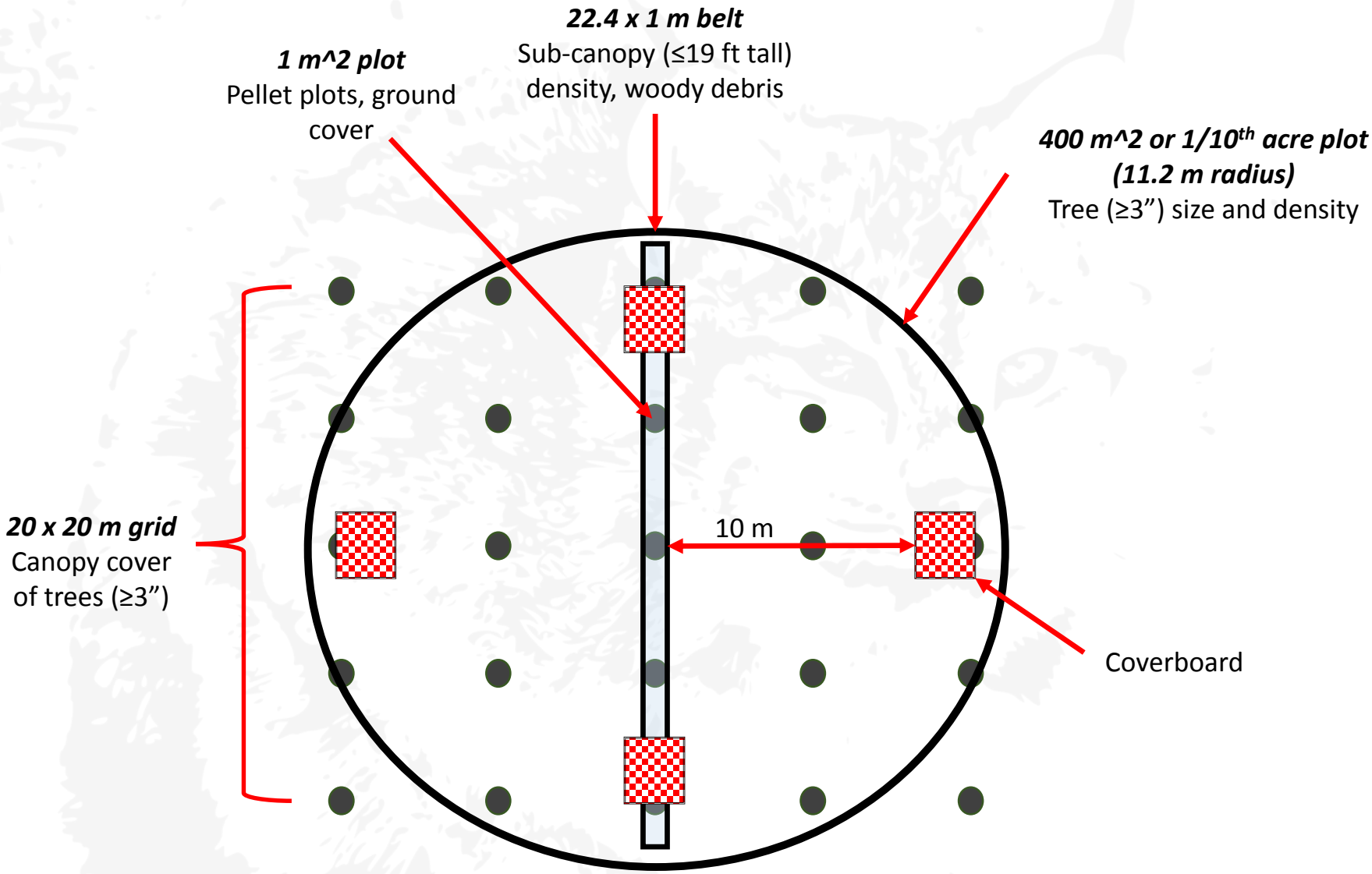

Lake City
Creede
Wagon Wheel Gap
South Fork
Pagosa Springs
Density of CPW
telemetry locations
1999-2011
West Fork Fire
Roads and Highways
Study Area
30
Kilometers


Lake City
Creede
Wagon Wheel Gap
South Fork
Pagosa Springs
2015-2017
Lynx Locations
West Fork Fire
Roads and Highways
Study Area
30
Kilometers


West Fork Fire
Roads and Highways
Study Area
20
Kilometers

Stand-Level Analyses


Male 10
Available
GPS Location


22.4 x 1 m belt
Sub-canopy (≤19 ft tall) density, woody debris
1 m^2 plot
Pellet plots, ground cover
400 m^2 or 1/10th acre plot (11.2 m radius)
Tree (≥3") size and density
20 x 20 m grid
Canopy cover of trees (≥3")
10 m
Coverboard

Stand Analyses

- 735 locations sampled
  - Use:availability sampled 1:1
- Winter (Jan-April)
  - 10 lynx (6 males, 4 females) at 457 locations
- Summer (May-August)
  - 6 lynx (2 males and 4 females) at 278 locations
- Build resource selection functions (RSF)

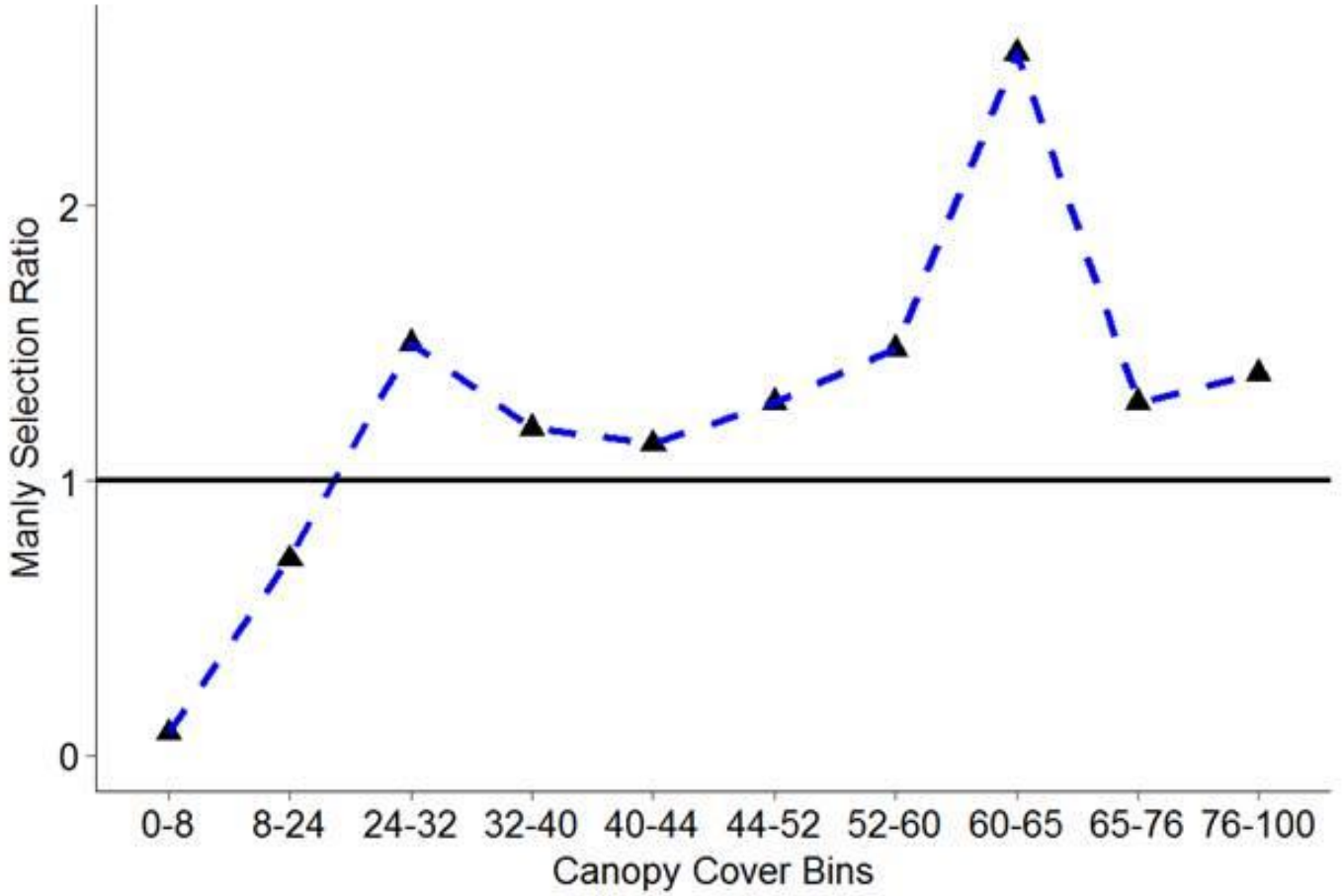
Summaries

Season	Variable	Available	Used
Winter	Horizontal cover	40 (26-48)	53 (47-61)
	Snowshoe hare pellets	2.7 (1.2-5.7)	5.9 (3.2-12.2)
	Grass cover	18 (12-24)	8 (5-12)
	ABLA Sub-canopy density	118 (16-437)	318 (53-523)
	PIEN Sub-canopy density	115 (9-232)	181 (115-301)
	POTR Sub-canopy density	365 (0-730)	458 (25-838)
	SALIX Sub-canopy density	91 (0-913)	1 (0-8)
	Total Sub-canopy density	912 (390-1496)	1174 (567-1577)

