Linking Wildfire Burn Mosaic and Lynx Habitat Modeling

AFE/IAWF Fire Continuum Conference
Monday, May 21st 8am - noon
University of Montana, Missoula, MT

Bill Gaines, Conservation Sciences Institute
Paul Hessburg, USFS Pacific Northwest Research Station
Nicholas Povak, USFS Pacific Northwest Research Station
Susan Prichard, University of Washington
Brion Salter, USFS Pacific Northwest Research Station

AGENDA

Agenda	Details	Presenter
0800 – 0830	Introductions Project overview and workshop goals	Prichard
0830 – 0915	Fire and lynx dynamics	Gaines
0915 – 0930	BREAK	
0930 – 1000	Landscape simulation modeling process	Povak/Prichard
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1115 – 1145	Implications for wildlife management (discussion)	All
1145 - 1200	Recommendations for next steps	All

INTRODUCTIONS

Workshop goals

1) Review fire and lynx habitat relationships

2) Present findings of our reburn study

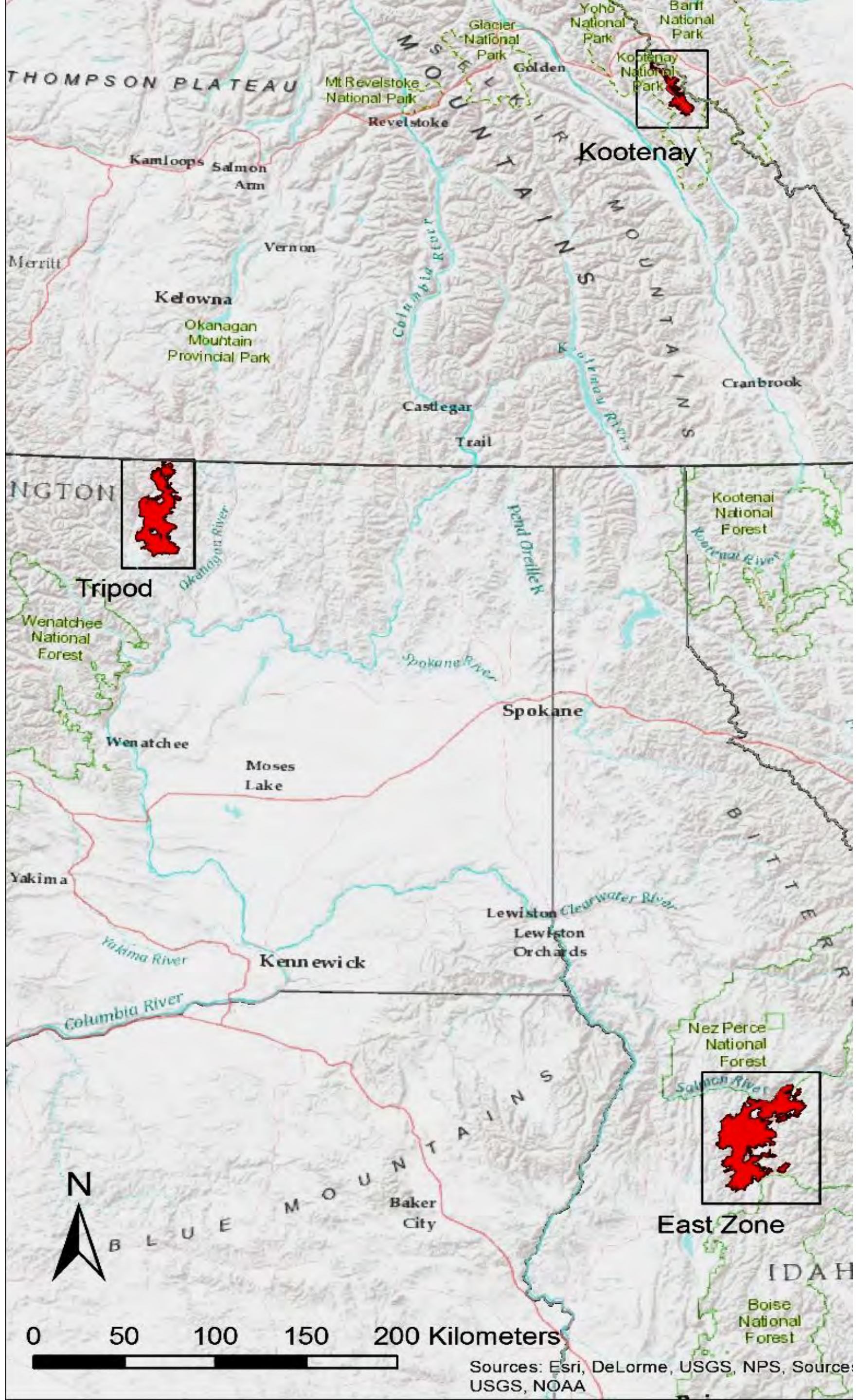
3) Discuss implications of alternative burn mosaic landscapes on critical wildlife habitat

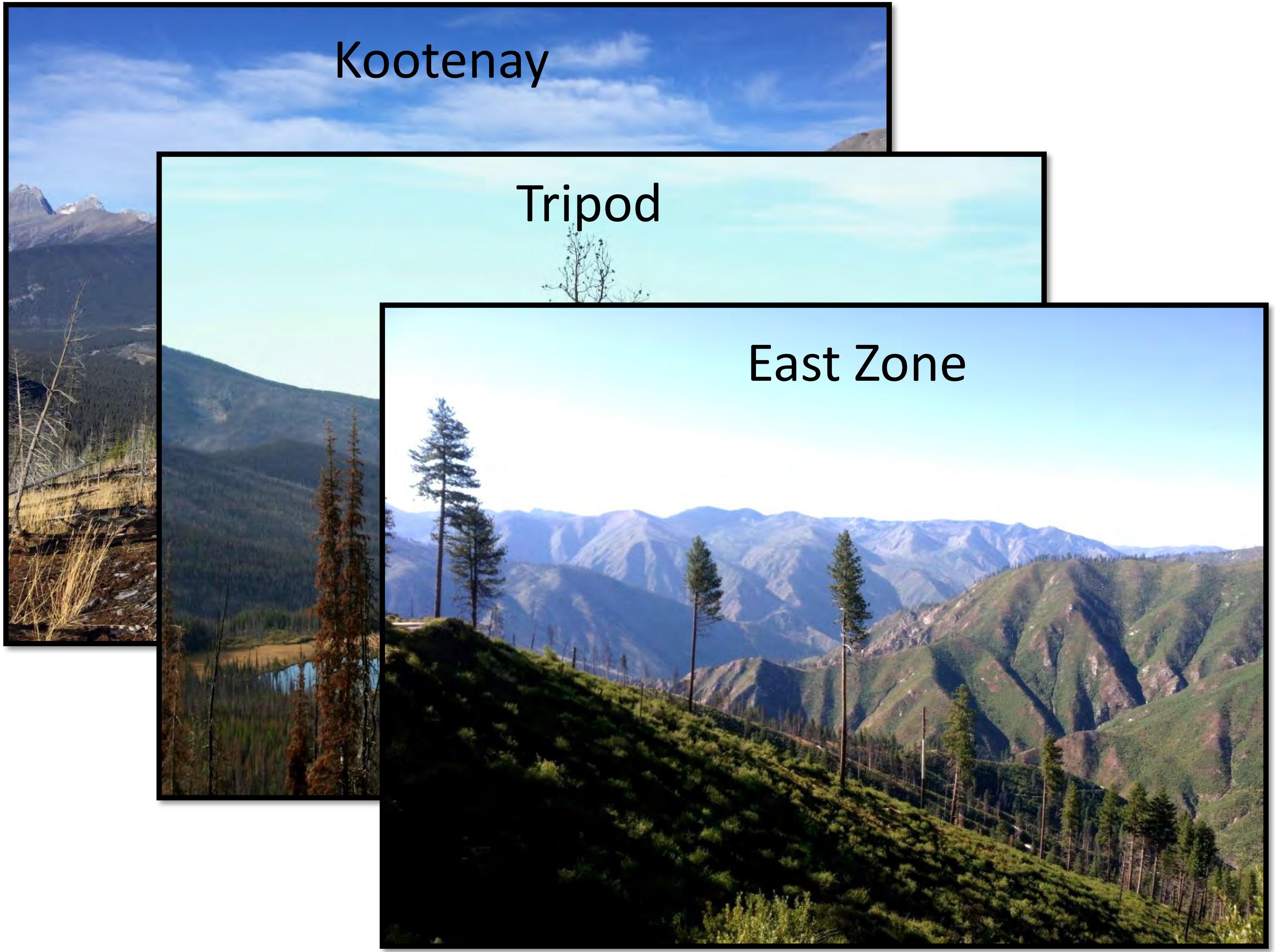
Project Overview

To evaluate the effects of past wildfires on the:

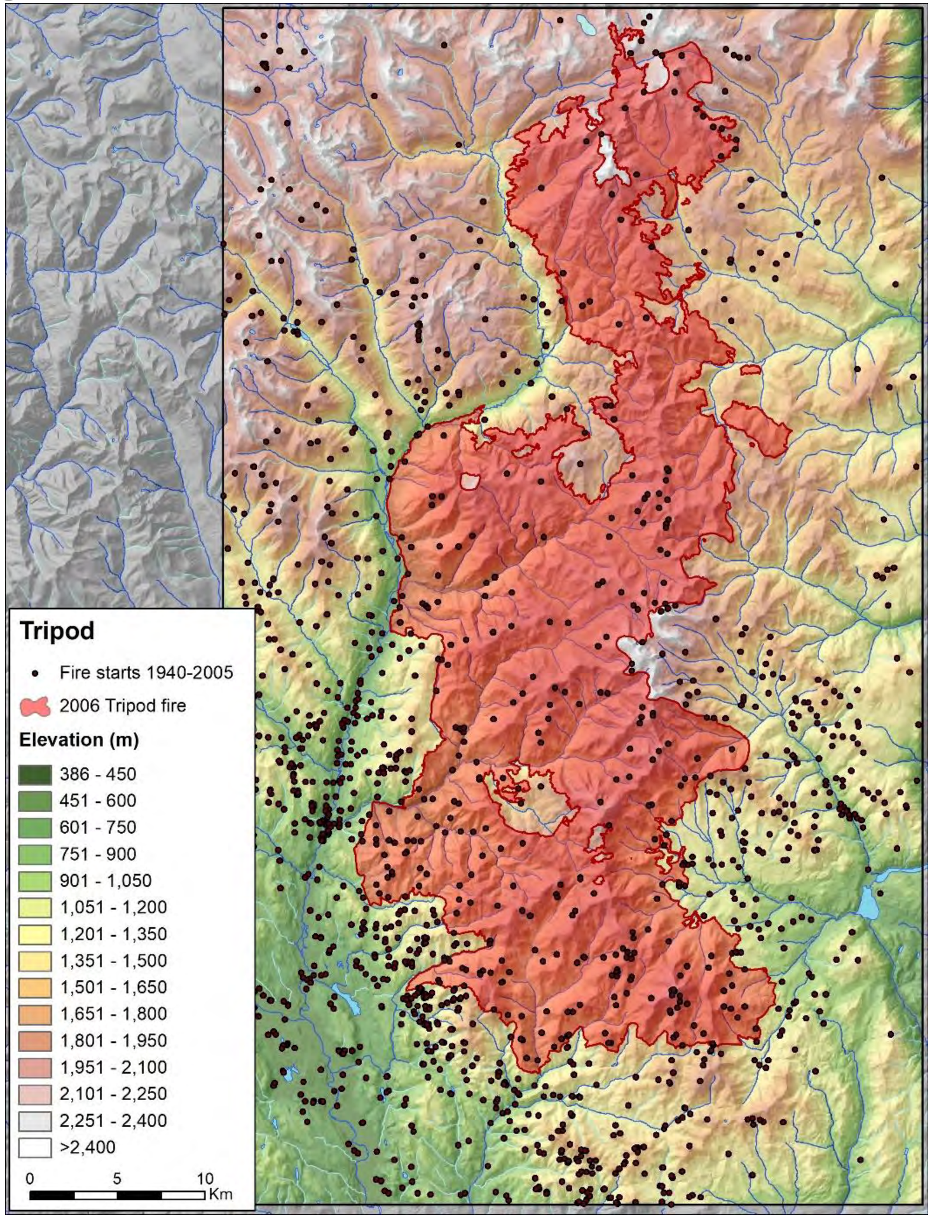
1) Characteristics
   - ✓ fire spread & severity

2) Management
   - ✓ firefighting tactics
   - ✓ costs of later wildfires




Kootenay
Tripod
East Zone

Tripod Historical Fire Starts

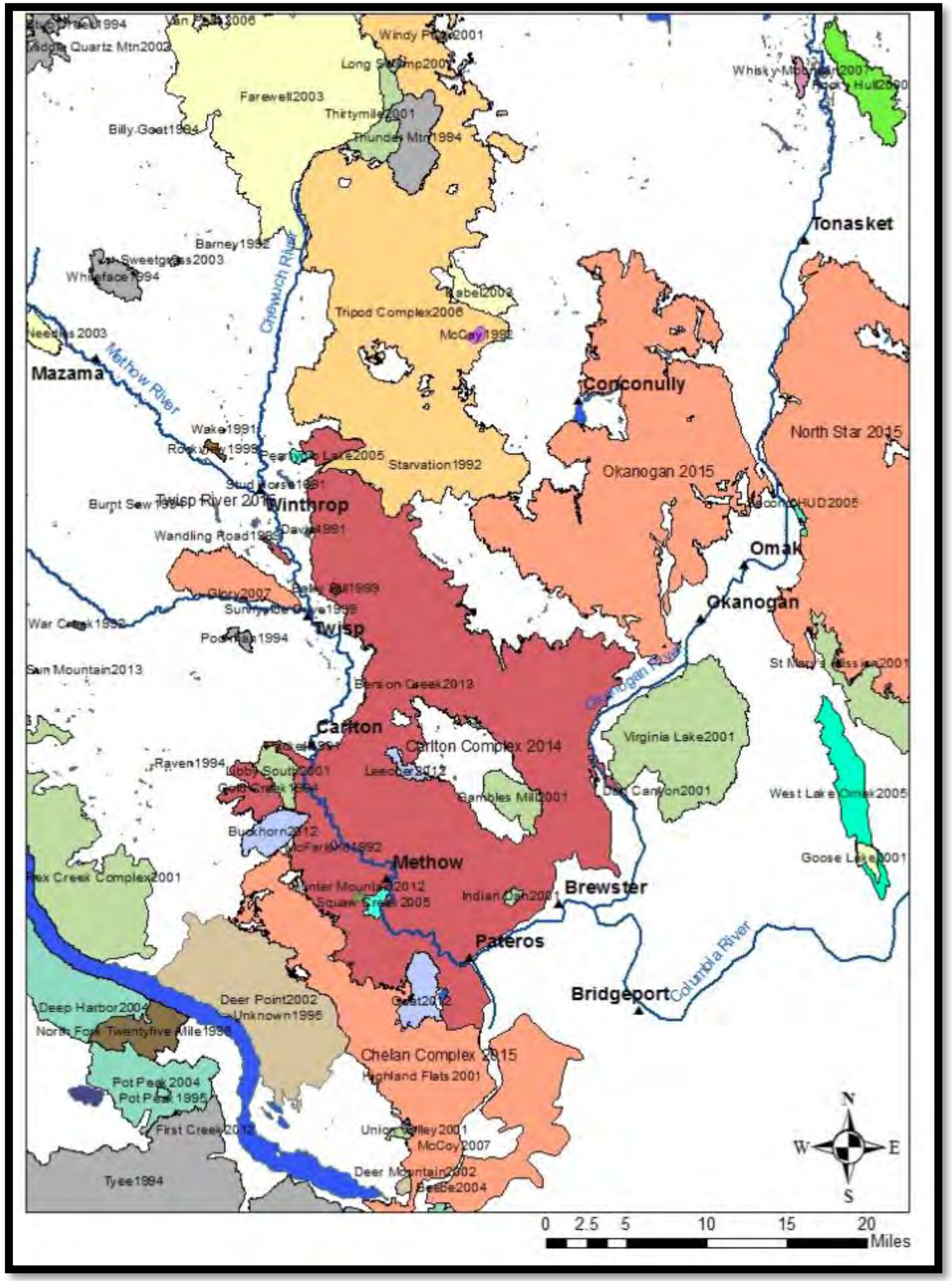


Suppressed fire starts (1940 – 2006, n > 300)

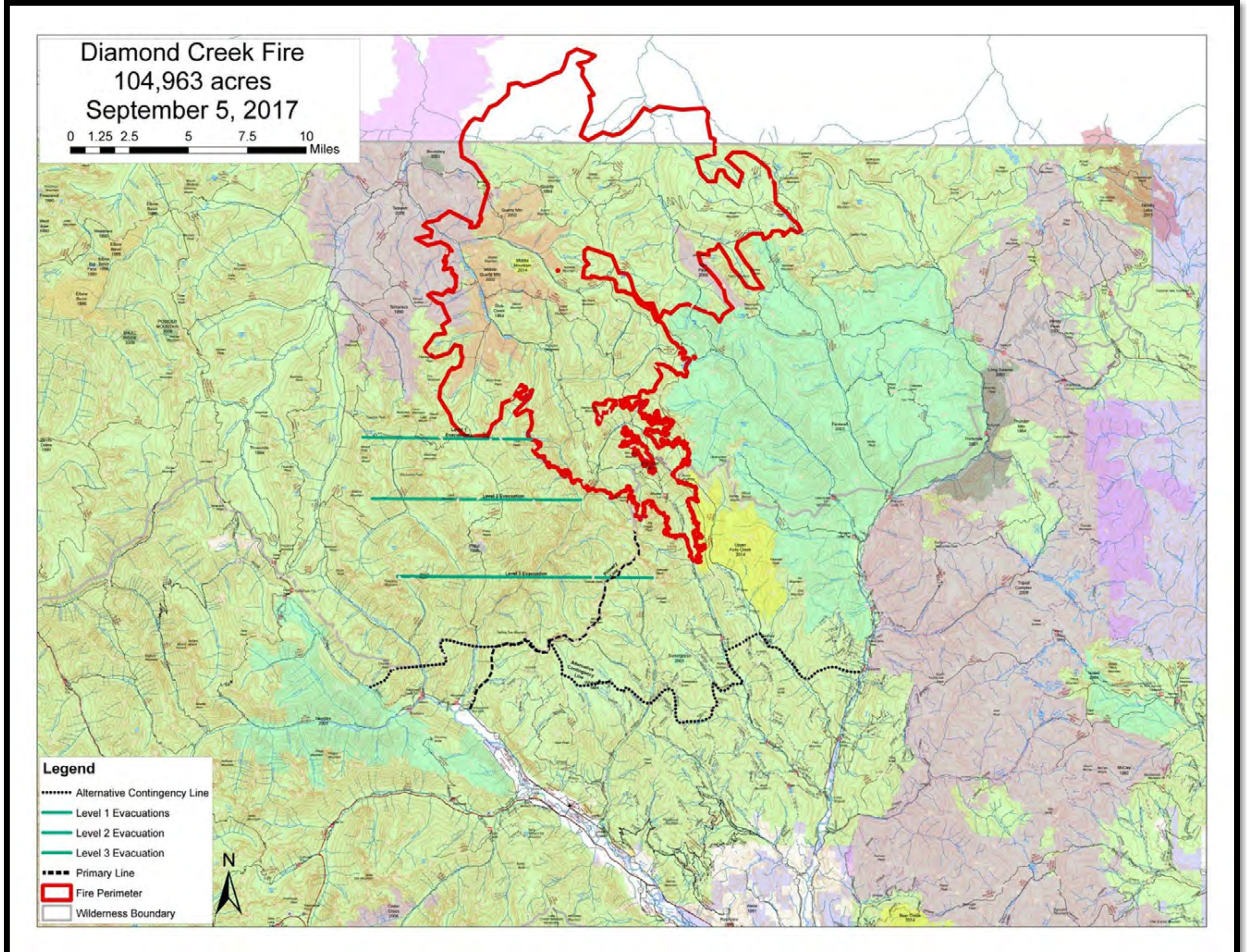
Research Questions

How do the location, size and age of past wildfires influence subsequent wildfire behavior and effects?

Were past wildfires effective as barriers to subsequent fire spread or to mitigate burn severity?

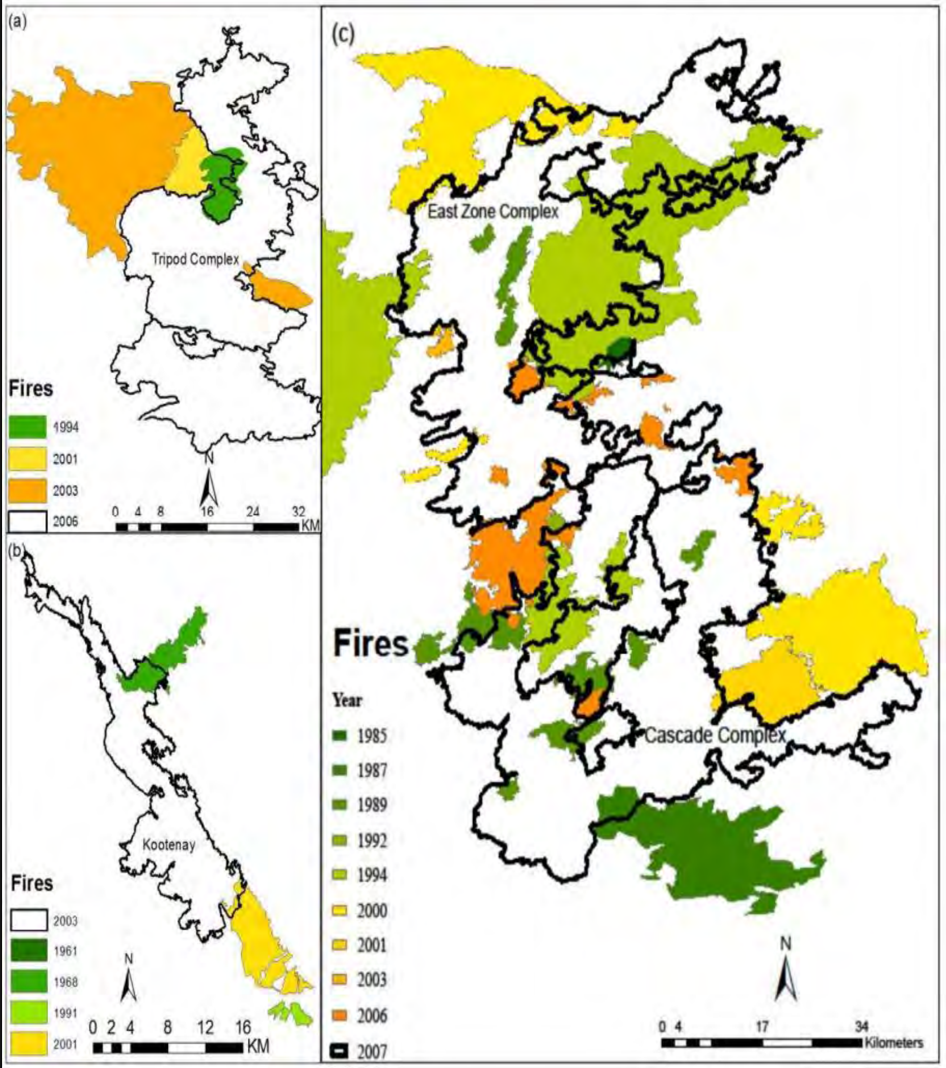


Research Questions, cont.



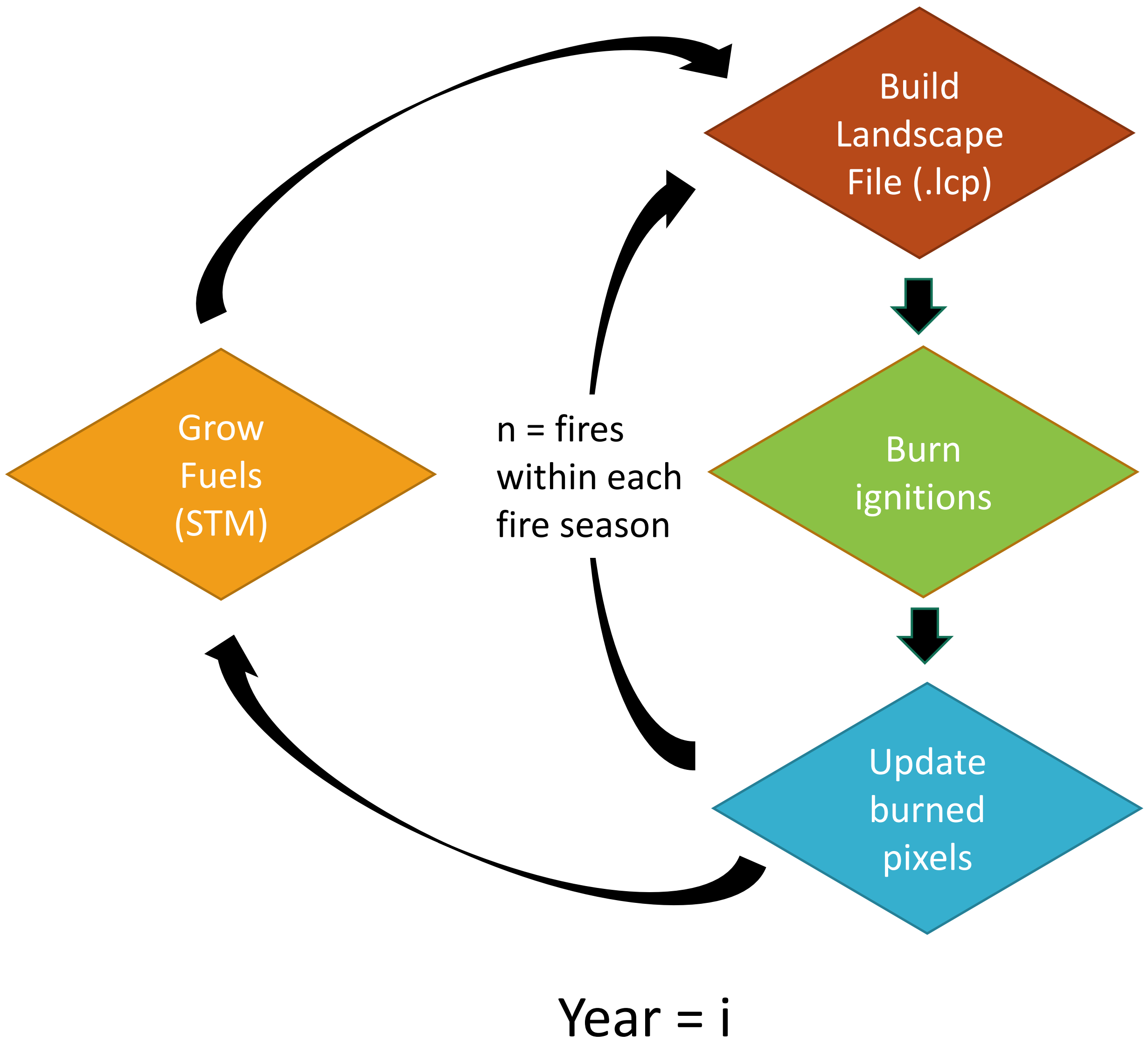
Task 1 – Burn Severity Analysis

Prior wildfires influence burn severity of subsequent large fires
Camille Stevens-Rumann, Susan Prichard, Eva Strand, Penelope Morgan
Canadian Journal of Forest Research, *46*(11), 1375-1385.

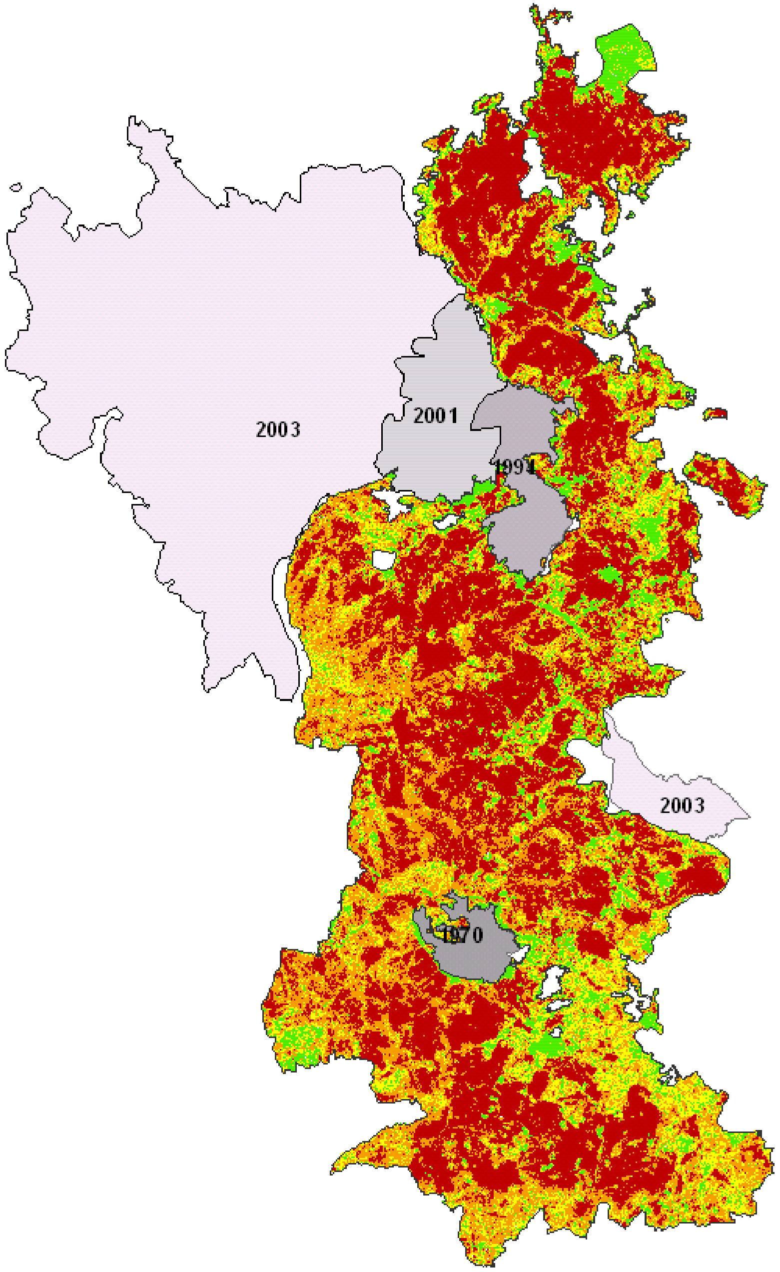


- ❖ Past burn severity reduced subsequent burn severity-more resistant
- ❖ Even under extreme fire weather conditions, vegetation, topography, and past burn severity all impacted reburn severity

Task 2 – Spatial Simulation Modeling



Task 3: Evaluate Alternatives to Tripod 2006



Severity Class
- High
- Moderate
- Low
- Unburned

Historic Fires
- Farewell & Isabel (2003)
- Thirtymile (2001)
- Thunder Mtn (1994)
- Forks (1970)

Tripod Weather and Burn Progression Days (July 2006)

BurnDate, Time	Cumulative Acres
7/24/06 9:00 PM	110
7/25/06 10:42 AM	1,267
7/26/06 8:00 AM	4,223
7/27/06 11:00 PM	14,985
7/28/06 9:00 AM	16,765
7/29/06 11:00 PM	27,106
7/30/06 11:00 PM	35,475
7/31/06 11:00 PM	35,838
8/1/06 11:00 PM	36,544
8/2/06 11:00 PM	40,831
8/4/06 2:19 AM	43,941
8/5/06 8:48 PM	49,328
8/6/06 10:13 PM	62,938
8/8/06 9:28 PM	74,587
8/10/06 2:00 AM	79,321
8/12/06 4:00 PM	82,754
8/13/06 2:00 AM	83,288
8/14/06 2:00 AM	89,509
8/15/06 2:00 AM	95,122
8/16/06 2:00 AM	99,388
8/17/06 2:00 AM	103,399
8/18/06 2:00 AM	109,441
8/19/06 2:00 AM	114,566
8/20/06 2:00 AM	119,640
8/21/06 2:00 AM	124,807

Burn Date	Max Temp (F)	Min RH (%)	Avg Wind (mph)	Avg Wind Dir (°)	Max Gust (mph)	Wind Direction	Haines Index
7/13/06	66	21	1	187	15	S	
7/14/06	69	31	2	221	15	SW	
7/15/06	72	22	1	194	14	S	
7/16/06	74	15	2	220	11	SW	
7/17/06	77	16	3	229	16	SW	
7/18/06	82	14	1	241	13	SW	
7/19/06	75	20	3	228	16	SW	
7/20/06	73	28	3	167	15	S	
7/21/06	82	16	2	181	12	S	
7/22/06	89	21	2	143	12	SE	
7/23/06	95	15	1	203	10		
7/24/06	92	14	4	252	12	W	
7/25/06	81	19	6	316	18	NW	
7/26/06	88	11	5	273	20	W	2 Very Low
7/27/06	91	12	3	267	19	W	3 Very Low
7/28/06	71	23	6	329	16	NW	5 Moderate
7/29/06	82	18	2	165	16	S	4-5 Moderate
7/30/06	65	25	2	244	14	SW	3 Very Low
7/31/06	61	24	2	225	15	SW	3 Very Low
8/1/06	70	21	1	233	13	SW	3 Very Low
8/2/06	74	16	5	263	20	W	3 Very Low
8/4/06	77	17	1.3	188	12	S	4 Low
8/5/06	76	20	2.7	210	14	SW	4 Low
8/6/06	81	17	2	194	13	S	4 Low

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Lynx and Fire

DESCRIPTION & LEGAL STATUS

Figure 1. Lynx

The lynx (*Lynx canadensis*) is the rarest of the three native felids that occur in Washington State, which also include bobcats (*Lynx rufus*) and mountain lions (*Felis concolor*). Lynx are slightly larger than bobcats and smaller than cougars, with adults averaging 8.5-10.0 kg and males being slightly larger and heavier than females. The lynx's longer legs, larger paws, fuller facial ruff, longer ear tufts (Figure 1), and the entirely black tip of its tail distinguish it from bobcats. Lynx were prized as a fur-bearing species but concern about decreasing population size led to protection from trapping or hunting in Washington in 1991. The species was listed as a state threatened species in 1993 and a recovery plan was developed for the lynx in Washington (Stinson 2001); lynx were federally listed as a threatened species in 2000 (USFWS 2000). A federal status review for the lynx is currently being conducted by the U.S. Fish and Wildlife Service (USFWS 2015).

