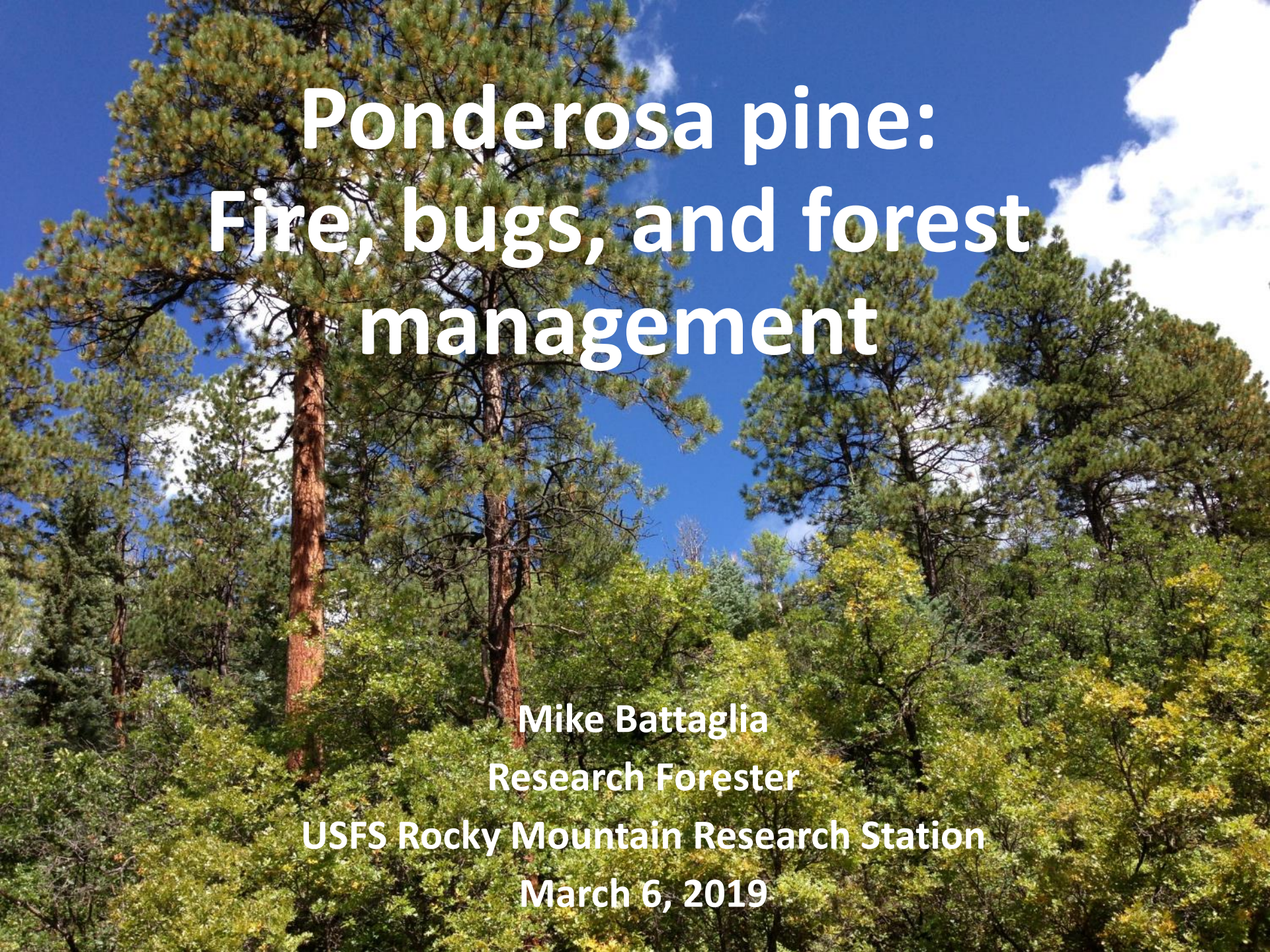
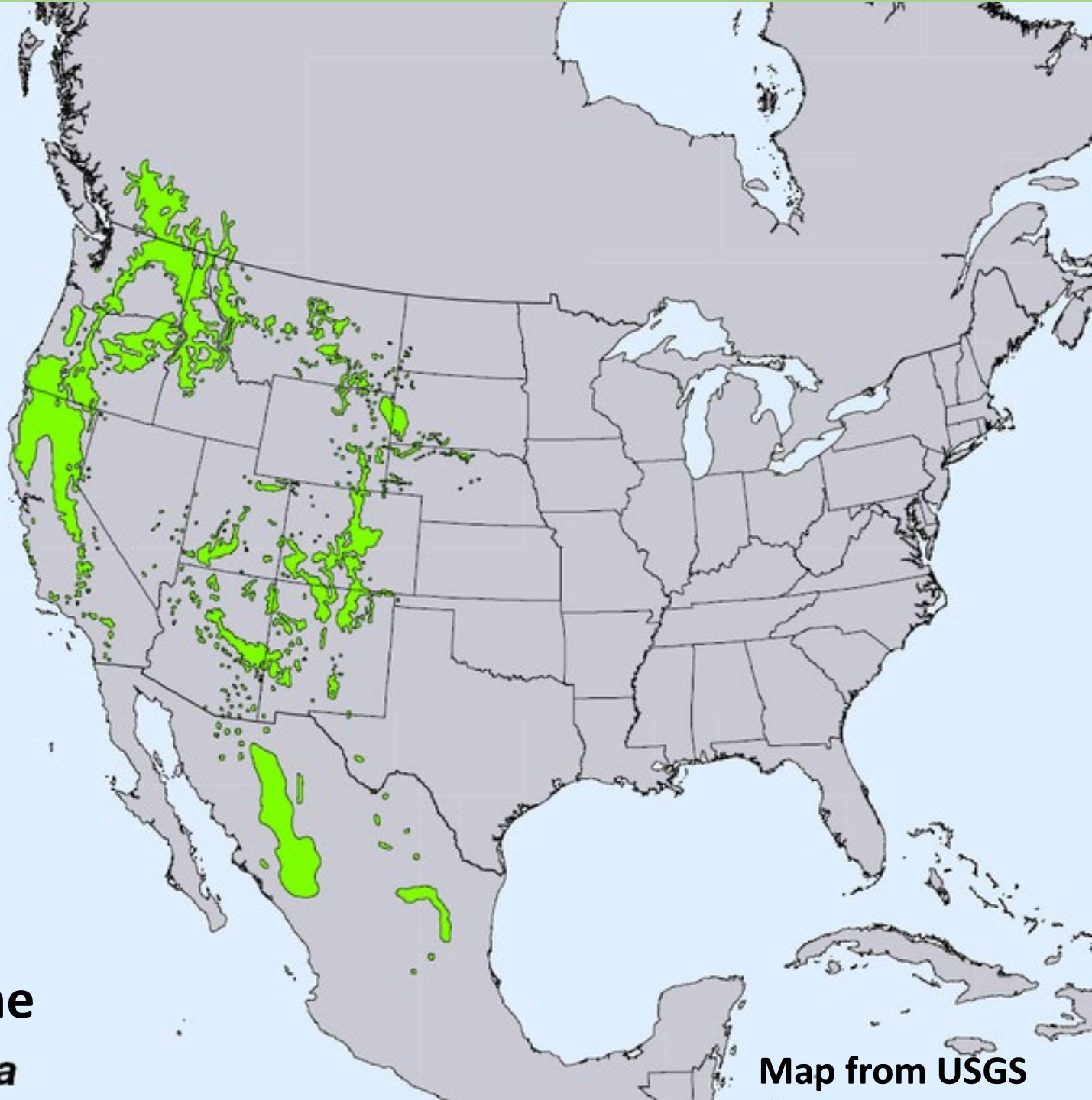


Ponderosa pine: Fire, bugs, and forest management

Mike Battaglia
Research Forester
USFS Rocky Mountain Research Station
March 6, 2019



Ponderosa Pine

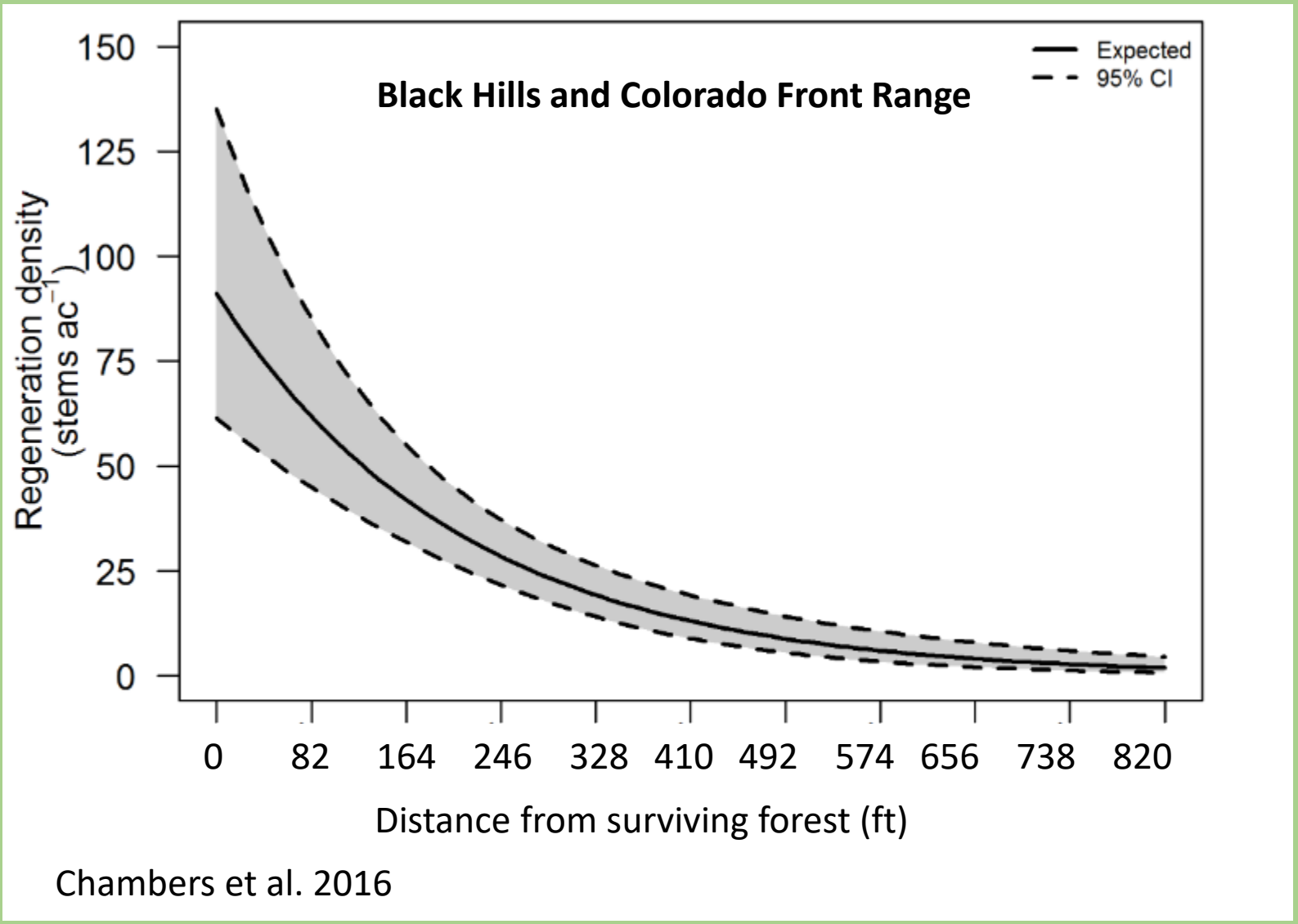
Pinus ponderosa

Map from USGS

Ponderosa pine life history traits

- **Non-serotinous, non-sprouting, short lived in seed bank**
- **Seed production episodic**
- **Evolved in low-moderate severity fires, with smaller burn patches than exist today**
- **Requires dispersal from existing seed sources**

http://upload.wikimedia.org/wikpedia/commons/a/a5/Pinus_ponderosa_brachyptera_seed.jpg,
http://3.bp.blogspot.com/-
http://tchester.org/plants/analysis/pinus/pix/SnGb_islip/Pinus_jeffreyi_Pinus_ponderosa_seed_1_crop_70.jpg
,