Horizontal Cover Analysis

	Winter			Summer		
Covariate	β	SE	p	β	SE	p
Intercept	46.743	0.886	<0.001	53.111	1.036	<0.001
ABLA sub-canopy TPA	7.303	1.064	<0.001	7.889	1.274	<0.001
PIEN sub-canopy TPA	3.985	1.027	<0.001	2.848	1.145	0.013
PIPU sub-canopy TPA	1.218	0.899	0.176	3.779	1.046	<0.001
POTR sub-canopy TPA	3.818	0.937	<0.001	7.565	1.161	<0.001
SALIX sub-canopy TPA	2.124	0.889	0.001	3.429	1.051	0.001
Live TPA	3.499	1.094	0.001	1.819	1.454	0.212
Live ABLA TPA	1.021	1.173	0.385	2.392	1.529	0.119
Live PIEN TPA	1.868	1.112	0.094	4.760	1.321	<0.001
Dead PIEN TPA	2.650	0.972	0.007	2.135	1.158	0.066
Model R^2	0.30			0.40		

Canopy Cover Assessment

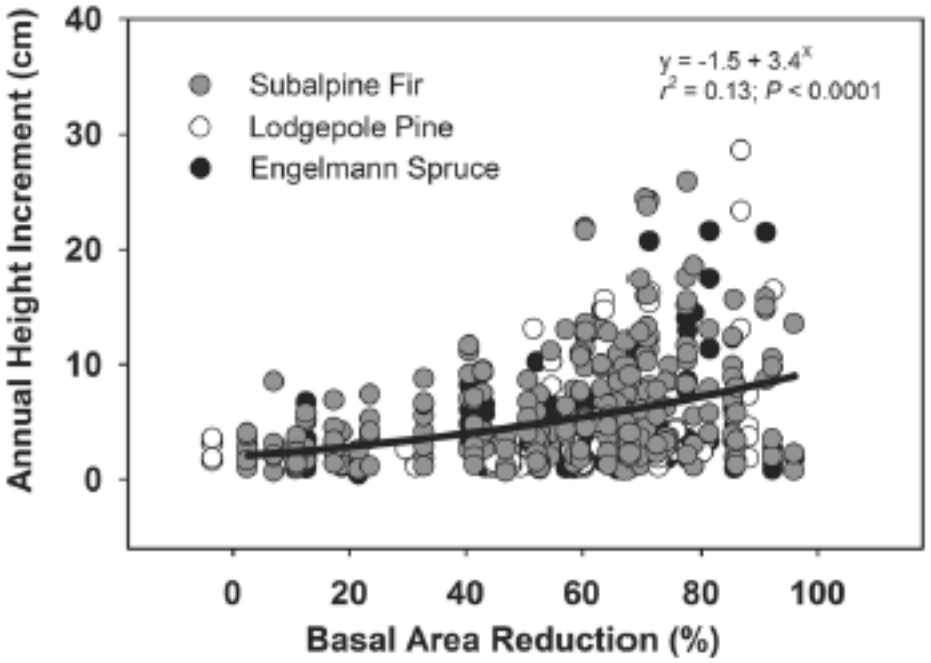


Top Models

Season	Covariate	β	SE	p
Winter	Horizontal cover	0.239	0.124	0.054
	Snowshoe hare pellets	0.245	0.132	0.063
	Canopy cover of live PIEN	0.353	0.118	0.003
	QMD of live ABLA	0.267	0.121	0.027
	QMD of live POTR	0.321	0.113	0.004
	QMD of dead trees	0.366	0.152	0.016
	TPA of live ABLA 3-4.9 inches in DBH	0.328	0.145	0.023
	TPA of dead PIEN 5-8.9 inches in DBH	0.328	0.143	0.022
	BA of dead trees	-0.319	0.161	0.047
Summer	Horizontal cover	0.427	0.139	0.002
	Snowshoe hare pellets	0.231	0.139	0.078
	QMD of dead PIEN	0.492	0.142	0.001
	QMD of dead ABLA	0.263	0.135	0.051

Relevant Studies

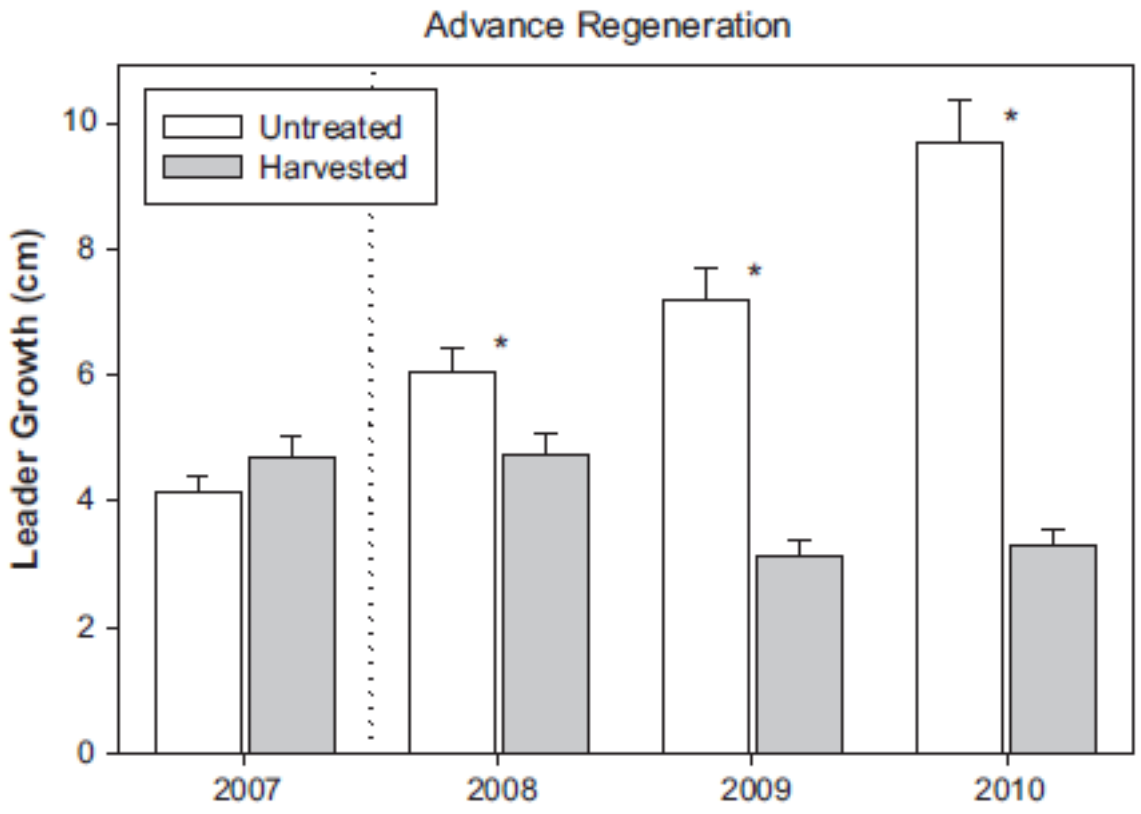
- Rhoades et al. 2017. Ecosystems.