DISTRIBUTION

Fire Continuum Conference

May 21-24, Missoula, MT

Linking Wildfire Burn Mosaic and Lynx Habitat Modeling

Presentation Overview

Part One

Interactions between Canada Lynx and Fire in the Okanogan LMZ

- Overview of the Study Area
- General overview of Canada lynx ecology
- Fire influences on Canada lynx resource selection

Part Two

Implications of Fire on the Canada Lynx Population in the Okanogan LMZ

- Population modeling and Canada lynx resource selection
  - fire influences at two time periods

Part Three

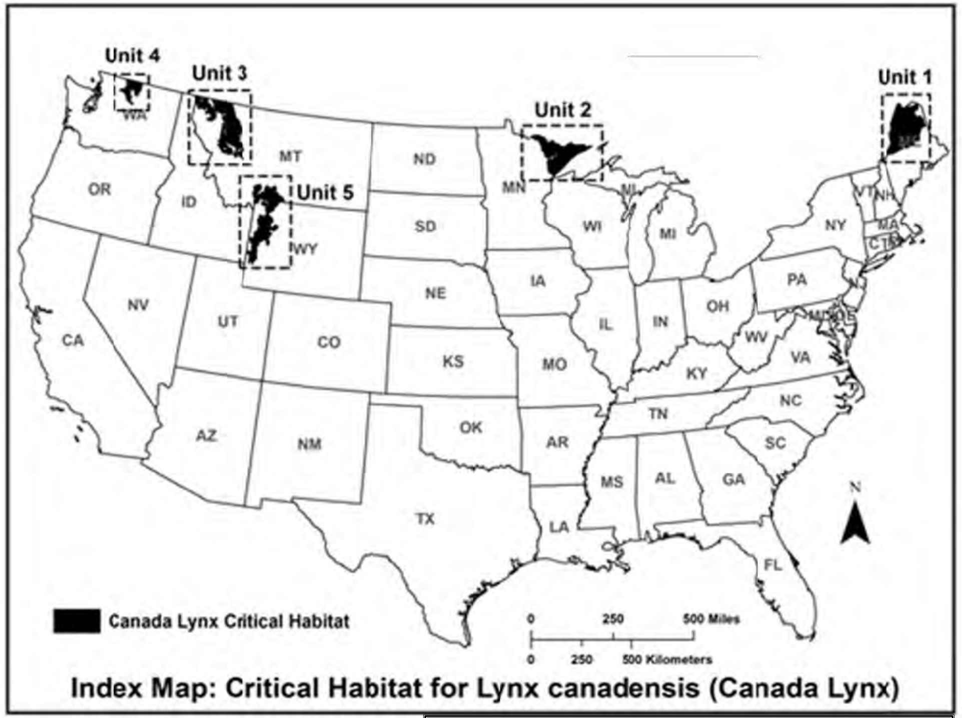
Informing Habitat/Fire Management Options in Lynx Habitat

- Linking population and fire modeling to inform management options

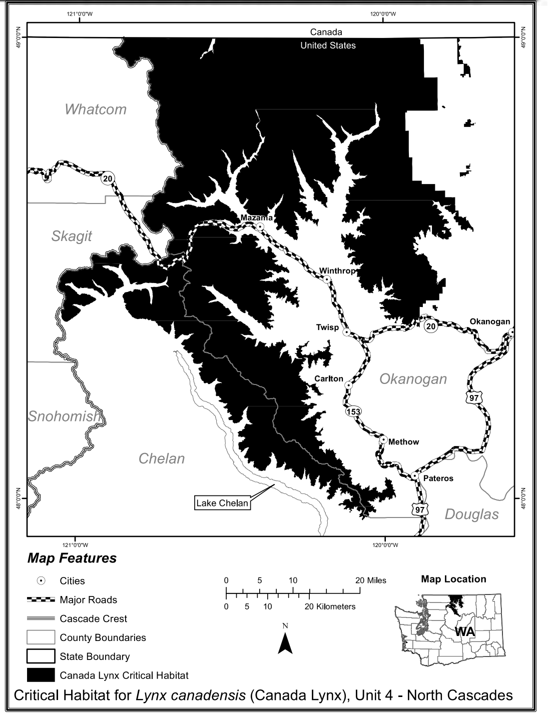
Part One:
Interactions between Canada lynx and fire

Canada Lynx Recovery in the US

- Federally Listed as Threatened in 2000
- Lynx Conservation Assessment and Strategy 2013
- Critical Habitat Designation 2014
- Proposed for Delisting 2018
  - "a scientific review of Canada lynx in the contiguous US showed they may no longer warrant protection"



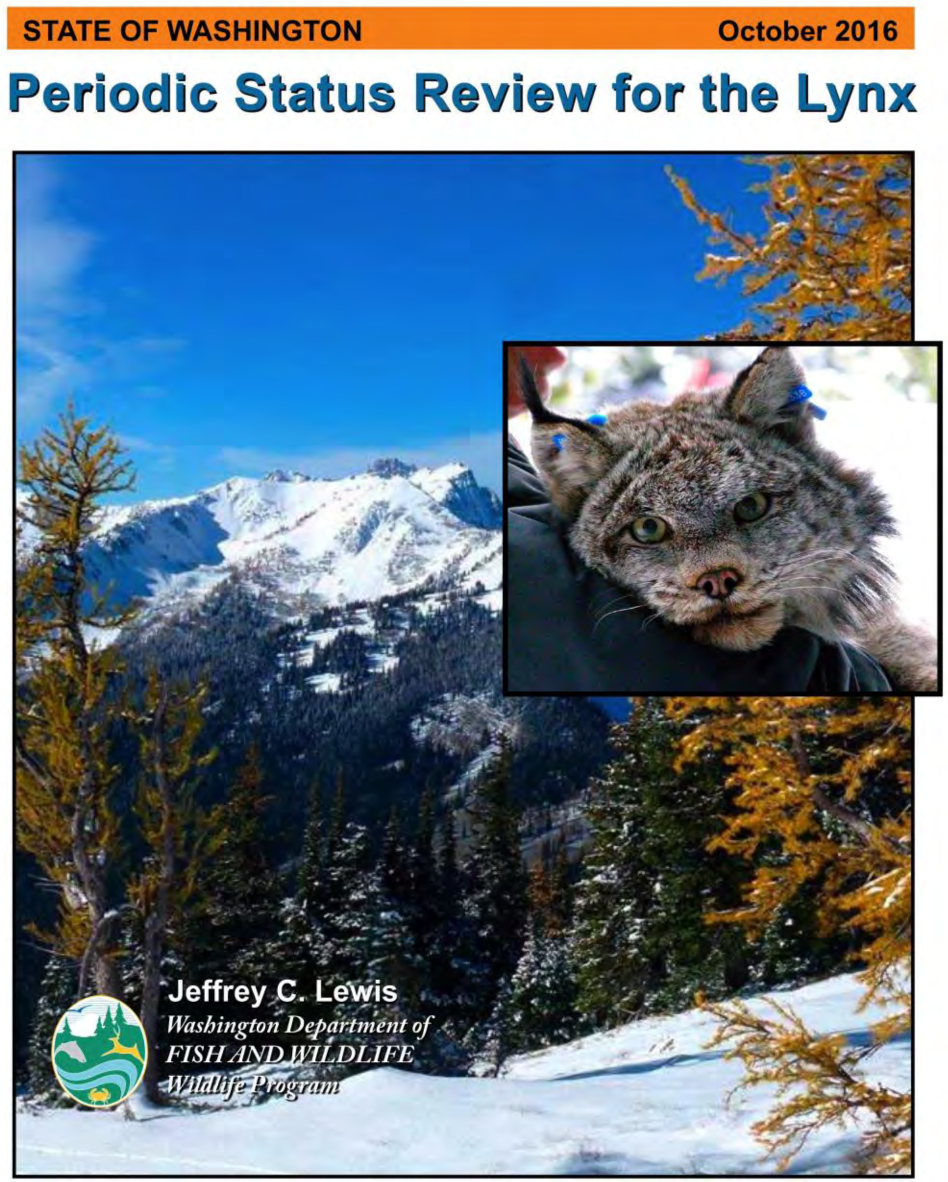
Index Map: Critical Habitat for Lynx canadensis (Canada Lynx)



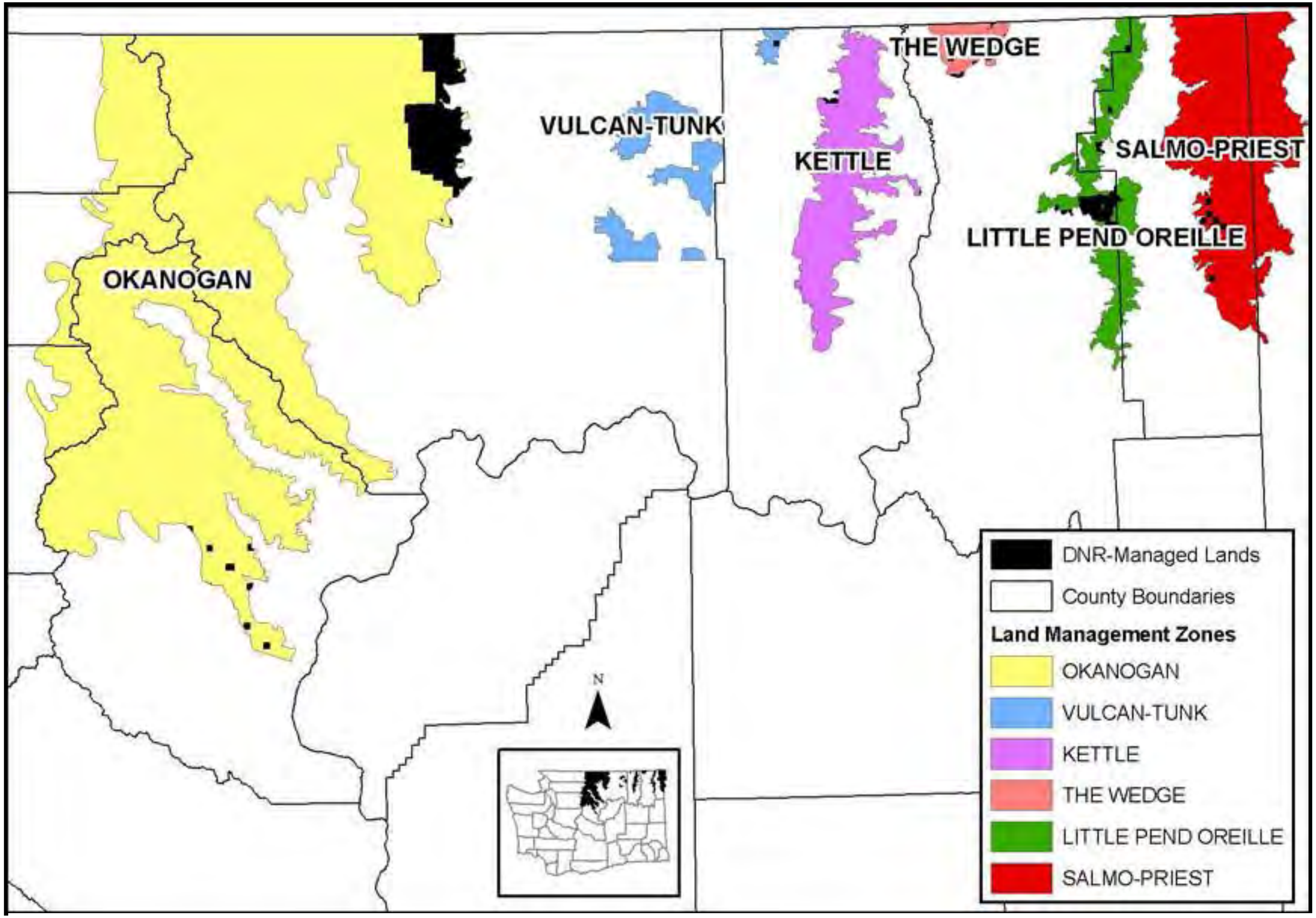
Critical Habitat for *Lynx canadensis* (Canada Lynx), Unit 4 - North Cascades

Canada Lynx in Washington

- Population Size
  - No good population estimates
  - 50-80 as a ballpark
- Factors Threatening Lynx
  - Loss and fragmentation of habitat as a result of wildfires
  - Direct (more fires) and indirect (changes to snowpack) effects of climate change
  - Small population size
  - Possible lack of immigration from British Columbia
- Up-Listing from Threatened to Endangered
  - Range contraction
  - Substantial habitat loss
  - Ongoing and anticipated threats



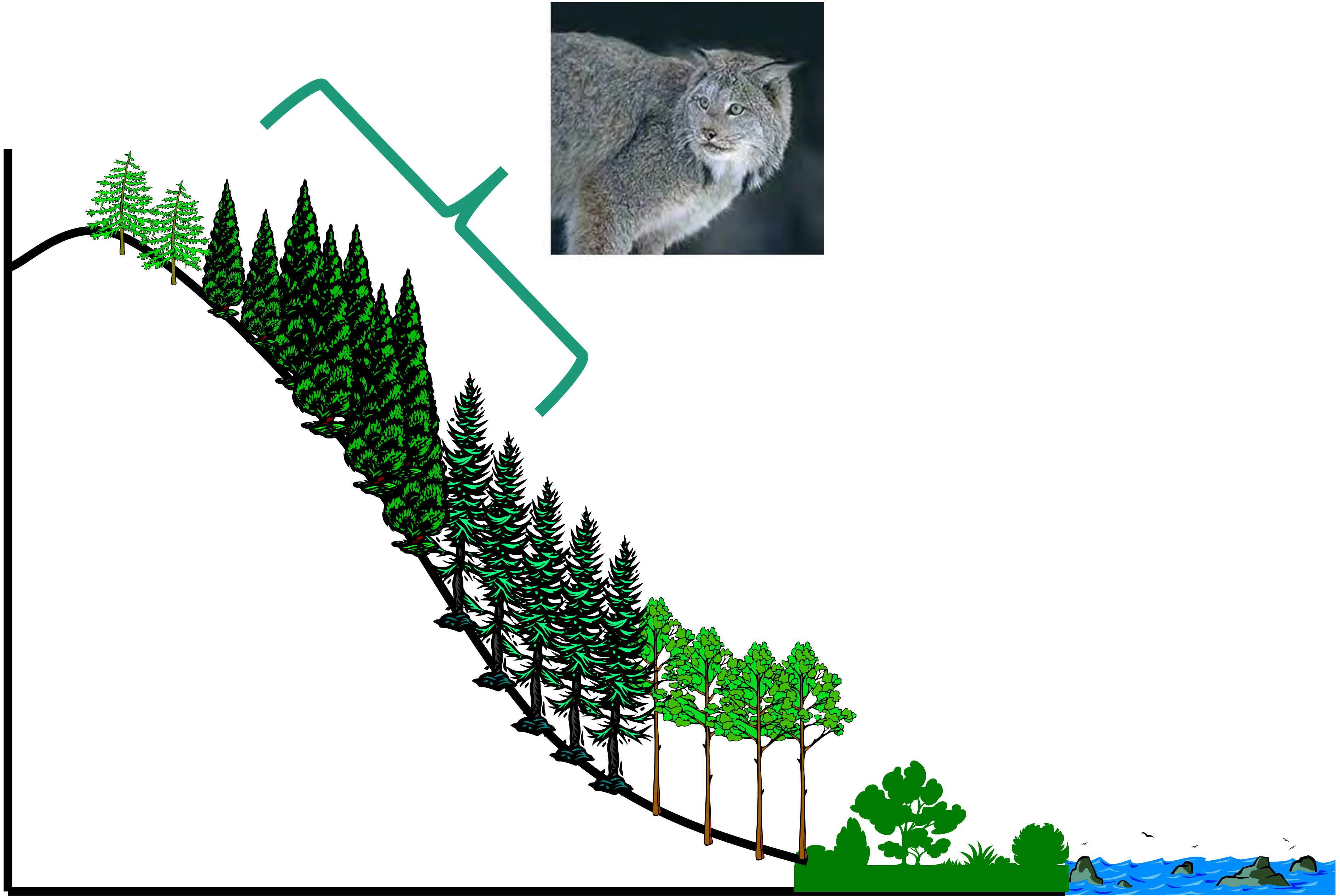
Lynx Management Zones



Research in the Okanogan LMZ

- Brittell, J.D., R.J. Sweeney, and G.M. Koehler. 1989. Native Cats of Washington. WDFW, Olympia, WA.
- Koehler, G.M. 1990. Population and habitat characteristics of lynx and snowshoe hares in north central Washington. Can. J. Zool. 72: 1518-1524.
- Maletzke, B.T., G.M. Koehler, R.B. Wielgus, K.B. Aubry, and M.A. Evans. 2008. Habitat conditions associated with lynx hunting behavior during winter in northern Washington. JWM 72: 1473-1478.
- Koehler, G.M., B.T. Maletzke, J.A. von Kienast, K.B. Aubry, R.B. Wielgus, and R.H. Naney. 2008. Habitat fragmentation and persistence of lynx populations in Washington State. JWM 72: 1518-1524.
- Vanbianchi, C.M., M.A. Murphy, and K.E. Hodges. 2017. Canada lynx use of burned areas: conservation implications of changing fire regimes. Ecology and Evolution 1-13.
- Vanbianchi, C., W.L. Gaines, M.A. Murphy, J. Pither, and K.E. Hodges. 2017. Habitat selection by Canada lynx: making do in heavily fragmented landscapes. Biodivers Conserv 26: 3343-3361

High-Mixed Severity Fire



Lynx-Fire-Hares

- Lynx show limited use recent moderate-high severity burned areas.
- Use "fire skips" that occur interior of the fire.
- Some studies show hare/lynx use 0-2 decades following fire
- 2-4 decades following fire provide high quality hare/lynx habitat.
- Mid-successional with high canopy closure and limited understory not so good hare/lynx habitat
- Old forests with canopy gaps provide understory cover and downed logs used as habitat for hare/lynx, including denning (not limited to old forests).
- Historically, fire of various ages, provided for a mix of forest ages classes and habitat components for lynx/hares across sub-boreal forest landscapes.

Natural disturbance processes that create early successional stages exploited by snowshoe hares include fire, insect infestations, wind throw, and disease outbreaks (Plate 2.15; Kilgore and Heinselman 1990, Veblen et al. 1998, Agee 2000). Both timber harvest and natural disturbance processes provide foraging habitat for lynx when the resulting stem densities and stand structure meet the habitat needs of snowshoe hare (Plate 2.16; Keith and Surrendi 1971; Fox 1978; Conroy et al. 1979; Wolff 1980; Parker et al. 1983; Litvaitis et al. 1985; Bailey et al. 1986; Monthey 1986; Koehler 1990*a, b*).

Landscapes containing a mix of forest age classes are more likely to provide lynx foraging habitat throughout the year (Poole et al. 1996, Griffin and Mills 2004, Squires et al. 2010). In winter, lynx do not appear to hunt in openings, where lack of cover limits habitat for snowshoe hares (Mowat et al. 2000, Maletzke et al. 2008, Squires et al. 2010). Areas with recent timber harvest and areas recently burned can contribute herbaceous summer foods for snowshoe hares, and woody winter browse will develop on older sites (Fox 1978). Multi-story stands may provide a greater availability of

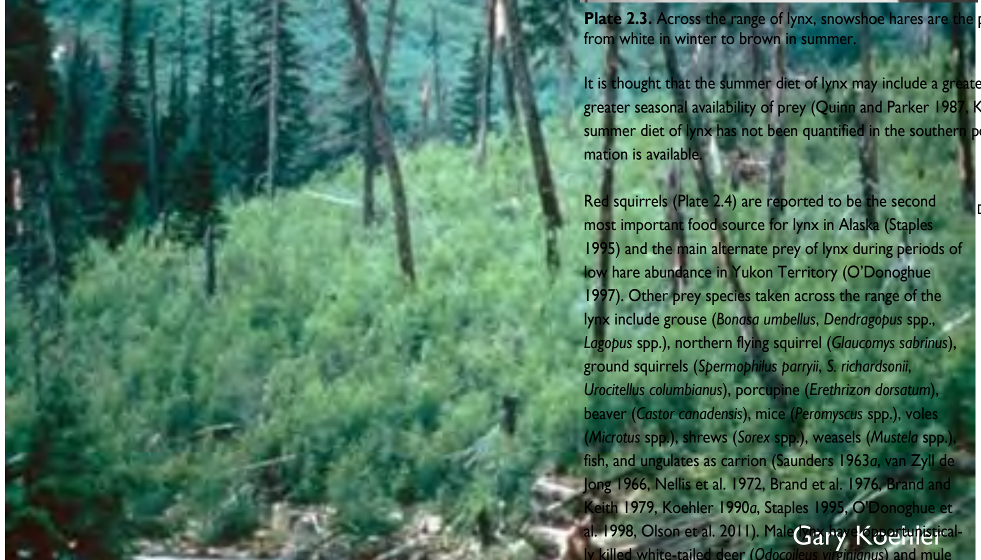
Lynx diet

Snowshoe hares (Plate 2.3) are the primary prey of lynx throughout their range (Mowat et al. 2000).

Ben Maletzke

Plate 2.3. Across the range of lynx, snowshoe hares are the primary prey. The color of the fur changes season from white in winter to brown in summer.

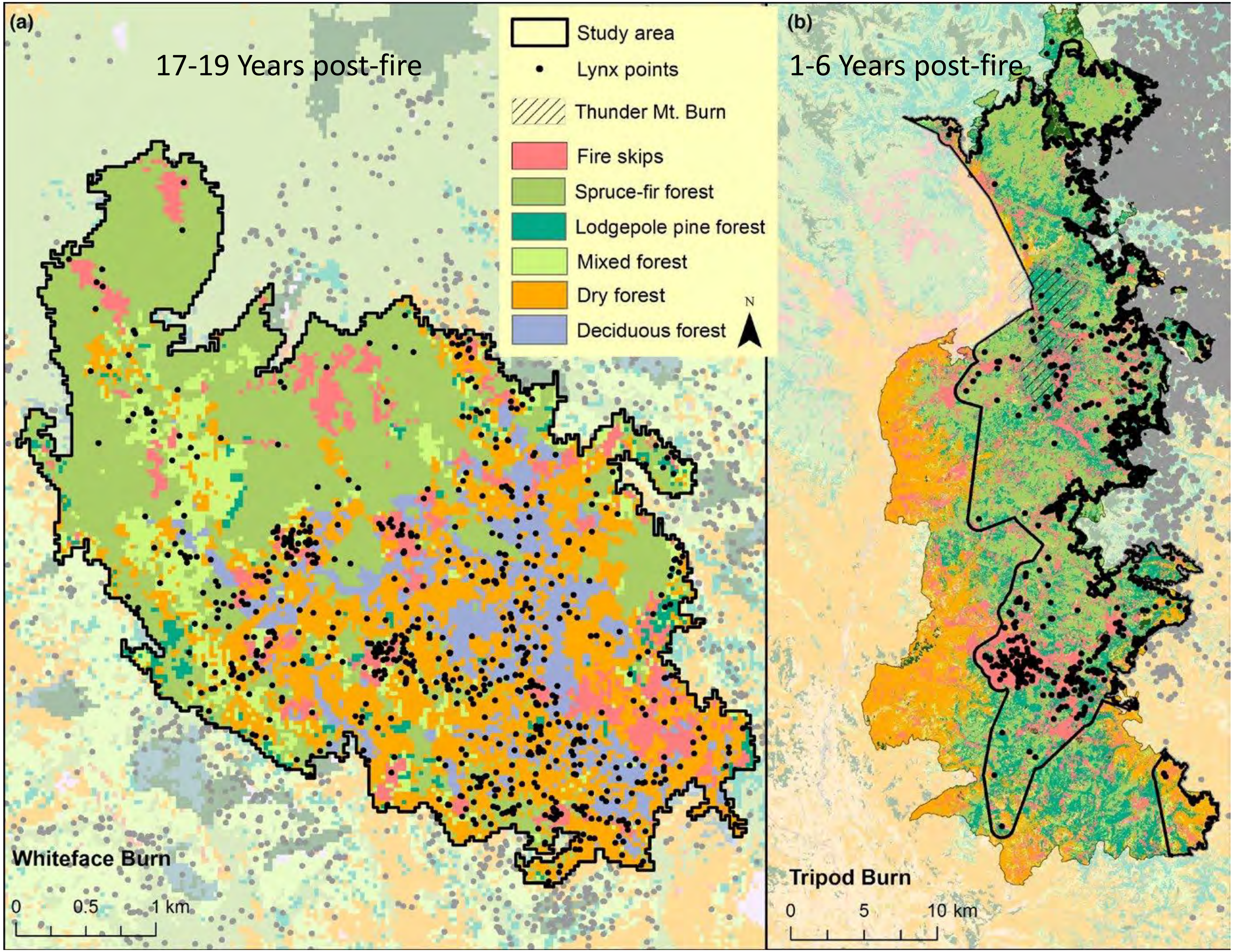
It is thought that the summer diet of lynx may include a greater diversity of prey species than in winter, due to t greater seasonal availability of prey (Quinn and Parker 1987, Koehler and Aubry 1994, Mowat et al. 2000). The summer diet of lynx has not been quantified in the southern portion of its range, although some anecdotal information is available.



Red squirrels (Plate 2.4) are reported to be the second most important food source for lynx in Alaska (Staples 1995) and the main alternate prey of lynx during periods of low hare abundance in Yukon Territory (O'Donoghue 1997). Other prey species taken across the range of the lynx include grouse (*Bonasa umbellus, Dendragopus* spp., *Lagopus* spp.), northern flying squirrel (*Glaucomys sabrinus*), ground squirrels (*Spermophilus parryii, S. richardsonii, Urocitellus columbianus*), porcupine (*Erethrizon dorsatum*), beaver (*Castor canadensis*), mice (*Peromyscus* spp.), voles (*Microtus* spp.), shrews (*Sorex* spp.), weasels (*Mustela* spp.), fish, and ungulates as carrion (Saunders 1963*a*, van Zyll de Jong 1966, Nellis et al. 1972, Brand et al. 1976, Brand and Keith 1979, Koehler 1990*a*, Staples 1995, O'Donoghue et al. 1998, Olson et al. 2011). Male lynx have opportunistically killed white-tailed deer (*Odocoileus virginianus*) and mule

Gary Koehler

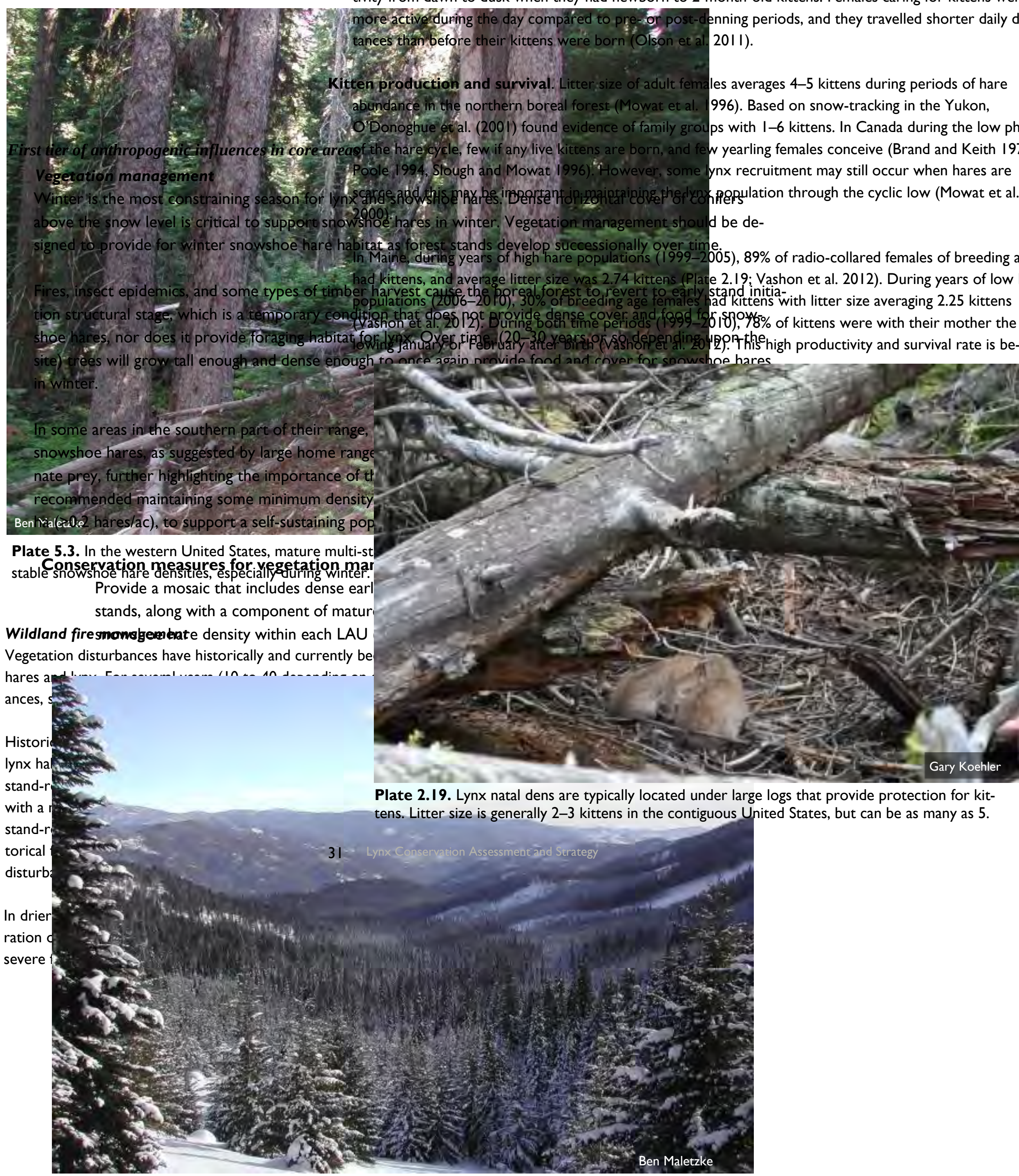
Donna Dewhurst/USFWS



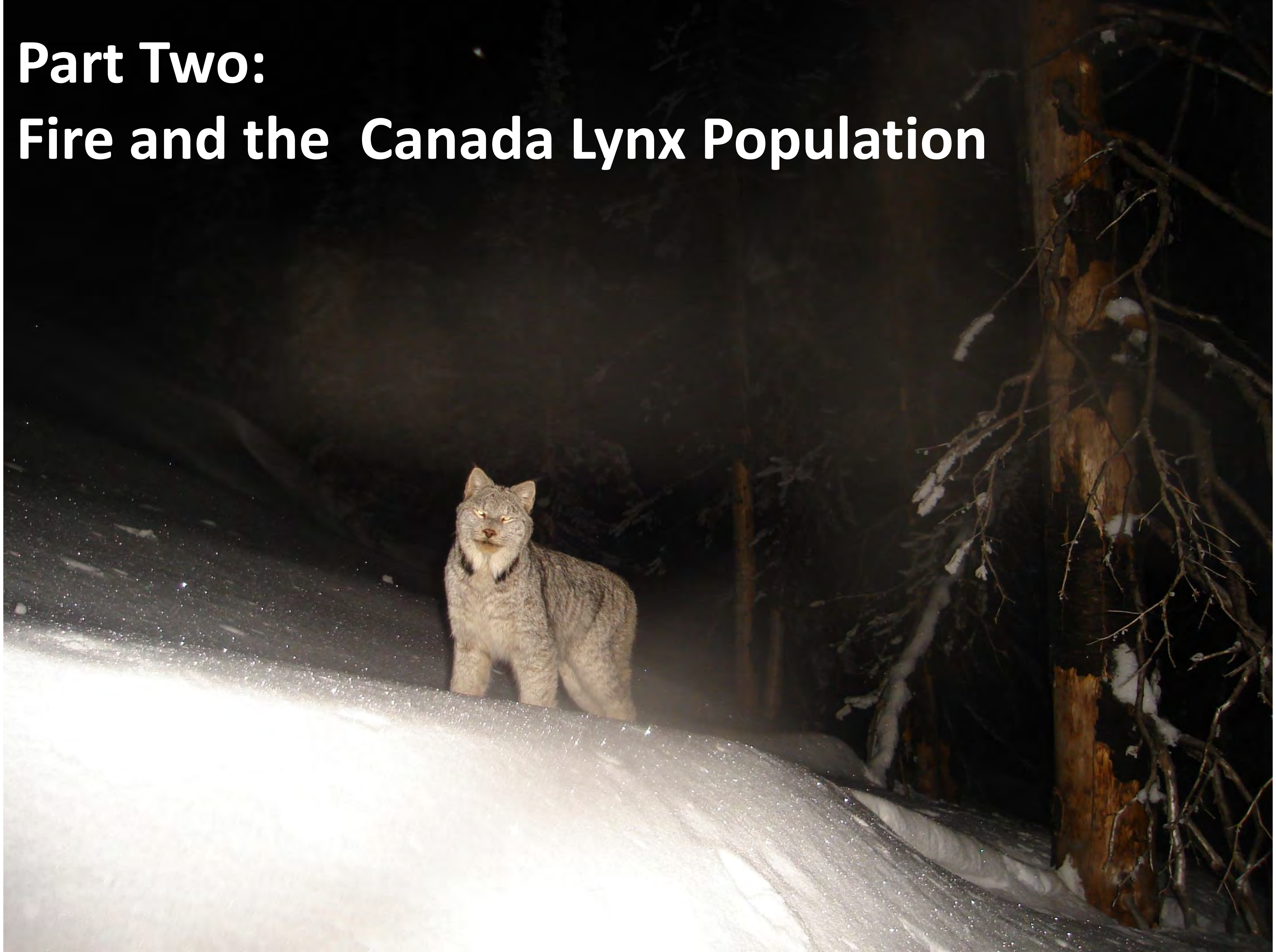
(a)
17-19 Years post-fire
Study area
Lynx points
Thunder Mt. Burn
Fire skips
Spruce-fir forest
Lodgepole pine forest
Mixed forest
Dry forest
Deciduous forest
N
Whiteface Burn
0
0.5
1 km
(b)
1-6 Years post-fire
Tripod Burn
0
5
10 km

Habitat Components

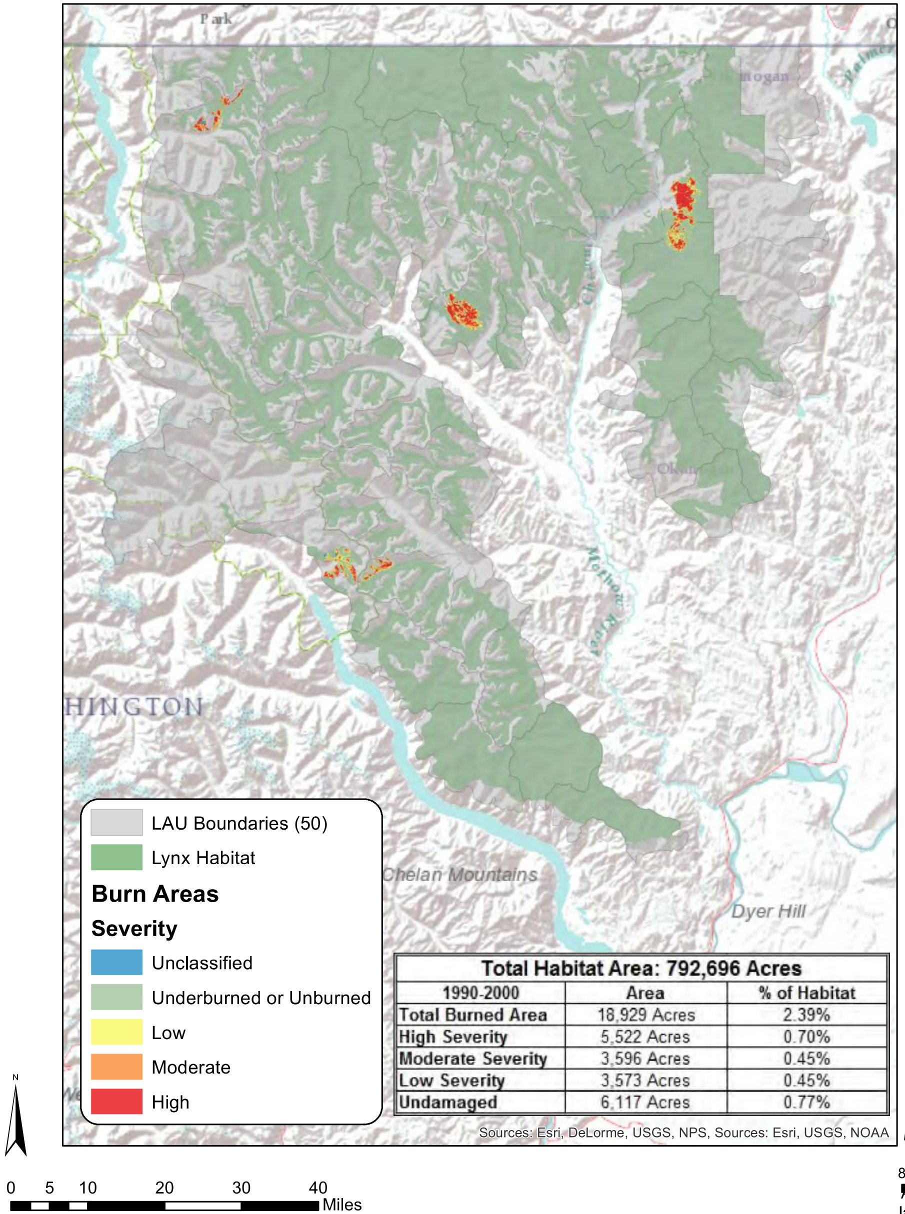
- Foraging Habitat
  - Areas that support snowshoe hares and has the vegetation structure suitable lynx capture of prey. Occur in early successional stands 10-20 years following disturbance and in older forest with substantial understory of shrub and young conifer trees. CWD, especially in early successional stages, provides important cover for prey.
- Denning Habitat
  - Includes large amounts of CWD. May occur in mature and old forests or areas with jack-strawed trees. Must be located within daily travel distance (5-10km) of foraging habitat.
- Other
  - Includes areas that lynx may use for travel or low quality foraging, these areas may provide for a variety of functions but not high quality of any one function. These typically include mid-successional forests.