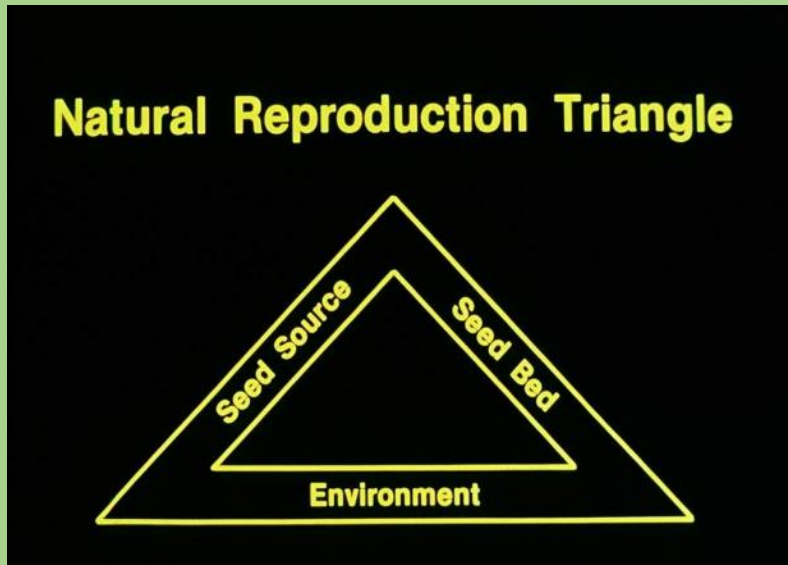


Chambers et al. 2016

Ponderosa pine regeneration density decreases as you get further from a live tree source

Ponderosa pine seedling establishment and growth

- Bare Mineral soil
- Sufficient moisture
- Avoid frost damage and high surface temperatures
- Shade intolerant
- Doesn’t compete well with grasses, Gambel Oak, and other trees



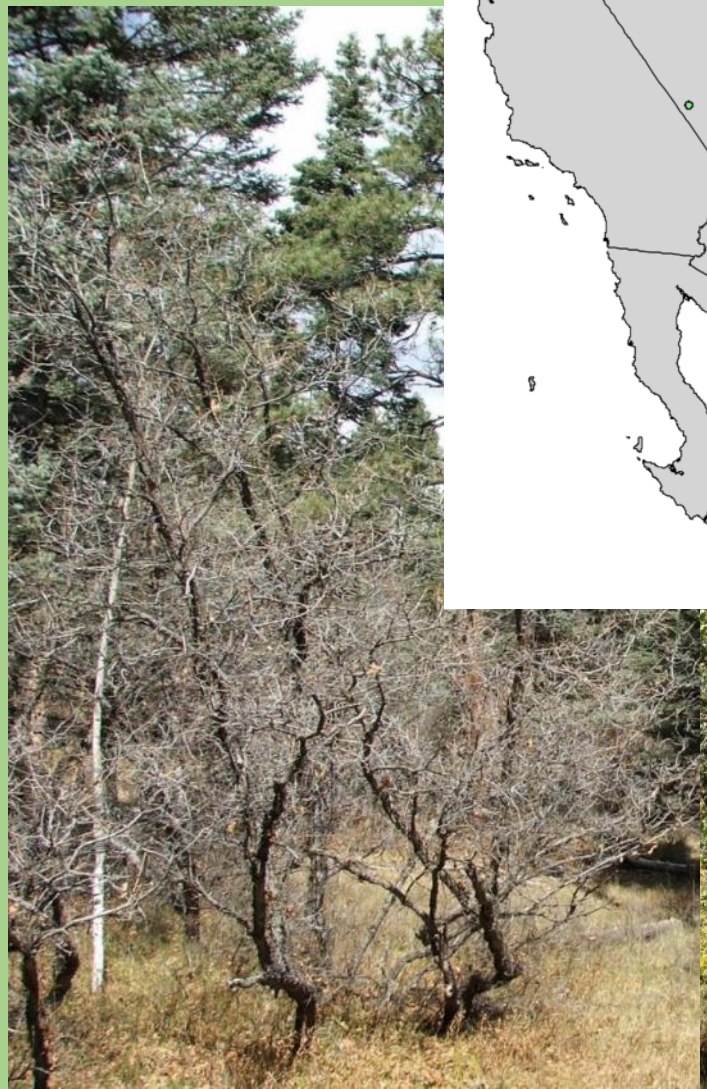
Ponderosa pine and fire adaptations

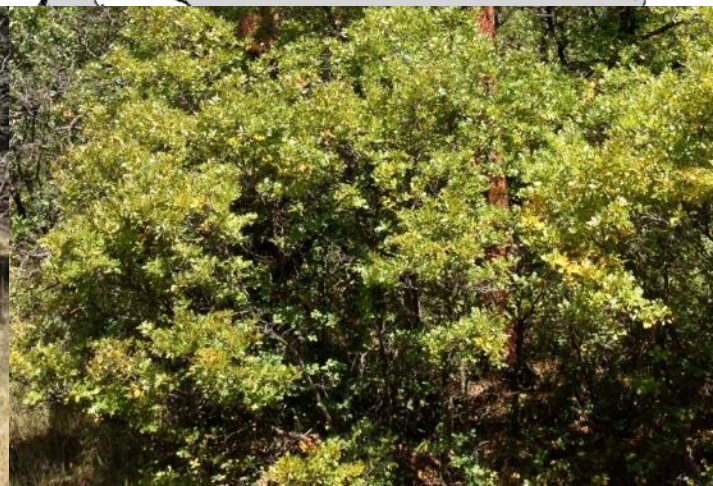
- Thick Bark, open crown, tall crown base height, large buds
- Seedlings are susceptible to fire

MAY 19 2006

Gambel Oak

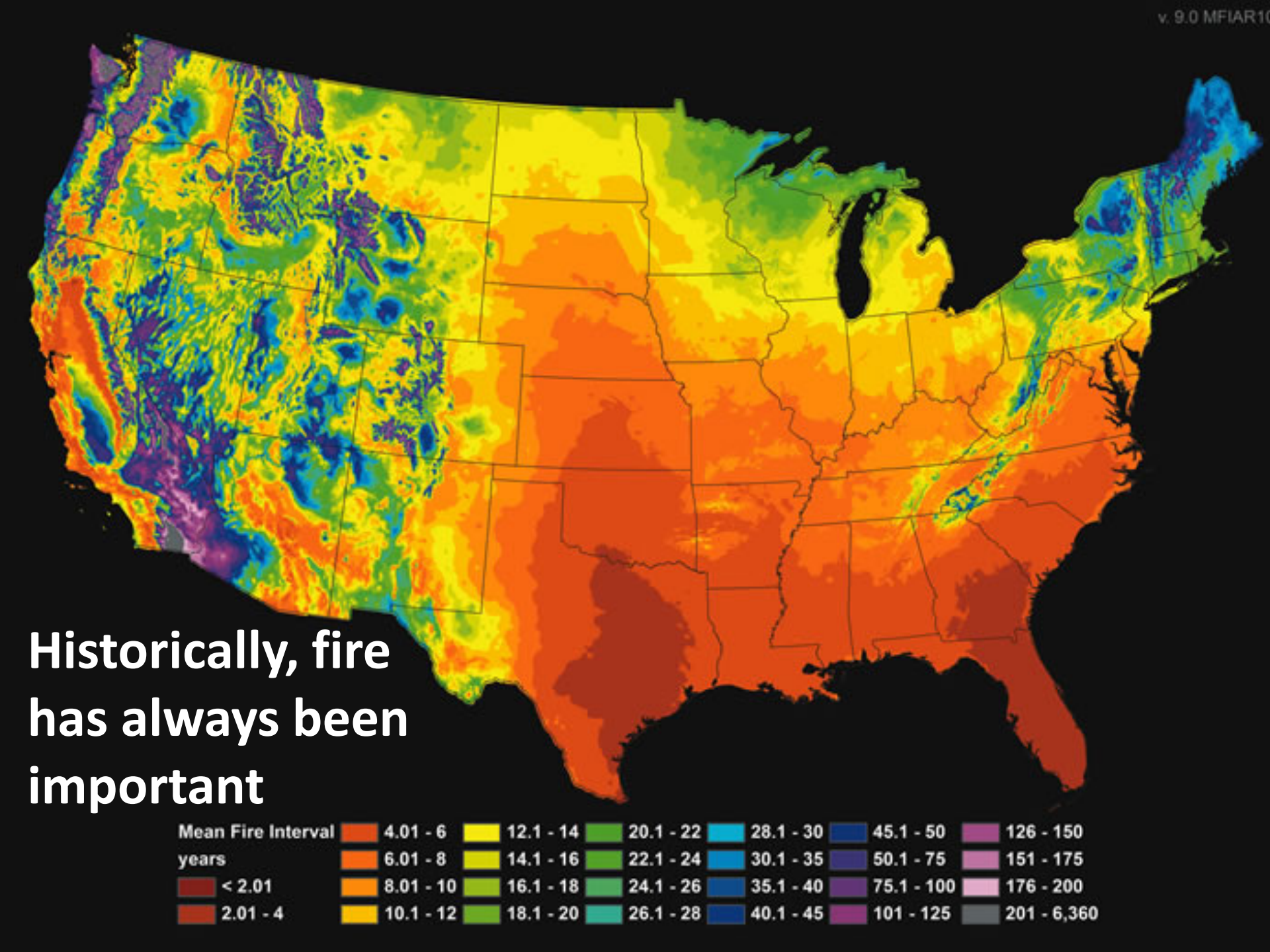
- Small tree or shrub
- Deciduous
- Acorn or sprouts





Gambel Oak and fire adaptations

- Thin bark and low resistance to fire, but RESPROUTS!


v. 9.0 MFIAR1
Historically, fire has always been important
Mean Fire Interval
years
< 2.01
2.01 - 4
4.01 - 6
6.01 - 8
8.01 - 10
10.1 - 12
12.1 - 14
14.1 - 16
16.1 - 18
18.1 - 20
20.1 - 22
22.1 - 24
24.1 - 26
26.1 - 28
28.1 - 30
30.1 - 35
35.1 - 40
40.1 - 45
45.1 - 50
50.1 - 75
75.1 - 100
101 - 125
126 - 150
151 - 175
176 - 200
201 - 6,360

Fire Severity: As defined by amount of tree mortality during a fire

100

Percent of landscape canopy mortality

0

Surface fire
Mainly surface fuels involved in fire spread across landscape

Passive crown fire
Patches of stand torching but fire spread mainly through surface fuels

Active crown fire
Mainly aerial fuels involved in fire spread across landscape

Historical Fire Regime in Ponderosa pine

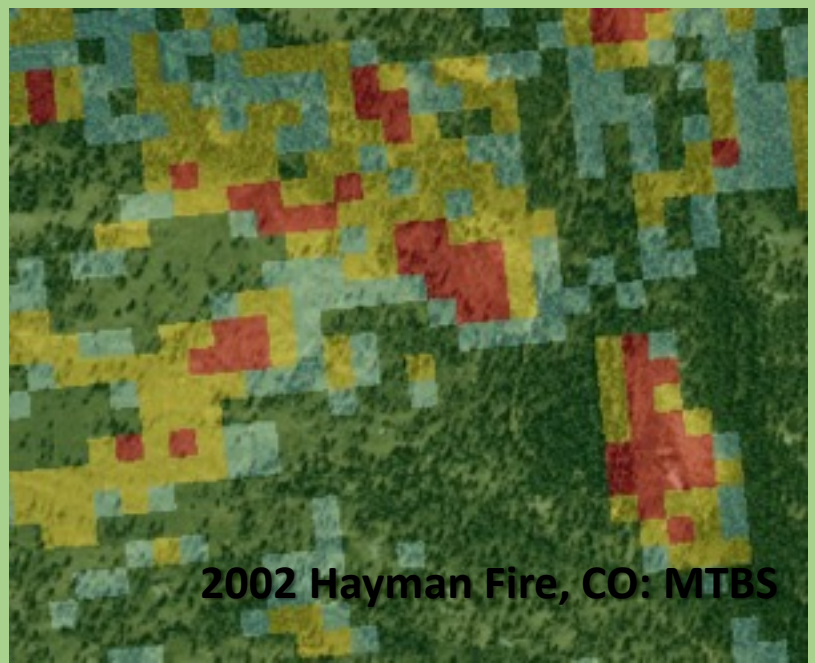
1) High frequency, low-moderate severity wildfires

- **Includes low and moderate severity burns**
- **Commonly associated with lower elevations**