- Understory growth post pine bark-beetle
- Impact of bark-beetle is on x-axis

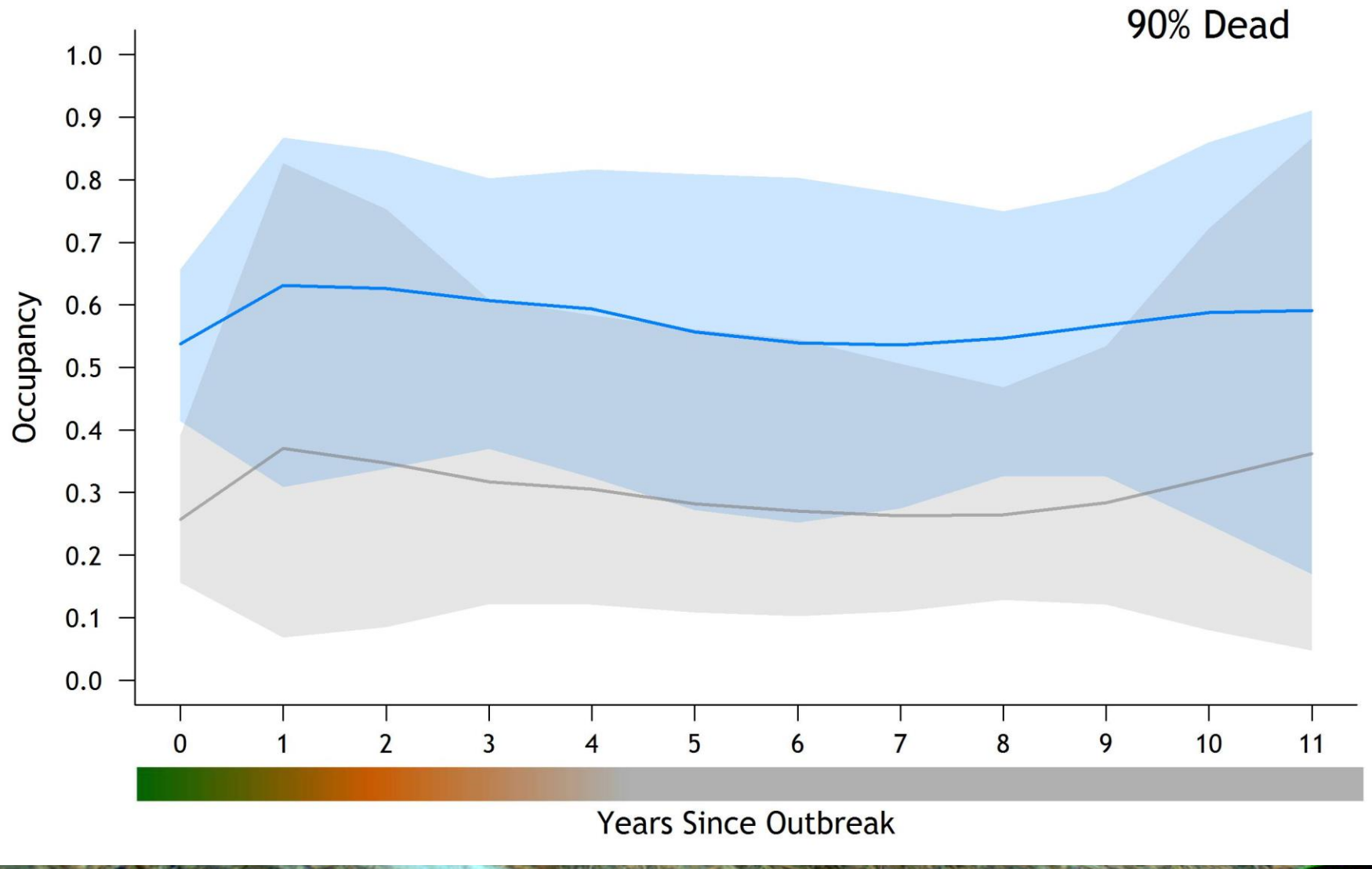
Relevant Studies

- Collins et al. 2011. FEM.