Part Two:
Fire and the Canada Lynx Population



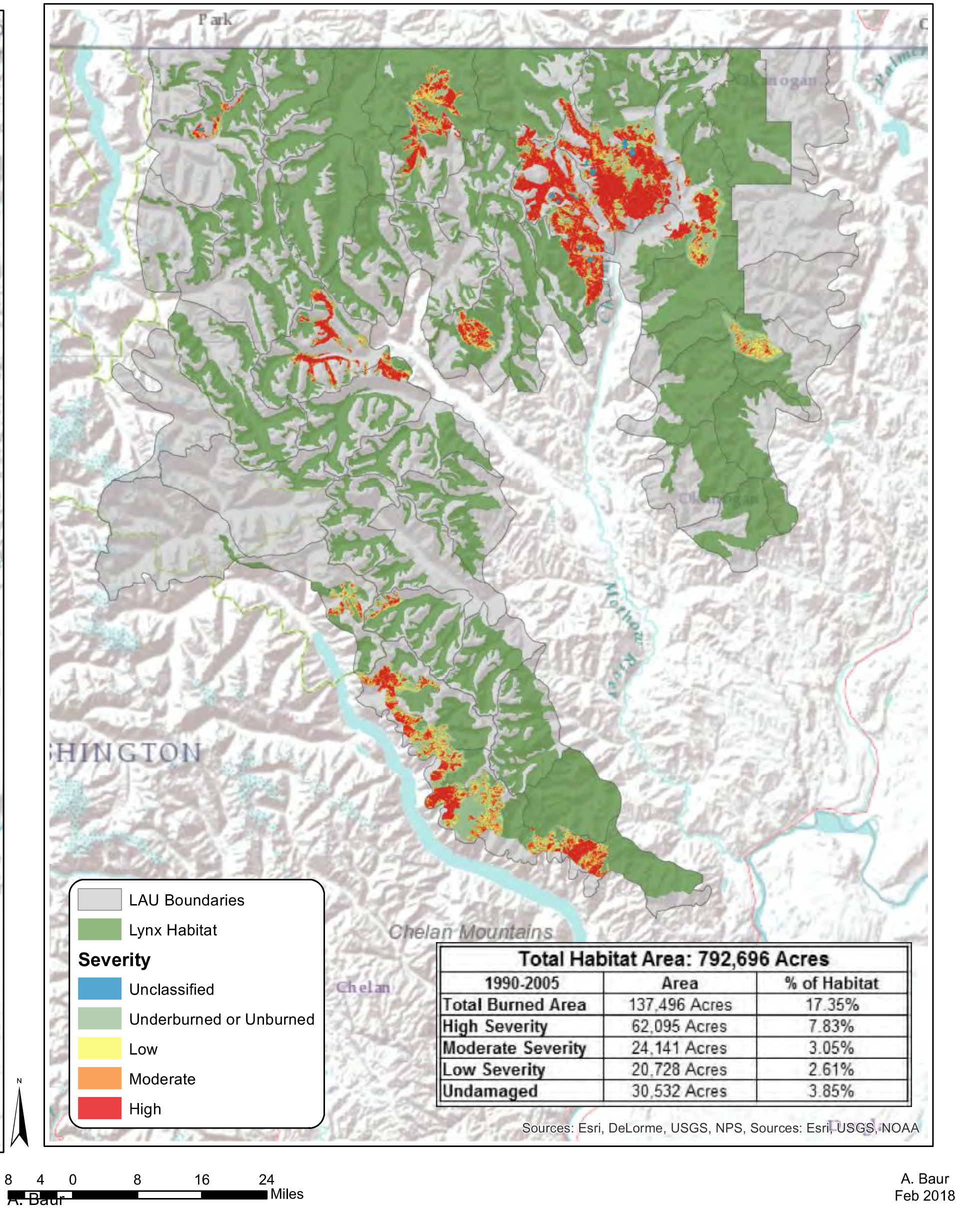
Lynx Habitat Burn Severity 1990-2000



Total Habitat Area: 792,696 Acres		
1990-2000	Area	% of Habitat
Total Burned Area	18,929 Acres	2.39%
High Severity	5,522 Acres	0.70%
Moderate Severity	3,596 Acres	0.45%
Low Severity	3,573 Acres	0.45%
Undamaged	6,117 Acres	0.77%

A. Baur
Jan 2018

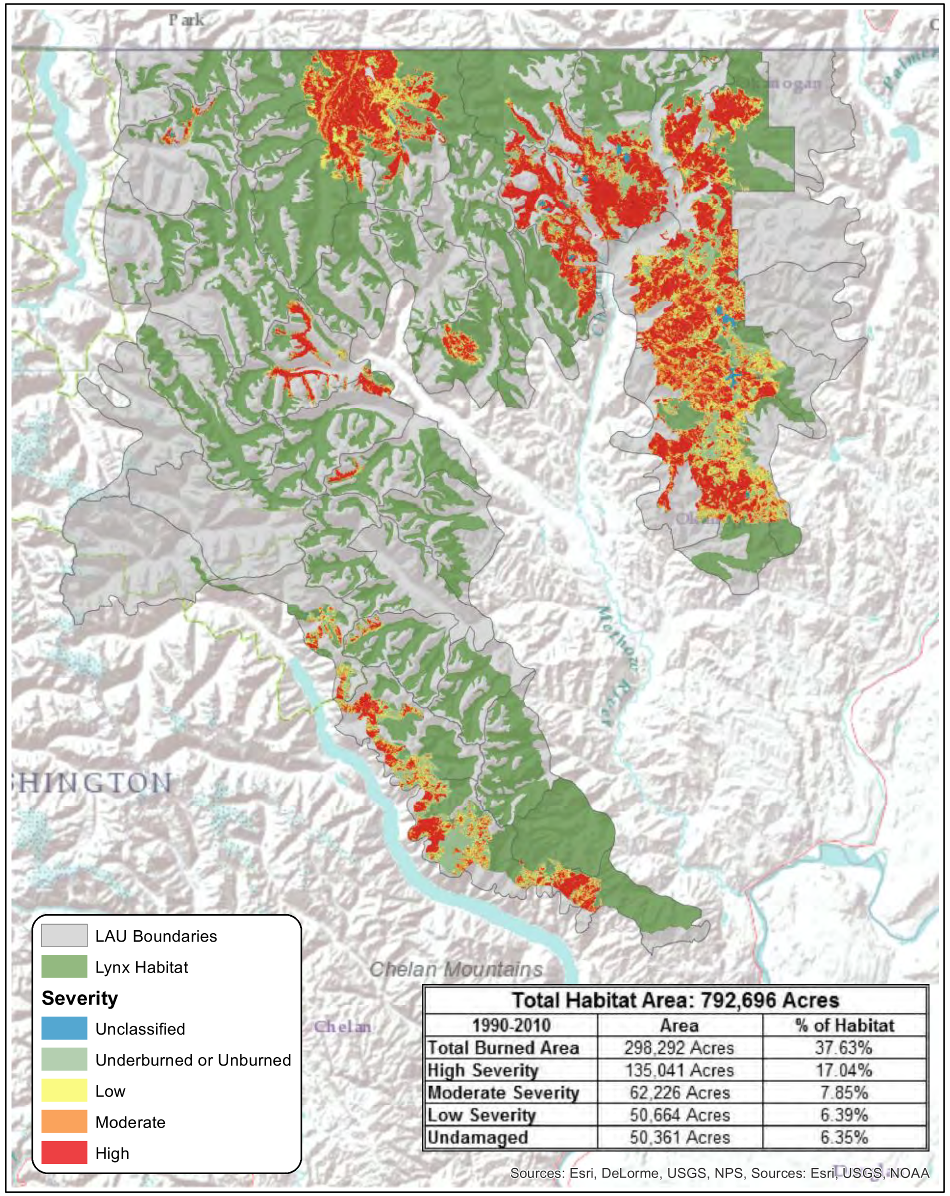
Lynx Habitat Burned 1990-2005



Total Habitat Area: 792,696 Acres		
1990-2005	Area	% of Habitat
Total Burned Area	137,496 Acres	17.35%
High Severity	62,095 Acres	7.83%
Moderate Severity	24,141 Acres	3.05%
Low Severity	20,728 Acres	2.61%
Undamaged	30,532 Acres	3.85%

A. Baur
Feb 2018

Lynx Habitat Burned 1990-2010



Total Habitat Area: 792,696 Acres		
1990-2010	Area	% of Habitat
Total Burned Area	298,292 Acres	37.63%
High Severity	135,041 Acres	17.04%
Moderate Severity	62,226 Acres	7.85%
Low Severity	50,664 Acres	6.39%
Undamaged	50,361 Acres	6.35%

8 4 0 8 16 24 Miles

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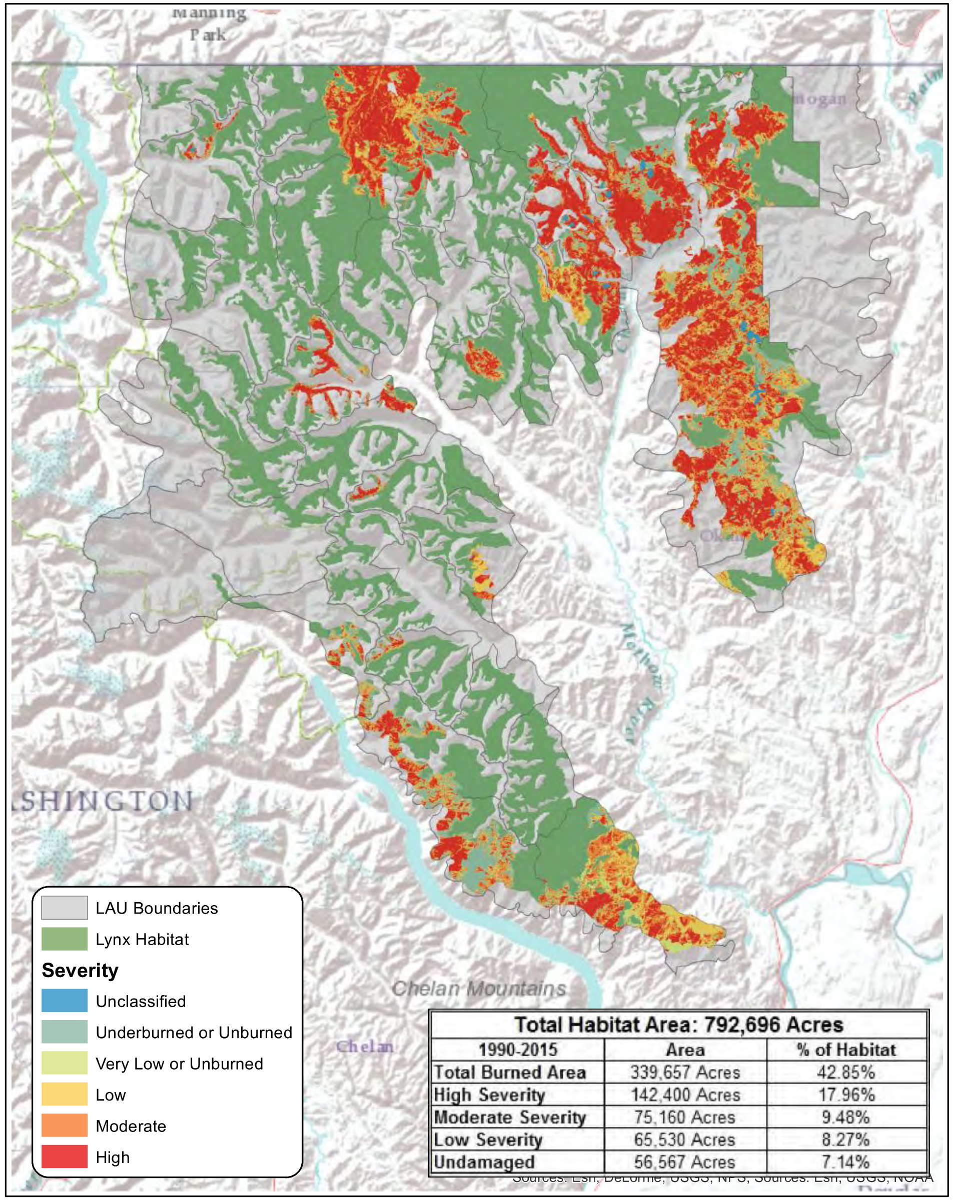
Feb 2018

Lynx Habitat Burned 1990-2015



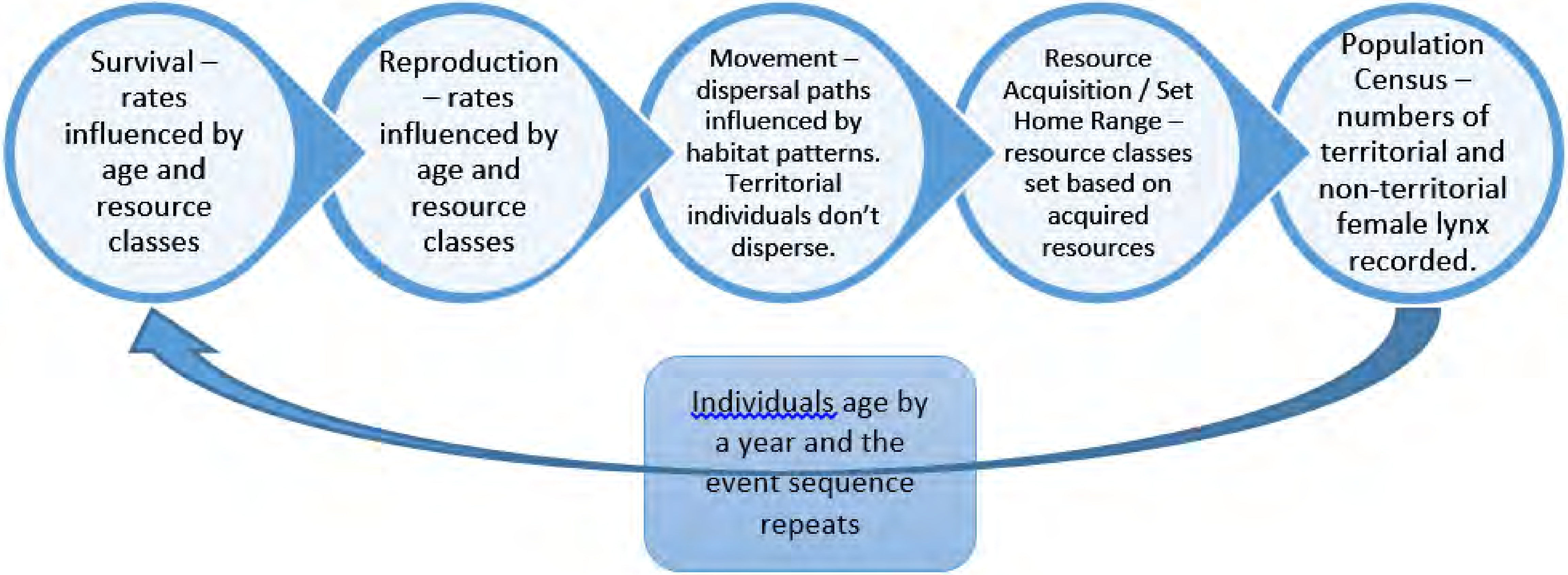
Total Habitat Area: 792,696 Acres		
1990-2015	Area	% of Habitat
Total Burned Area	339,657 Acres	42.85%
High Severity	142,400 Acres	17.96%
Moderate Severity	75,160 Acres	9.48%
Low Severity	65,530 Acres	8.27%
Undamaged	56,567 Acres	7.14%

8 4 0 8 16 24 Miles

A. Baur
Feb 2018

Figure 3. HexSim flowchart – HexSim is an individual-based population modeling framework that represents population function based on a series of annual life history events. Events in the lynx model included: 1) Survival, 2) Reproduction, 3) Movement, 4) Resource Acquisition / Home Range Establishment, and 5) Population Census. The process repeats as individuals age by a year.

Carrying Capacity Model - HexSim



Habitat Resources

HexSim uses a hexagonal grid to represent habitat conditions that influence individual movement, survival, and reproduction. The Okanogan and Kettle landscapes were represented as a grid of 16.2 ha (500m diameter)

HexSim Model

- **Spatially-Explicit, Individual Based**
  - Focused on females
- GPS telemetry data
  - 16 lynx
  - ≈14,000 locations
  - 2008-2013

Key Model Elements

Habitat Resources

Mixed-effects logistic regress

Classified habitat quality

Focal sum for 500m dia. Hex

Survival

Literature and expert panel

Reproduction

Local data, literature, expert panel

Movement

Local data, literature, expert panel

Home Range

39, 55, 72 km^2

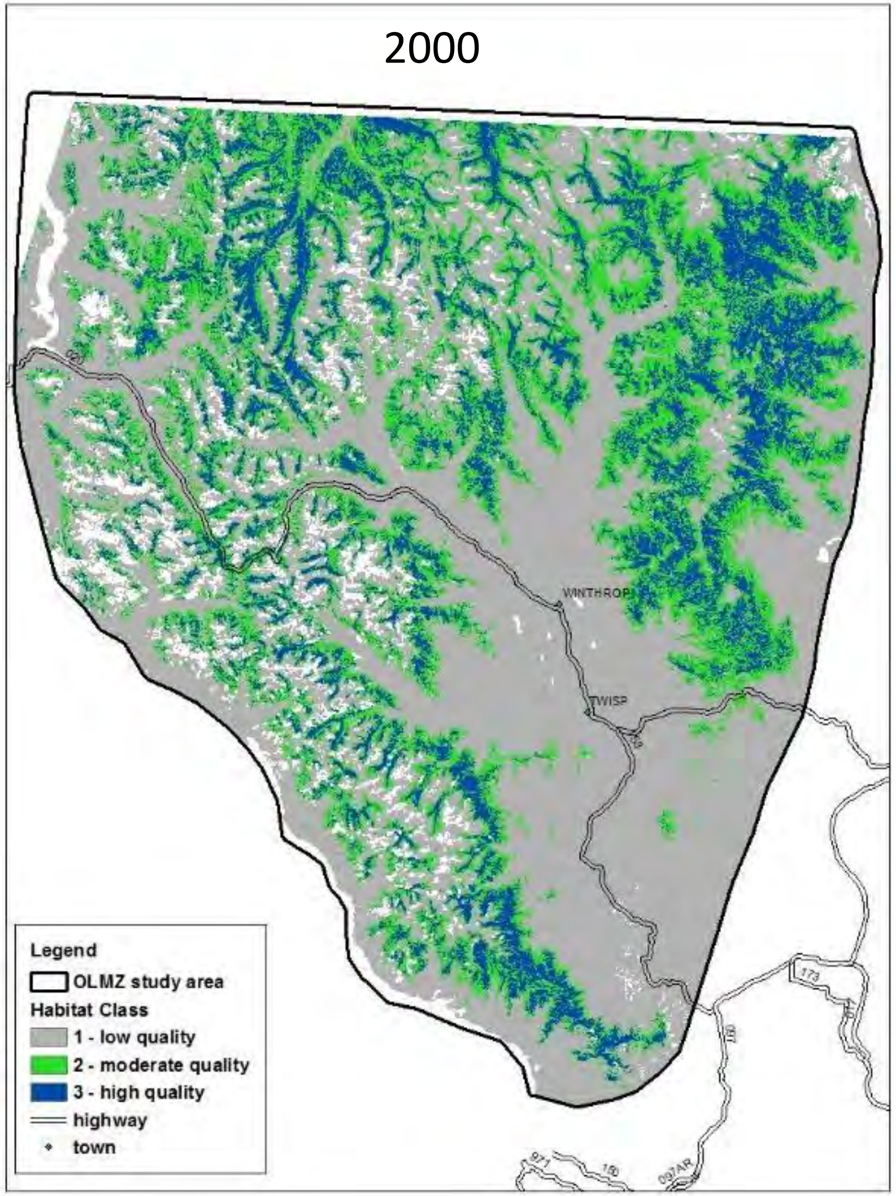
Territoriality

Local data (HR overlap)

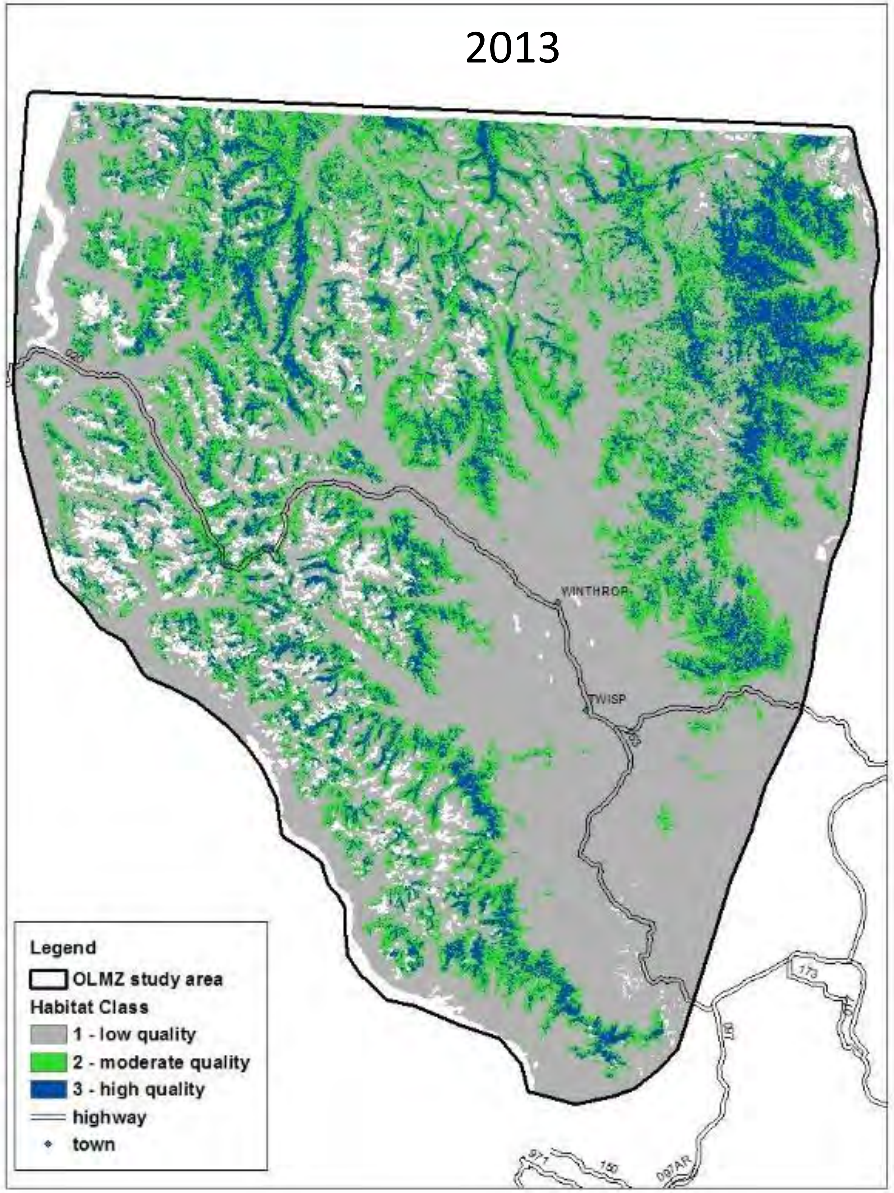
Carrying Capacity at Two Time Periods

Figure 4. Annual mixed effects resource selection function reclassified to relative habitat quality classes mapped within the Okanogan Lynx Management Zone. 4a) depicts the 2000 pre-fire condition, prior to substantial wildfire activity from 2000-2013, while 4b) depicts the 2013 post-fire condition.

4a) 2000 pre-fire



4b) 2013 post-fire



Canada Lynx Population Metrics for 2000 and 2013

Time Step	Number Females	90% Quantile Range	SE	Group Members	Floaters	Decrease in Population Size	Number Simulations 100 Years (N=25)	Mean Persistence (years)
2000	39	24-54	0.4	23	16		25	100
2013	21	0-36	0.4	12	9	-46%	4	90

Based on:

-75 year “burn in” period and 100 year simulation period

-25 simulations (based on preliminary analyses

-55km^2 home range

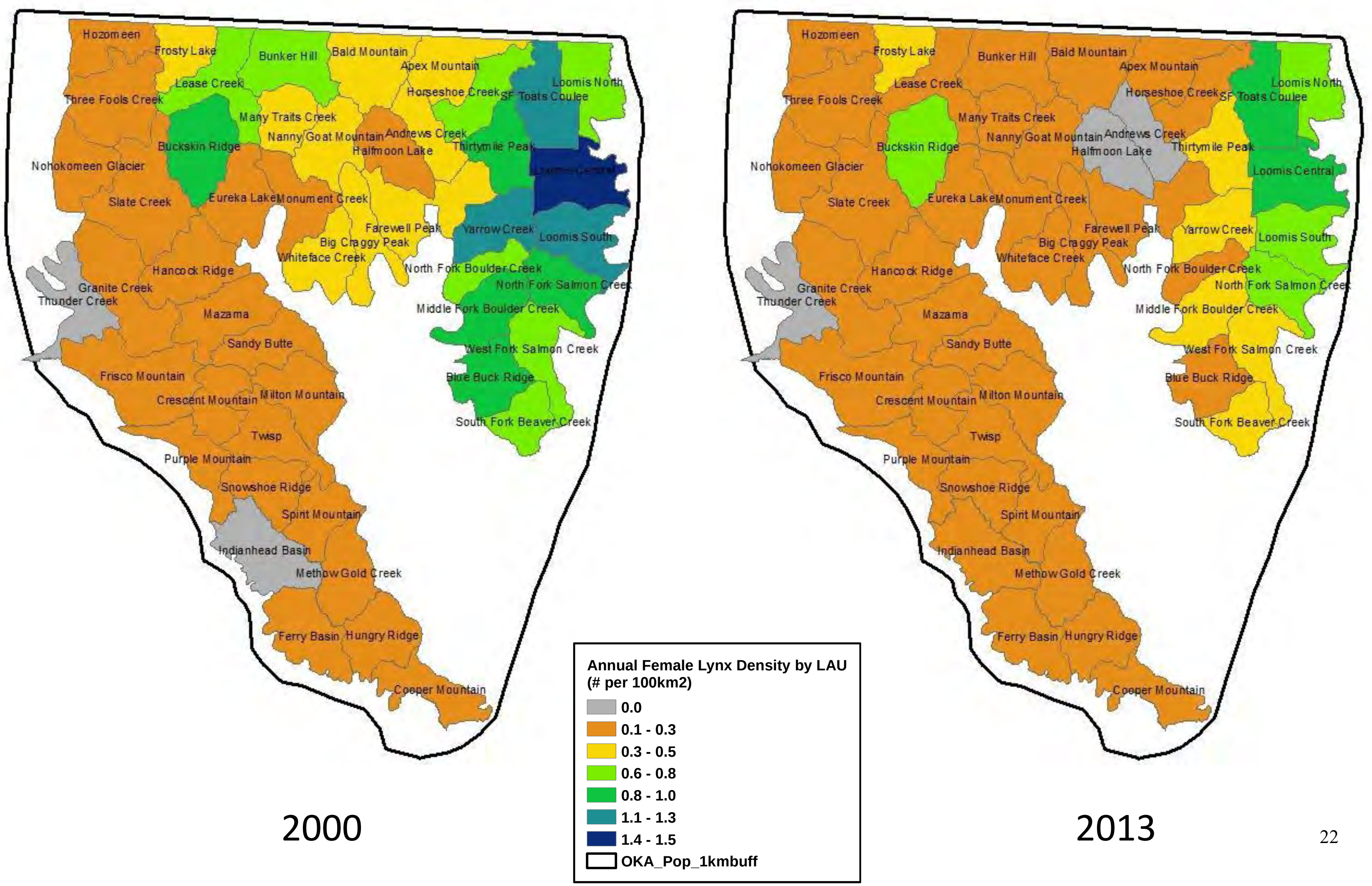
Spatial distribution of mean annual territorial female lynx density (no./100km^2)