Historical Fire Regime in Ponderosa pine

2) Mixed frequency and severity wildfires

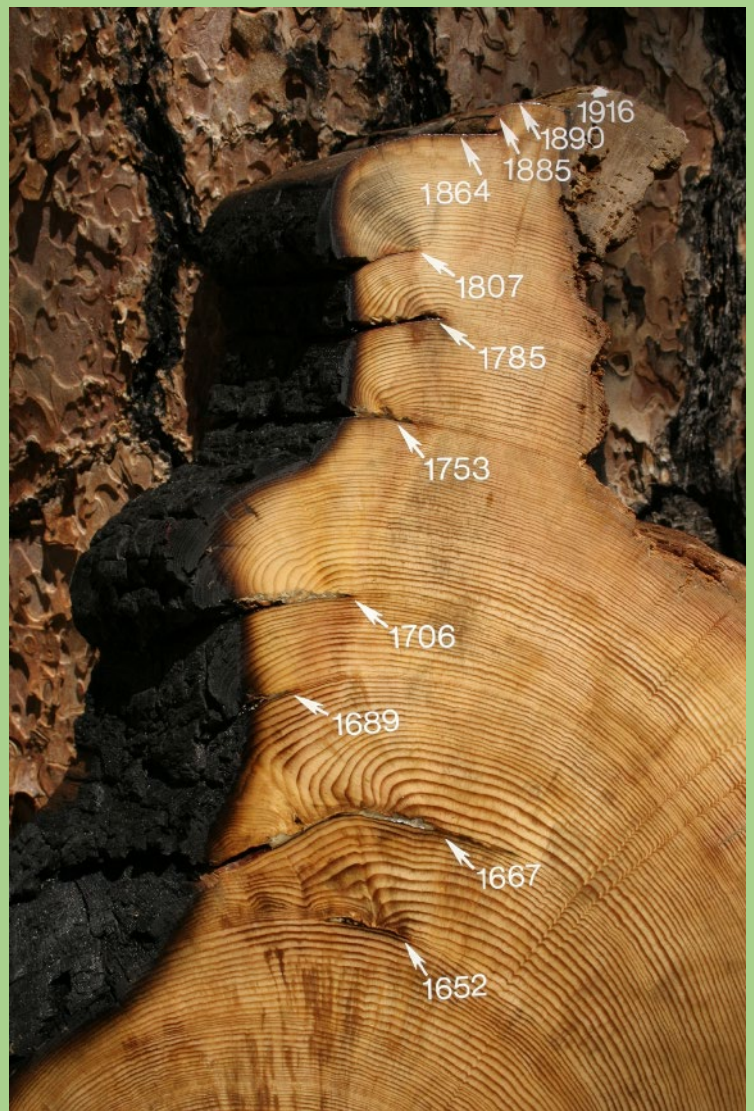
- **Includes low, moderate, and high severity burn patches**
- **Associated with higher elevations and mixed conifer forests**



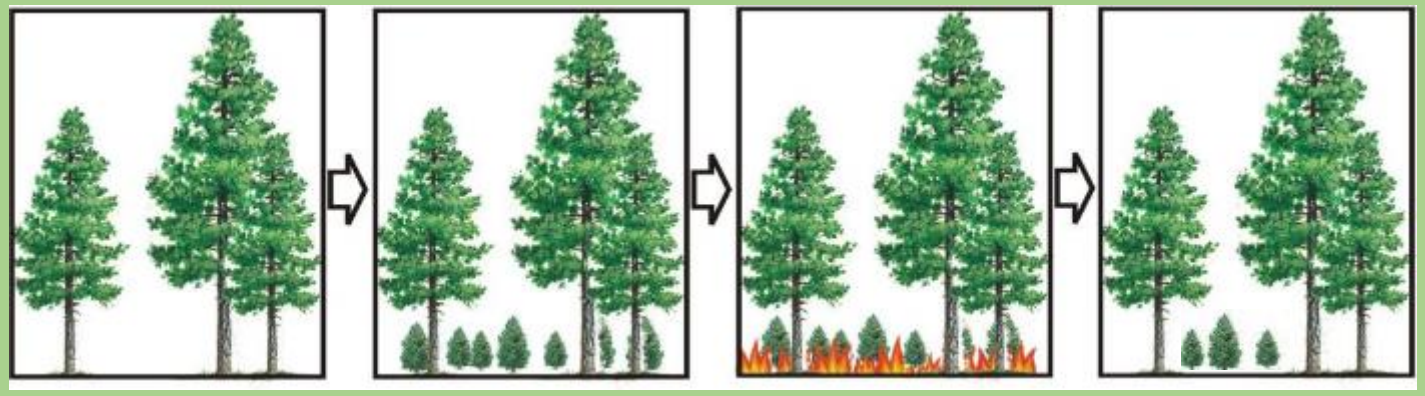
2002 Hayman Fire, CO: MTBS

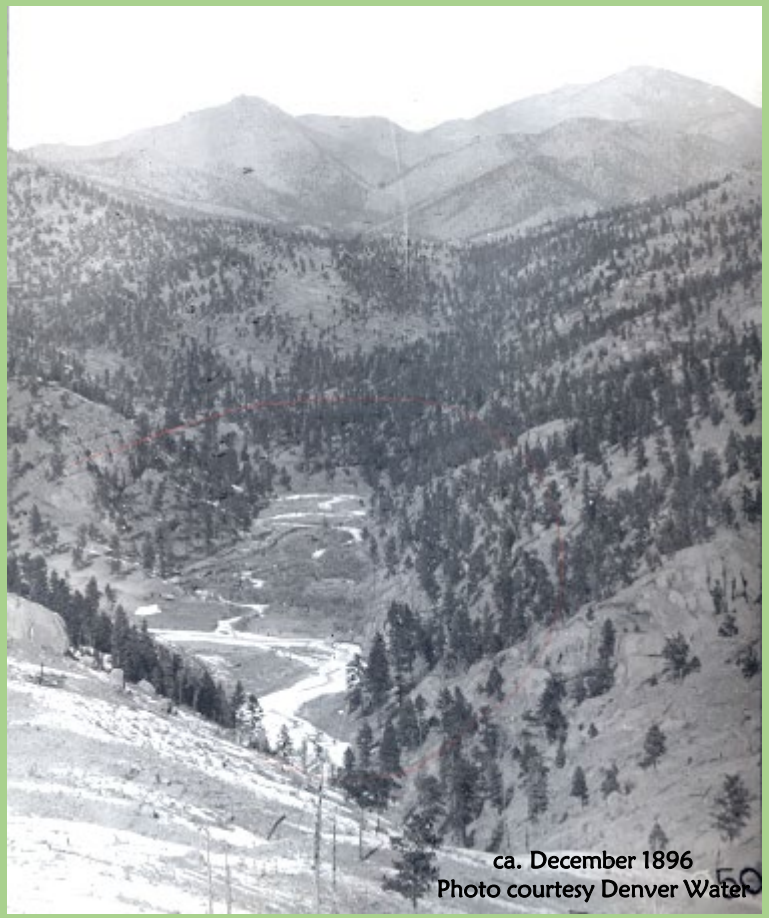
Fire frequency in ponderosa pine forests varies with region

- Southwest (AZ, NM): 5 to 23 yrs
- Eastern Cascades (OR, WA): 3 to 38 yrs
- Black Hills (SD): 10 to 35 yrs
- CO Front Range: 7 to 64 yrs
- CO San Juans: 16 to 38 yrs



Historically, wildfires helped regulate forest structure and fuels





ca. December 1896
Photo courtesy Denver Water

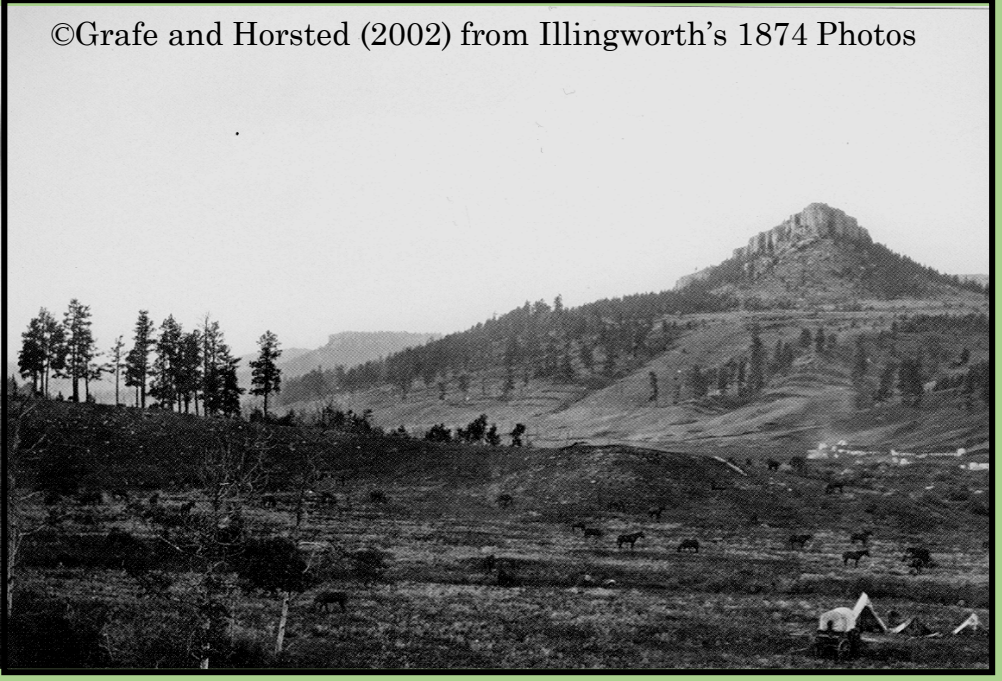
December 1896
Photo courtesy Denver Water

Southwest

San Francisco Peak ~1904

Eastern Cascades, Oregon and Washington

A. FOREST OF YELLOW PINE.



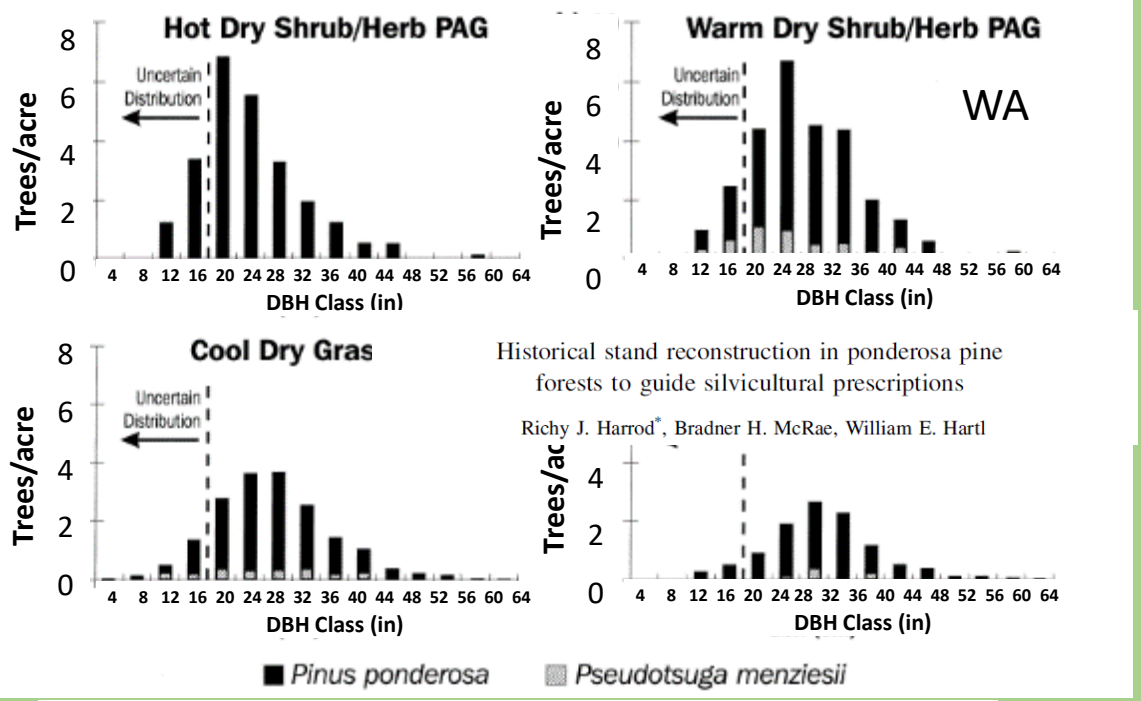
"Forest continuity was broken by fire…"