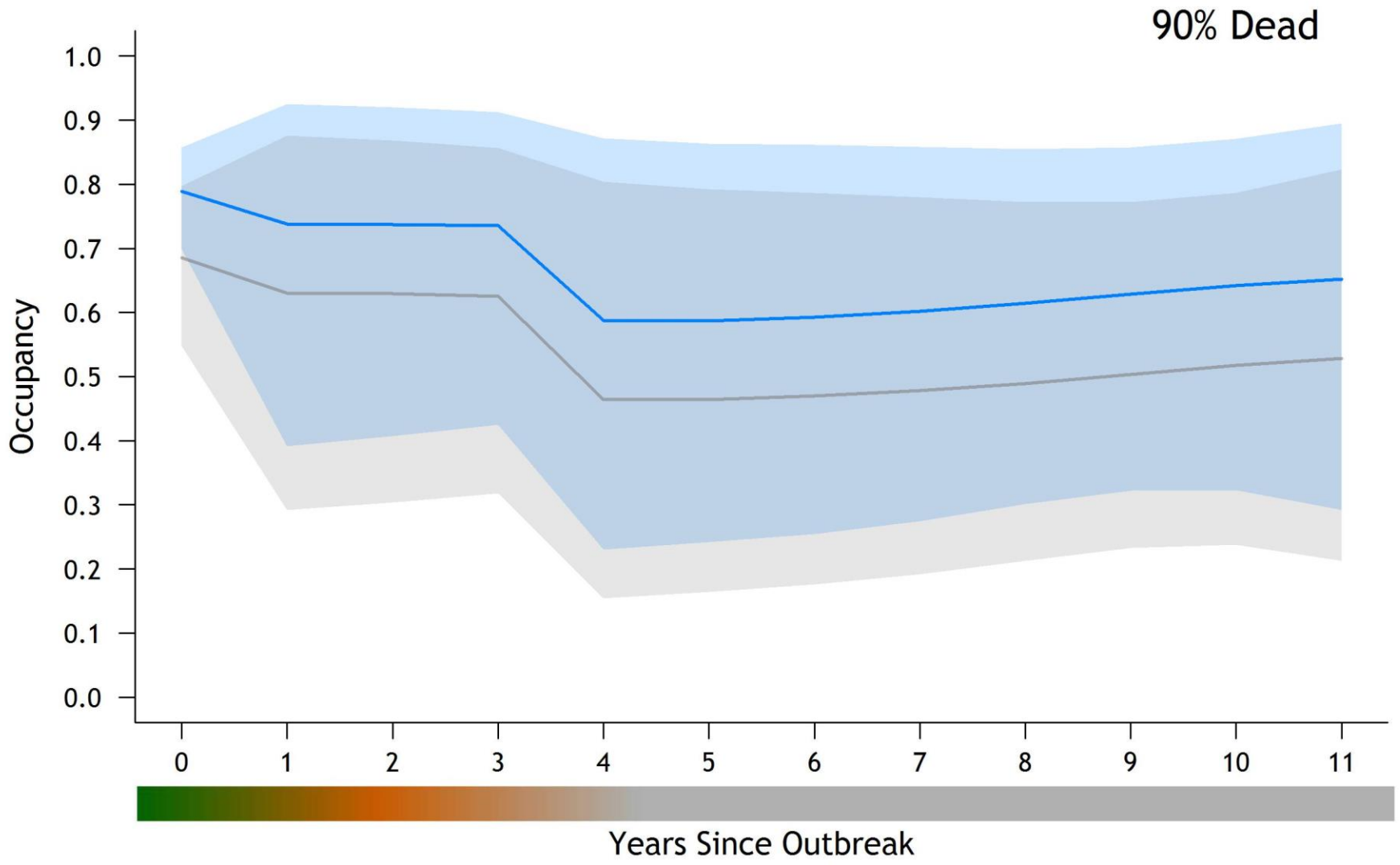


- Advance Regeneration: <2.5 cm DBH, >3 yrs old)
- Subalpine fir response

Snowshoe Hare



Red Squirrel



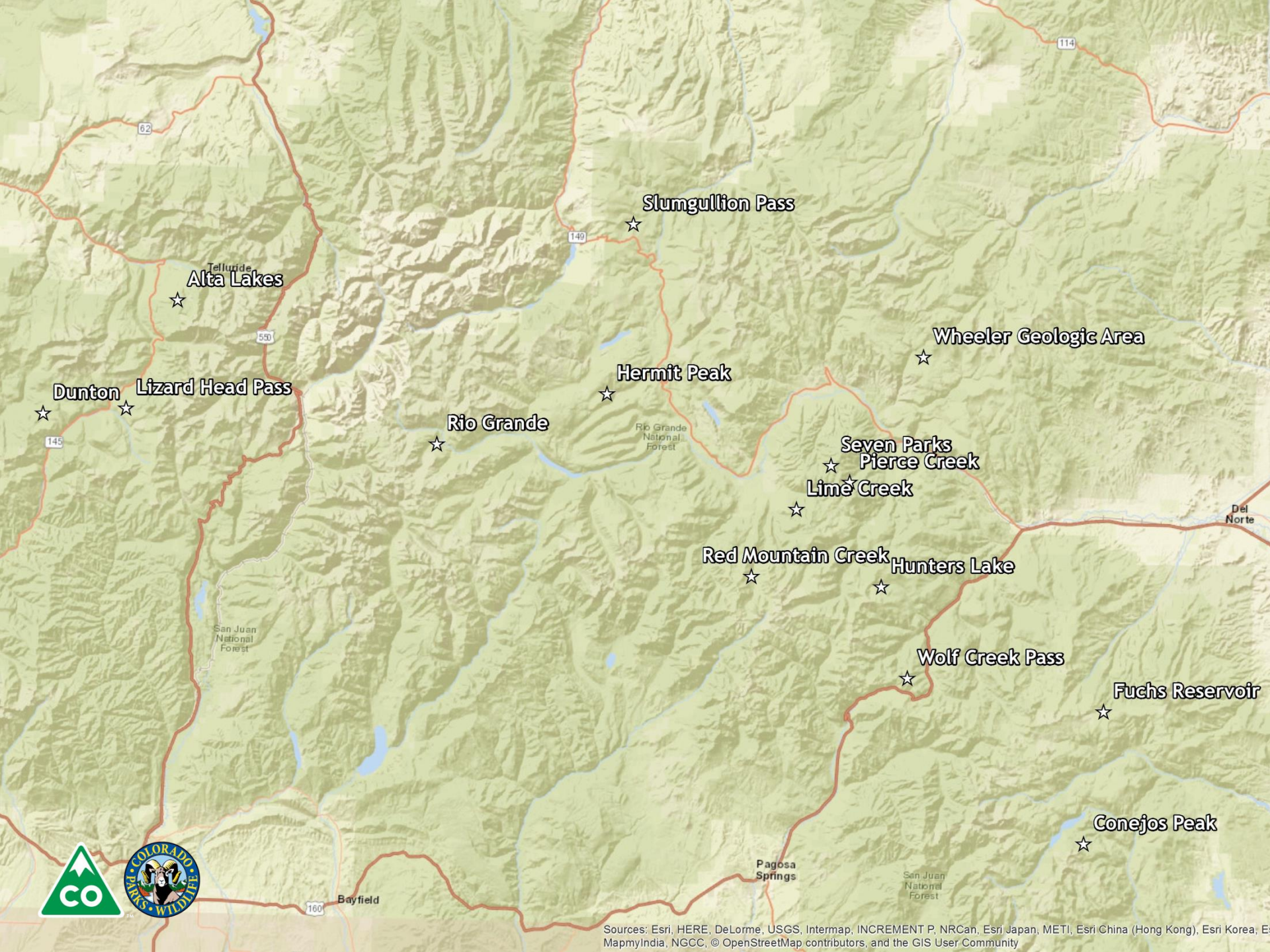
The Journal of Wildlife Management 80(6):1049–1058; 2016; DOI: 10.1002/jwmg.21101

Research Article

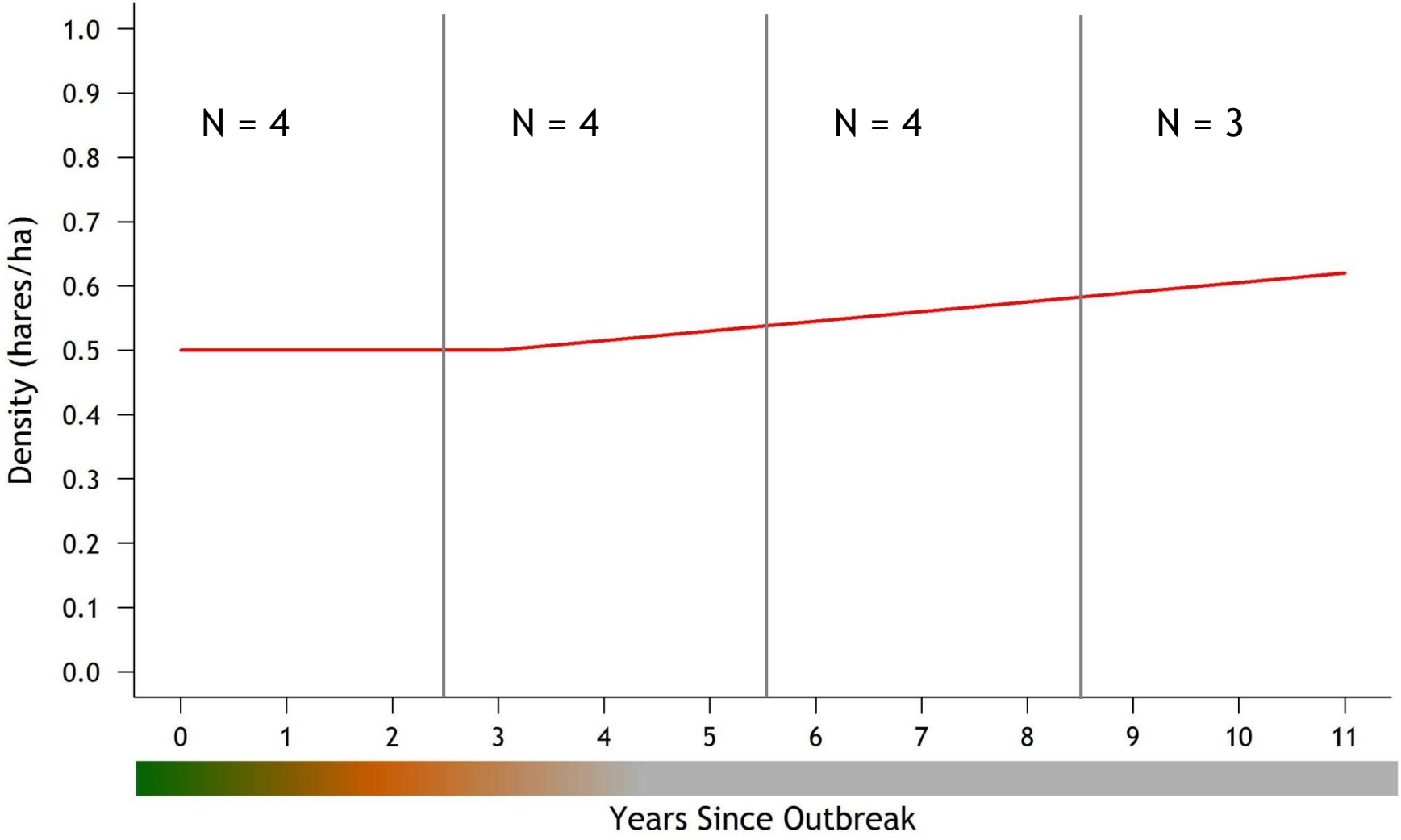
Winter Diet and Hunting Success of Canada Lynx in Colorado

Table 1. Percent occurrence (% biomass) of snowshoe hares, red squirrels, and other prey items in the winter diet of Canada lynx in Colorado, USA, 1999–2009.