Figure 7. continued

Home Range: 55km^2

Scenario: 55_pre-fire

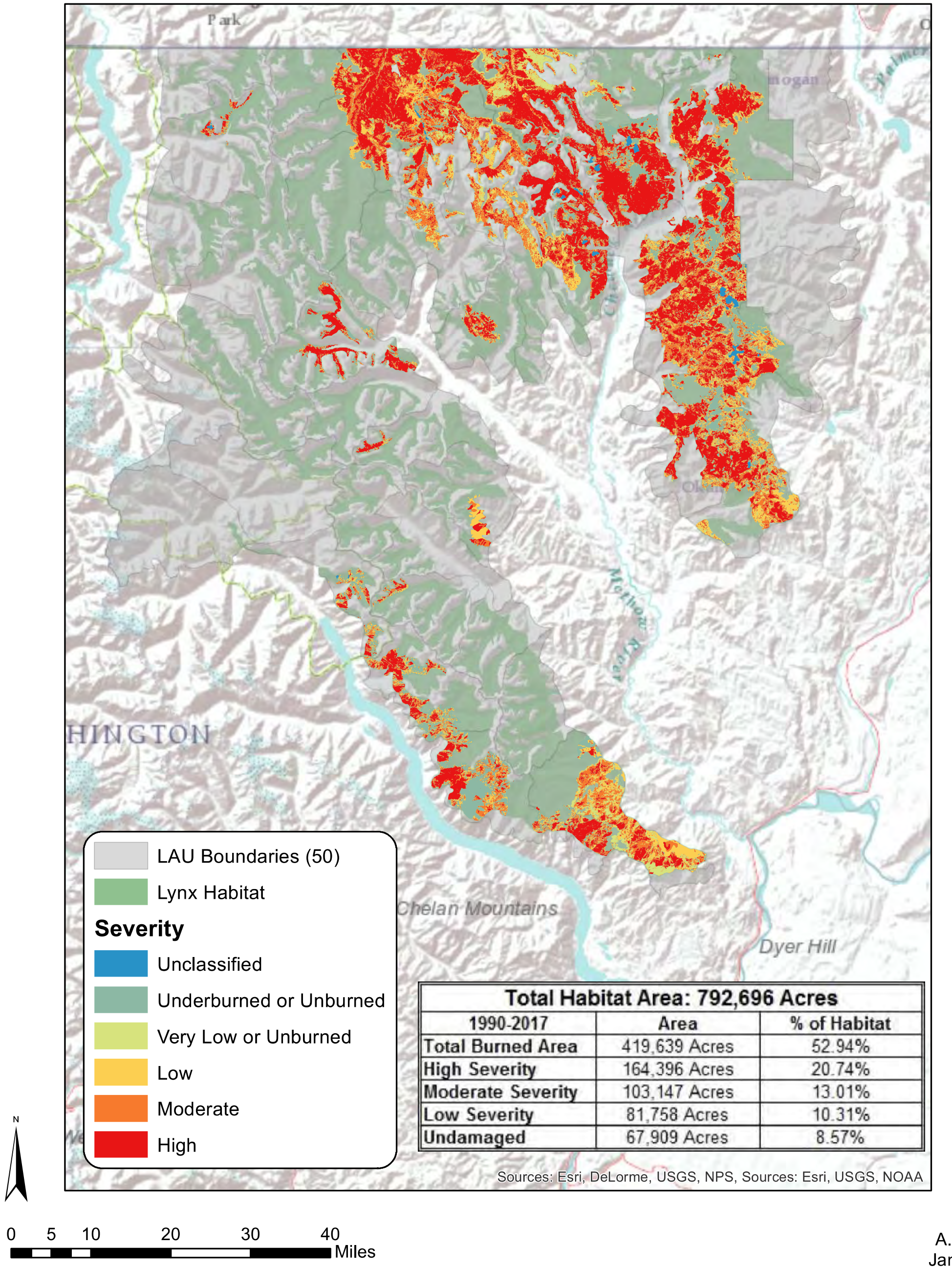
Scenario: 55_post-fire



2000

2013

Lynx Habitat Burn Severity 1990-2017

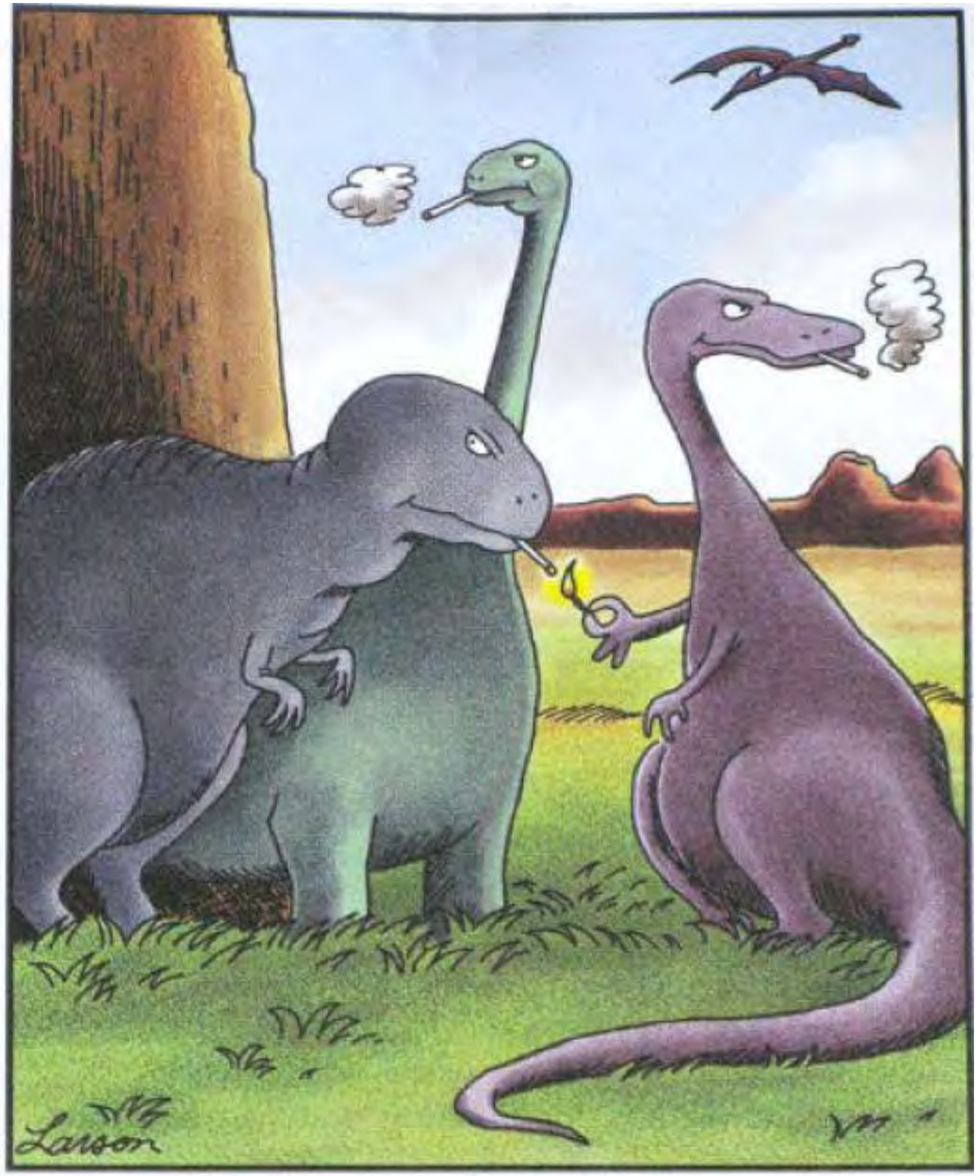


Total Habitat Area: 792,696 Acres		
1990-2017	Area	% of Habitat
Total Burned Area	419,639 Acres	52.94%
High Severity	164,396 Acres	20.74%
Moderate Severity	103,147 Acres	13.01%
Low Severity	81,758 Acres	10.31%
Undamaged	67,909 Acres	8.57%

A. Baur
Jan 2018

Summary

- Learned about how lynx use post-fire landscapes
- Fires reduced the capacity of the OLMZ to support lynx
- Additional fires have continued to occur
- Climate projections suggest 2x to 3x more fire in the future
- Managers need tools to assess the impacts of fire management options on lynx habitat and populations



The real reason dinosaurs became extinct

- BREAK -

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State and Transition Models

State 1A: Post-fire bare ground. Fuel model NB9. 0-14 yr.

State 2A: Stand initiation. Fuel model GS1. 15-49 yr.

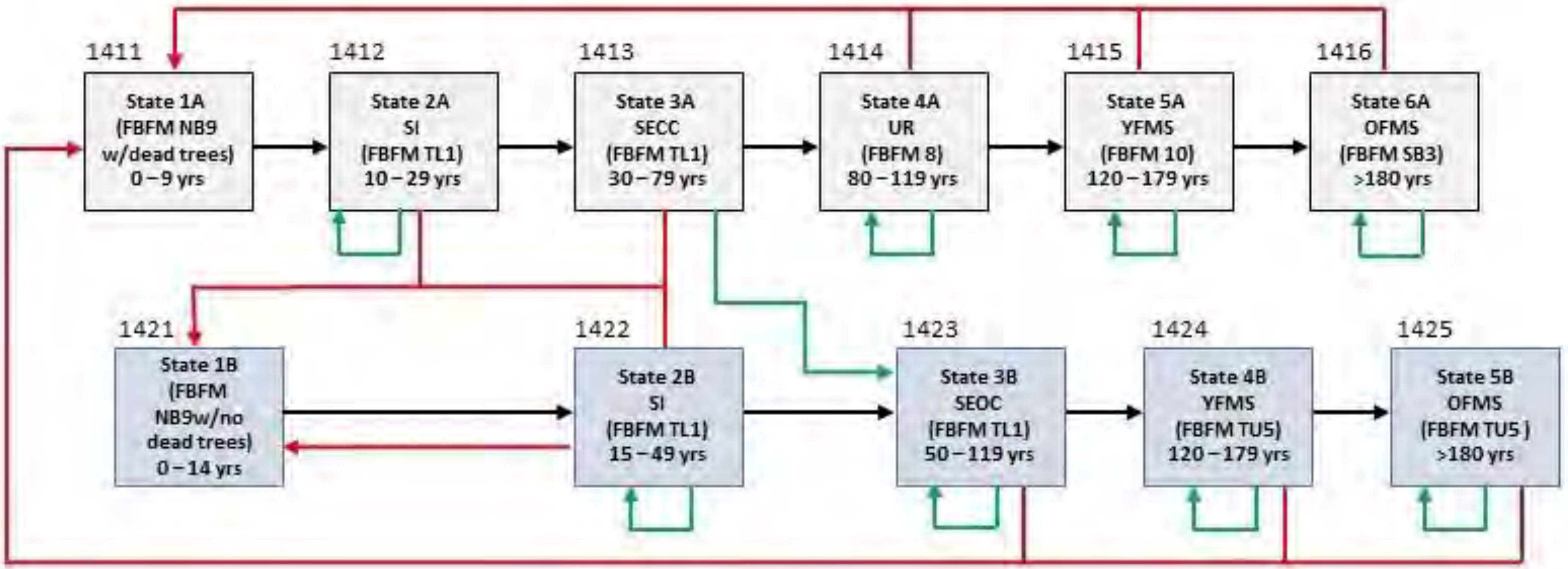
State 3A: Stem exclusion closed-canopy. Fuel model 2. 50-89 yr.

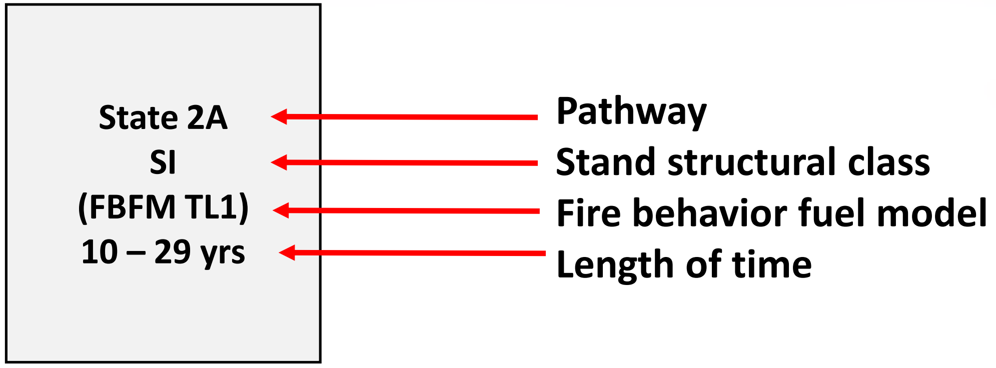
State 4A: Understory reinitiation. Fuel model TU5. 90-129 yr.

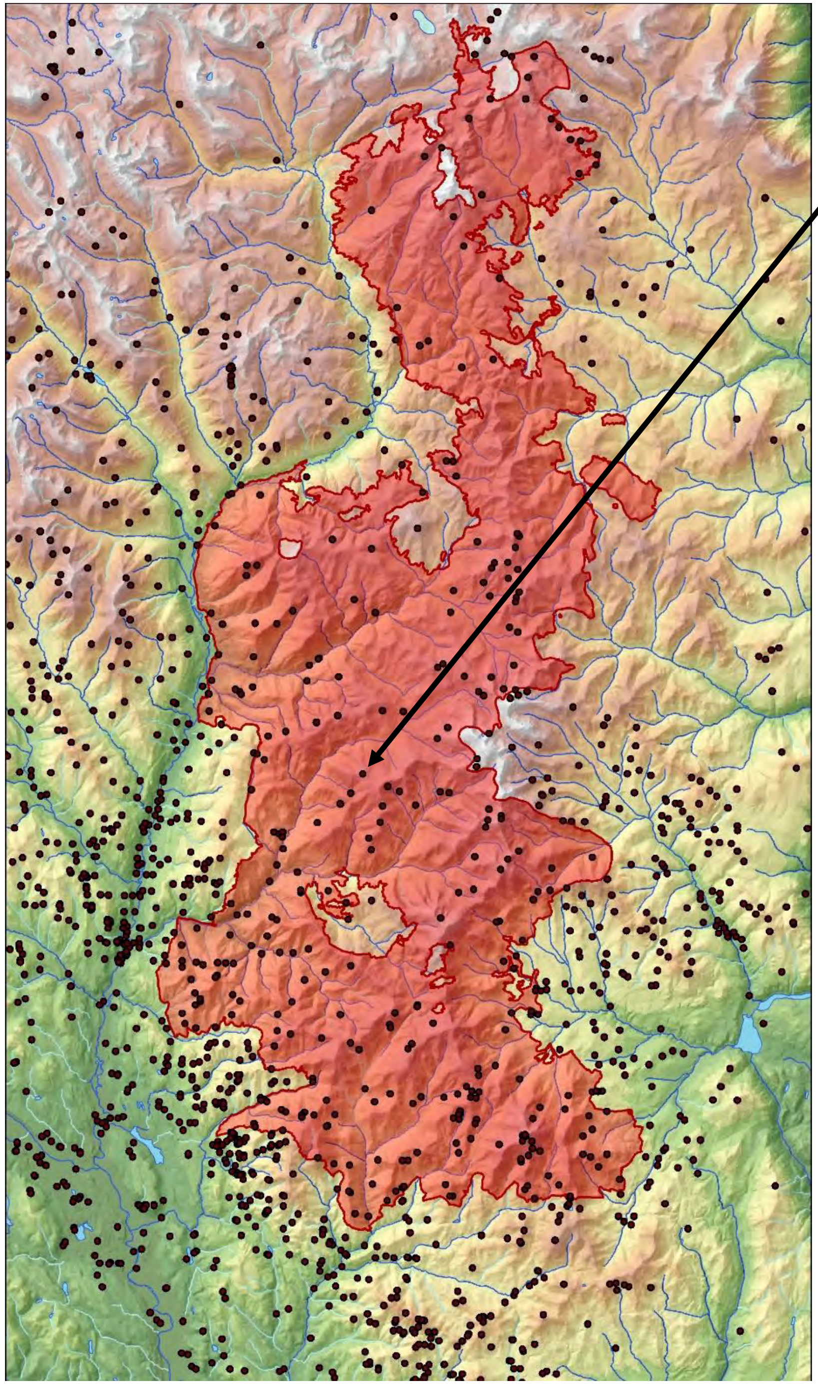
State 5A: Young forest multi-story. Fuel model TU5. 130-179 yr.

State 6A: Old forest multi-story. Fuel model TU5. ≥ 180 yr.

State and Transition Model Tripod Cold Moist Conifer







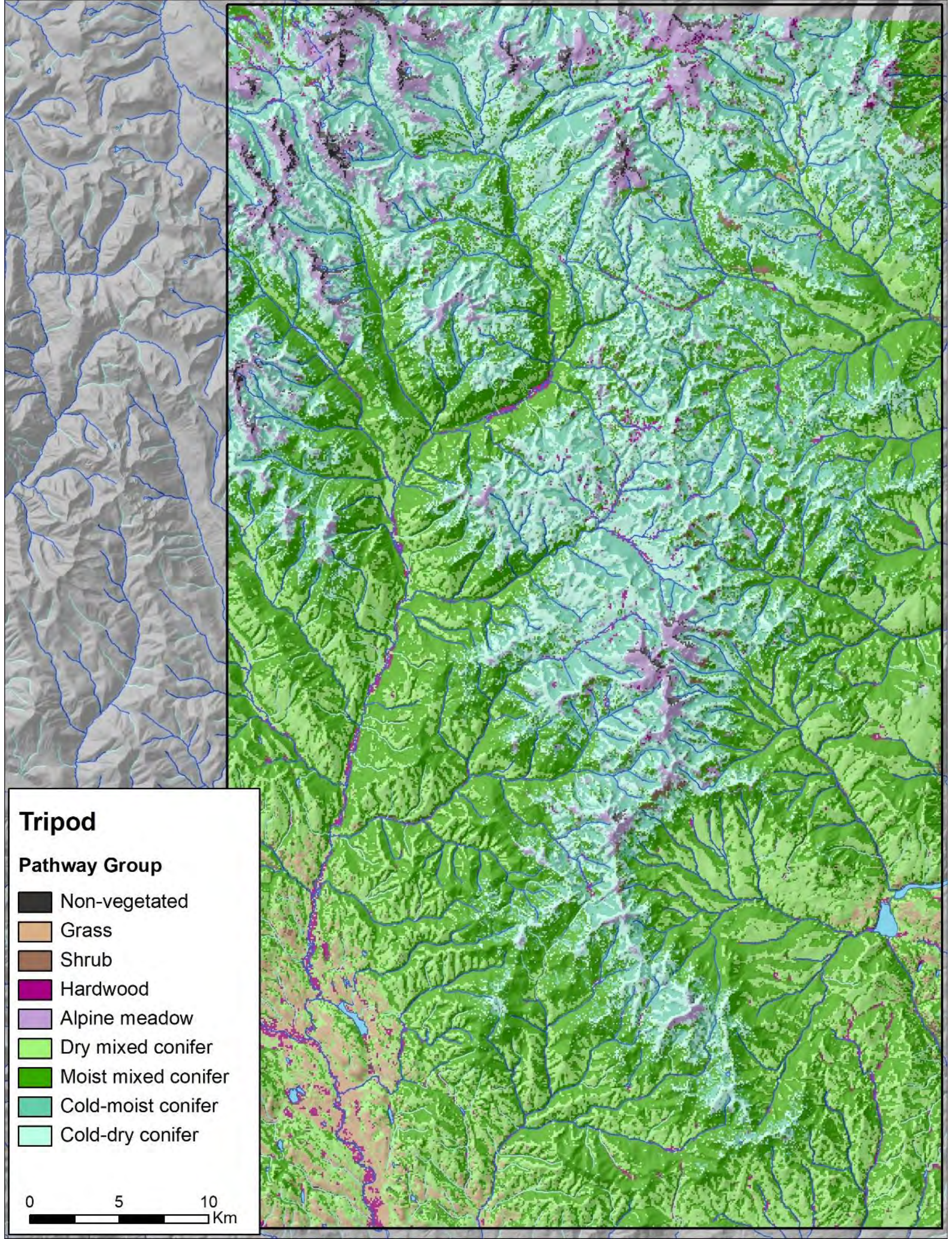
DMC Pixel burned 1940

- Assigned State 1A following fire season
- Add a time step prior to 1941
- In the absence of fire, this pixel will transition to State 2A in 1949.

State and Transition Models of semi-arid forest landscapes in western North America: fire and fuel pathways

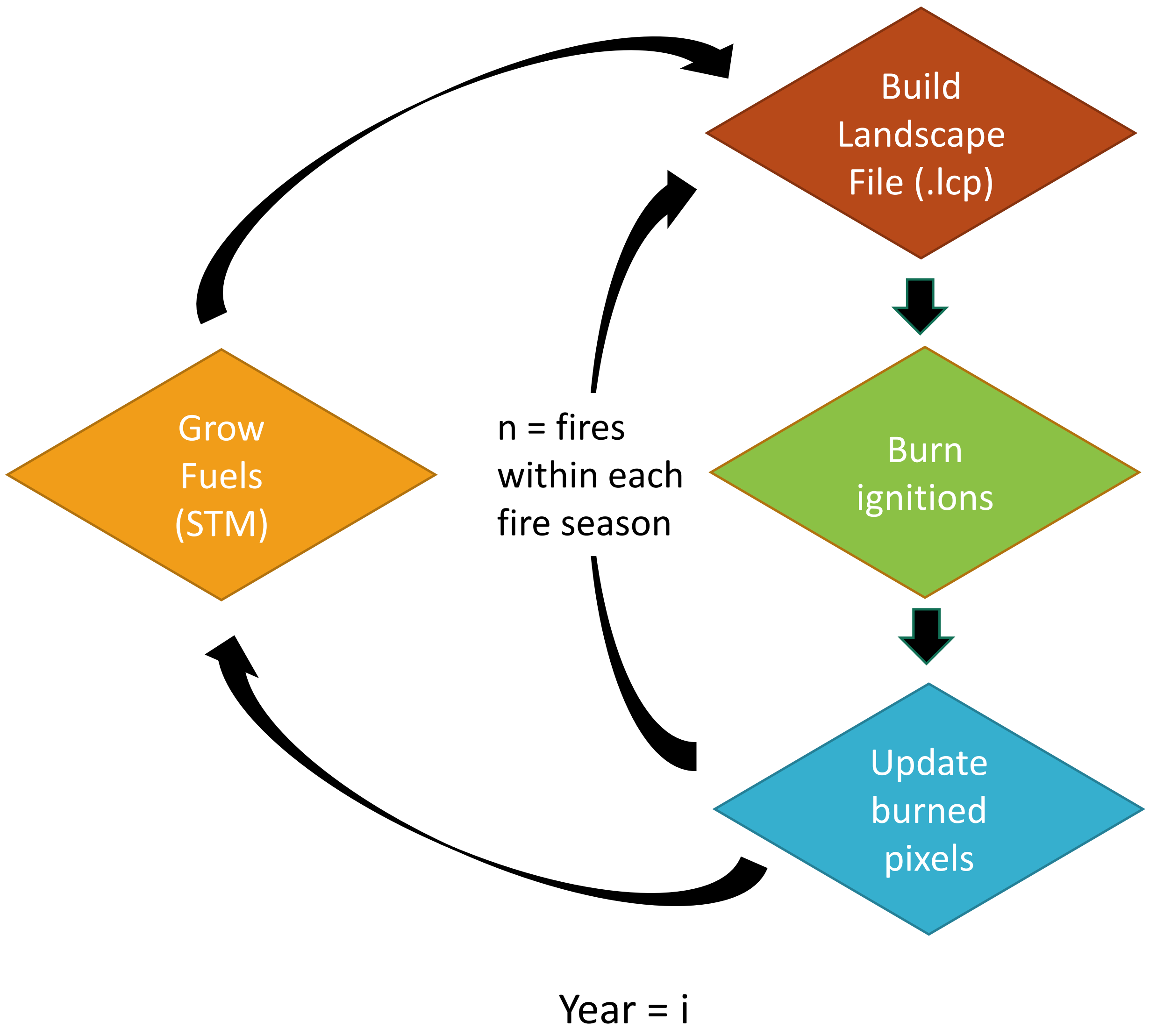
Authors:
Susan Prichard, Bob Gray, Richy Harrod, Paul Hessburg, Nicholas Povak, and Brion Salter

Base Landscape Development



StateID	Pathway Group	State	Max Time in State	FBFM Name	FBFM	CC	CH	CBH	CBD	FRST_SS	Structure
1111	NoPath	1A	9999	NB9	99	0	0.0	0.0	0.0000	20	BG - rock/water/ice
1121	NoPath	1B	9999	GR4	104	0	0.0	0.0	0.0000	17	herbland
1131	NoPath	1C	9999	GS2	122	0	0.0	0.0	0.0000	18	shrubland
1141	NoPath	1D	9999	TU1	161	60	15.0	5.0	0.1314	19	hardwoods
1151	NoPath	1E	9999	TU1	161	0	0.0	0.0	0.0000	17	montane meadow
1211	DMC	1A	10	NB9	99	1	2.1	0.0	0.0019	20	PFBG
1212	DMC	2A	15	GS1	121	18	6.4	0.6	0.0320	10	SI
1213	DMC	3A	35	2	2	60	14.6	0.8	0.0298	12	SECC
1214	DMC	4A	40	TU5	165	34	19.8	1.0	0.0275	13	UR
1215	DMC	5A	60	TU5	165	45	27.4	1.0	0.0275	14	YFMS
1216	DMC	6A	9999	TU5	165	55	36.6	1.5	0.0320	15	OFMS
1222	DMC	2B	15	GS1	121	15	5.5	0.6	0.0205	10	SI
1223	DMC	3B	35	GS1	121	25	13.7	1.5	0.0228	11	SEOC
1224	DMC	4B	40	2	2	30	18.3	1.0	0.0259	11	SEOC
1225	DMC	5B	60	2	2	40	27.4	2.0	0.0275	11	SEOC
1226	DMC	6B	40	2	2	55	36.6	3.0	0.0275	16	OFSS
1231	DMC	1C	10	NB9	99	1	2.1	0.0	0.0019	20	PFBG
1232	DMC	2C	15	GR1	101	15	5.5	0.6	0.0205	10	SI
1233	DMC	3C	35	GR1	101	25	13.7	1.5	0.0228	11	SEOC
1234	DMC	4C	40	2	2	30	18.3	1.0	0.0259	13	UR
1235	DMC	5C	60	2	2	40	27.4	1.5	0.0275	14	YFMS
1236	DMC	6C	40	2	2	55	36.6	1.0	0.0275	13	UR
1244	DMC	4D	40	10	10	34	19.8	1.5	0.0275	11	SEOC
1245	DMC	5D	60	10	10	45	27.4	1.5	0.0275	11	SEOC
1246	DMC	6D	40	10	10	55	36.6	2.5	0.0320	16	OFSS

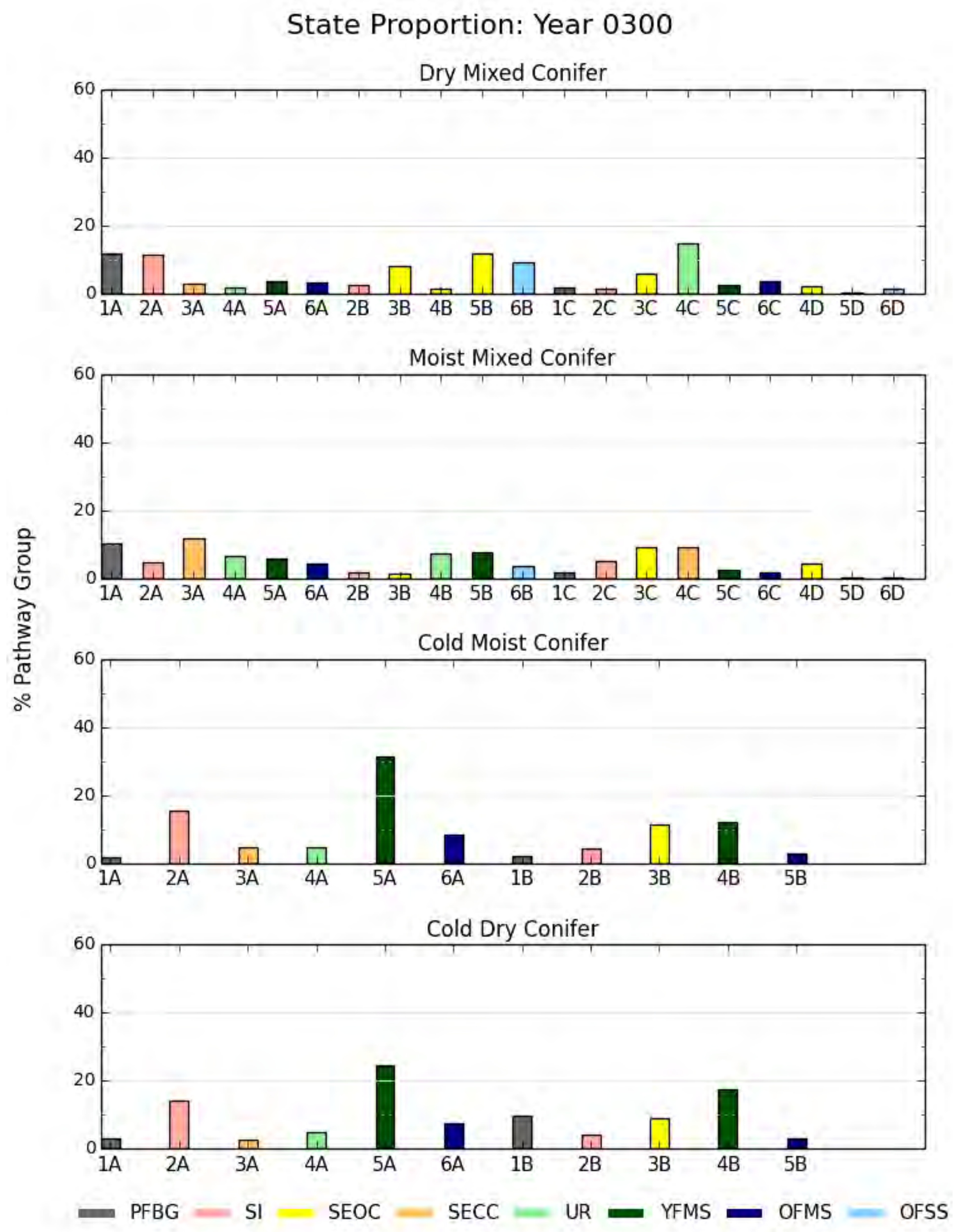
Spatial Simulation Modeling



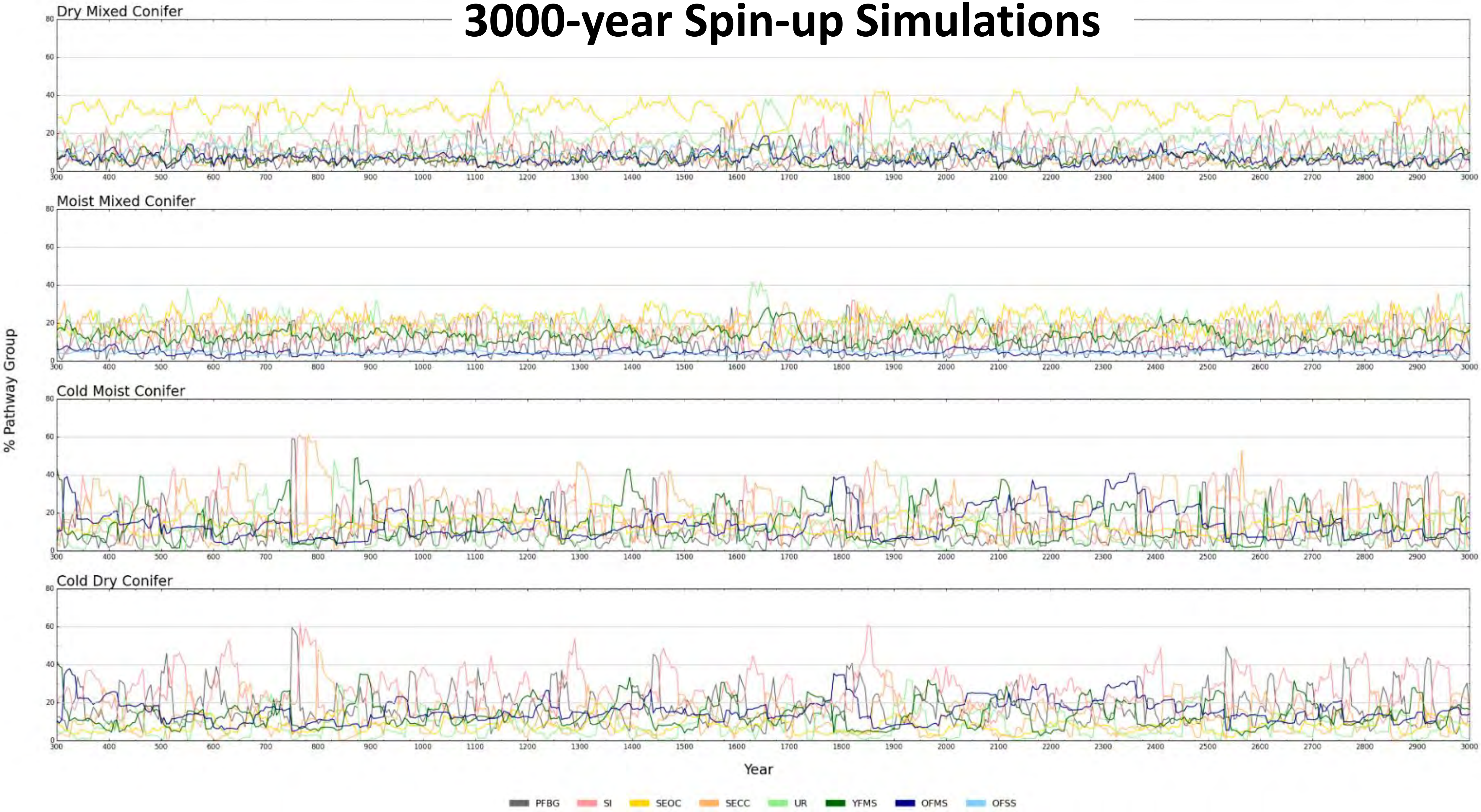
Simulation Modeling Steps

1. Start fire season with year + 1 and any STM transitions.
2. Randomly select fire year (number of fires)
3. For each fire, randomly select Julian date for ignition (based on known distributions of events)
4. Spatially allocate fires using lightning probability map
5. Ignite ea. fire by date (drawn from daily weather stream)
6. Fire runs until two consecutive days of ERC < 55 (2 week maximum)
7. Burned pixels remain NB9 through fire season
8. At end of fire season convert modeled flame lengths to burn severity and update state map