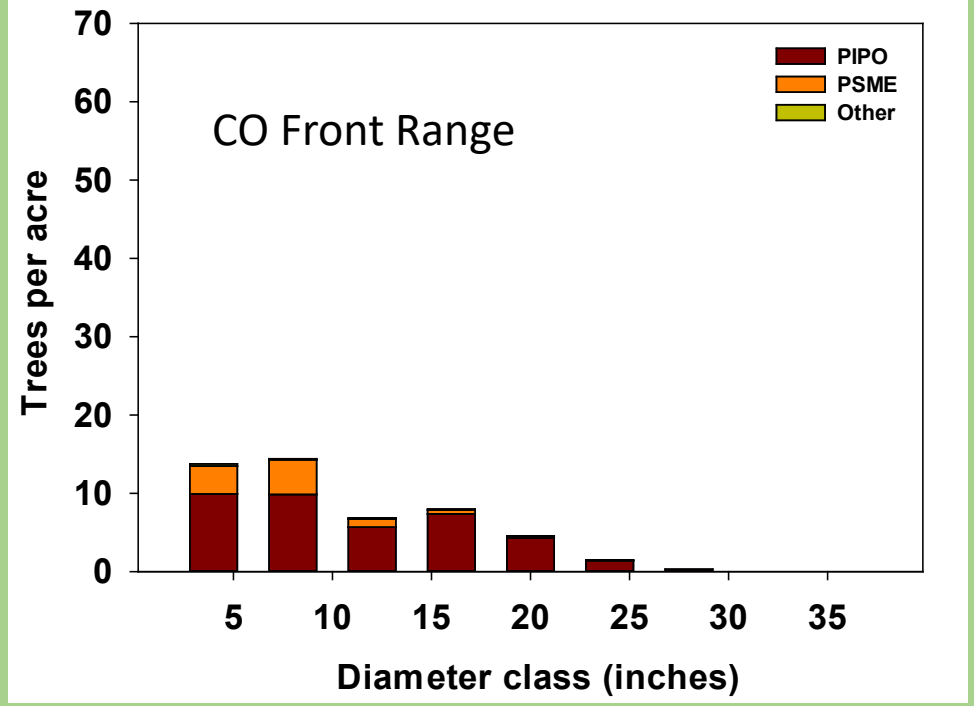
(Graves 1899) Black Hills, SD

©Grafe and Horsted (2002) from Illingworth's 1874 Photos

Historical Tree Density

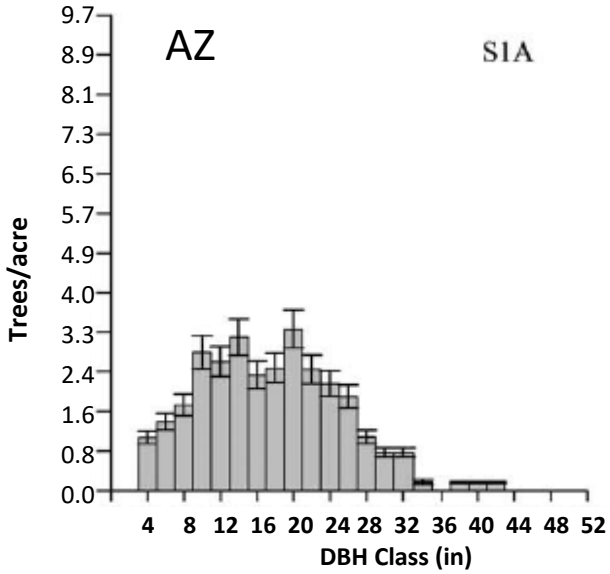
Region	Basal Area (ft2/acre)	Trees per acre
Southwest (AZ, NM)	22 to 90	15 to 124
Eastern Cascades (OR)	48 to 125	13 to 51
Eastern Cascades (WA)	45 to 97	11 to 25
Black Hills (SD)	0 to 240	0 to 287
Front Range LM	0 to 87	0 to 241
Front Range UM	3 to 147	2 to 311

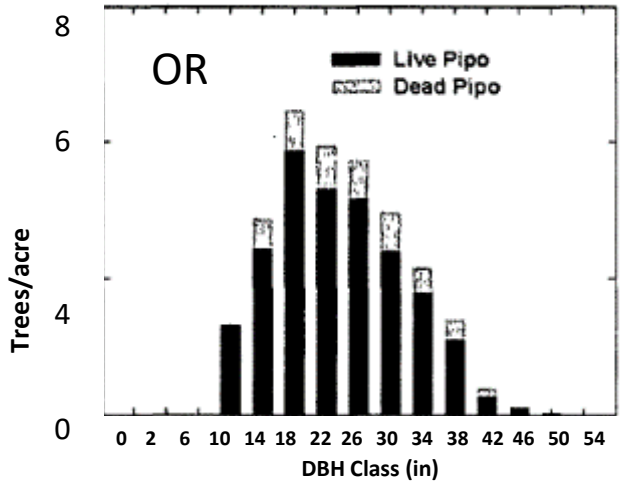




Historical Stem-Mapped Permanent Plots Increase Precision of Reconstructed Reference Data in Ponderosa Pine Forests of Northern Arizona

Andrew J. Sánchez Meador,[1,2,3] Pablo F. Parysow,[1] and Margaret M. Moore[1]





Stand structure in eastside old-growth ponderosa pine forests of Oregon and northern California

Andrew Youngblood[a,*], Timothy Max[b], Kent Coe[a]

Pearson Natural Area, Arizona

circa 1909

Showing grass-forb matrix and spacing and interspersion of VSS groups, ponderosa pine

Grass/forb

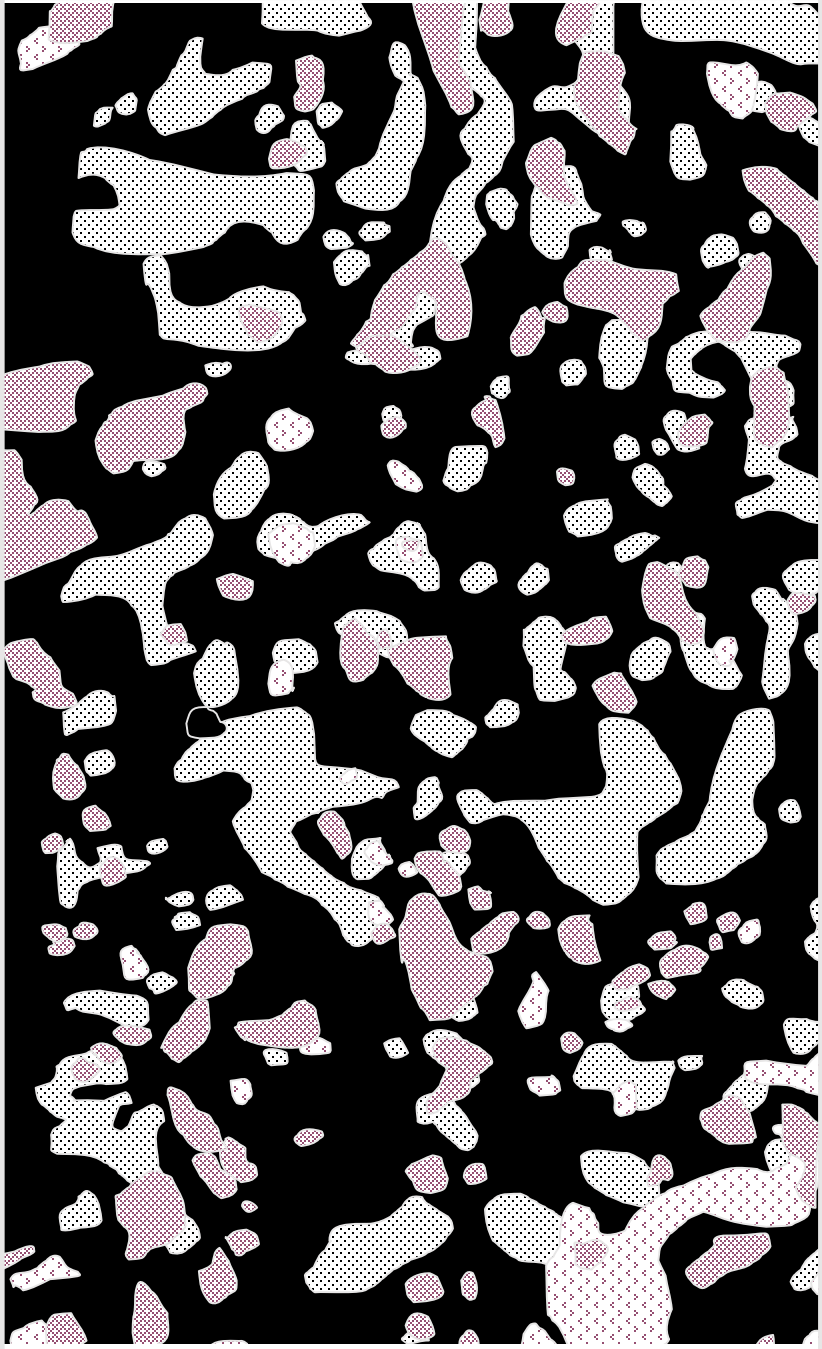
Blackjack
80-200 years

Poles
25-80 years

Yellow pine
200+ years

0 100 200 300

Scale - feet



Southwest Ponderosa Pine
Uneven-aged forest with interspersion of tree groups of different ages

Southwestern Ponderosa Pine Groups, openings, and single trees

Reynolds et al (*2013)*

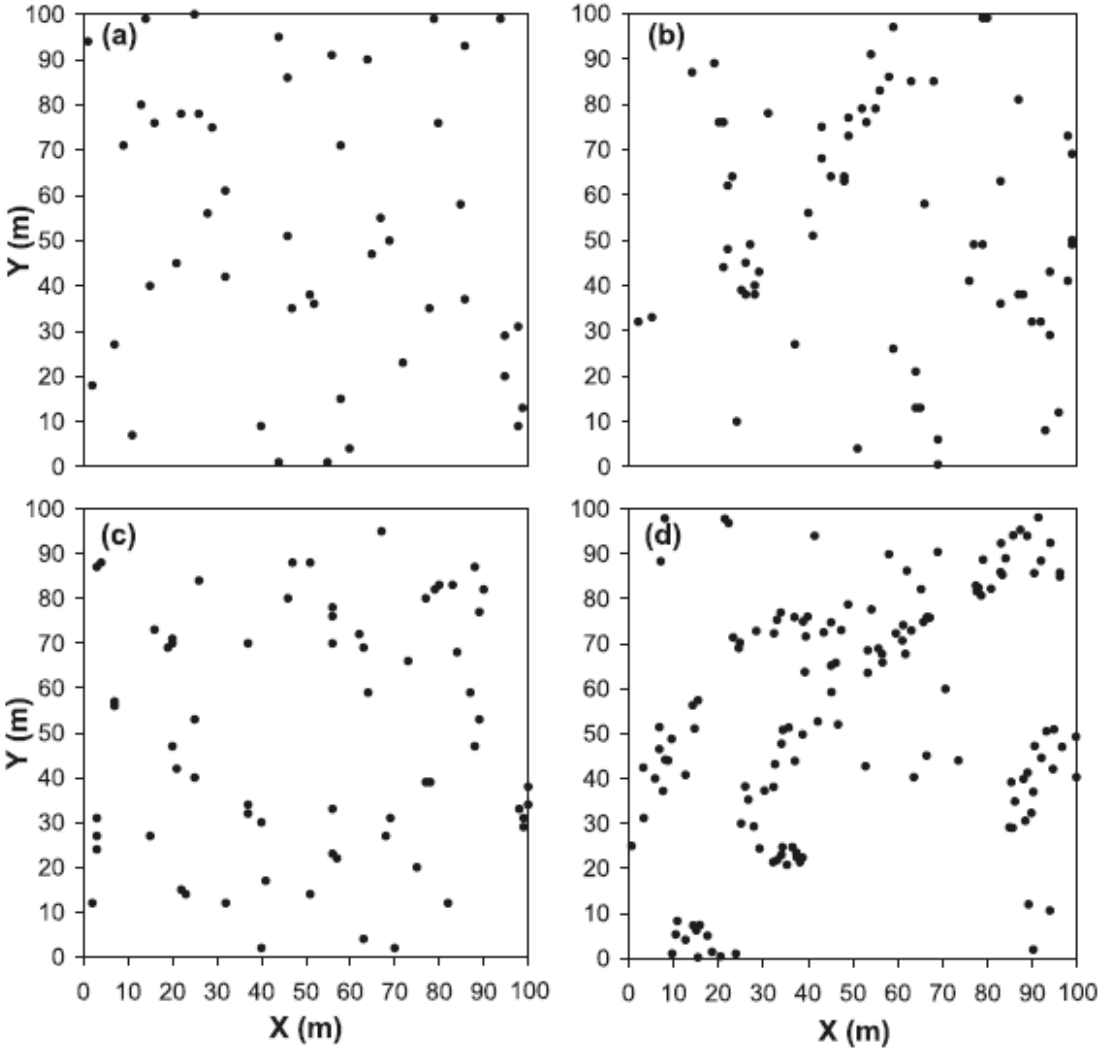
Spatial variation in reference conditions: historical tree density and pattern on a *Pinus ponderosa* landscape

Can. J. For. Res. 39: 2391–2403 (2009)

Scott R. Abella and Charles W. Denton

Fig. 4. Examples of distributions of historical trees for individual sites in four ecosystem types: (*a*) black cinder, (*b*) mesic limestone, (*c*) rocky basalt, and (*d*) mesic basalt. Graphs correspond to spatial statistics in Fig. 5.