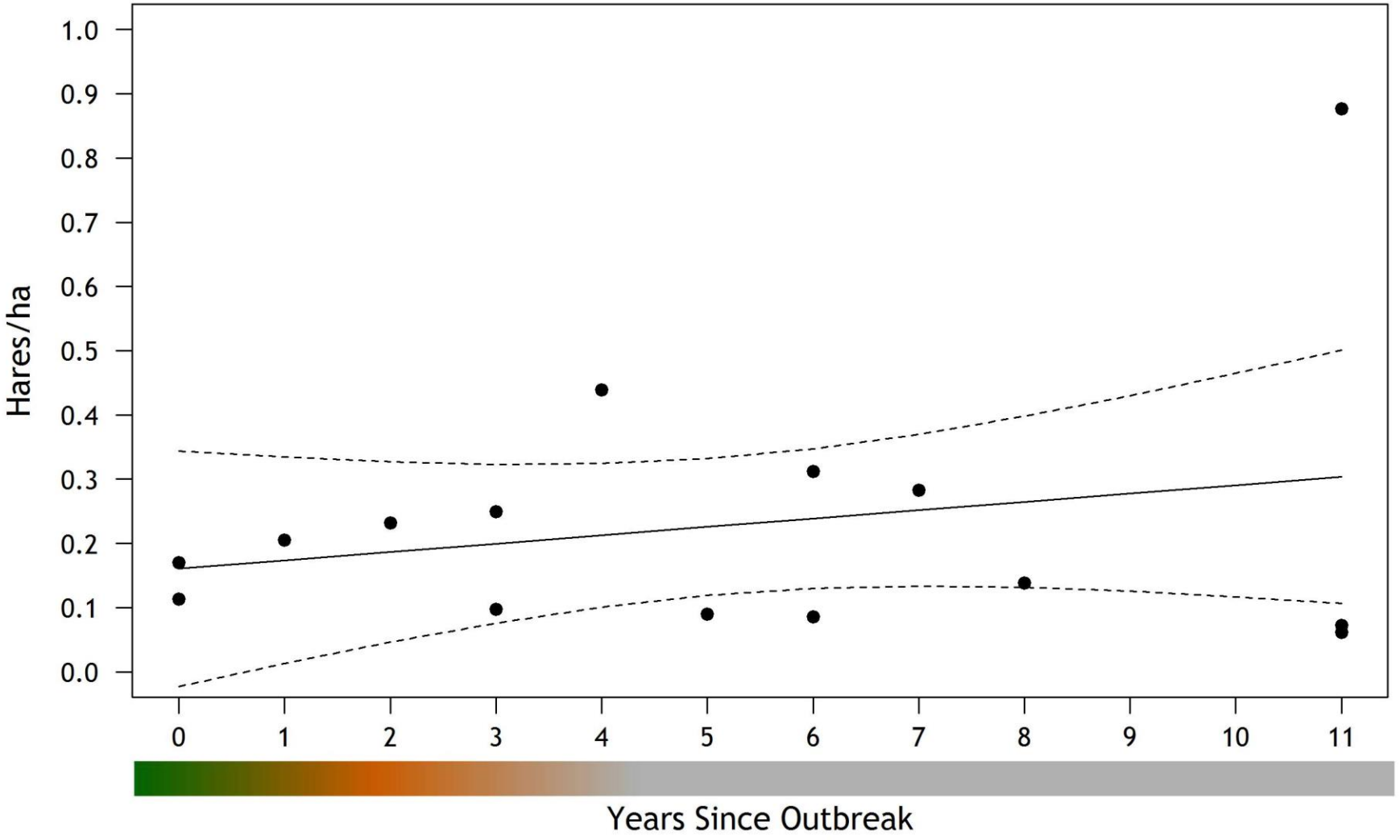
Winter	No. lynx tracked	Total km tracked	Total kills	Snowshoe hare (%)	Red squirrel (%)	Other (%)
1999	12	157	6	67 (92)	33 (8)	0 (0)
1999–2000	19	493	68	72 (84)	22 (5)	6 (12)
2000–2001	47	611	77	65 (84)	22 (5)	13 (11)
2001–2002	32	388	42	90 (97)	7 (1)	2 (2)
2002–2003	27	557	50	88 (97)	8 (2)	4 (2)
2003–2004	33	403	36	69 (91)	28 (7)	3 (3)
2004–2005	42	520	65	86 (97)	12 (2)	2 (1)
2005–2006	45	485	67	88 (98)	9 (2)	3 (1)
2006–2007	32	357	36	56 (87)	44 (13)	0 (0)
2007–2008	25	345	46	59 (89)	39 (11)	2 (0)
2008–2009	25	296	53	26 (65)	72 (32)	2 (4)
$\bar{x}$	31	419	50	70 (89)	27 (8)	3 (3)


Slumgullion Pass
Telluride
Alta Lakes
Wheeler Geologic Area
Hermit Peak
Dunton
Lizard Head Pass
Rio Grande
Rio Grande National Forest
Seven Parks
Pierce Creek
Lime Creek
Del Norte
Red Mountain Creek
Hunters Lake
San Juan National Forest
Wolf Creek Pass
Fuchs Reservoir
Conejos Peak
Pagosa Springs
San Juan National Forest
Bayfield
62
114
149
550
145
160
Sources: Esri, HERE, DeLorme, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri
MapmyIndia, NGCC, © OpenStreetMap contributors, and the GIS User Community

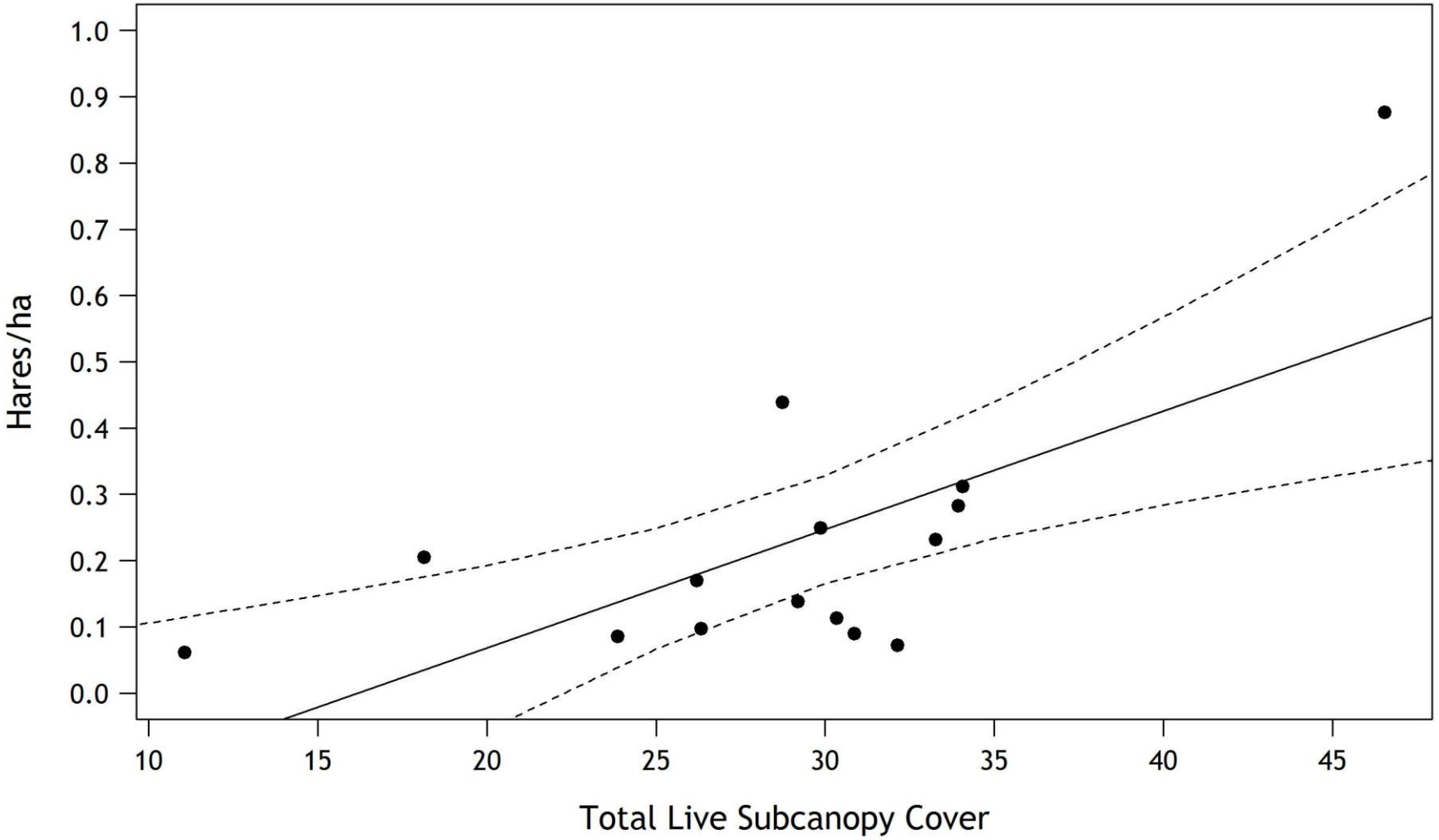
Snowshoe Hare



Snowshoe Hare



Snowshoe Hare



Take-Homes

- Lynx in Colorado are rare, low in density, and spatially restricted – San Juans and Vail/Leadville
- Lynx habitat is disproportionately out of wilderness and in timber base (Statewide lynx RSF ongoing)
- Localized lynx populations are vulnerable to extensive fragmentation – (Garnet Range – Montana, Wyoming Range – Wyoming). San Juan Range is critical to lynx in Colorado – there is no population rescue