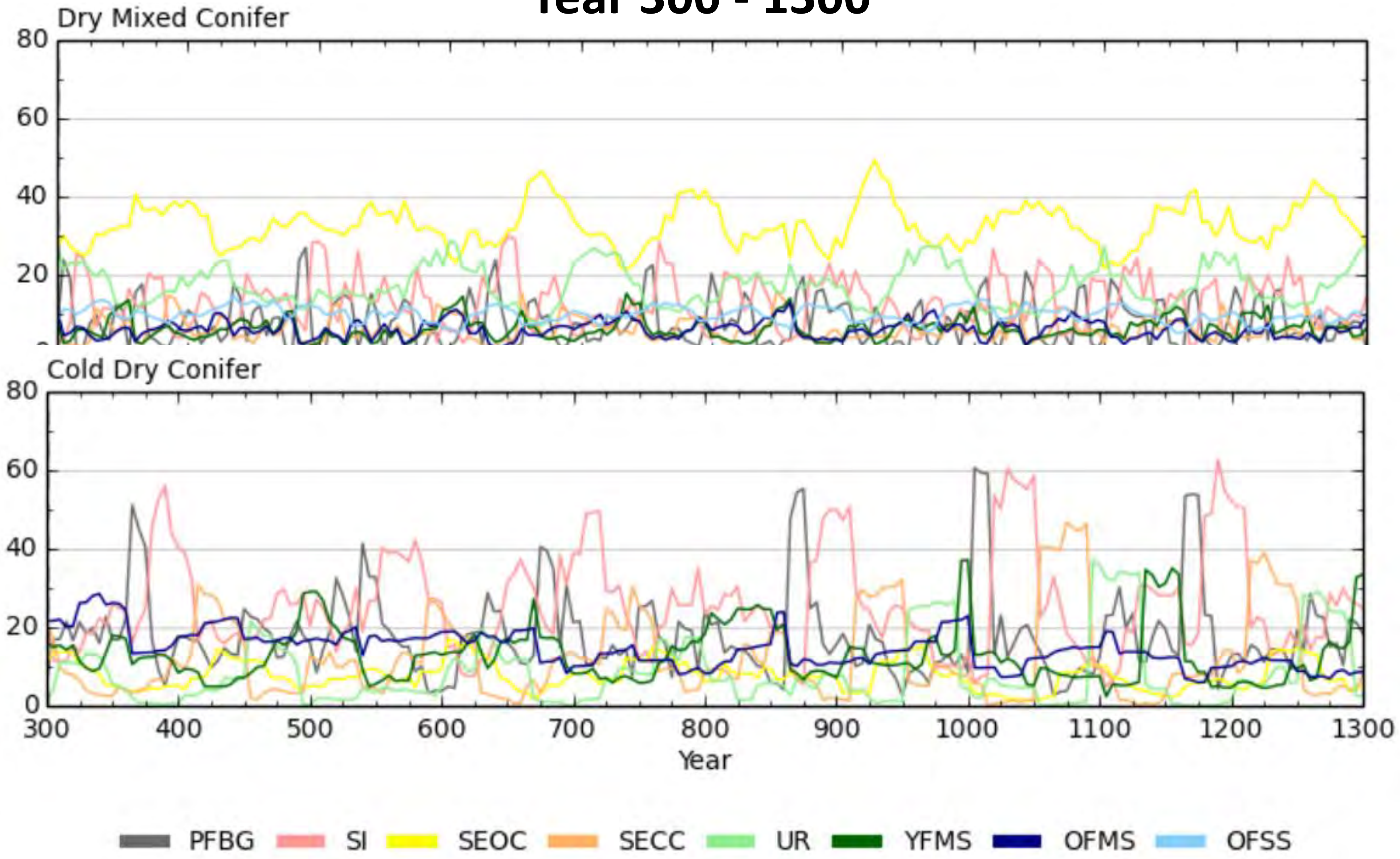
Calibration Tool – time in state movies



3000-year Spin-up Simulations



Year 300 - 1300



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Wildland Fire Management Scenarios

A) Complete absence of fire -- no ignitions

B) Modern Suppression -- only fires that escape suppression

- Escaped wildfire threshold:
  - Ignition date between 135 and 304 (May 15 to Oct 31)
  - Minimum of 1 burnable pixel within ignition perimeter
  - Ignition day threshold to burning: ERC ≥ 67 and Wind ≥ 20 mph

C) Partial Suppression -- managed wildfires in the late-summer and fall fire seasons and escaped wildfires (above)

- Ignition date between 187 and 304 (July 5 to Oct 31)
- ERC < 67 and Wind ≤ 10 mph within first 5 days

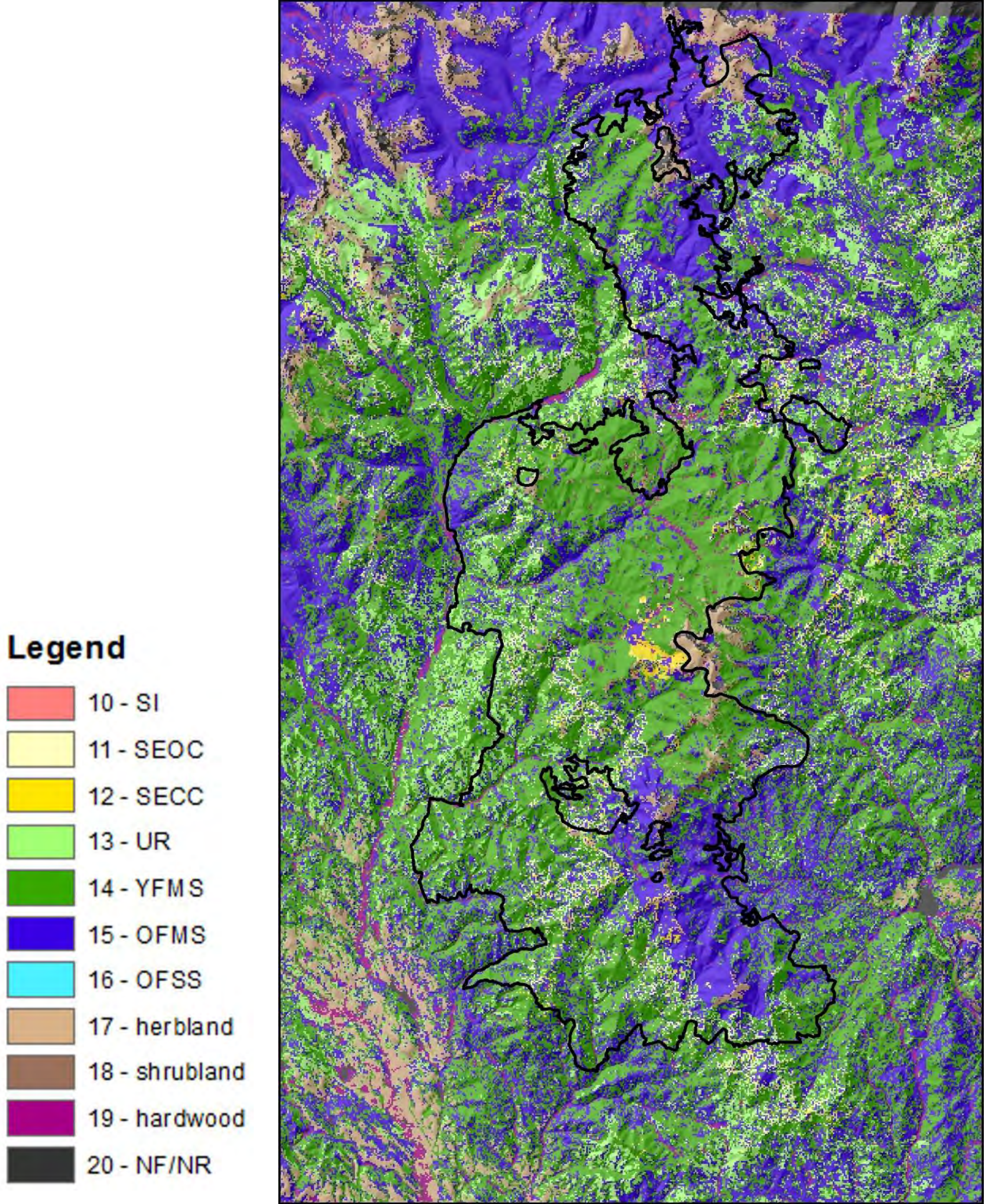
D) No Suppression – all ignitions that meet thresholds to burning:

- Ignition date between 135 and 304 (May 15 to Oct 31)
- Ignition day threshold to burning: ERC ≥ 55
- Minimum of 1 burnable pixel within ignition perimeter

Results - Tripod

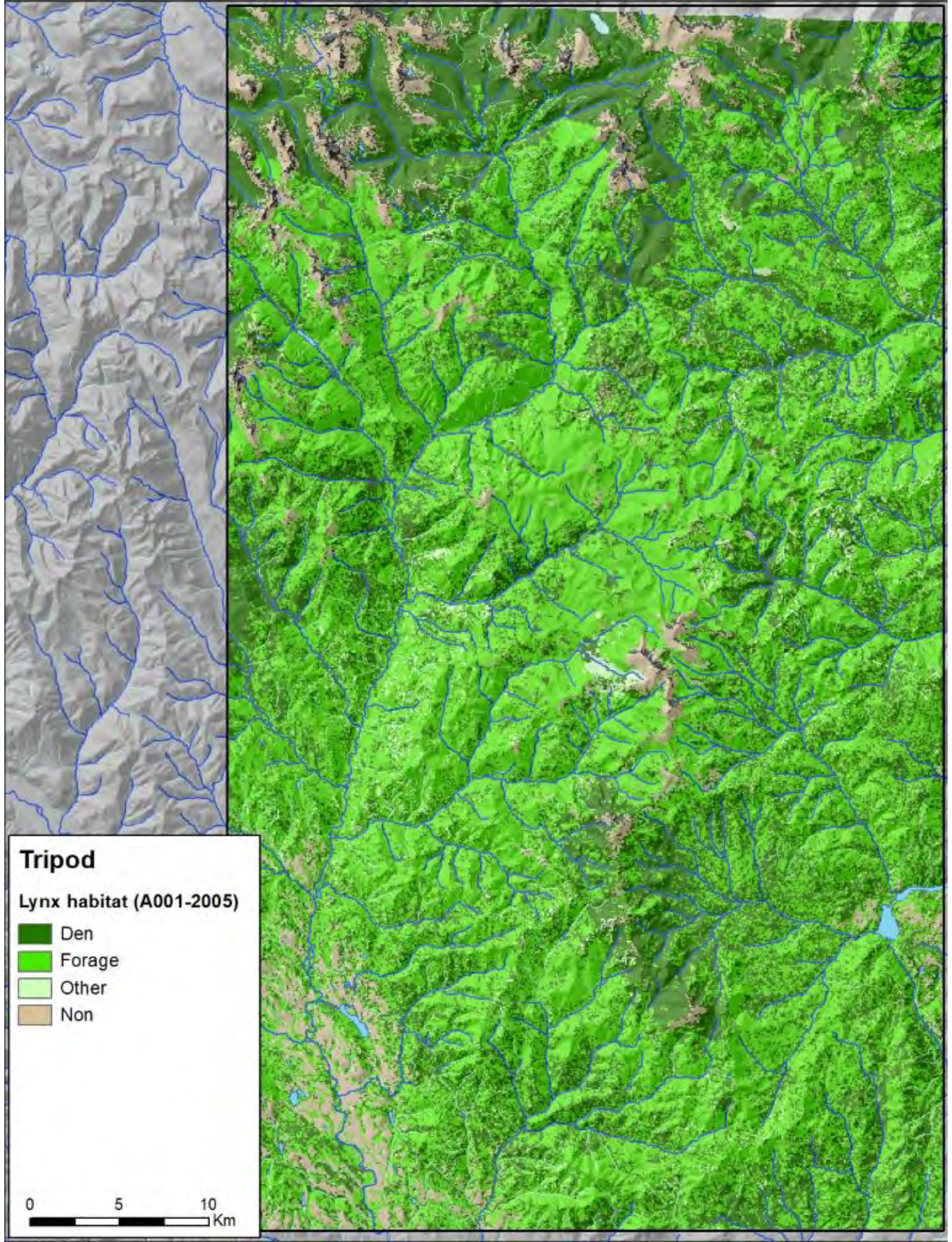
A) Complete absence of fire
(no ignitions from 1940 to 2005)

Homogenous landscape, mostly of young and old multi-storied forests



Lynx Habitat

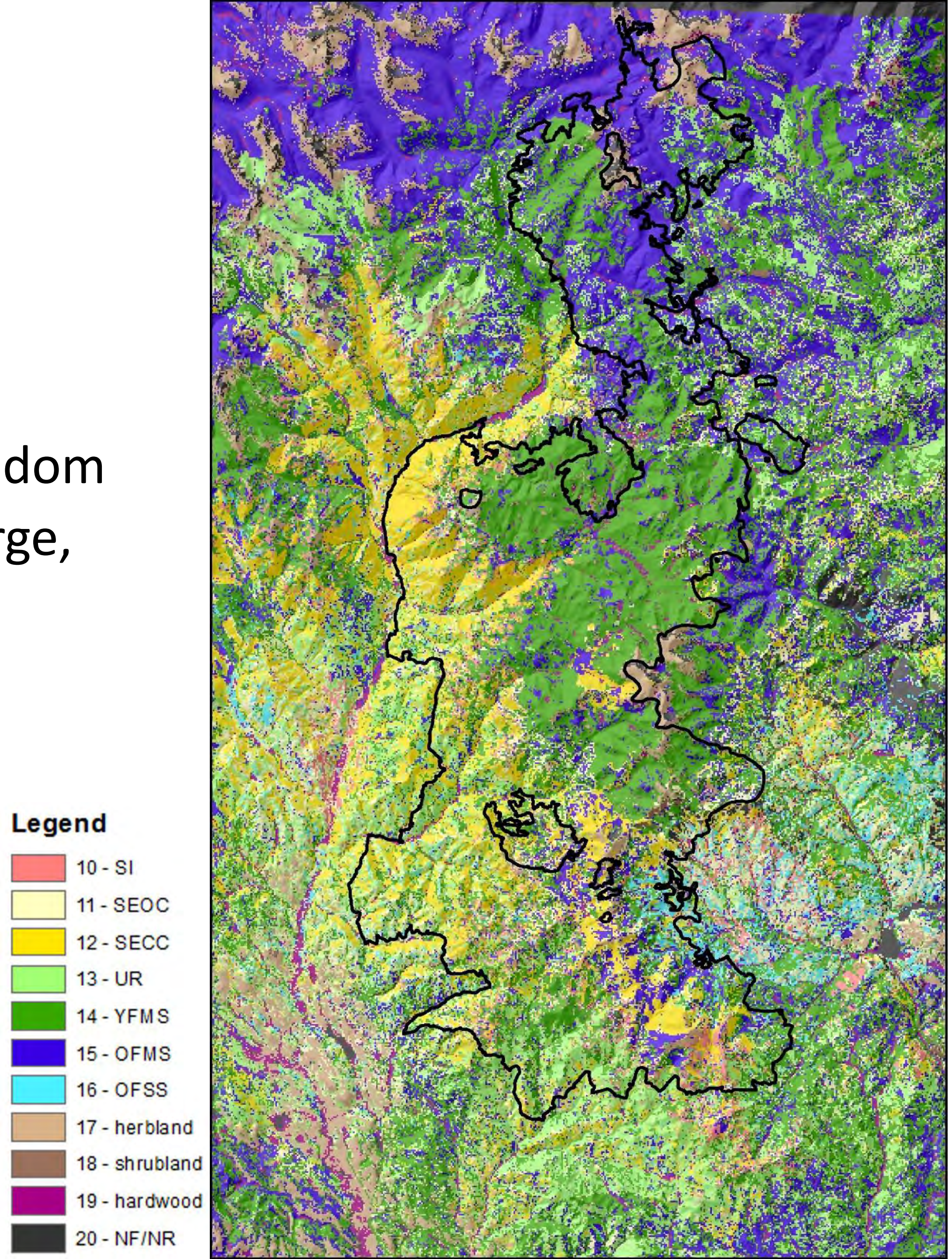
A) Complete absence of fire
(no ignitions from 1940 to 2005)



Results - Tripod

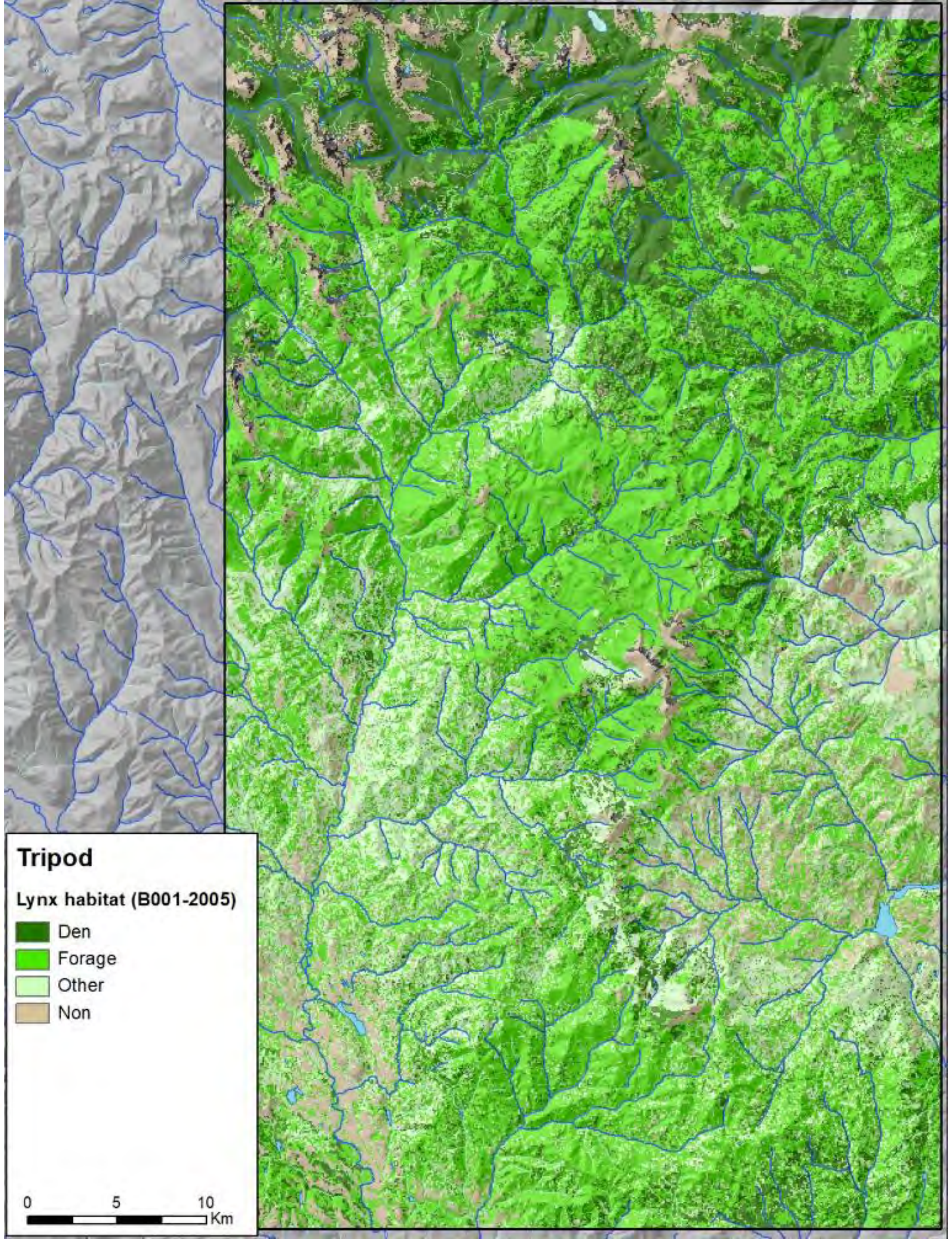
B) Full Suppression (2% fires)

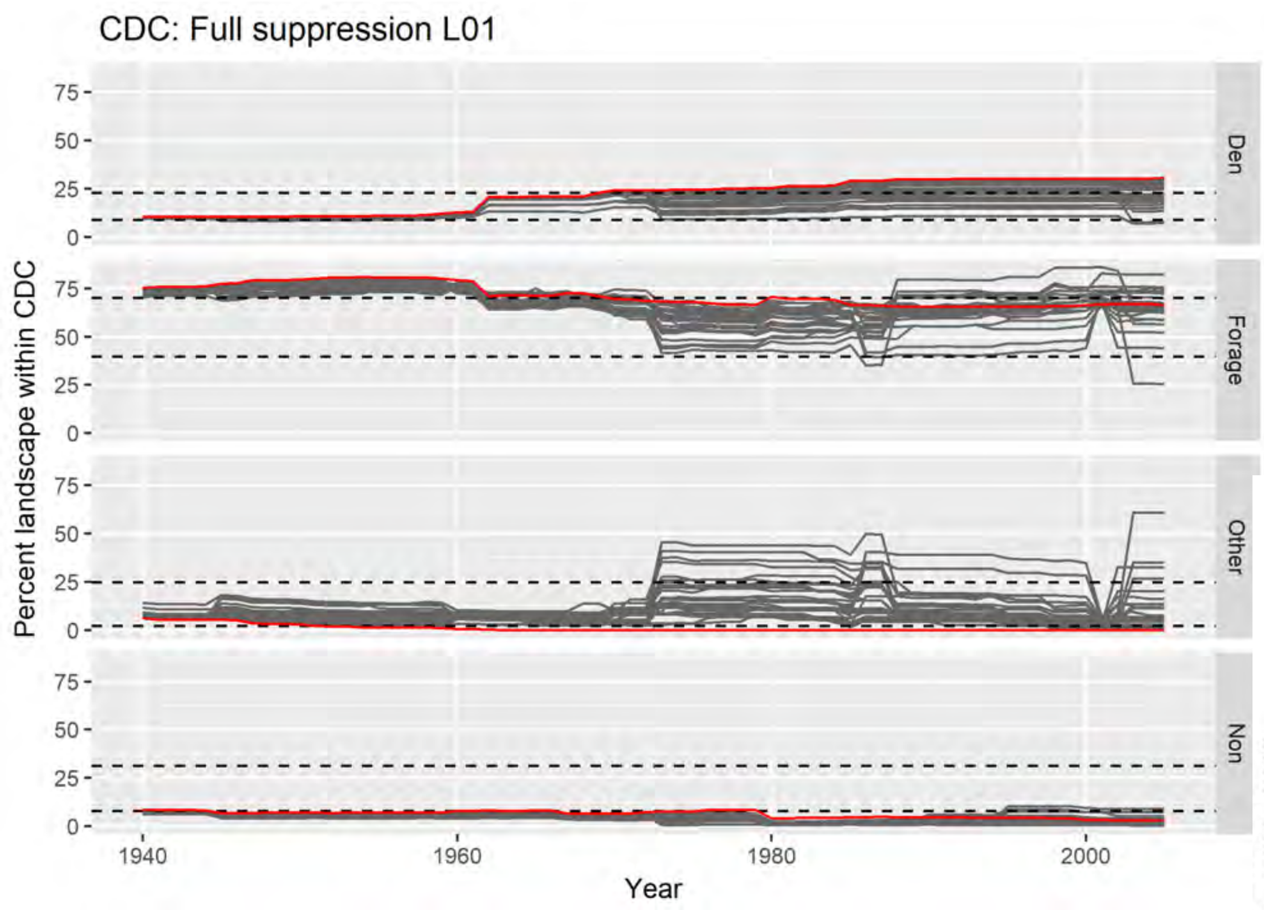
- General infilling of the landscape with more mature forests prior to 2006.
- In some iterations of this scenario, random draws of wind scenarios resulted in large, recent fires before 2006.

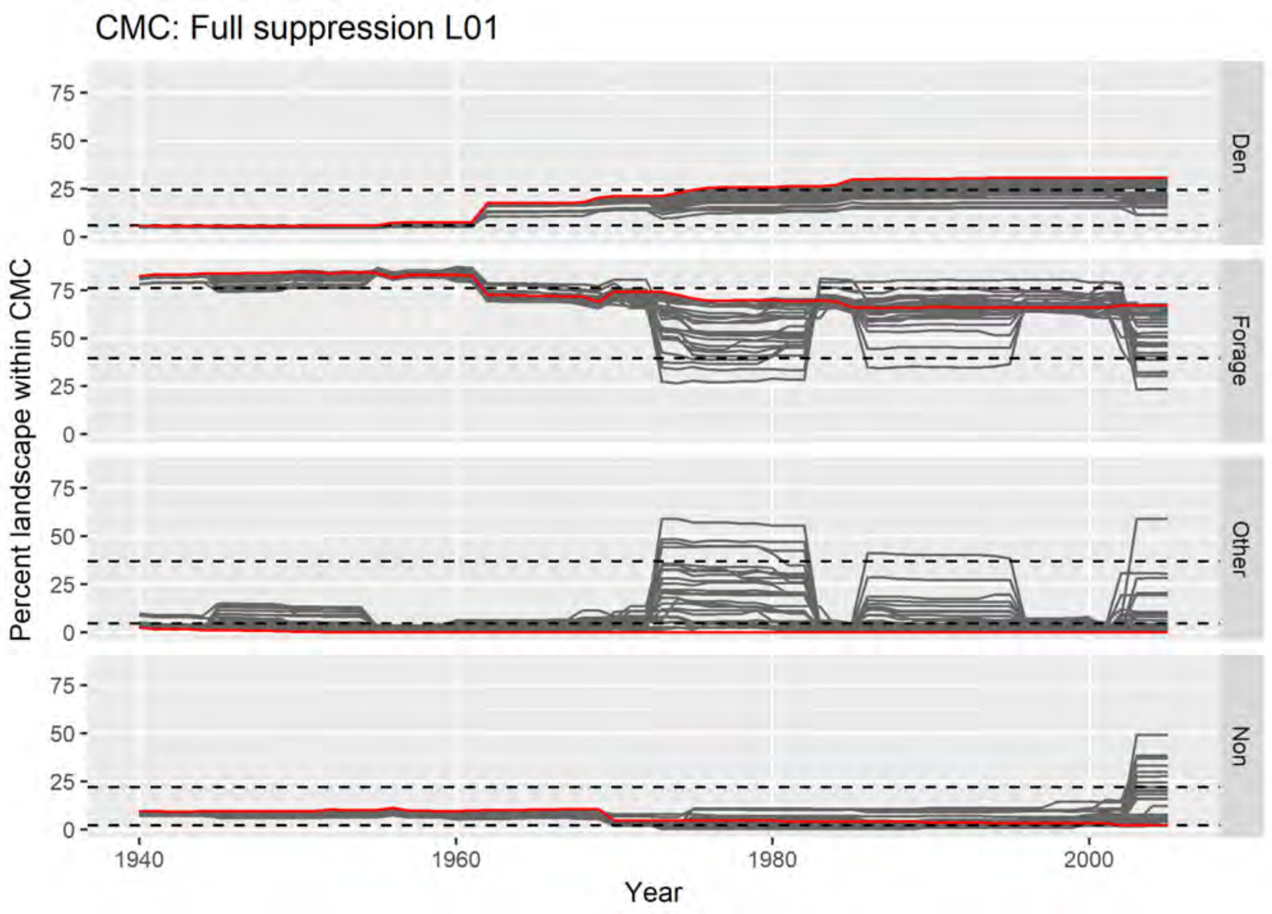


Lynx Habitat

B) Full Suppression (2% fires)




CDC: Full suppression L01
Percent landscape within CDC
Den
Forage
Other
Non
0
25
50
75
1940
1960
1980
2000
Year

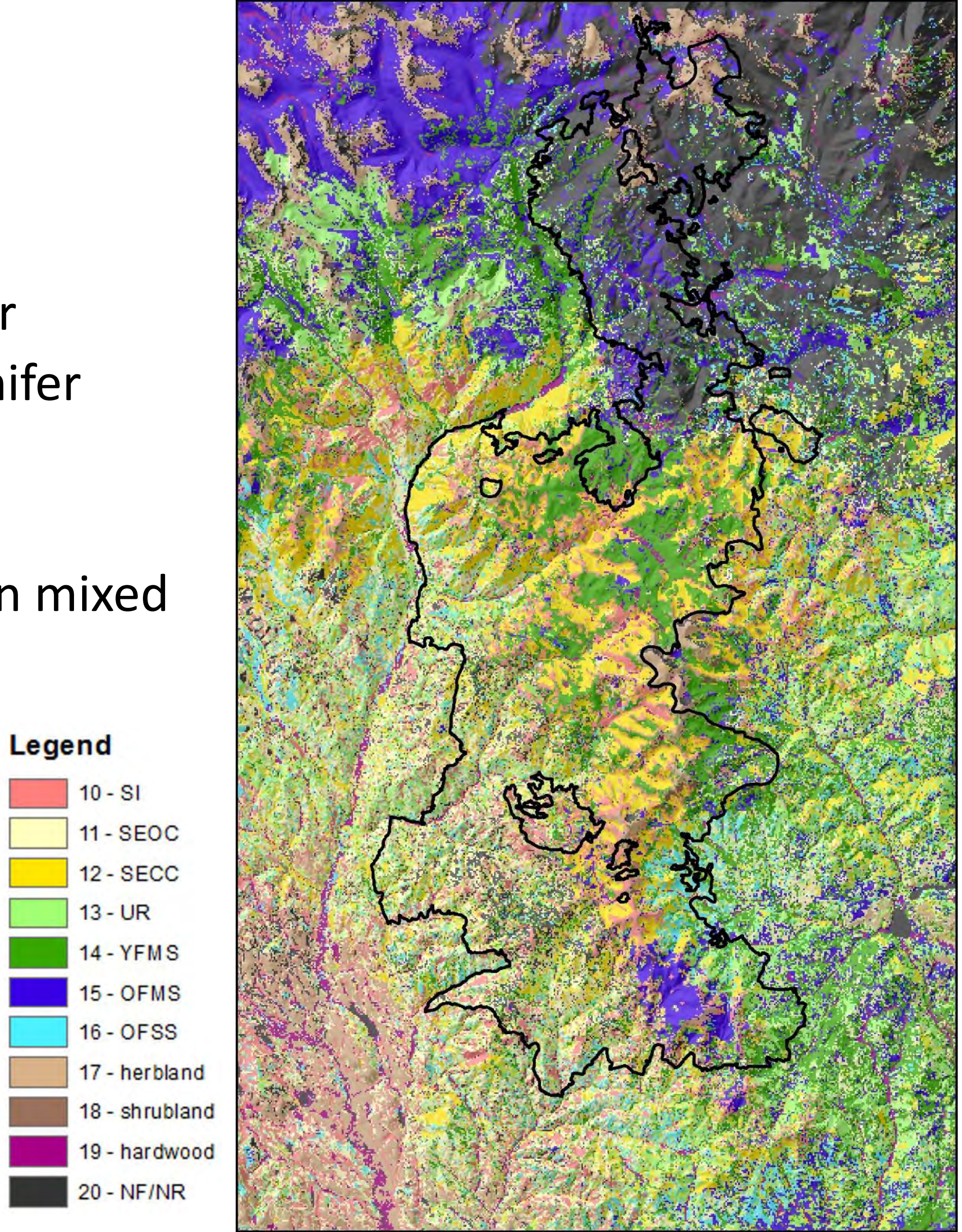

CMC: Full suppression L01
Percent landscape within CMC
Den
Forage
Other
Non
0
25
50
75
1940
1960
1980
2000
Year

Results - Tripod

C) Partial Suppression

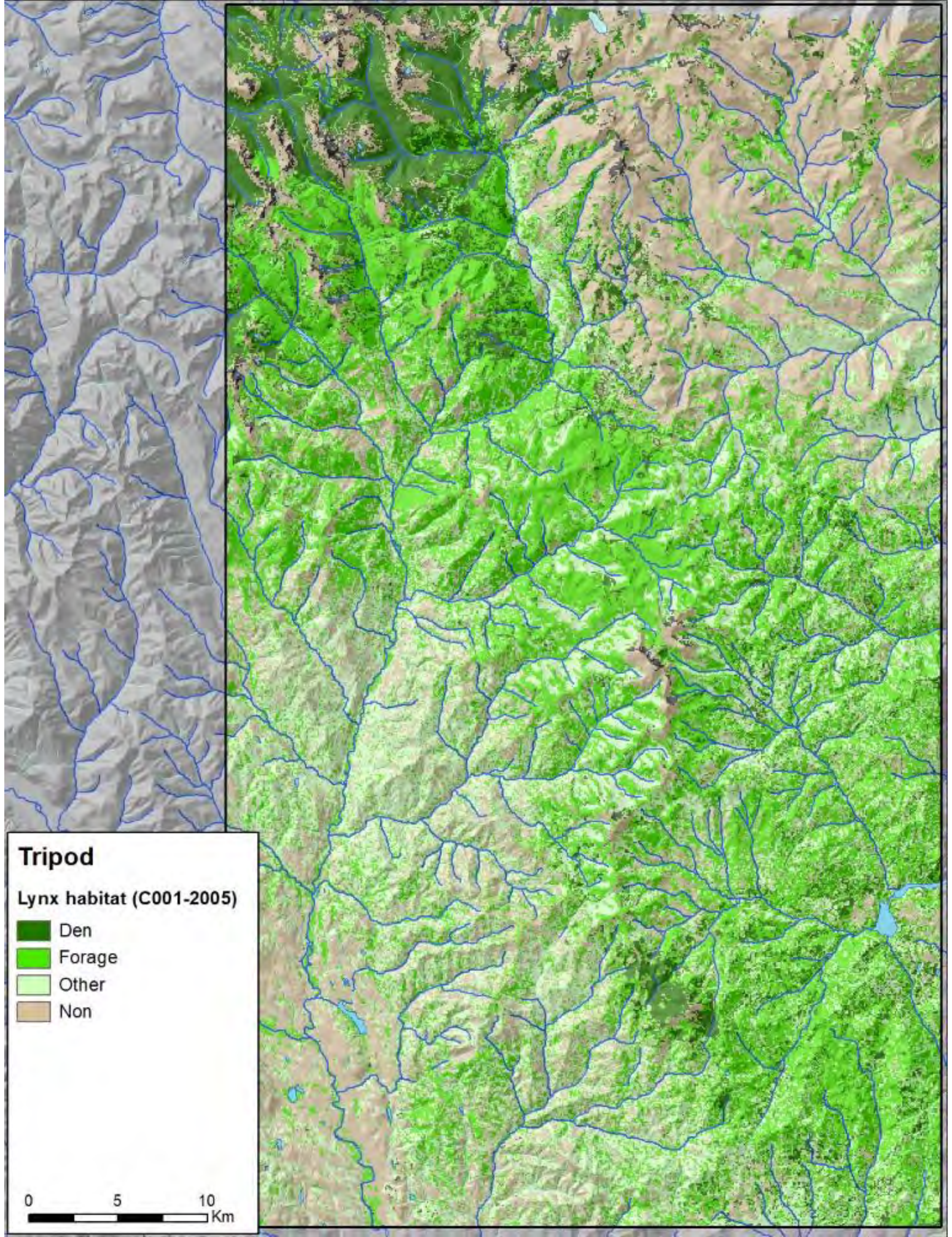
- Finer-grain landscape mosaics at lower elevations that support dry, mixed conifer forests

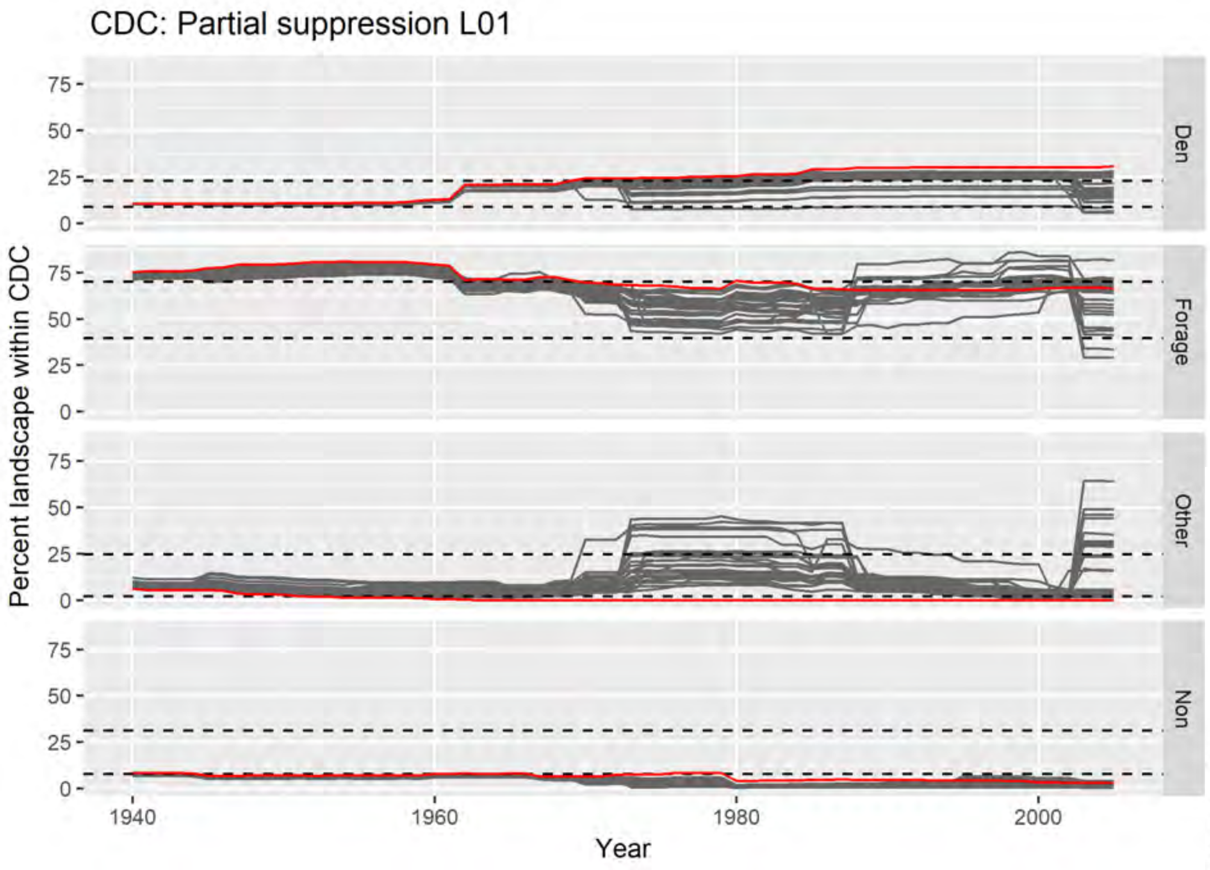
- Large, recent fire in cool high-elevation mixed conifer forests.