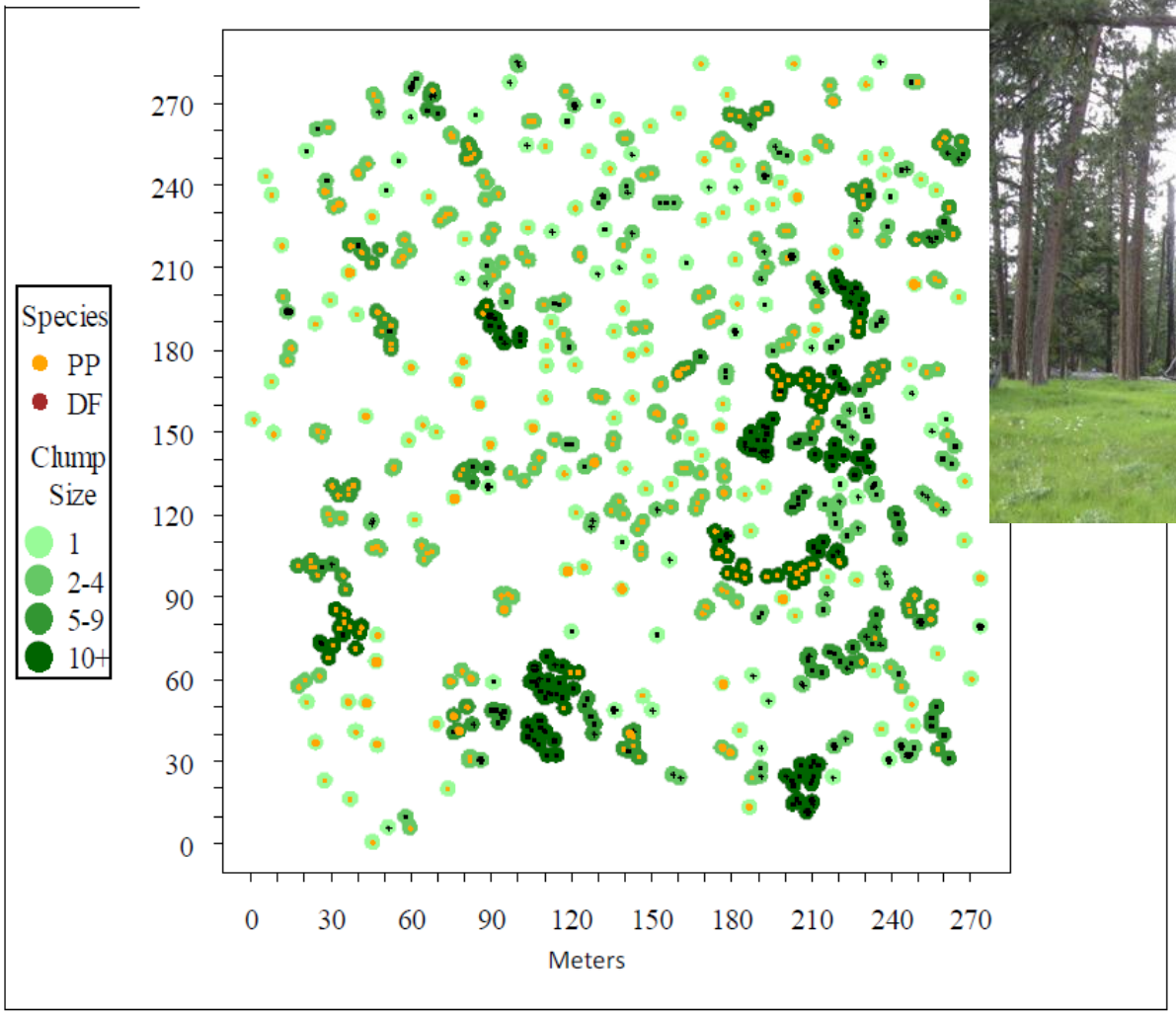
Black cinder
RANDOM



Mesic Limestone
AGGREGATED

Rocky Basalt
AGGREGATED

Mesic Basalt
AGGREGATED

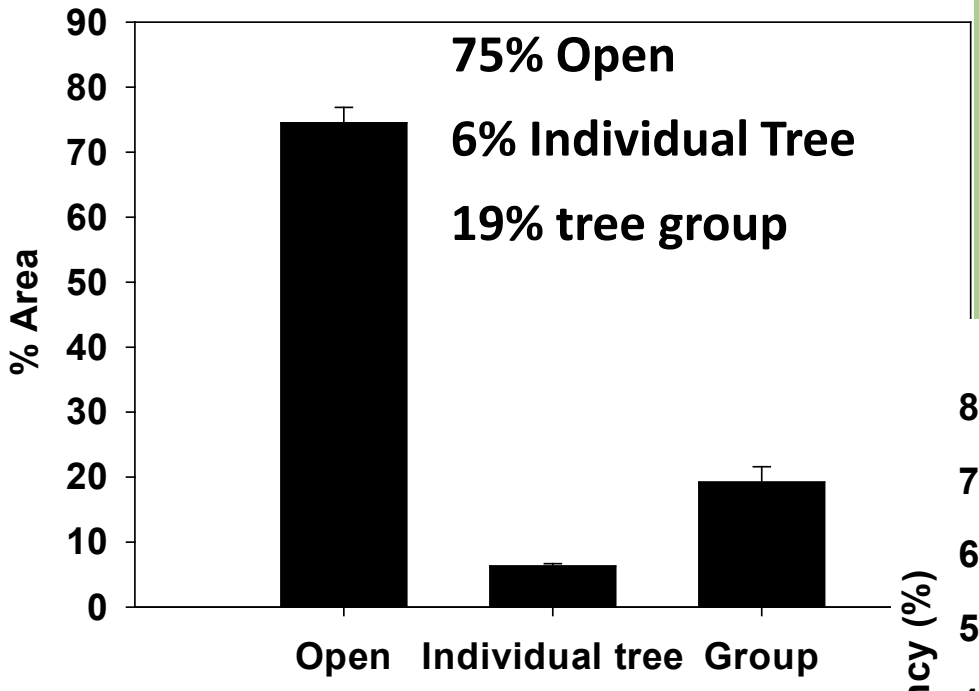


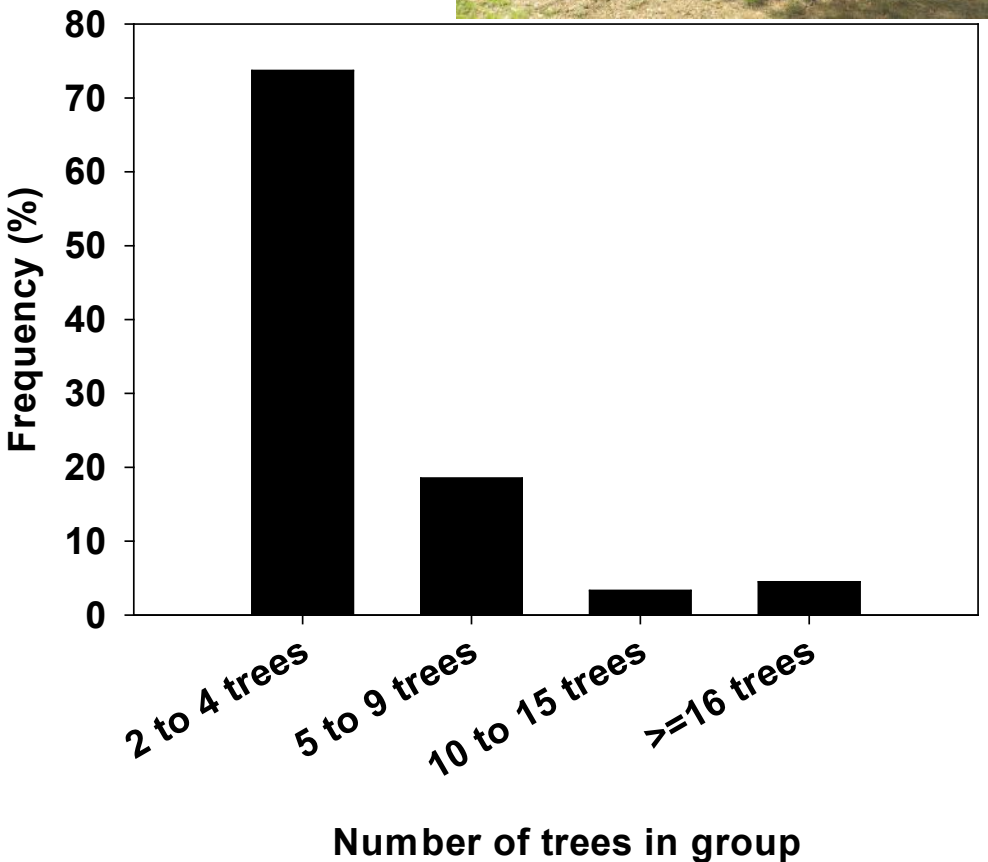
Washington

Figure 3. A ~13 acre stem map of pre-settlement trees near Naches, Washington. Three meter radius tree crowns are projected around each tree to illustrate formation of clusters using the Plotkin et al. (2002) algorithm.

Suggested citation: Churchill, D.J., M.C. Dalhgreen, A.J. Larson, and J.F. Franklin. 2013. The ICO approach to restoring spatial pattern in dry forests: Implementation guide. Version 1.0. Stewardship Forestry, Vashon, Washington, USA.

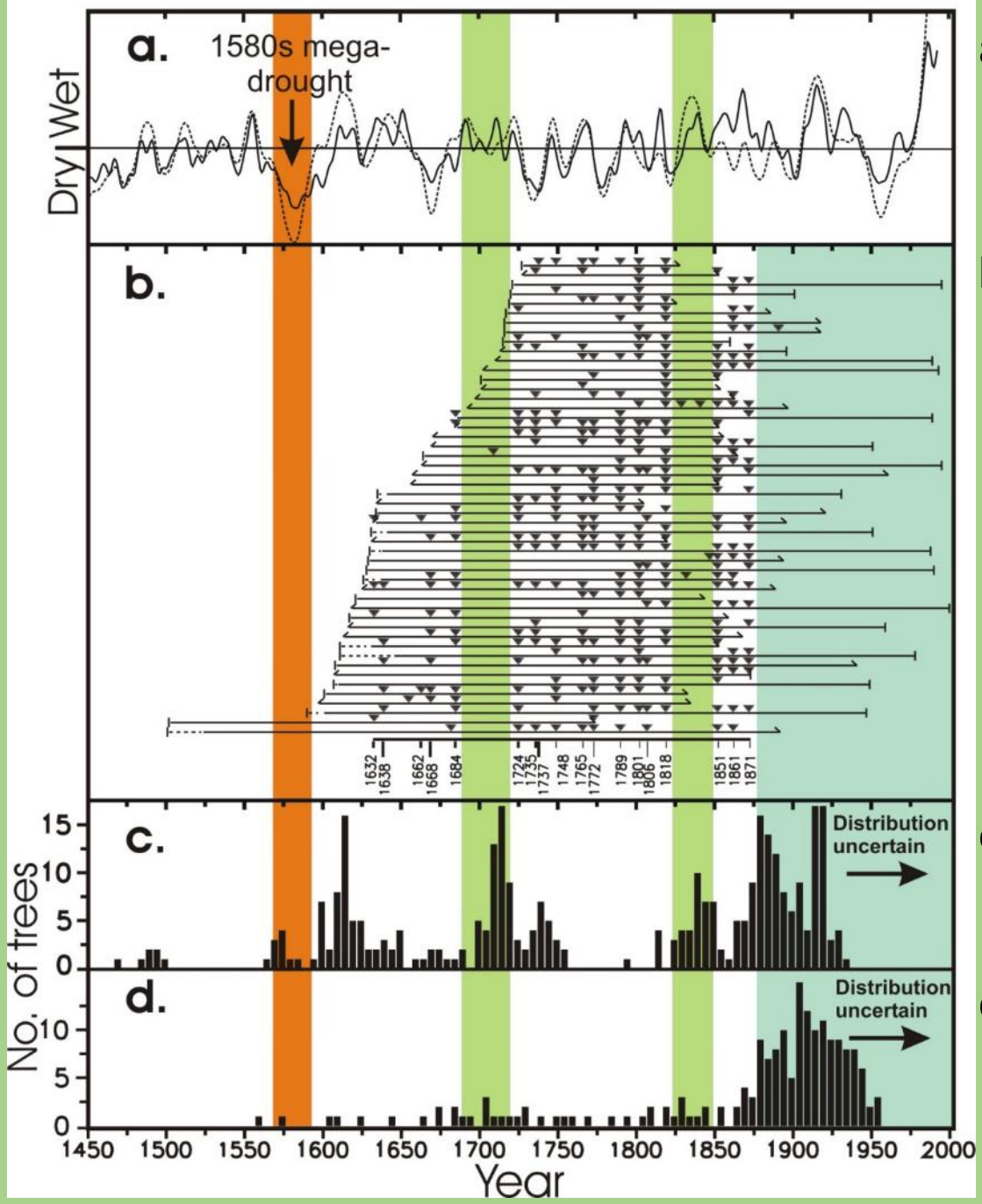
CO Front Range: Historical Lower Montane





Grazing, logging, favorable climate, and fire exclusion has resulted in a change in our forests

Photo: Gary Chancey, USFS



a. **Tree-ring reconstructions of precipitation and drought (smoothed)**

b. **Fire-scar history**

c. **Ponderosa pine establishment**

d. **Other species (Douglas-fir, juniper, piñon)**

(Brown and Wu, 2005)

Landscapes with complex structures of single trees, groups of trees, and various opening sizes have been replaced with dense landscapes of contiguous trees.