Take-Homes

- Despite large-scale change from beetles, lynx occupying similar habitat as pre-beetle (i.e., CPW data) and reproducing
- Lynx habitat in beetle-kill will improve over time , but the species in Colorado is currently in the “emergency room” – vulnerable to fluctuations in prey abundance (i.e., no squirrels)
- Fortunately, hare occupancy and density stable and relatively high in beetle-kill

Take-Homes

- Important components of lynx habitat in beetle-kill include - horizontal cover (>45%), live ABLA, TPA and canopy cover of live trees, understory conifers (ABLA and PIEN) in subcanopy, size/basal area of dead trees, and hares. – need to be addressed in stand-level prescriptions
- Location of salvage is central to minimizing potential population impacts – Platoro greatest potential conflict zone

Take-Homes

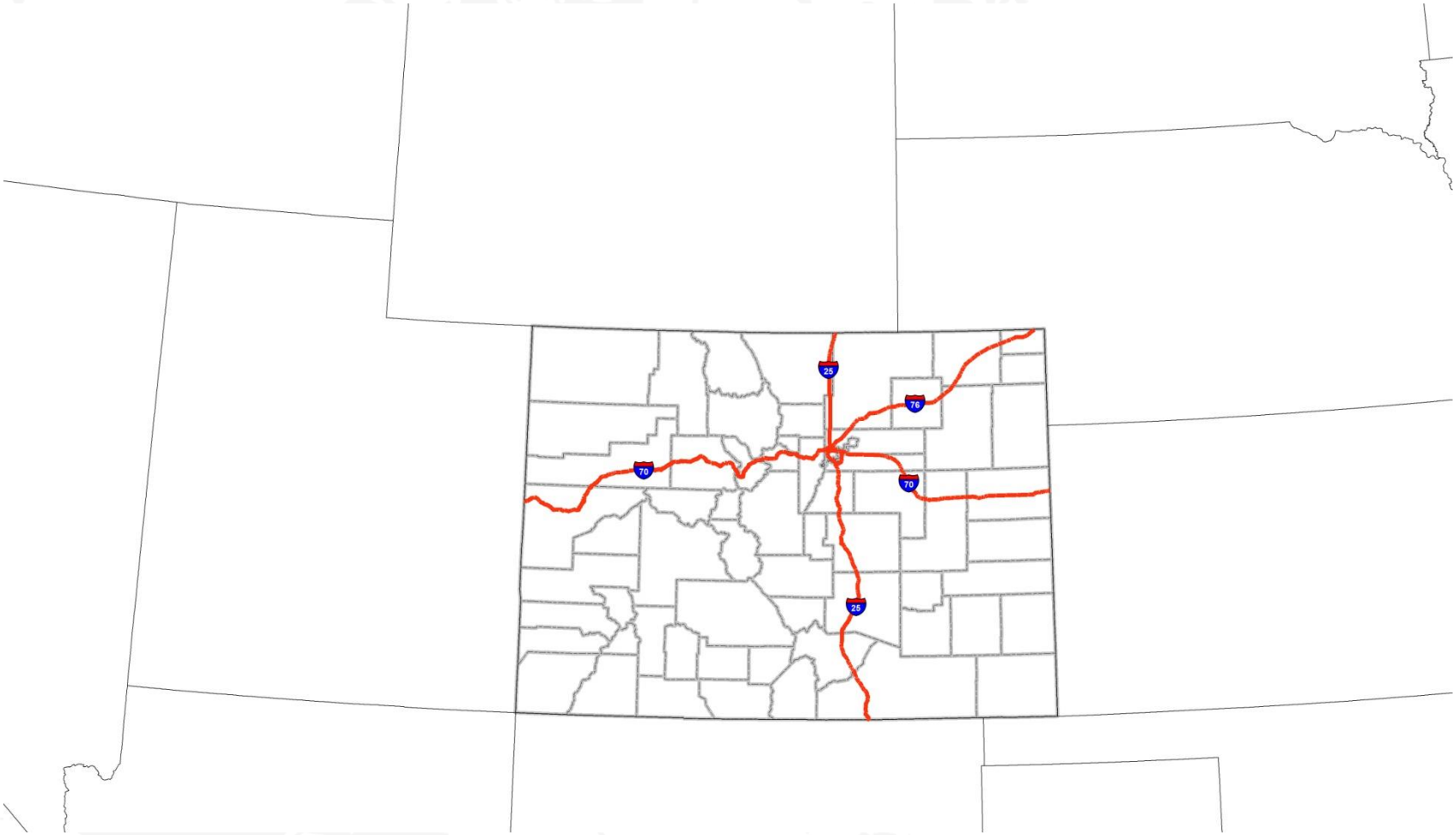
- Beetle-induced release, but sub-canopy development is reduced by salvage (Battaglia, Rhoades; e.g., GMUG dead tree retention); consult with the GMUG for lessons learned.

Take-Homes

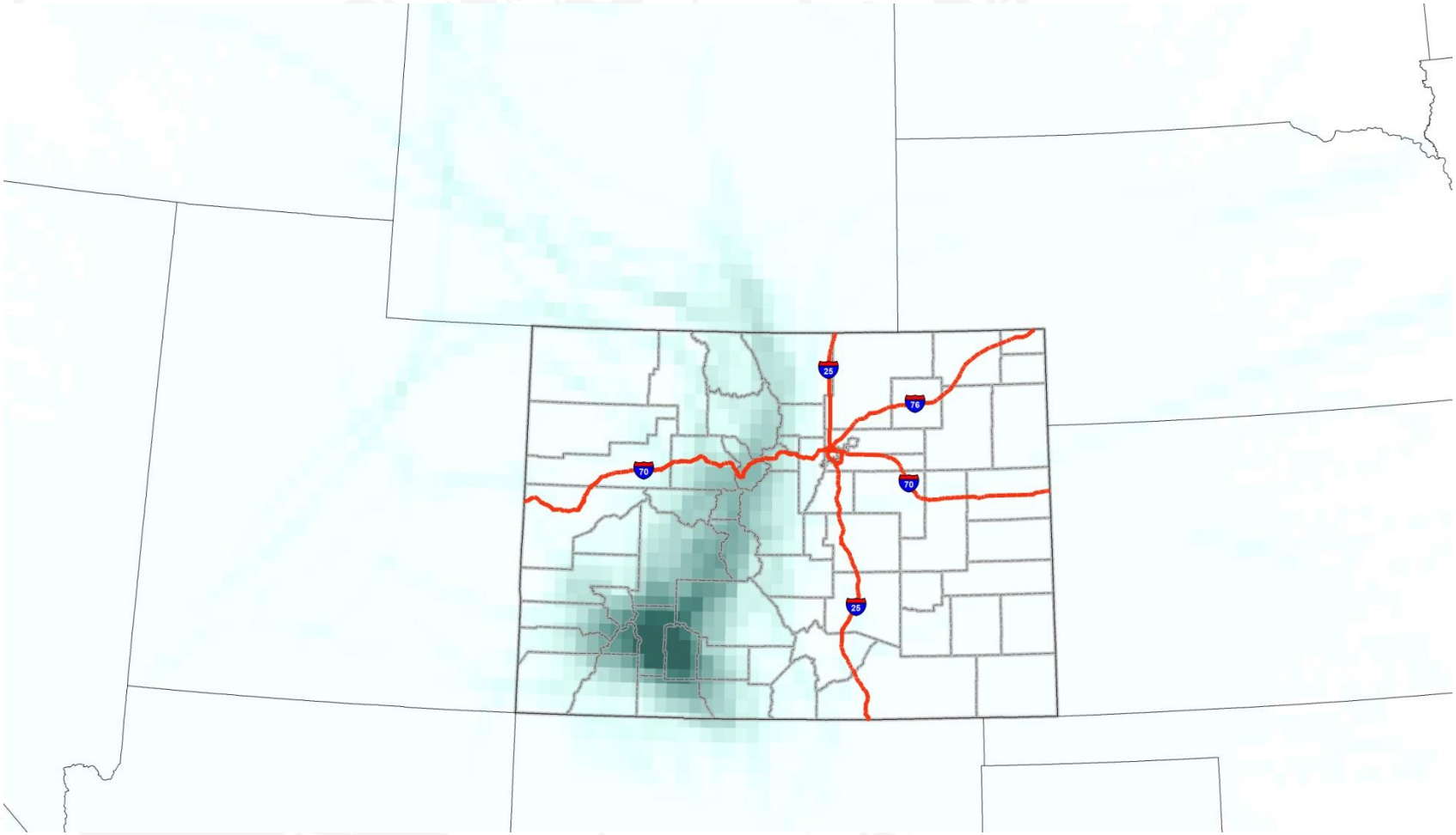
- What can we do to improve lynx habitat?
  - Preserve understory during harvest (i.e., winter logging, skid trail management)
  - Shade retention (i.e., live trees and dead trees)
  - Salvaging in a mosaic framework
  - Planting subalpine fir post-harvest