Lynx Habitat

C) Partial Suppression




CDC: Partial suppression L01
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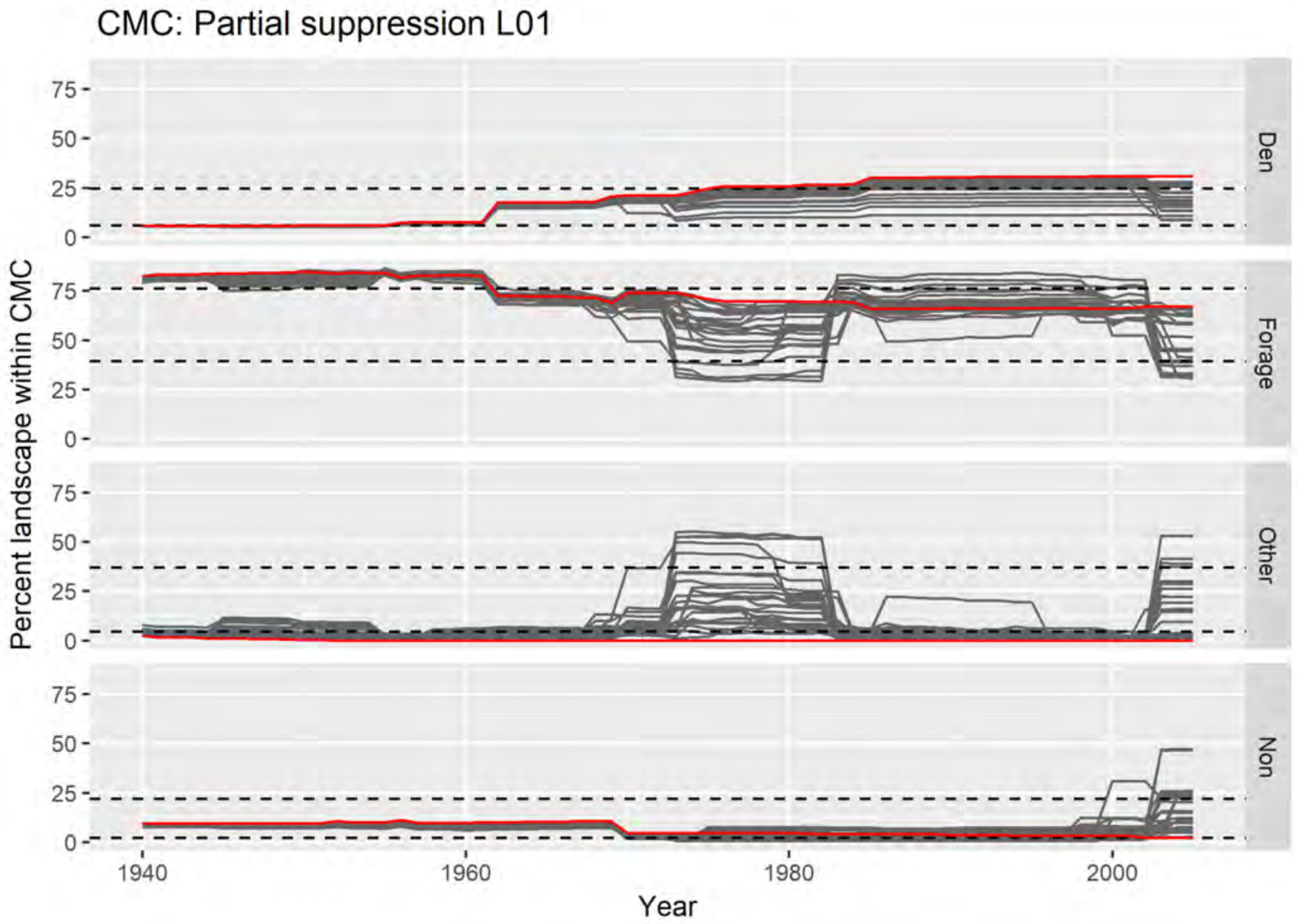
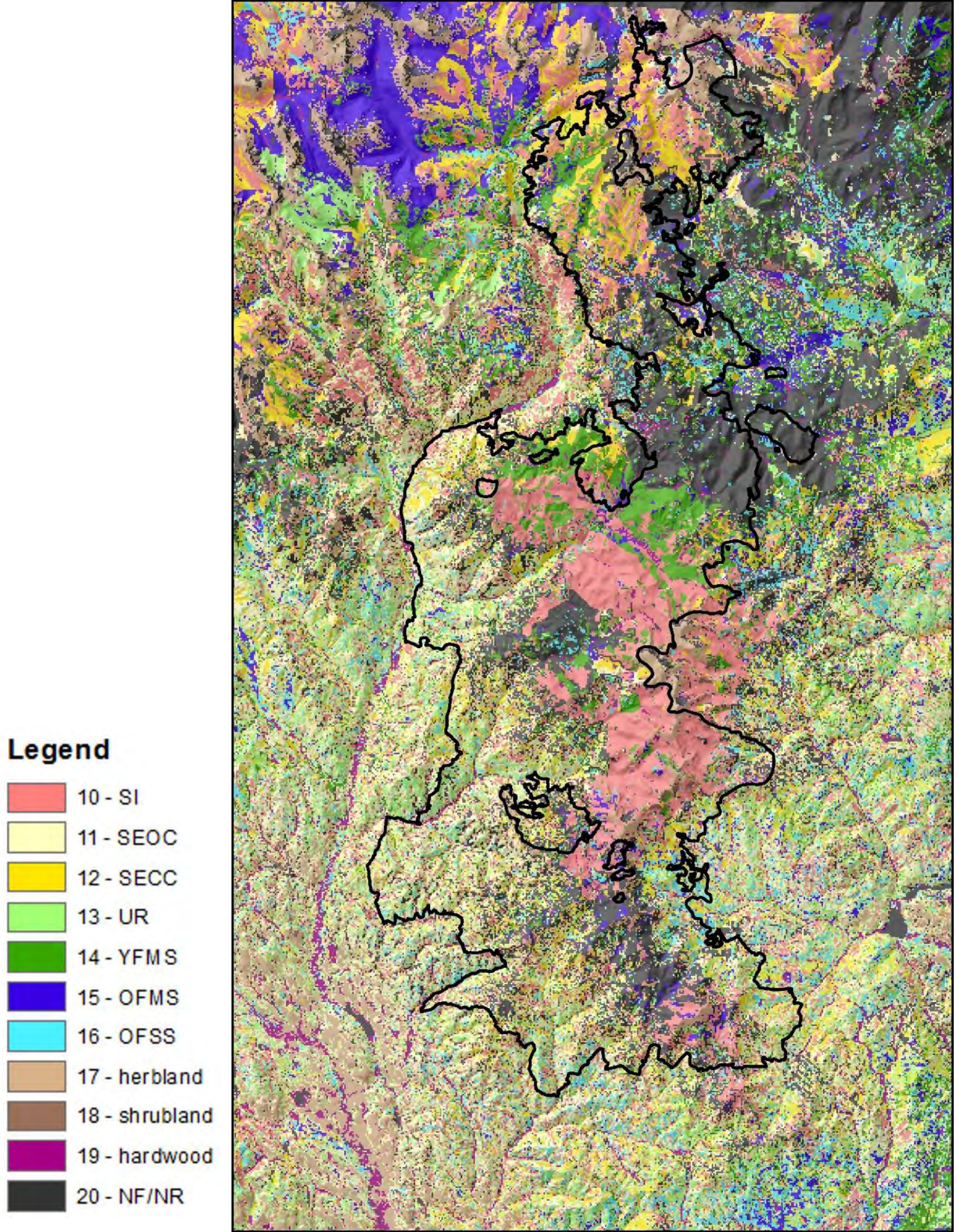

CMC: Partial suppression L01
Percent landscape within CMC
Den
Forage
Other
Non
Year
1940
1960
1980
2000
0
25
50
75

Results - Tripod

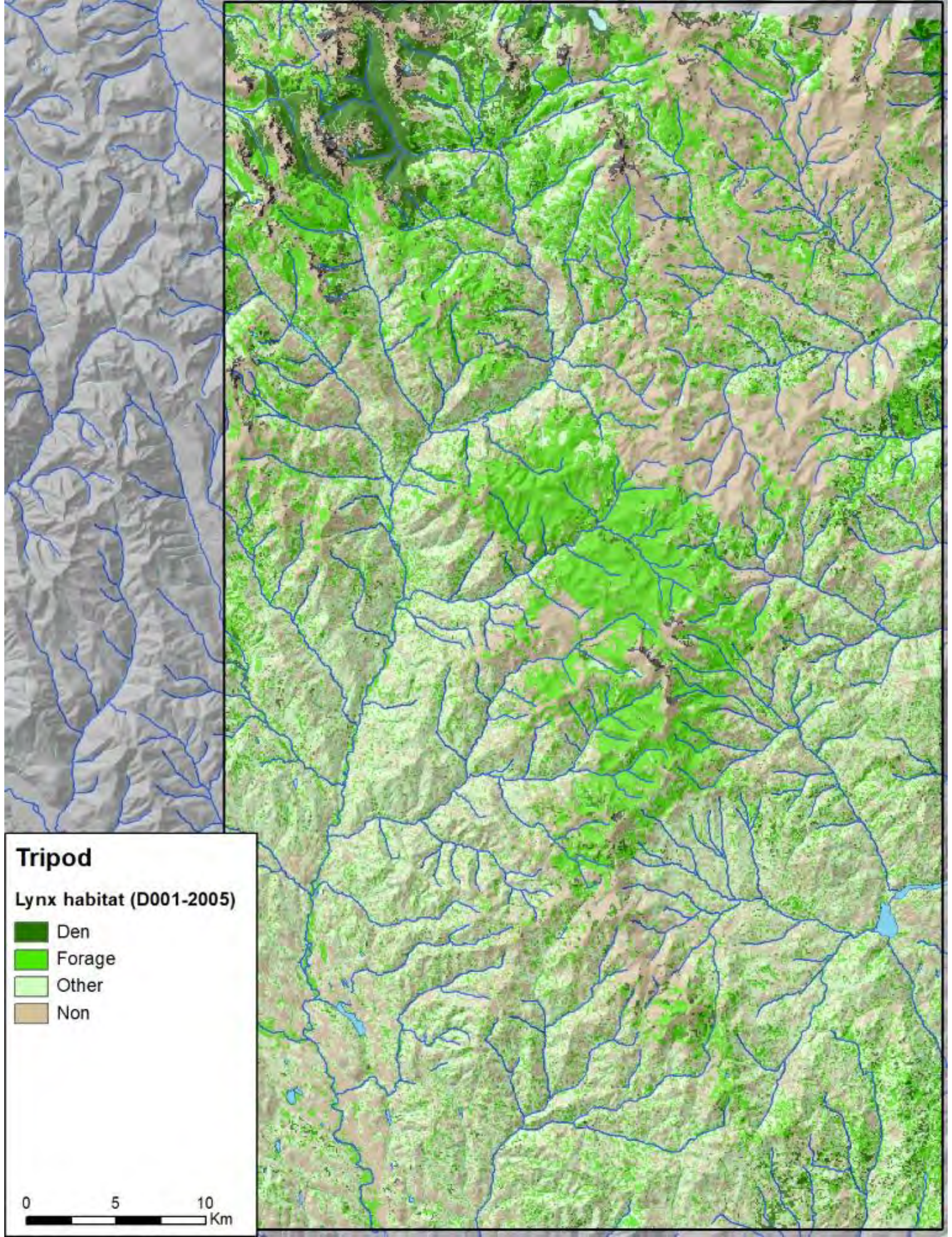
D. No suppression

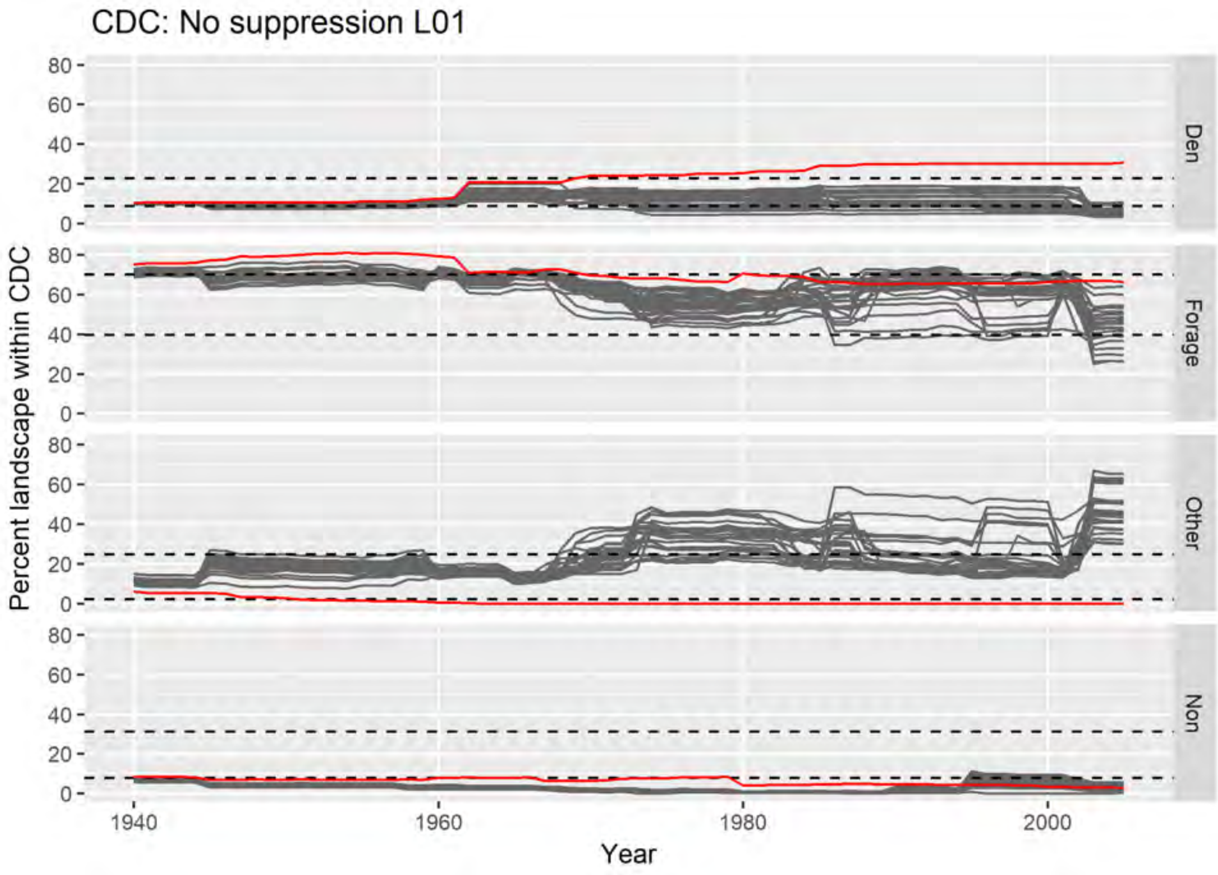
- Landscape supports low percentage of mature forest
- Highest pixilation of any of the scenarios.
- Patches of young forest multistory and old forest multistory generally surrounded by recent burns (black pixels) and regenerating forest.



Lynx Habitat

D. No suppression
(let it burn)




CDC: No suppression L01
Percent landscape within CDC
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Forage
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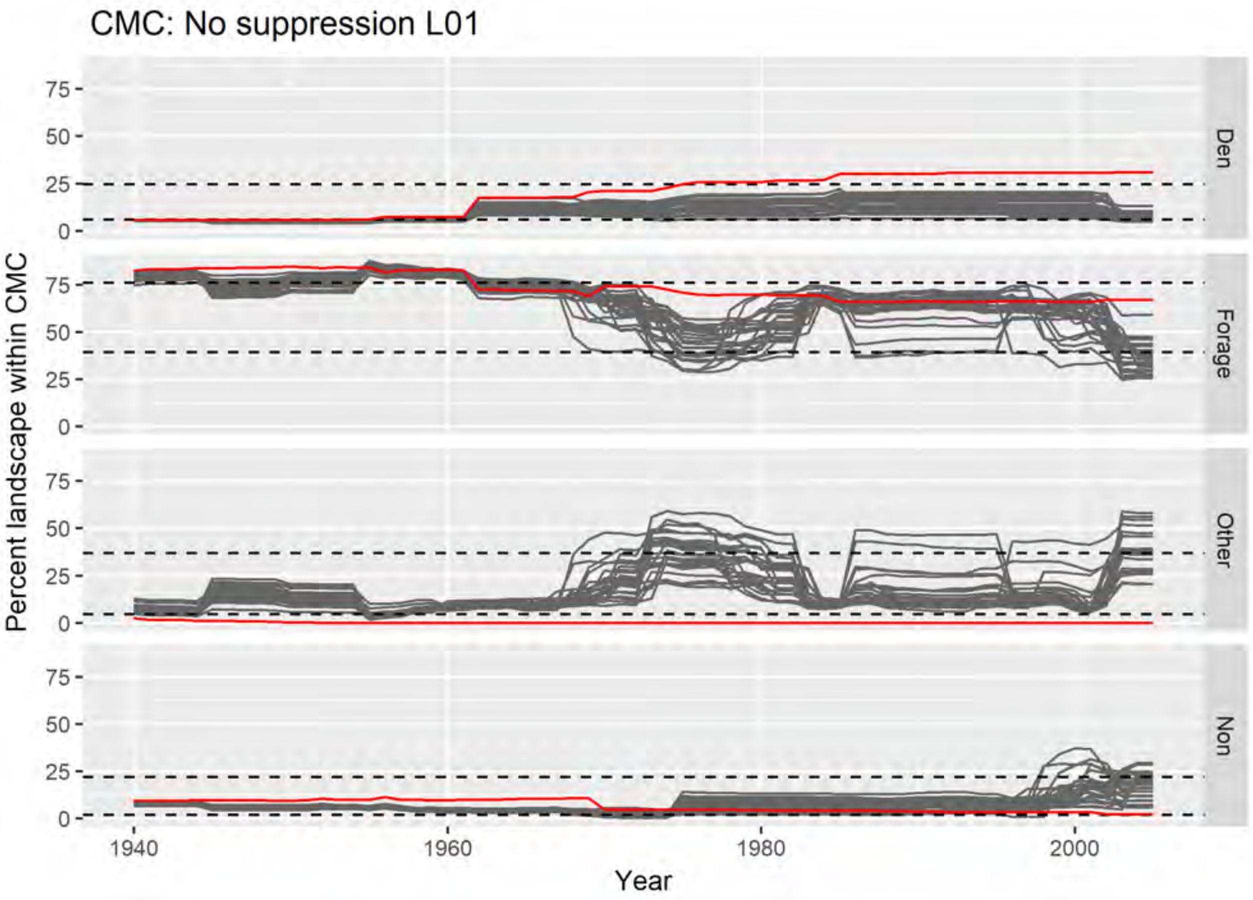
1980
2000
0
20
40
60
80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Percent landscape within CMC
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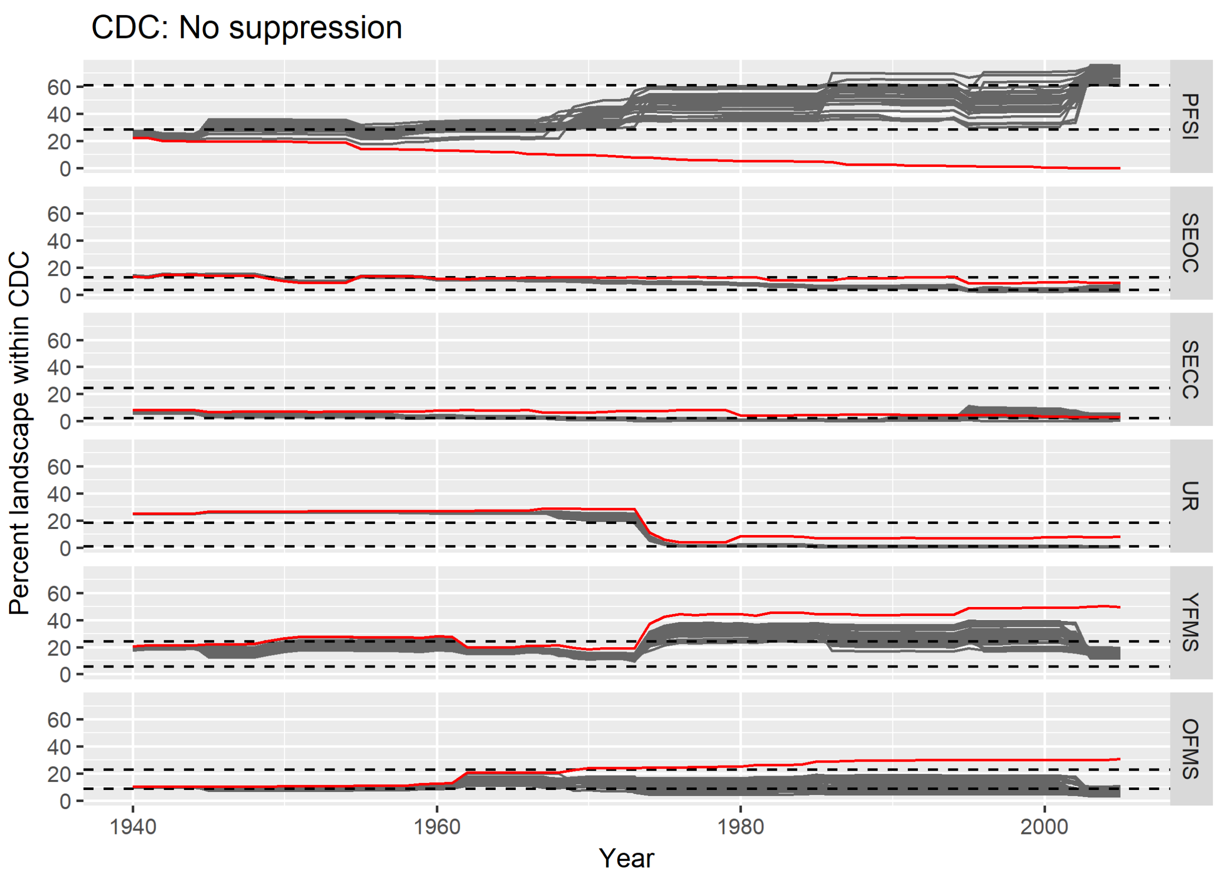
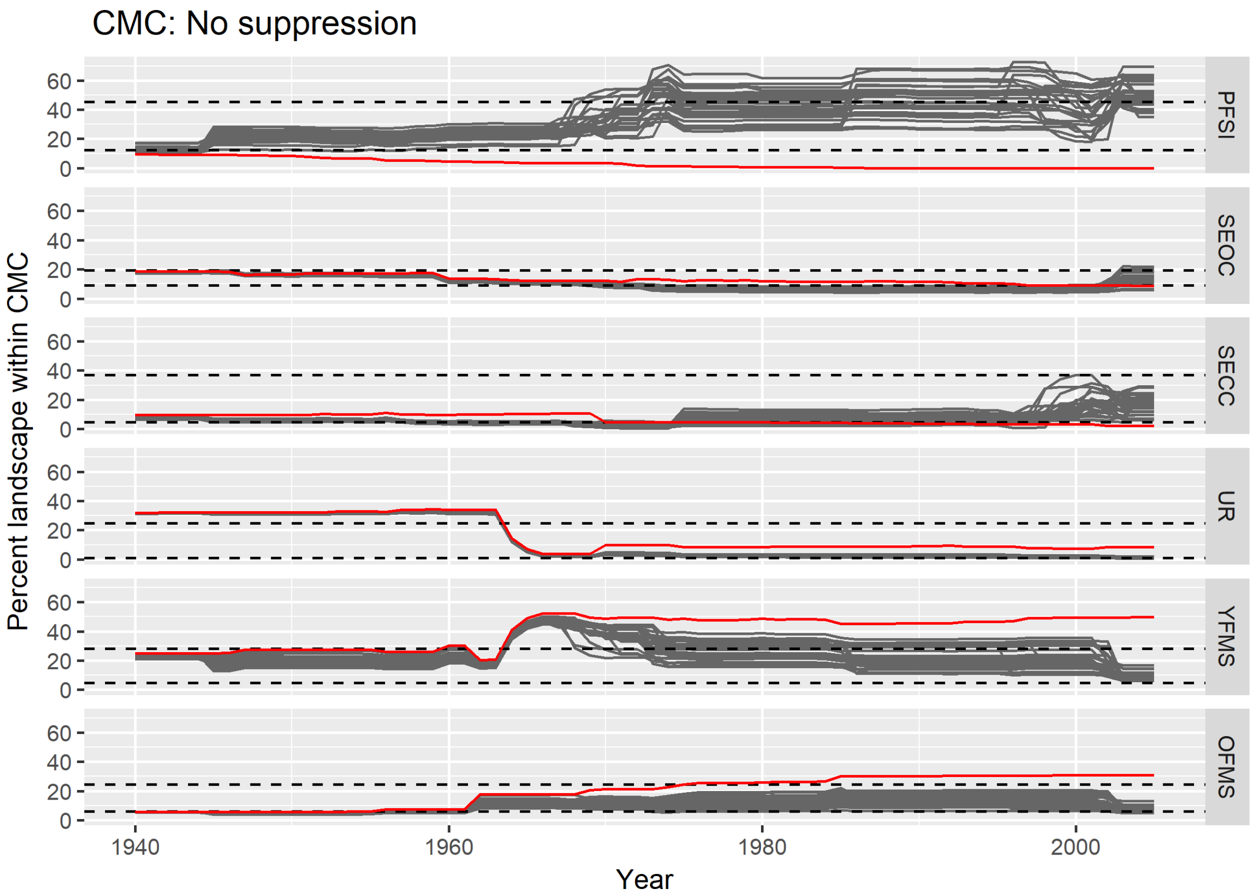

CDC: No suppression
Percent landscape within CDC
PFSI
SEOC
SECC
UR
YFMS
OFMS
0
20
40
60
1940
1960
1980
2000
Year


CMC: No suppression
Percent landscape within CMC
PFSI
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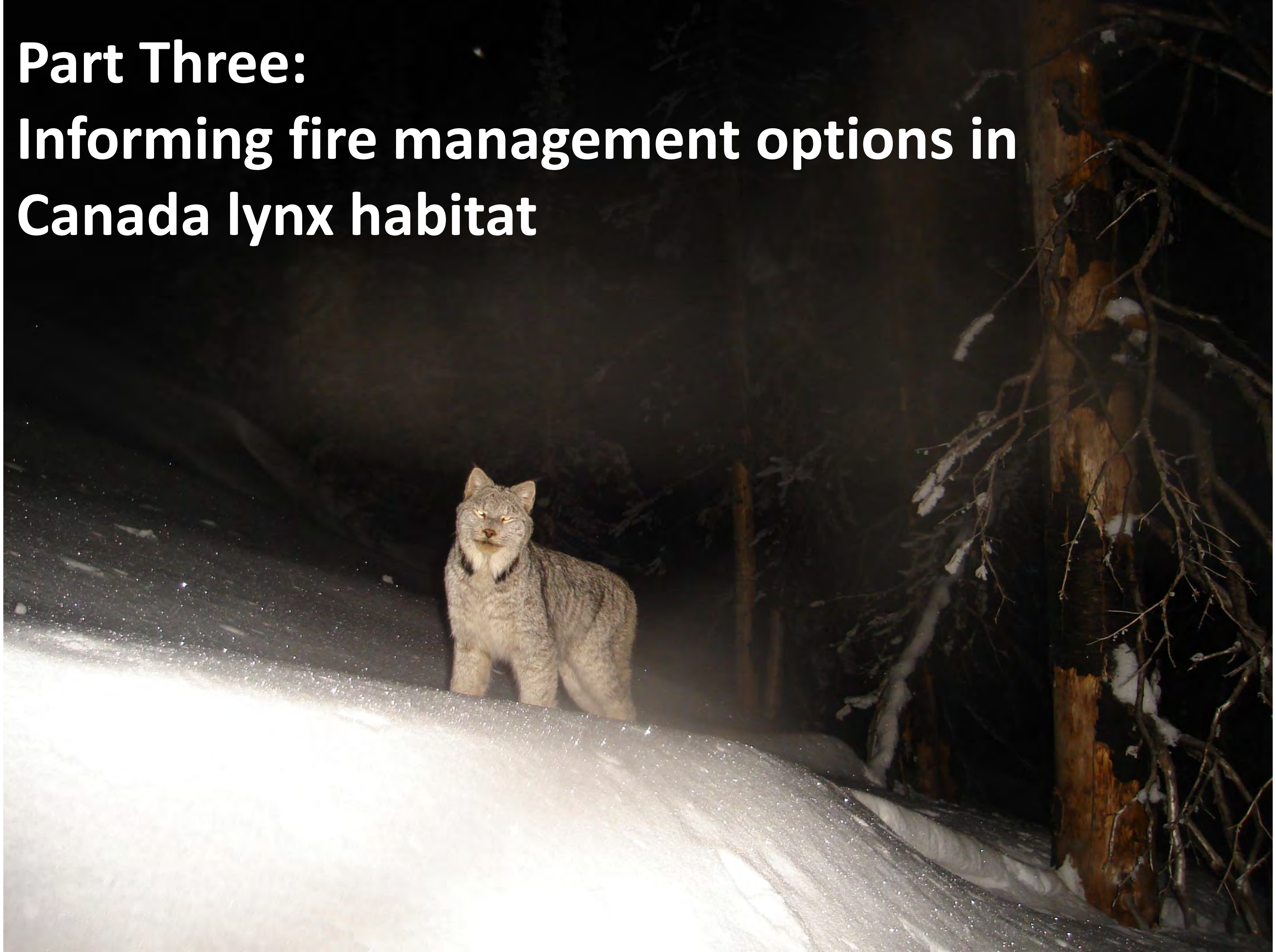
Part Three:
Informing fire management options in Canada lynx habitat