CO Front Range
Lower Montane (5453 to 8533 ft)
Change in Basal Area: 1860 vs 2012

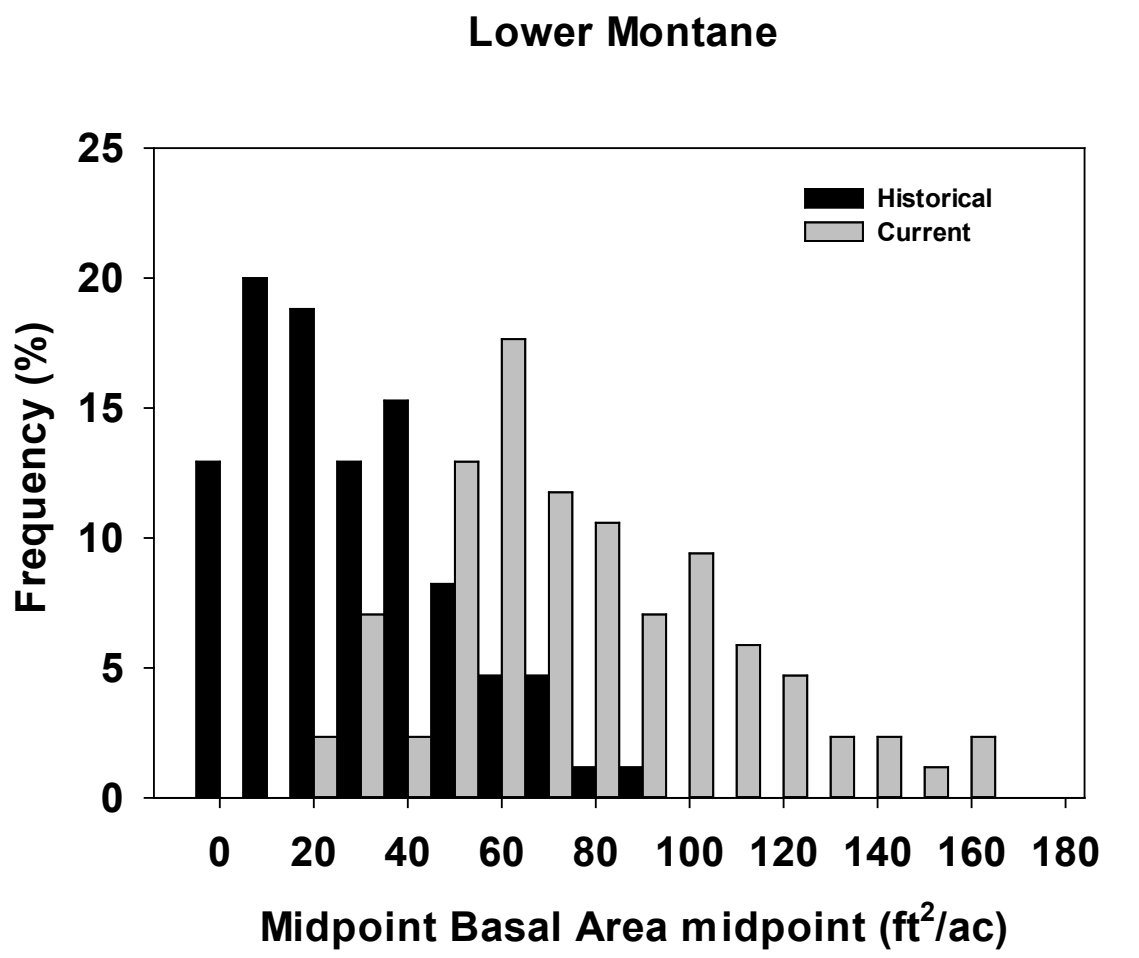
Historical: 27.4 ft^2/ac

Current: 76.7 ft^2/ac

179% increase

Historically, 80% of stands < 44 ft^2/ac

Currently, only 10% of stands < 44 ft^2/ac



What density looks like
Diameters 9 to 15 inch

160 ft^2/ac

100 ft^2/ac

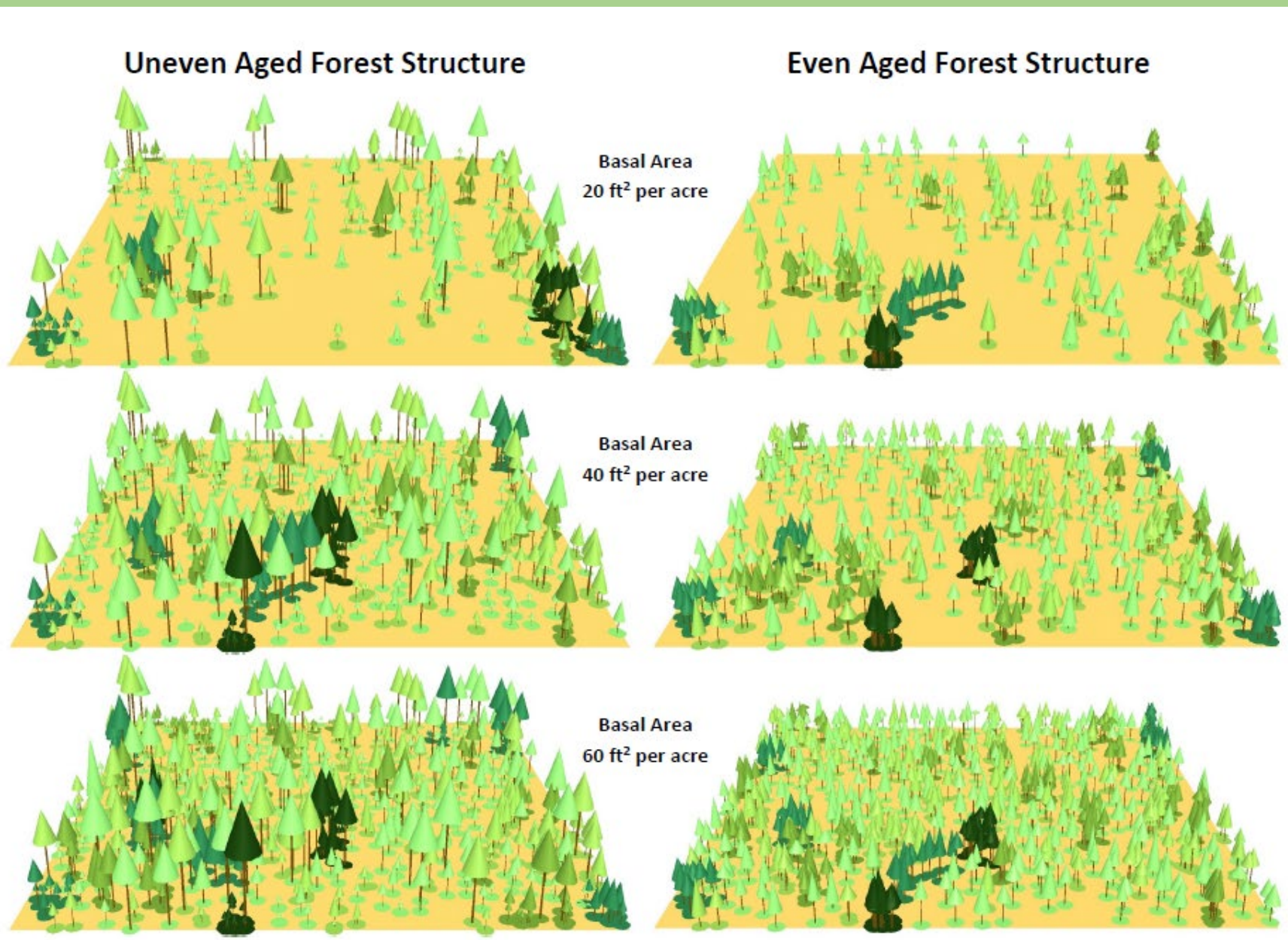
122 ft^2/ac

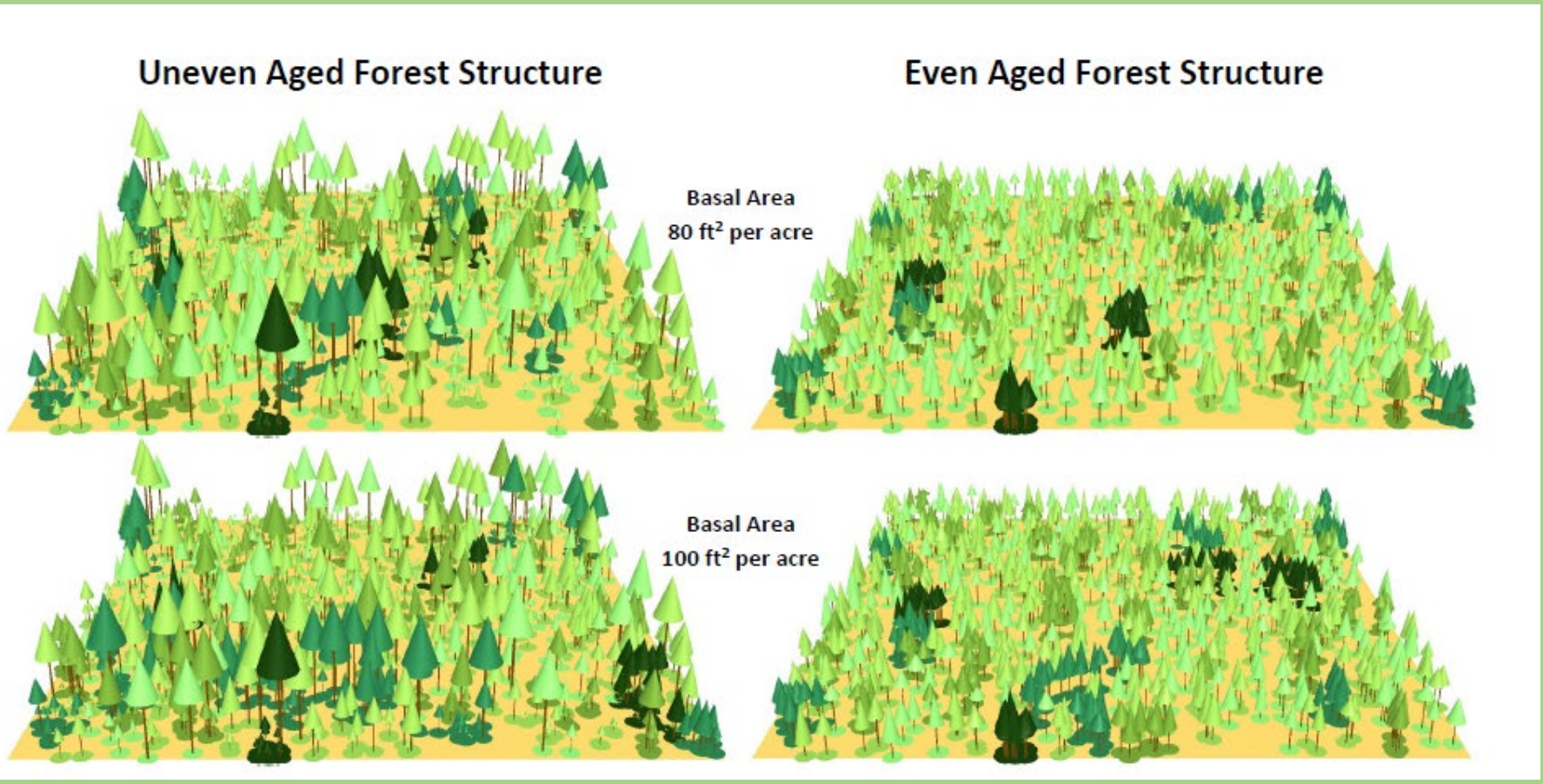
78 ft^2/ac

61 ft^2/ac

39 ft^2/ac

22 ft^2/ac

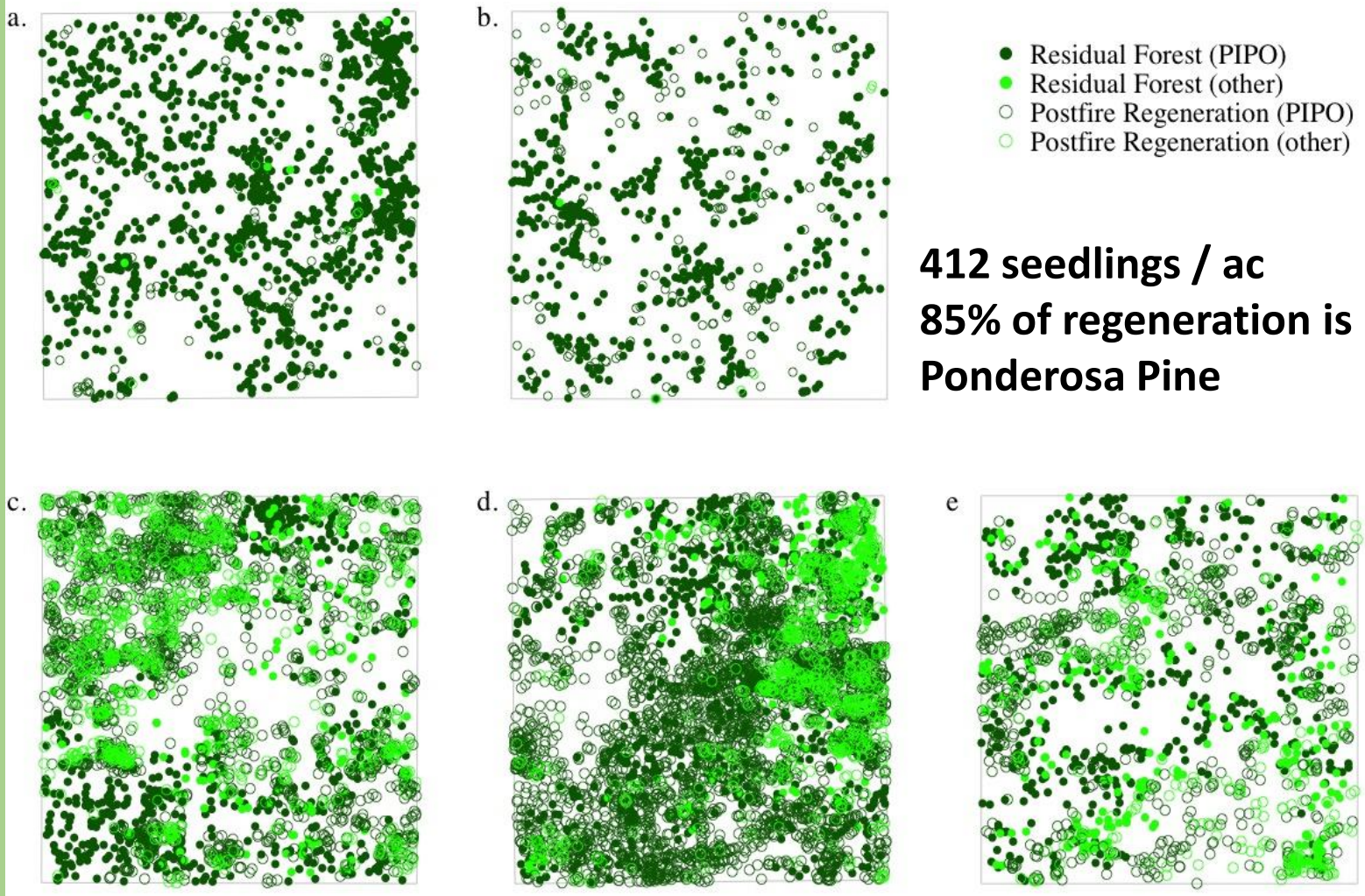

Uneven Aged Forest Structure
Even Aged Forest Structure
Basal Area
20 ft² per acre
Basal Area
40 ft² per acre
Basal Area
60 ft² per acre


Uneven Aged Forest Structure
Even Aged Forest Structure
Basal Area