Discussion

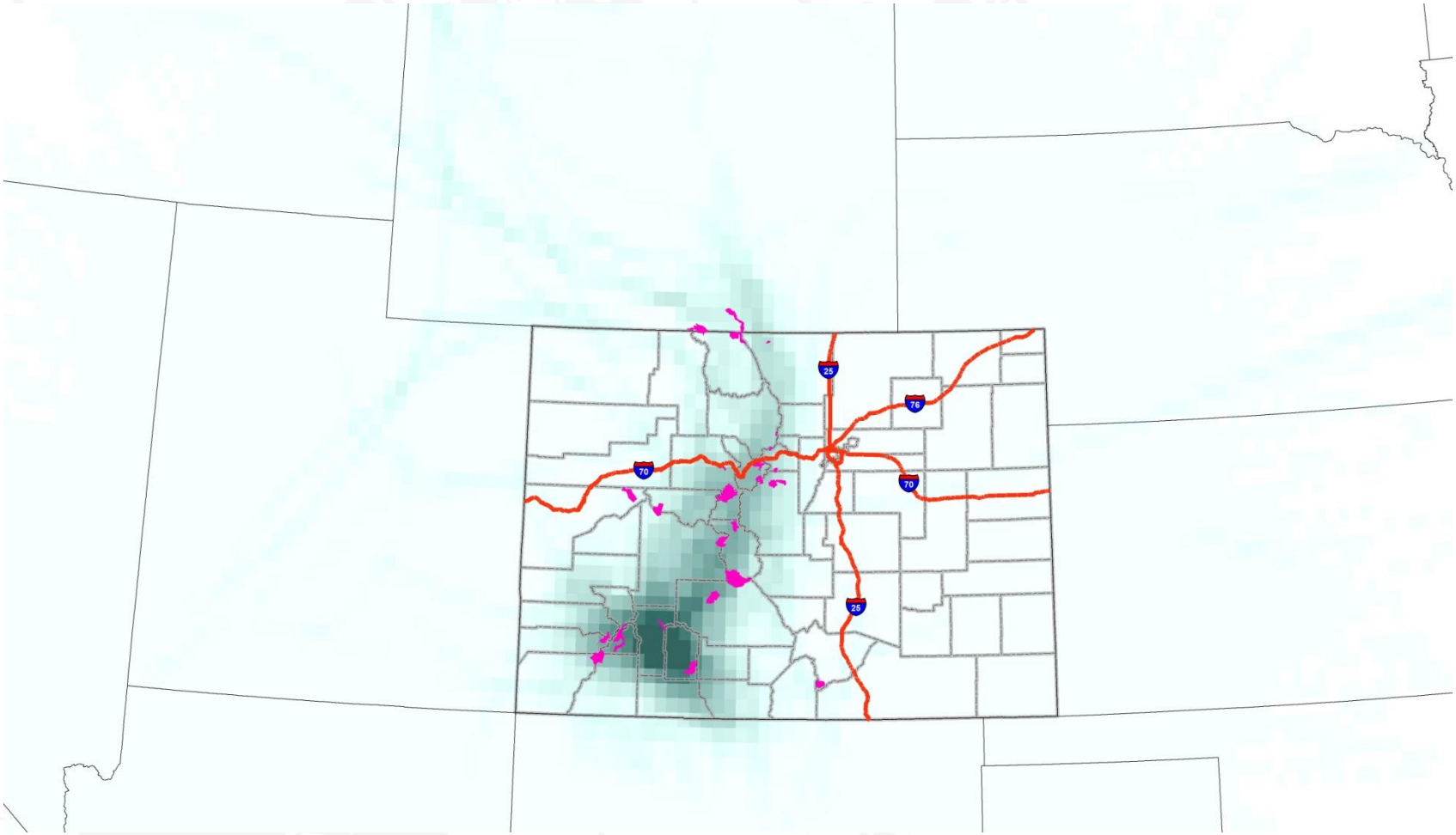
Lynx Movements



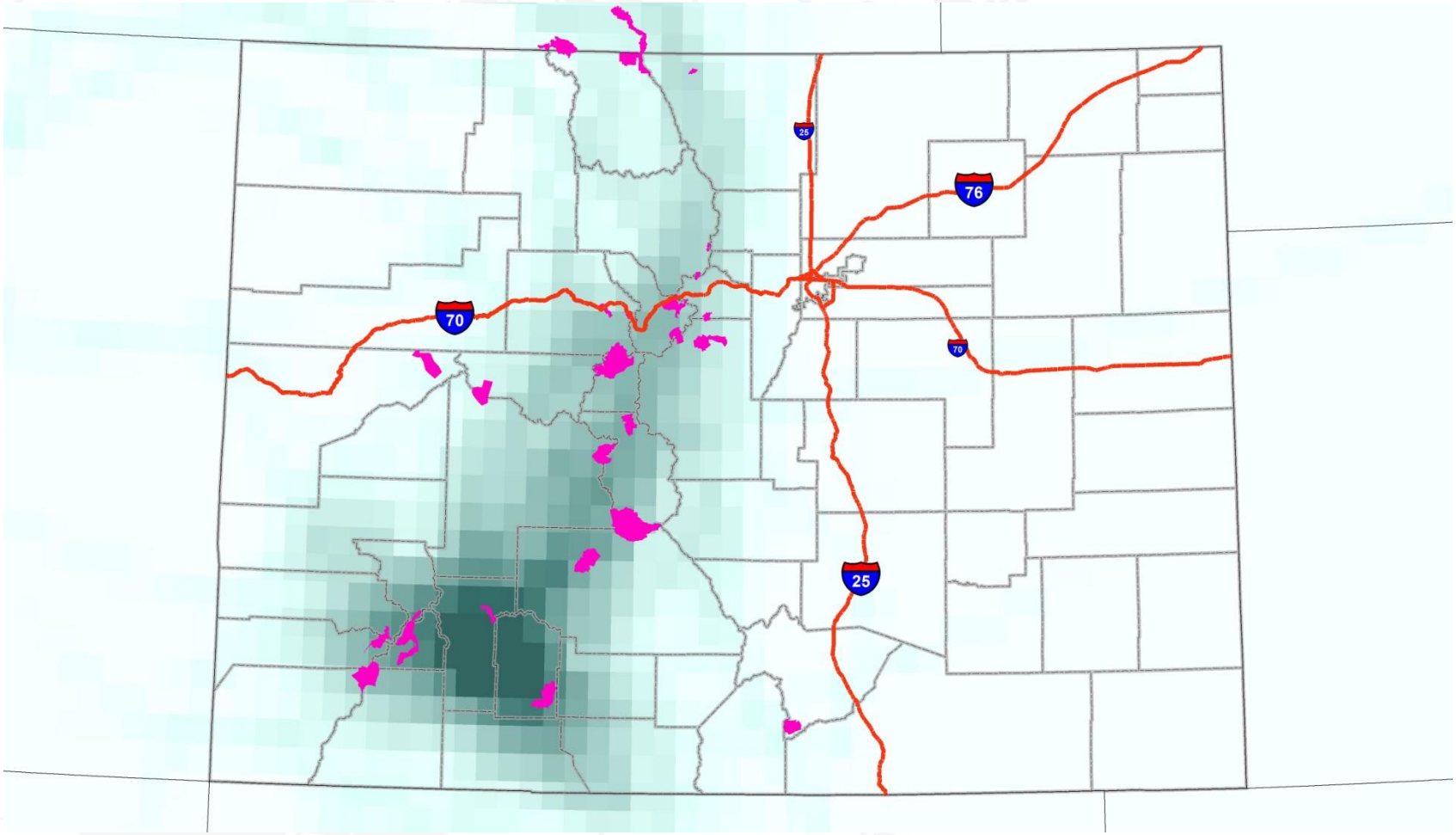
High Speed + Directed



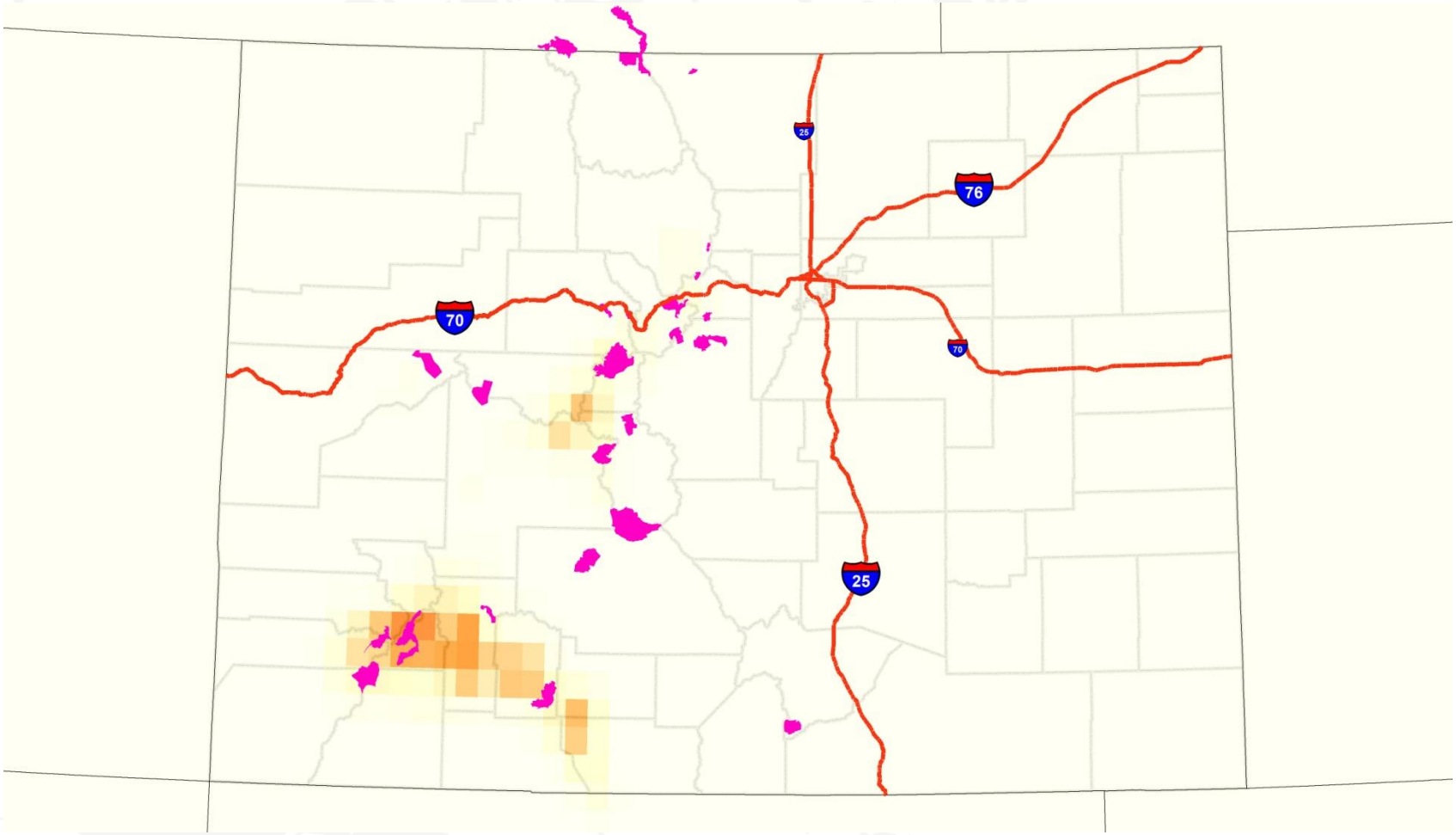