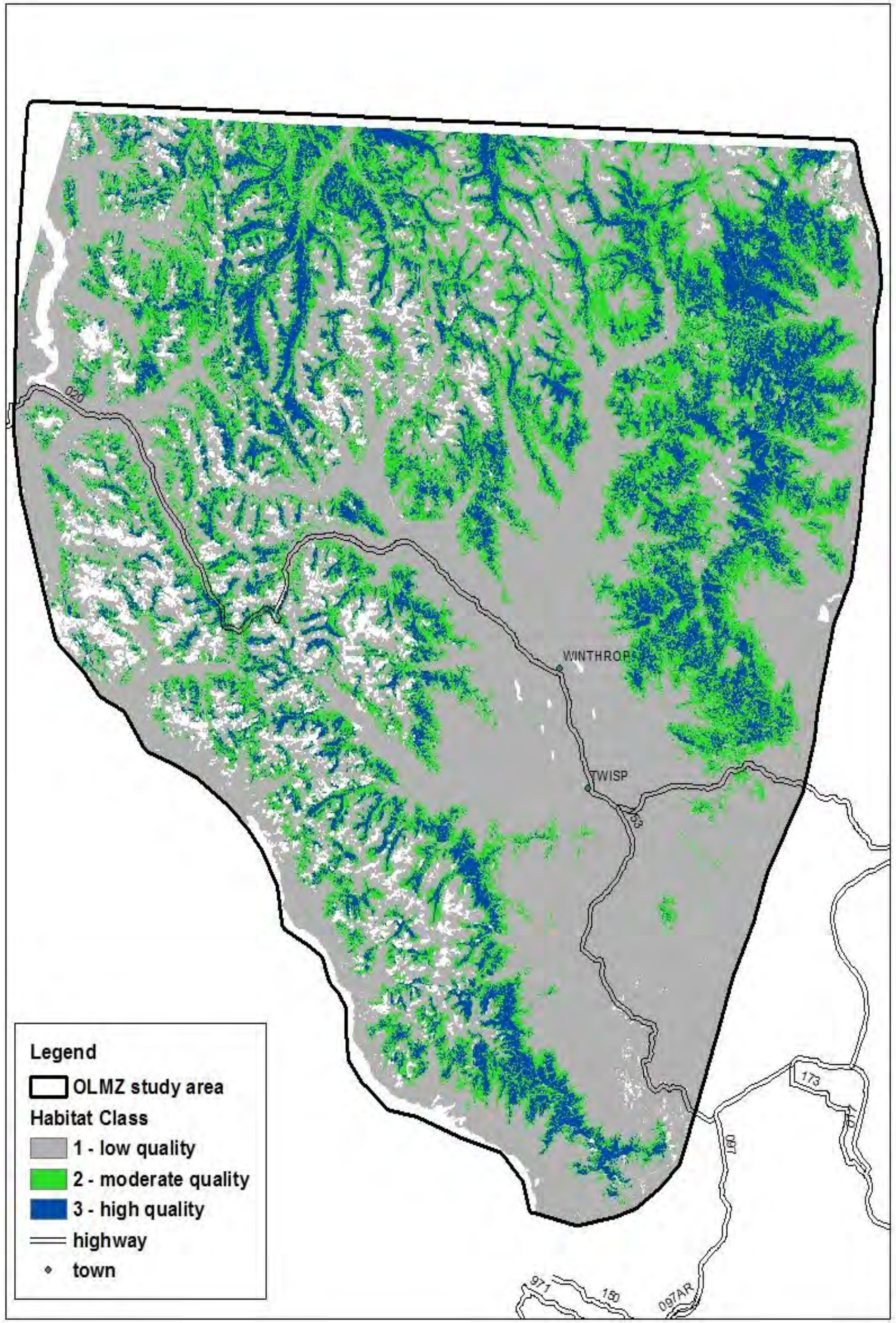


Crosswalk – Fuel Beds to Lynx Habitat

- Forest Type - Composition
  - Focused on Cold Dry and Cold Moist
  - Surface Vegetation
- Forest Age
- Structure
  - Tree Size
  - Canopy Layers
  - Canopy Closure
  - Downed Wood
- Retained Others Variables of the RSF
  - Elevation
  - Aspect
  - Slope

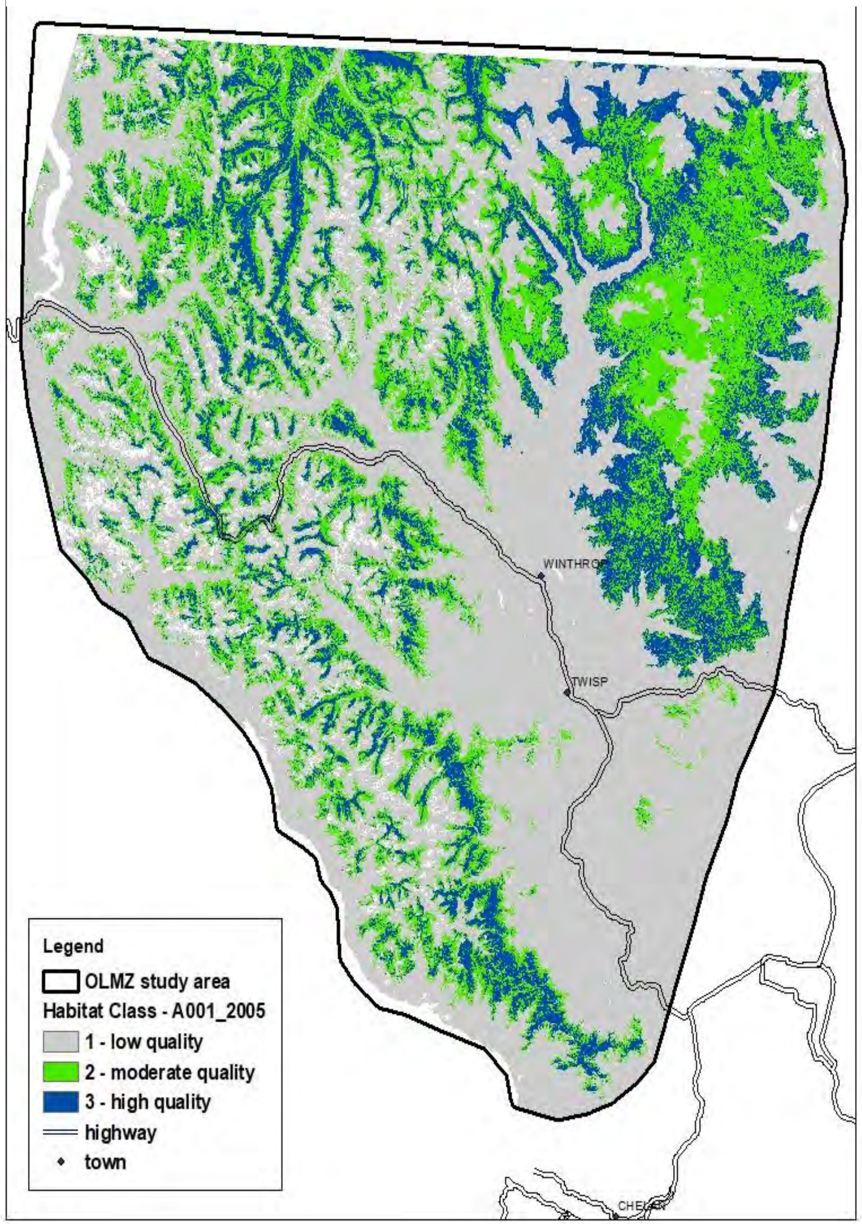
Fuelbed	LynxQualRank	LynxHabFunct
STM1211_DMC1A_OW03	0	Non
STM1212_DMC2A_OW10	1	Non
STM1213_DMC3A_OW17	10	Forage
STM1214_DMC4A_OW22	9	Forage
STM1215_DMC5A_OW28	8	Forage
STM1216_DMC6A_OW30	7	Den
STM1222_DMC2B_OW006	0	Non
STM1223_DMC3B_OW014	2	Other
STM1224_DMC4B_OW020	3	Other
STM1225_DMC5B_OW025	3	Forage
STM1226_DMC6B_OW030	3	Non
STM1231_DMC1C_OW006	0	Non
STM1232_DMC2C_OW012	0	Non
STM1233_DMC3C_OW018	1	Other
STM1234_DMC4C_OW023	1	Other
STM1235_DMC5C_OW028	2	Other
STM1236_DMC6C_OW030	2	Other
STM1244_DMC4D_OW020	2	Other
STM1245_DMC5D_OW025	3	Other
STM1246_DMC6D_OW030	3	Other
STM1511_CDC1A_OW073	0	Non
STM1512_CDC2A_OW074	10	Forage
STM1513_CDC3A_OW075	4	Other
STM1514_CDC4A_OW076	6	Forage
STM1515_CDC5A_OW078	5	Forage
STM1516_CDC6A_OW112	8	Den
STM1521_CDC1B_OW071	0	Non
STM1522_CDC2B_OW074	10	Forage
STM1523_CDC3B_OW075	6	Forage
STM1524_CDC4B_OW077	7	Forage
STM1525_CDC5B_OW112	8	Den
NON-PATHWAY FUELBEDS		
STM1111_NP1A_FCCS0	0	Non
STM1121_NP1B_OW582	0	Non
STM1111_NP1C_OW083	1	Other
STM1111_NP1D_FCCS224	5	Forage

Original 2000 Habitat Layer

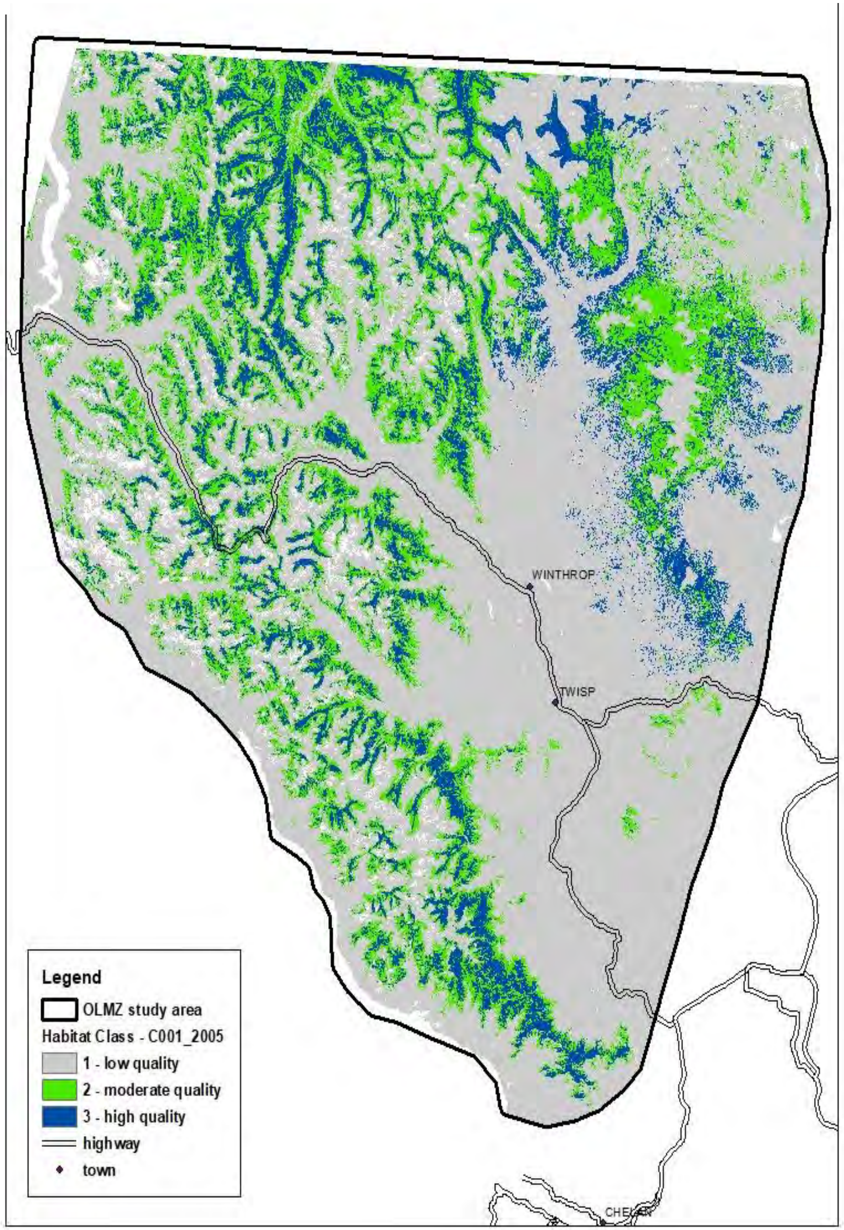


Habitat layers

Grow Out



Partial Suppression

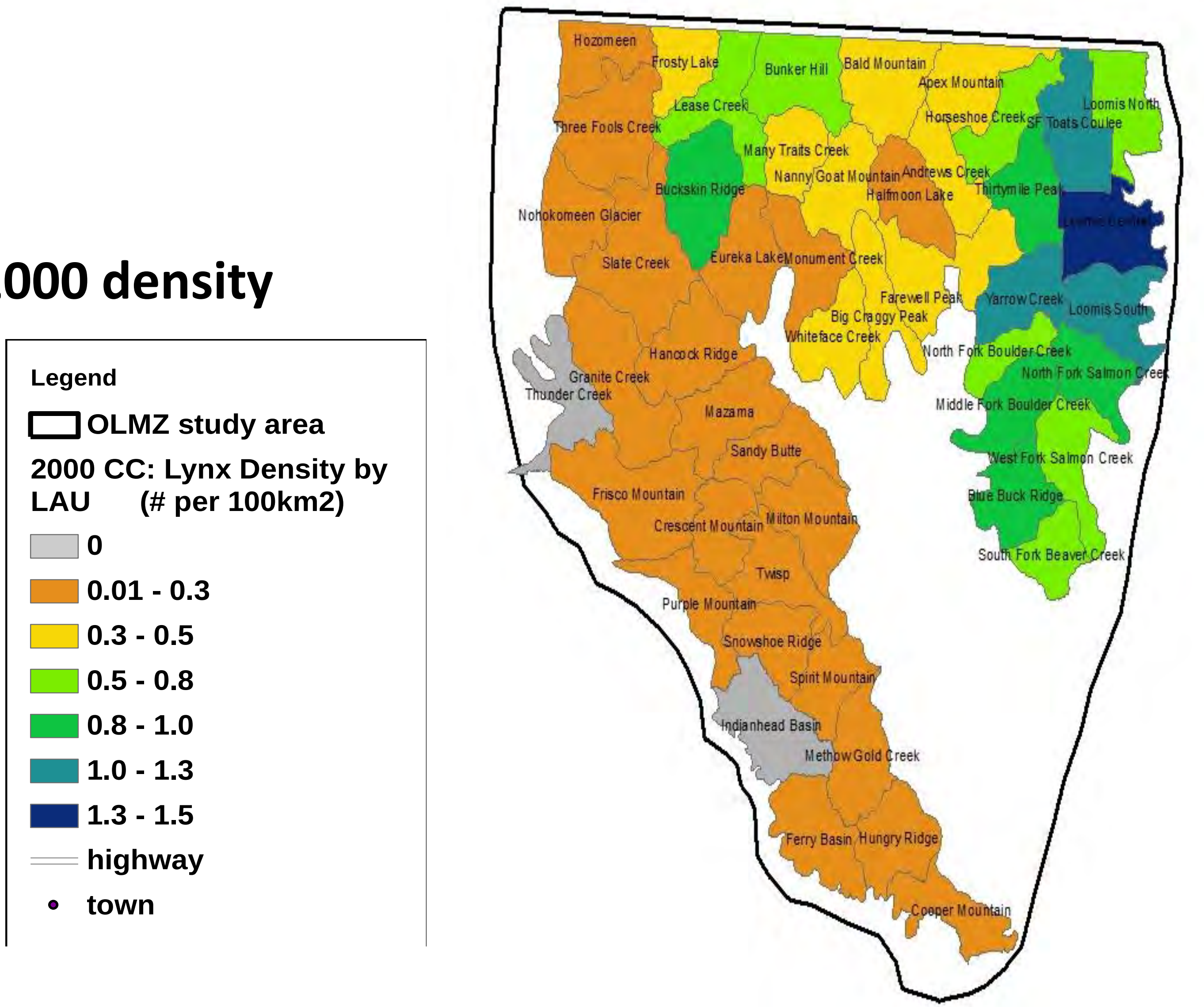


Canada Lynx Population Metrics for 2000 and Two Scenarios

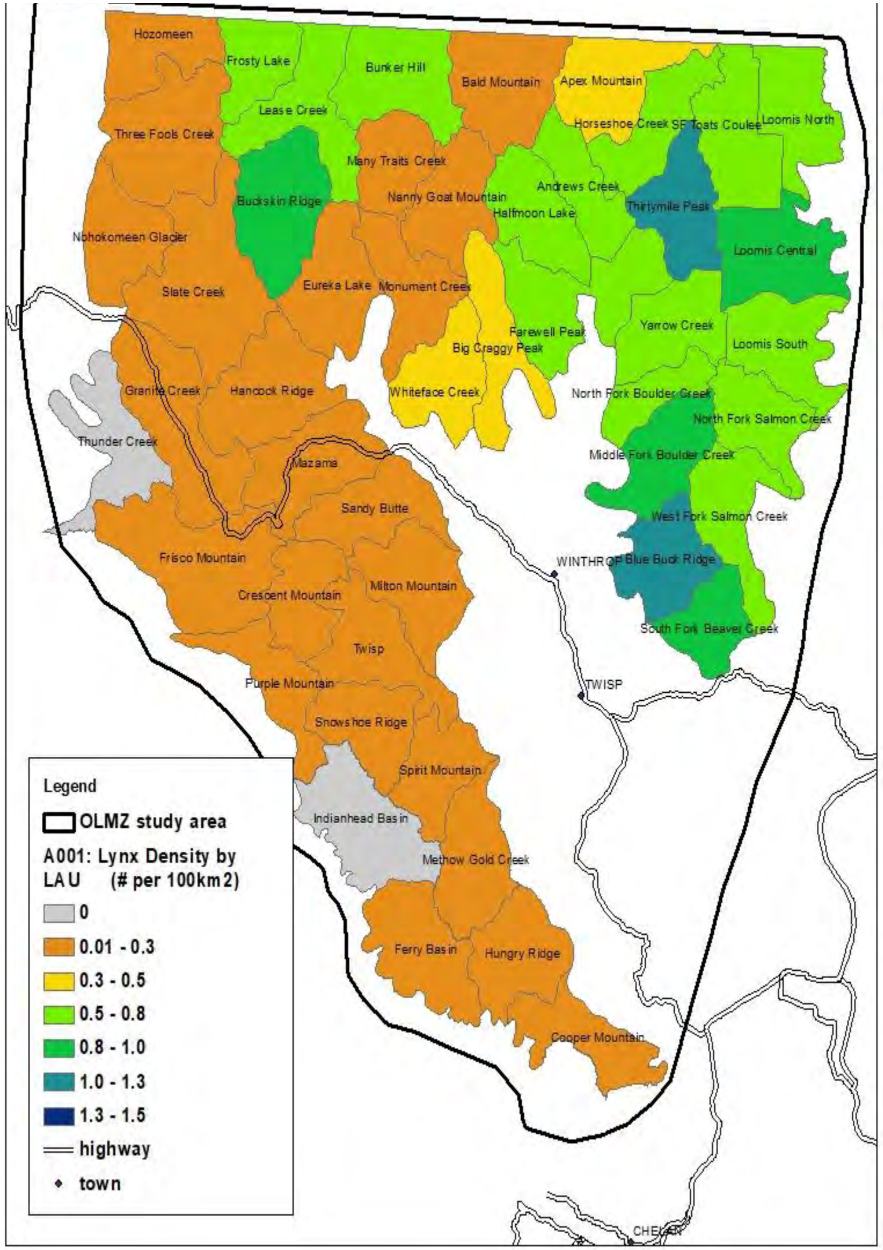
Scenario	Population Mean (total number of females)	Range	SE	Probability of persistence (n=25)
Original CC 2000	39	24-54	0.4	1.0
Grow Out	40	23-58	0.3	1.0
Partial Suppression	16	0-32	0.2	0.64

Spatial distribution of mean annual territorial female lynx density (# per 100 km^2) by LAU

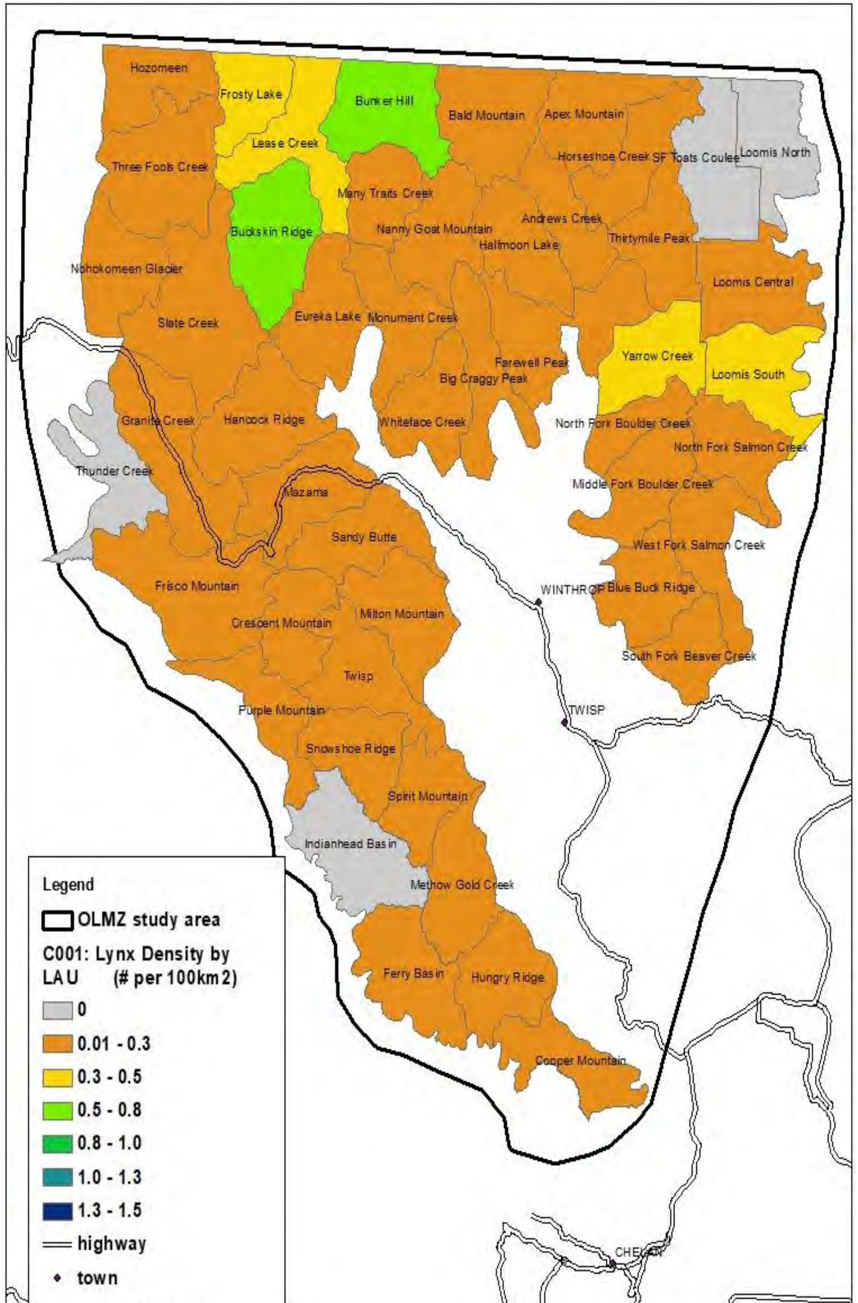
CC 2000 density



Grow Out



Partial Suppression



Summary and Next Steps

- Provides an Initial Linkage between Fire Models and Canada Lynx Carrying Capacity Models
  - Productive discussions between researchers, wildlife managers and fire managers
  - Inform landscape strategies
- Need to Refine and Automate the Steps from Fire/STM Modeled Vegetation to Lynx Habitat Quality to Carrying Capacity Estimates
  - Allow more simulations and more scenarios to be assessed
- Ultimately Provides a Tool to Show Managers the Trade-offs in how Various Management Scenarios Influence Lynx Habitat and Population
  - Much concern has been raised about the future of lynx in this area as a result of fires and climate change
  - Need to raise awareness in the conservation and science community
- Canada Lynx is One Example but Similar Approach Could be Used for Other Focal Species of Conservation Concern

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Summary –

- Proactive wildland fire management can reduce the likelihood of large-scale vegetation and fire regime shifts associated with large fires.
- **No fire** and **Full Suppression** scenarios represent "boom and bust" landscapes -- continuous mature forests (and lynx habitat) are capable of supporting large fire spread.
- **Managed wildfires** and **No Suppression** Scenarios have finer-grained patch mosaics and would potentially result in markedly different approaches to wildland fire management.

Management Applications –

1) **Wildlife habitat management in the context of fire**– habitat is dynamically generated and tied to burn mosaics

2) **Managed wildfires - I**mplications of managed fire scenarios for wildlife habitat (e.g., Canada Lynx)

3) **Climate change** – improving resilience of landscapes

4) **Carbon storage** – stabilizing carrying capacity of landscapes under varying wildfire scenarios

Next Steps

1) Correct historical ignitions on Tripod landscape
   (remove anthropogenic ignitions)

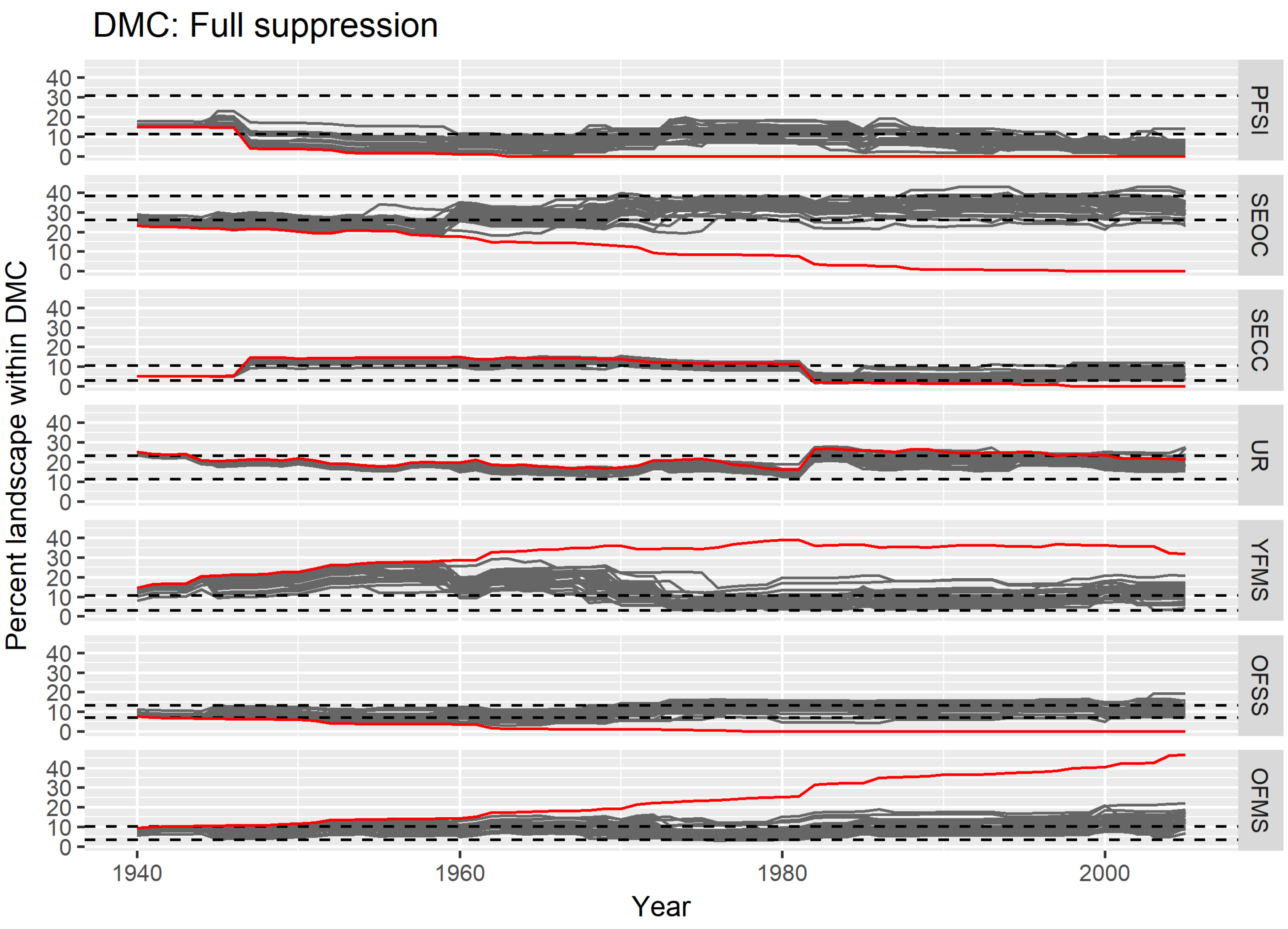
2) State and Transition Models
   (better syncing with Lynx habitat may be possible)

3) WFDSS training layers to explore management scenarios

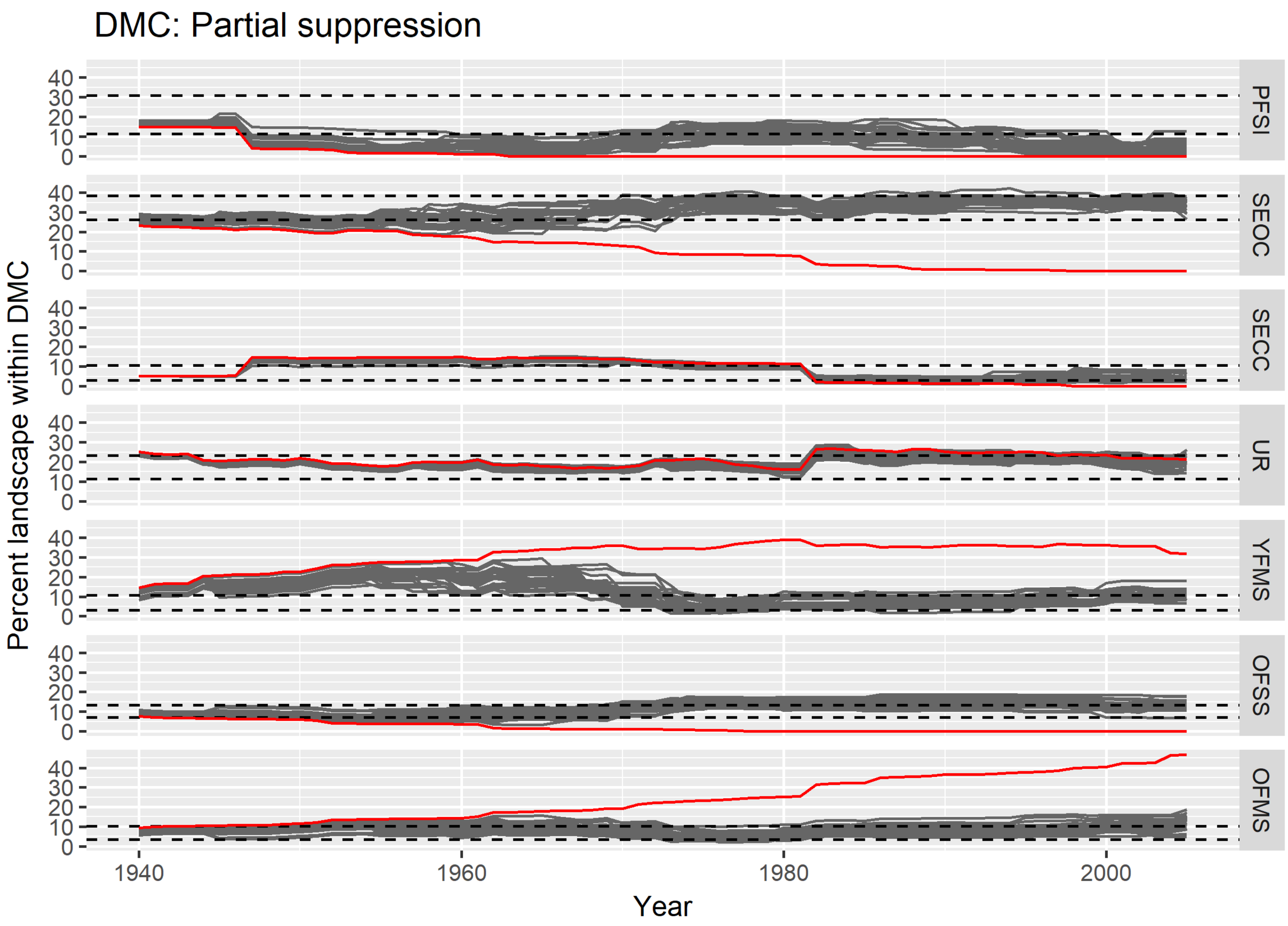
4) Climate change scenarios, what happens when 2006 is a moderate scenario?