80 ft² per acre
Basal Area
100 ft² per acre

Recent fires

- Trend toward large, mixed-high severity fires
- Large stand-replacing high-severity burn patches

http://www.pikespeakphoto.com/aerials/a_images/frontrange/hayman-fire.jpg



412 seedlings / ac
85% of regeneration is Ponderosa Pine

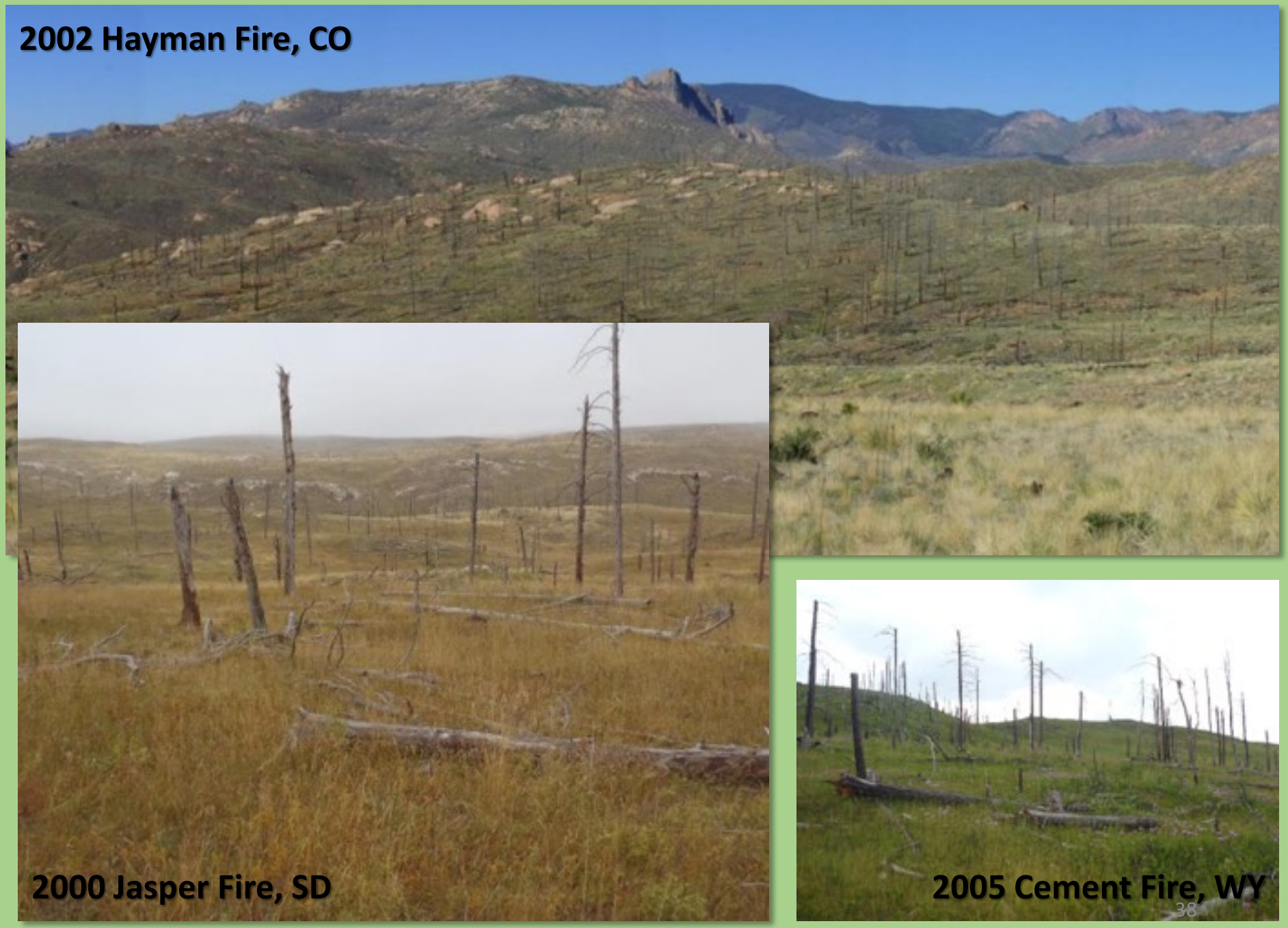
Low to moderate burned areas are regenerating, Hayman Fire CO

Mixed-Severity Fire Fosters Heterogeneous Spatial Patterns of Conifer Regeneration in a Dry Conifer Forest

Forests 2018, *9*, 45; doi:10.3390/f9010045

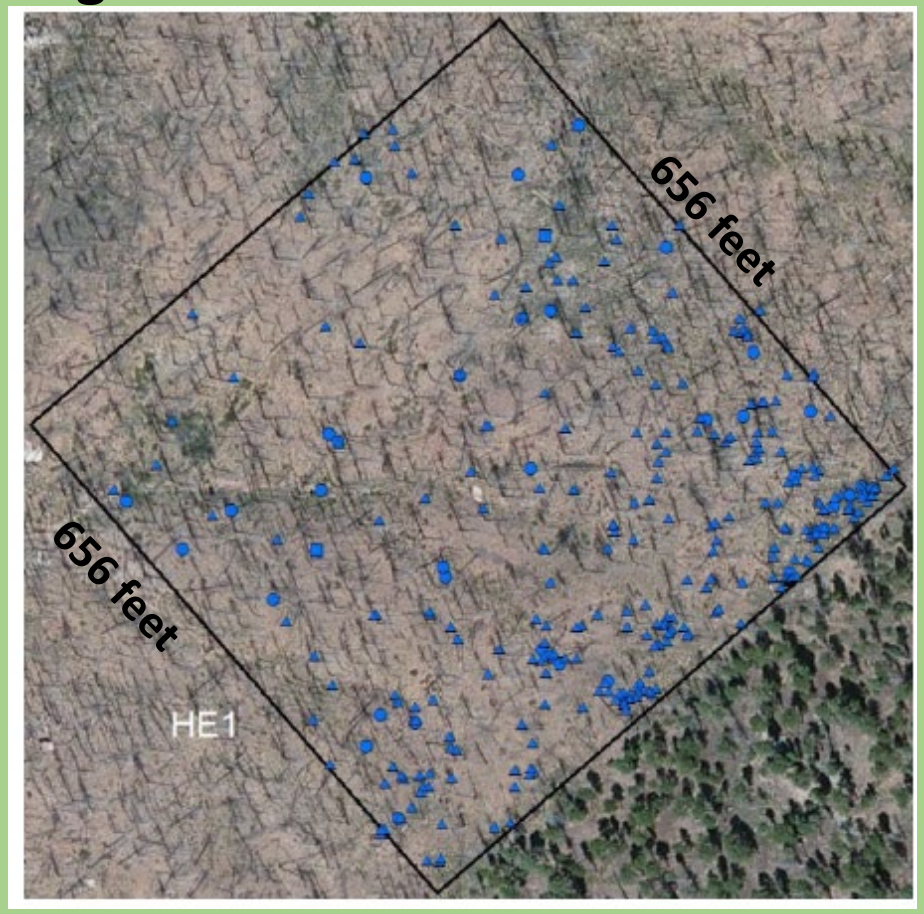
Sparkle L. Malone [1,2,*], Paula J. Fornwalt [1], Mike A. Battaglia [1], Marin E. Chambers [3], Jose M. Iniguez [4] and Carolyn H. Sieg [4]