High Speed + Directed



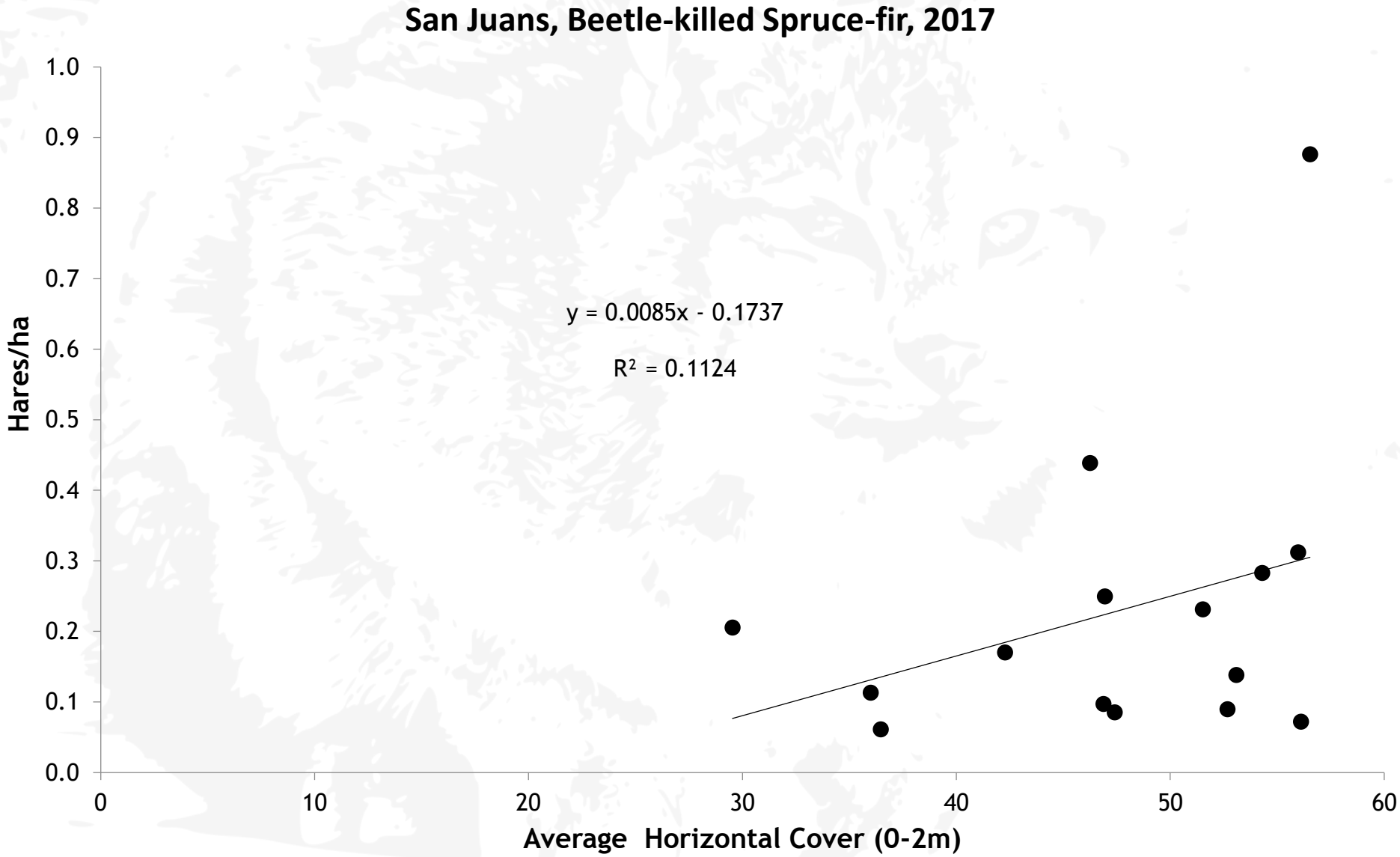
High Speed + Directed



Slow Speed + Tortuous



Snowshoe Hare



Snowshoe Hare