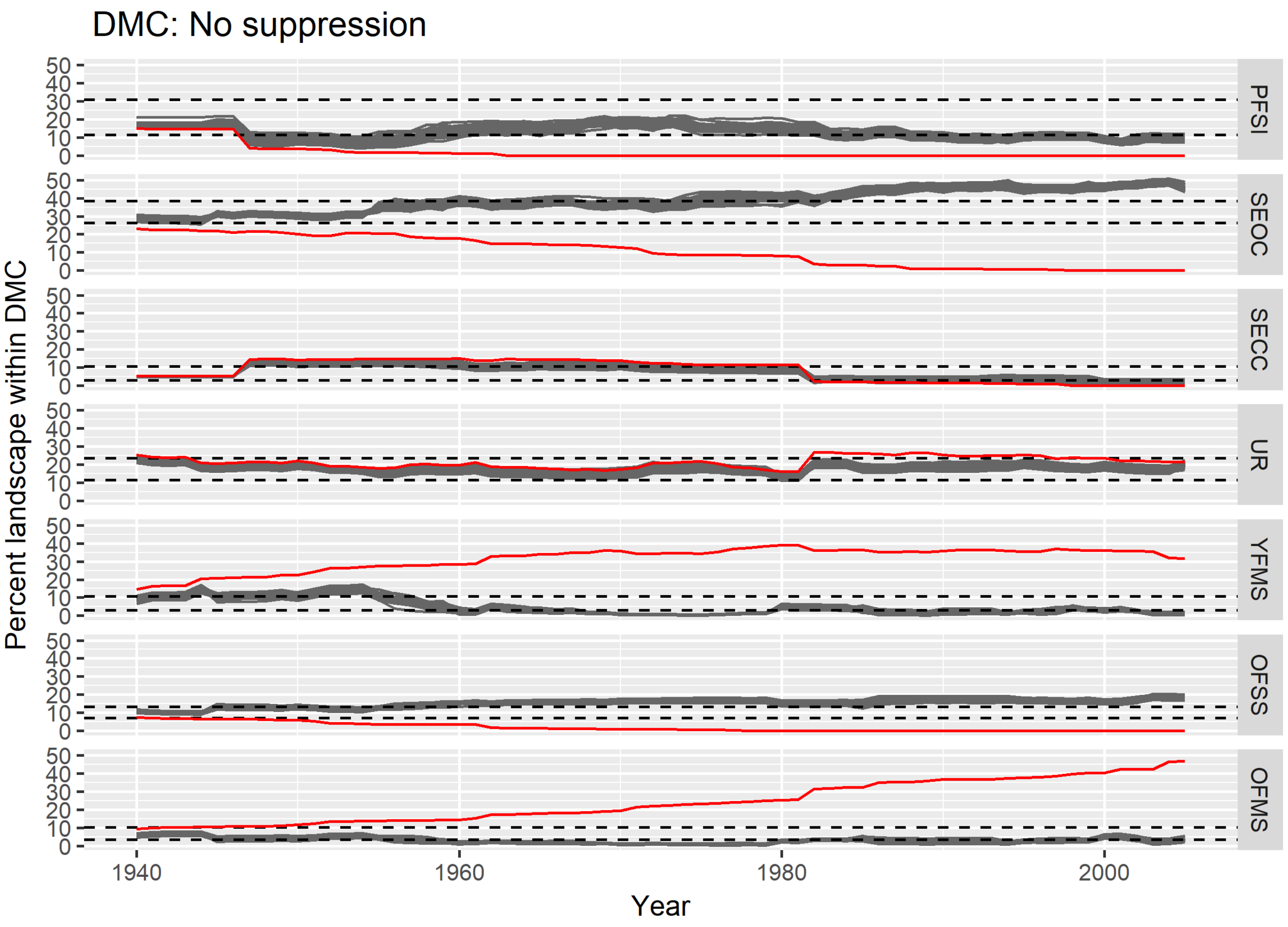
FEEDBACK?

EXTRA SLIDES

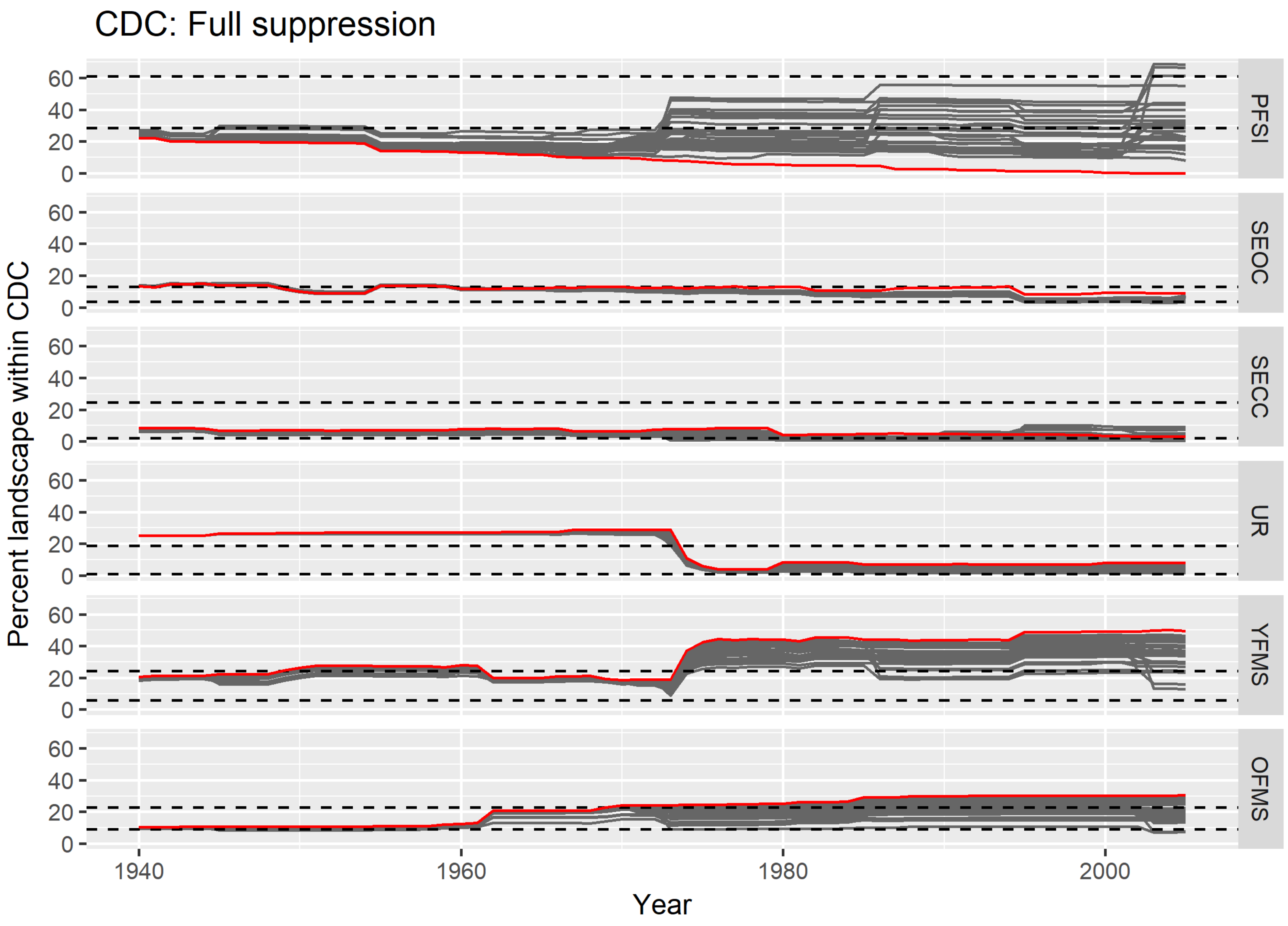


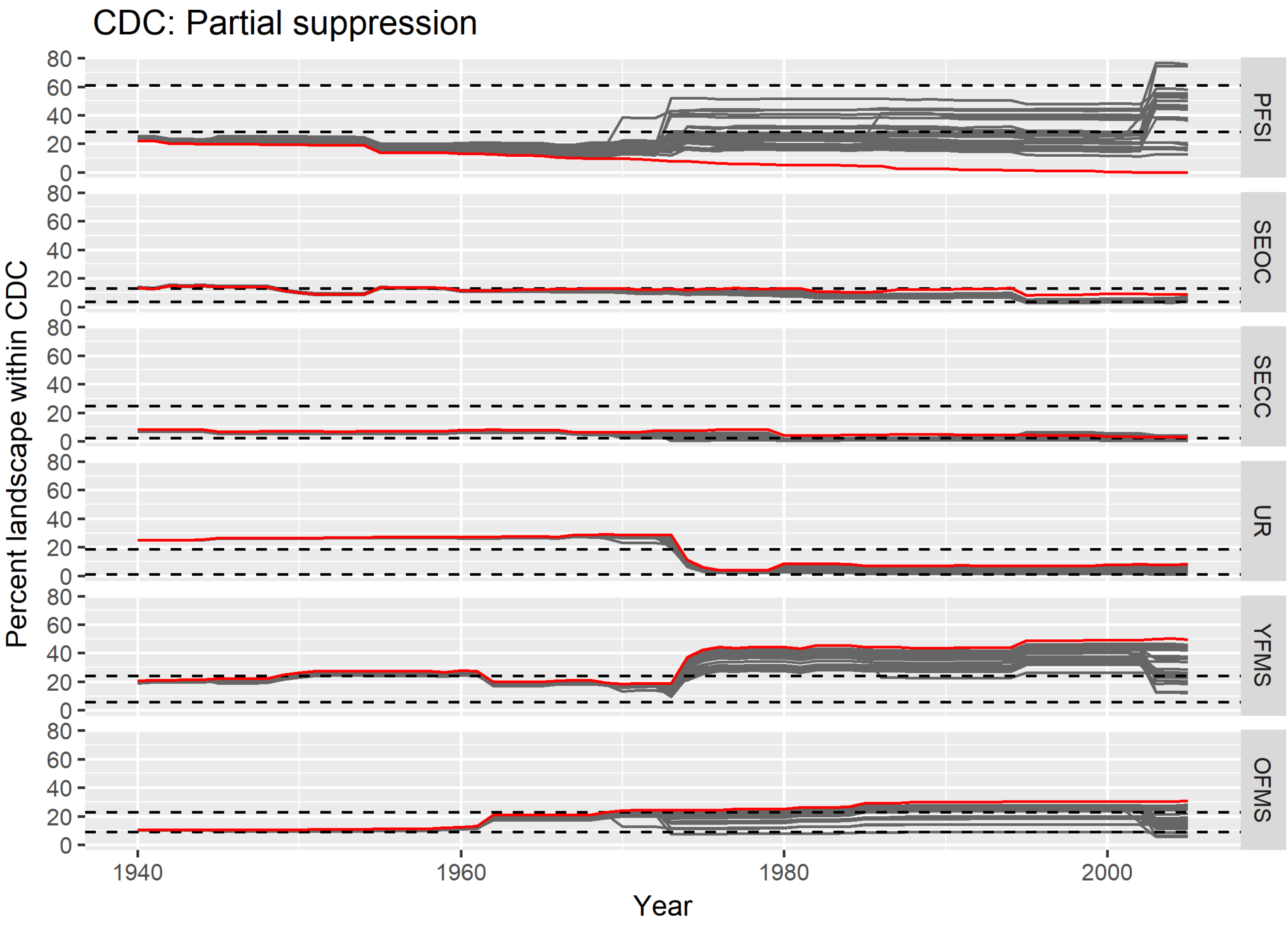
DMC: Full suppression
Percent landscape within DMC
PFSI
SEOC
SECC
UR
YFMS
OFSS
OFMS
0
10
20
30
40
1940
1960
1980
2000
Year

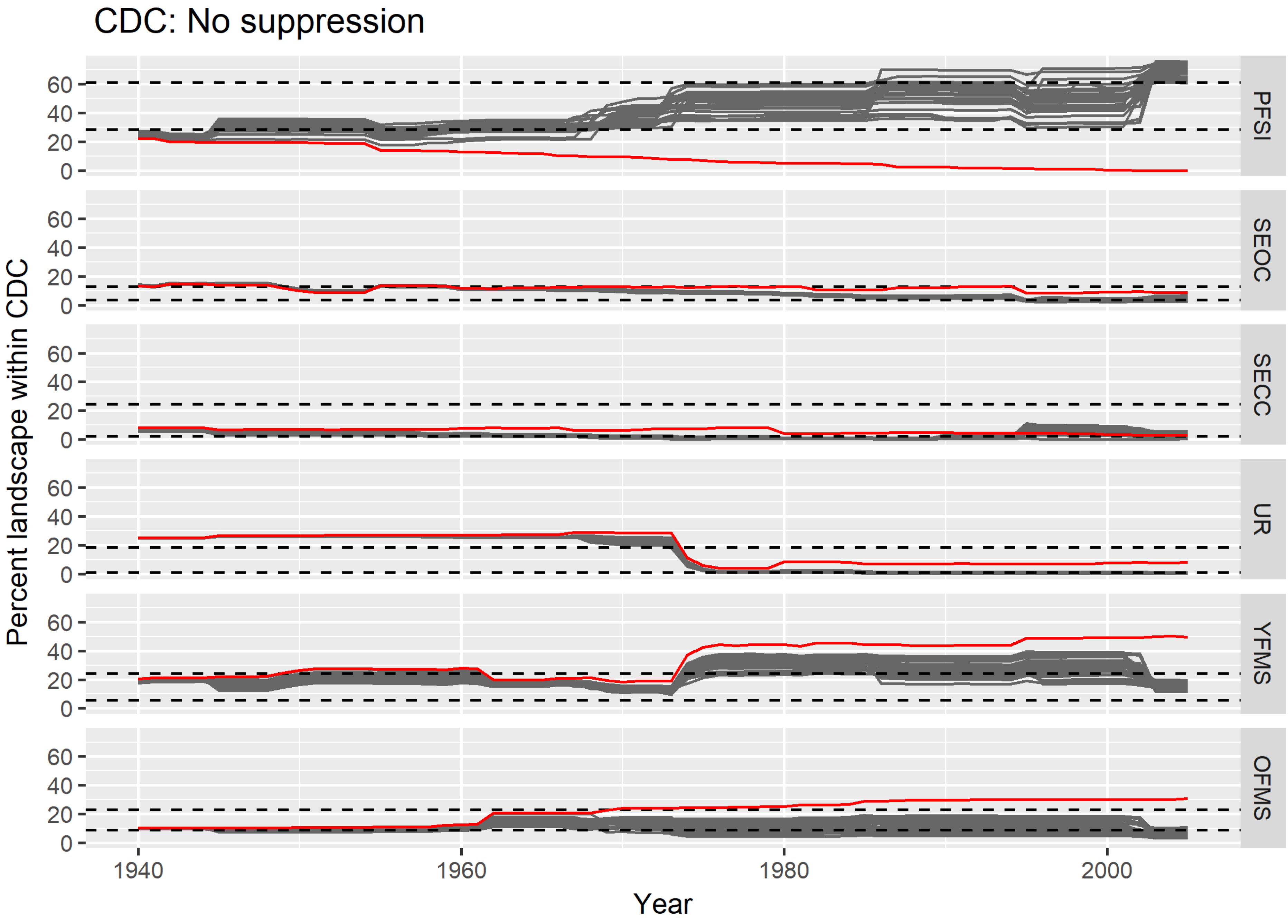

DMC: Partial suppression
Percent landscape within DMC
Year
1940
1960
1980
2000
0
10
20
30
40
PFSI
SEOC
SECC
UR
YFMS
OFSS
OFMS

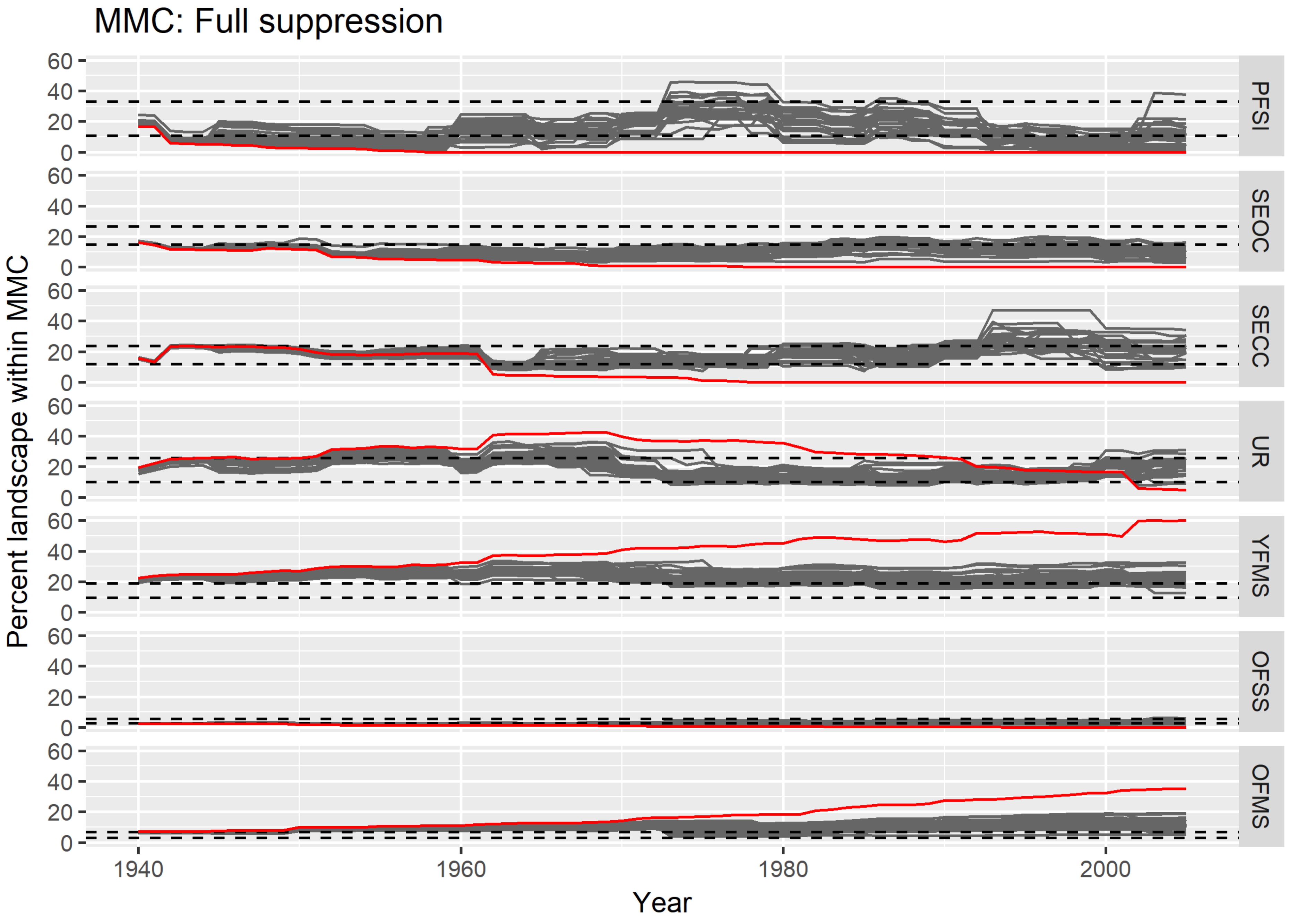


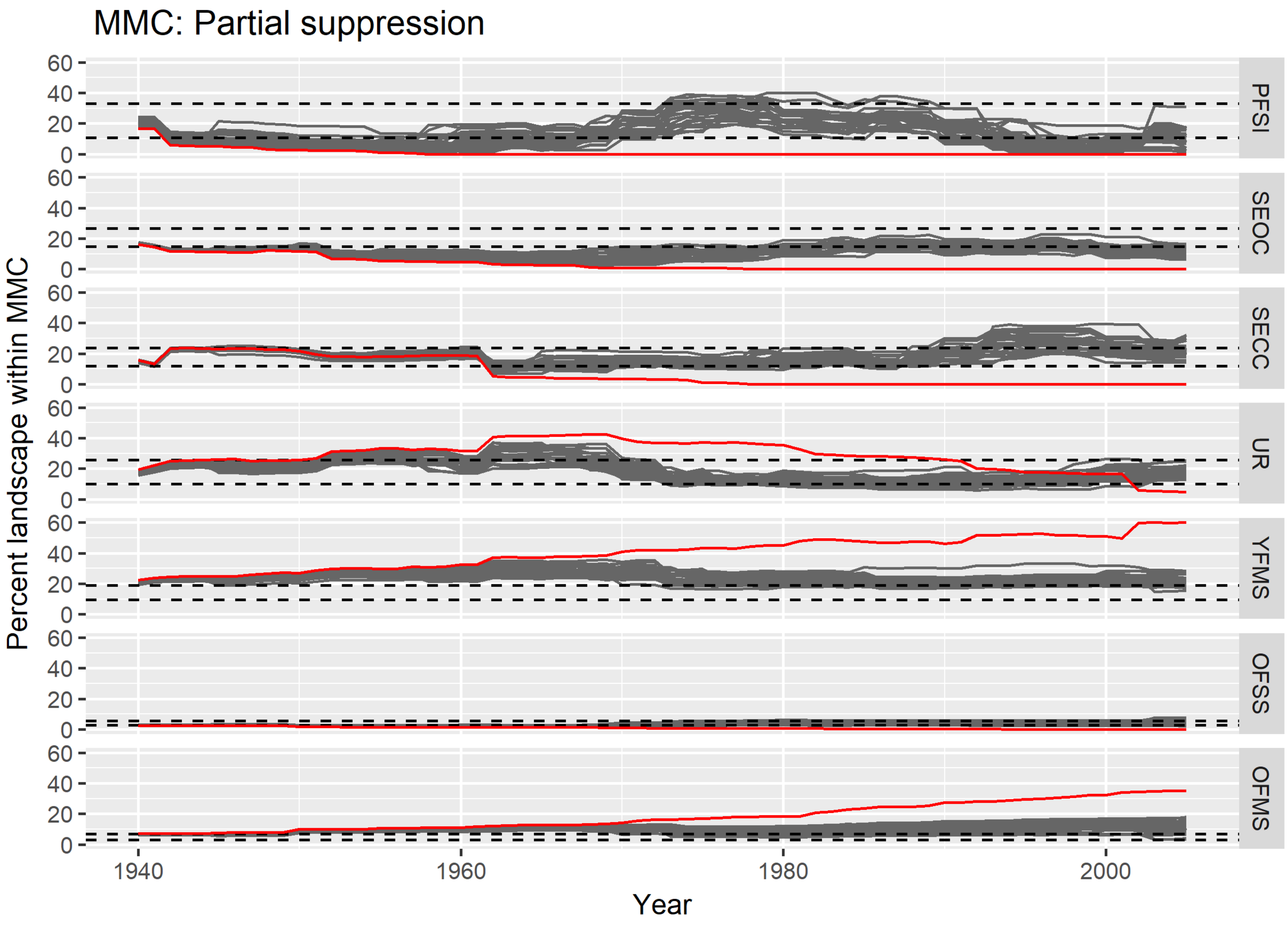
DMC: No suppression
Percent landscape within DMC
Year
PFSI
SEOC
SECC
UR
YFMS
OFSS
OFMS
0
10
20
30
40
50
1940
1960
1980
2000


CDC: Full suppression
Percent landscape within CDC
PFSI
SEOC
SECC
UR
YFMS
OFMS
0
20
40
60
1940
1960
1980
2000
Year

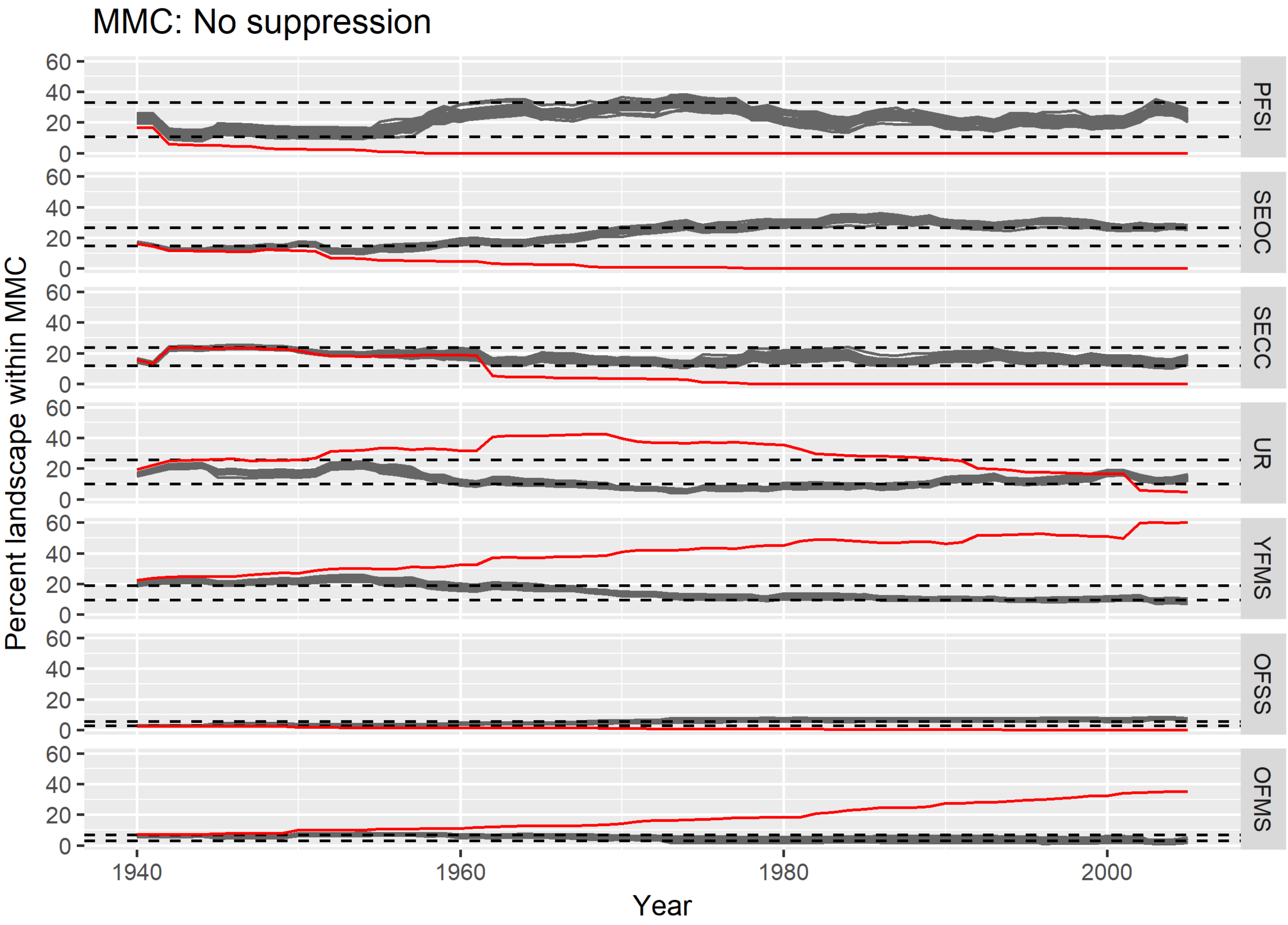

CDC: Partial suppression
Percent landscape within CDC
Year
1940
1960
1980
2000
0
20
40
60
80
PFSI
SEOC
SECC
UR
YFMS
OFMS

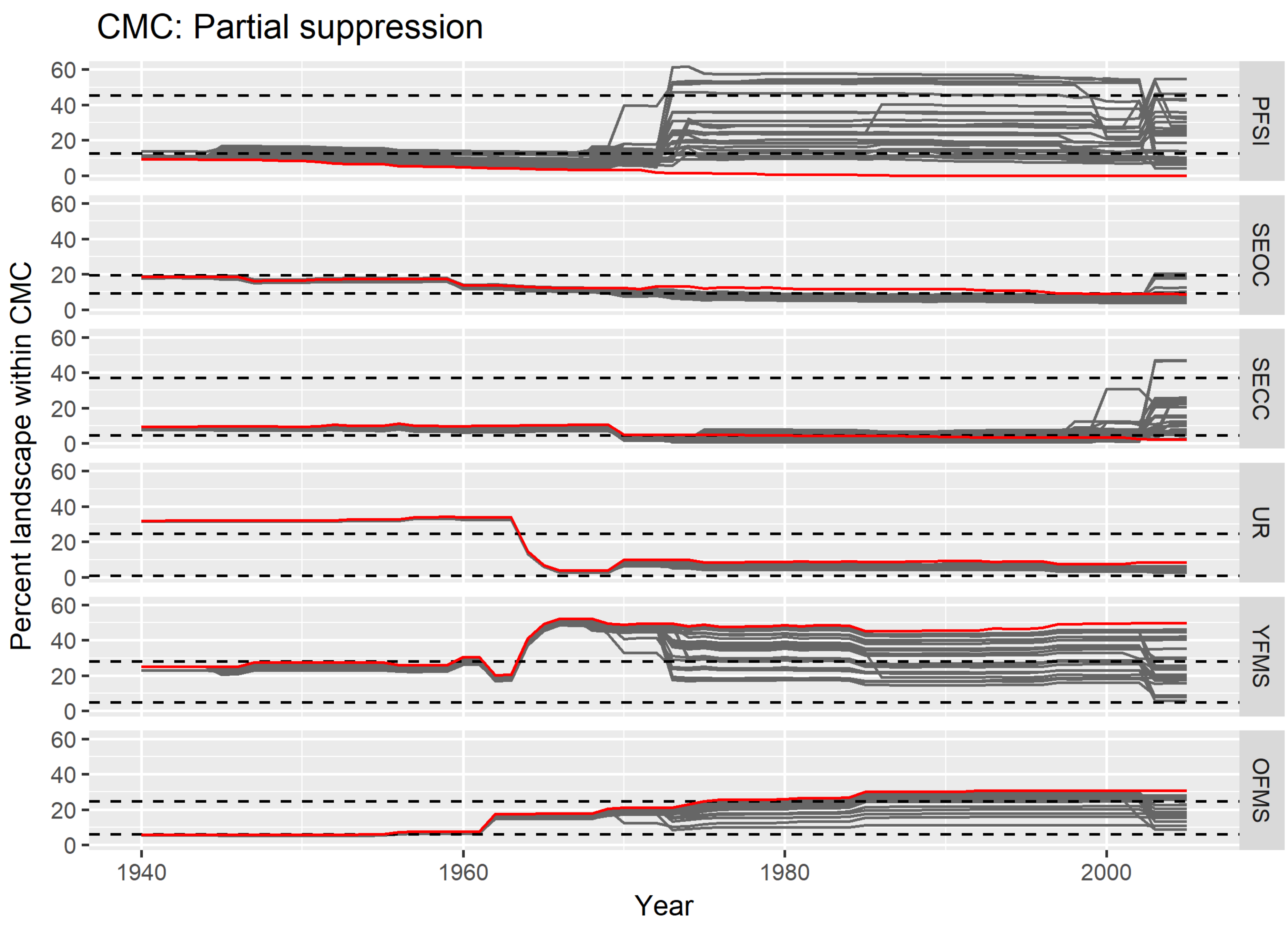

CDC: No suppression
Percent landscape within CDC
PFSI
SEOC
SECC
UR
YFMS
OFMS
0
20
40
60
1940
1960
1980
2000
Year


MMC: Full suppression
Percent landscape within MMC
Year
PFSI
SEOC
SECC
UR
YFMS
OFSS
OFMS
60
40
20
0
1940
1960
1980
2000

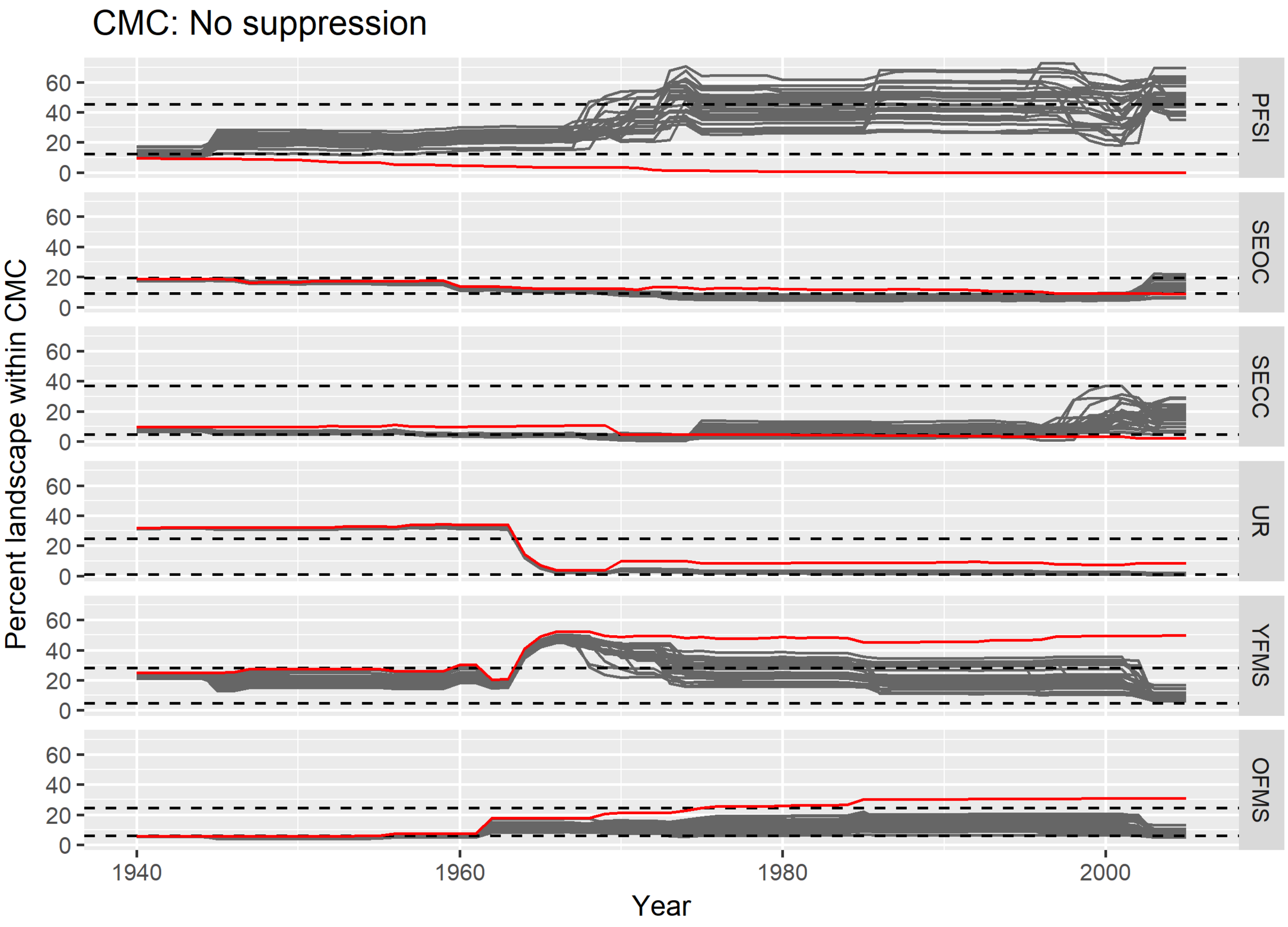


MMC: Partial suppression
Percent landscape within MMC
Year
PFSI
SEOC
SECC
UR
YFMS
OFSS
OFMS
0
20
40
60
1940
1960
1980
2000


MMC: No suppression
Percent landscape within MMC
Year
PFSI
SEOC
SECC
UR
YFMS
OFSS
OFMS
0
20
40
60
1940
1960
1980
2000



CMC: Partial suppression
Percent landscape within CMC
Year
PFSI
SEOC
SECC
UR
YFMS
OFMS
0
20
40
60
1940
1960
1980
2000



CMC: No suppression
Percent landscape within CMC
Year
PFSI
SEOC
SECC
UR
YFMS
OFMS
0
20
40
60
1940
1960
1980
2000