Residual live overstory tree density: 68 to 79 tpa

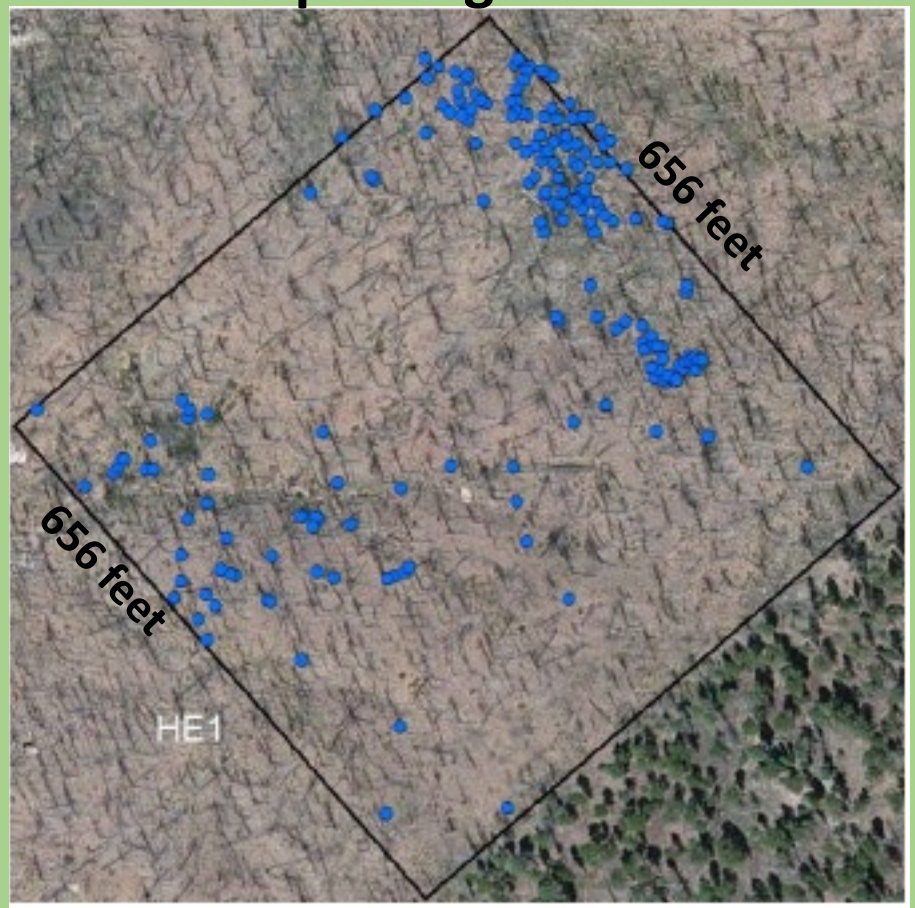

2002 Hayman Fire, CO
2000 Jasper Fire, SD
2005 Cement Fire, WY

Conifer Regeneration along the edge of live forest
Hayman Fire, CO

Ponderosa pine and Douglas-fir regeneration

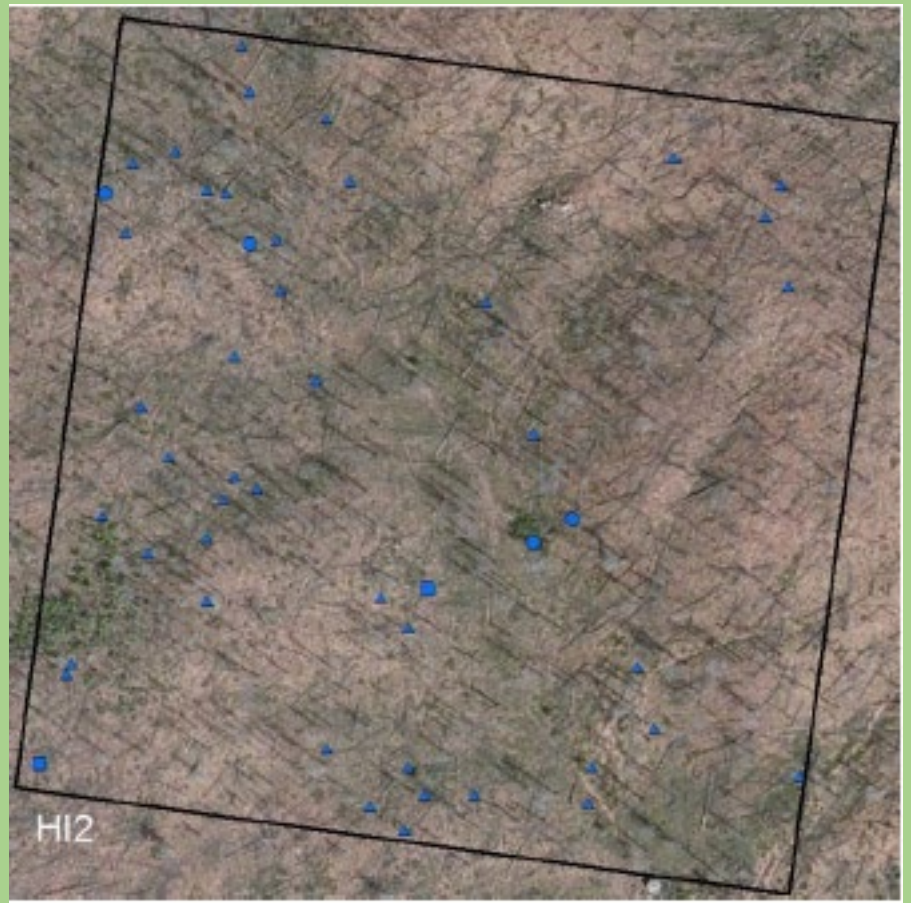


Aspen regeneration

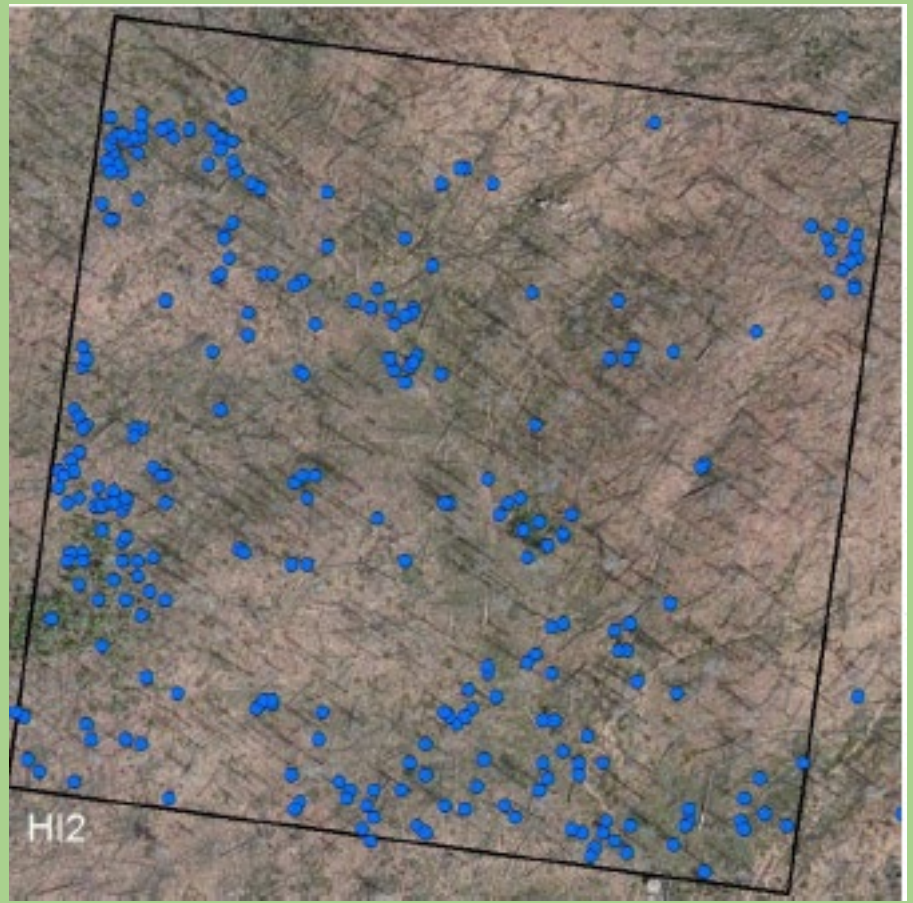


Regeneration patterns > 656 ft from a living tree
Hayman Fire, CO

Ponderosa pine and Douglas-fir regeneration



Aspen regeneration

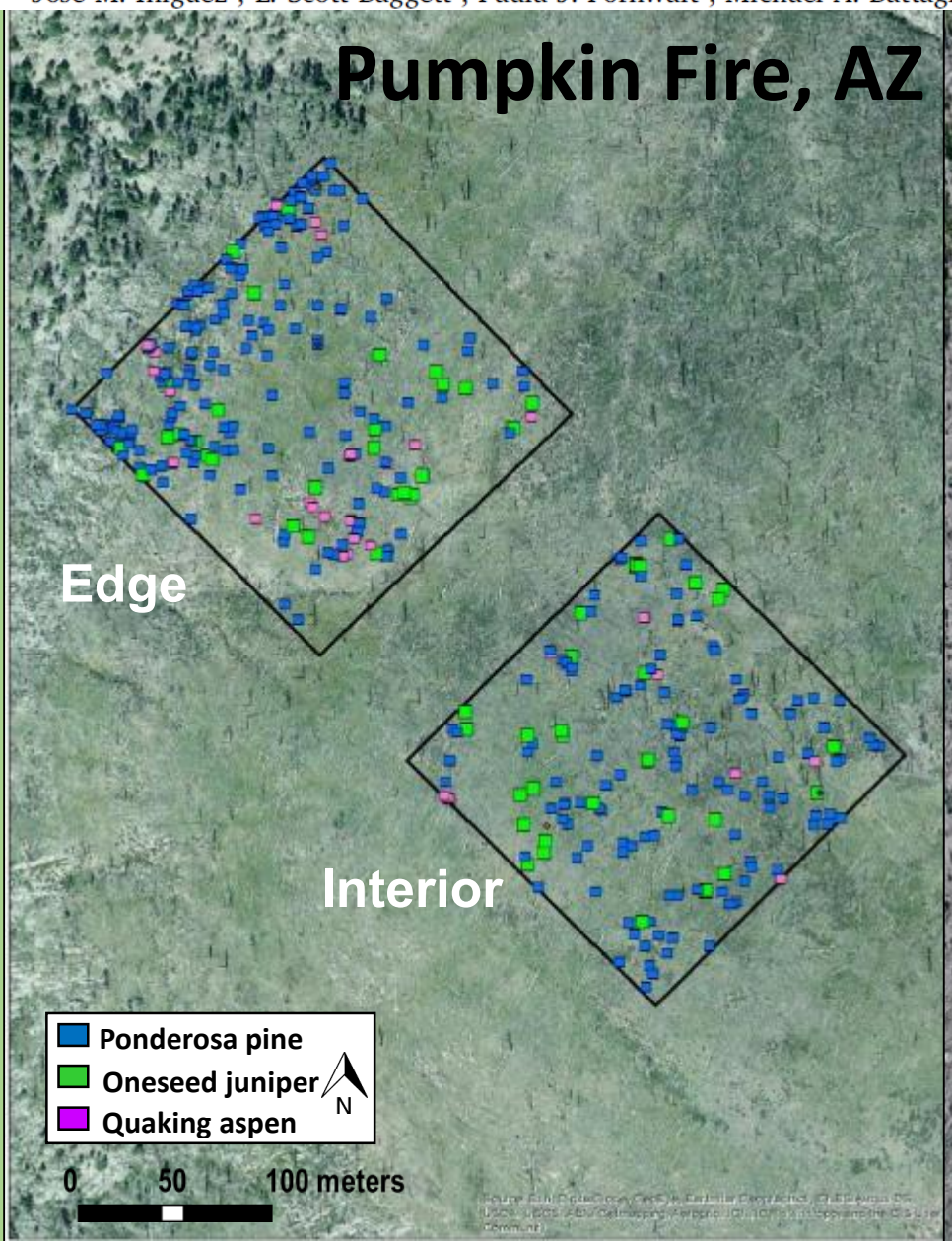


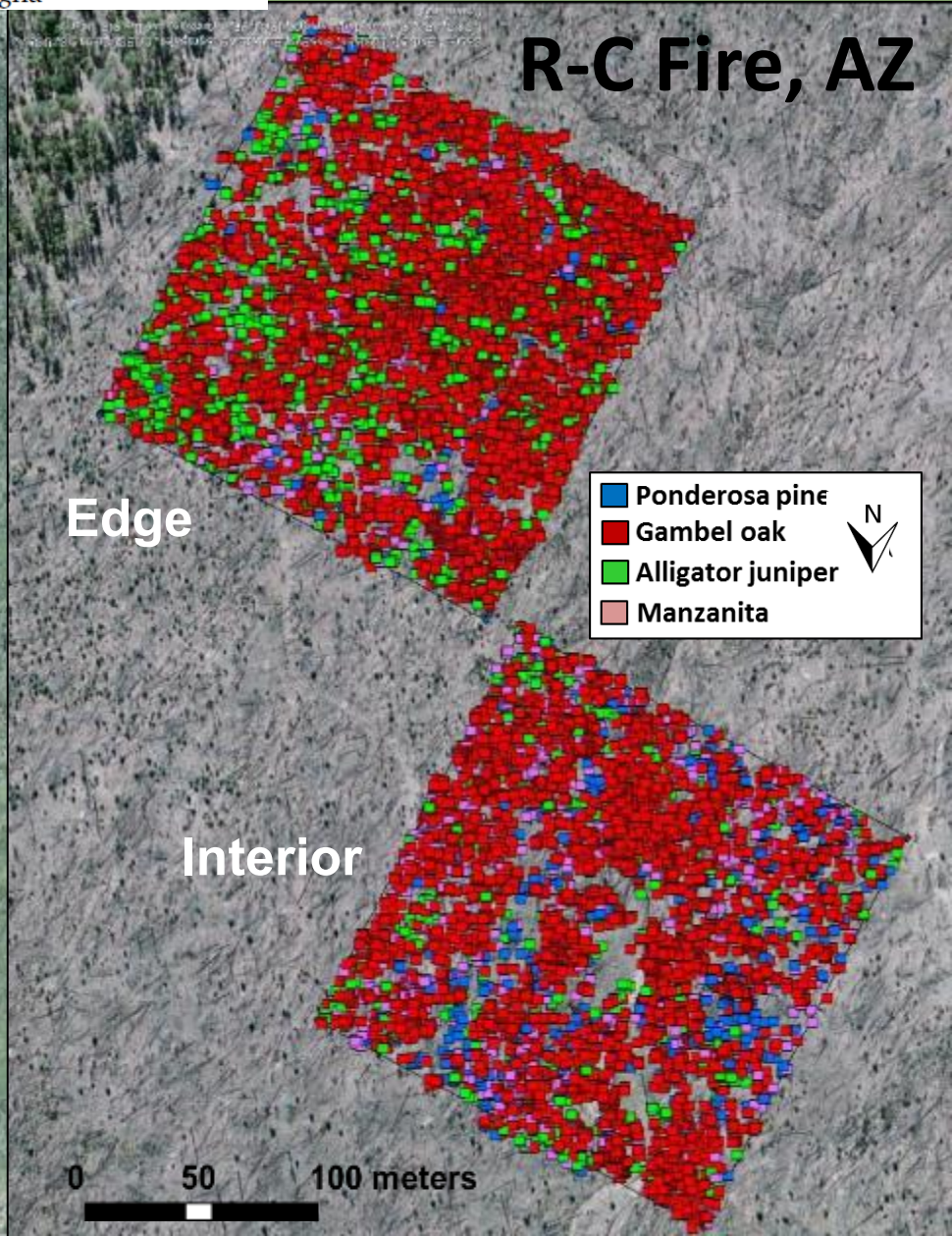
Spatial patterns of ponderosa pine regeneration in high-severity burn patches

Forest Ecology and Management 405 (2017) 134–149

Suzanne M. Owen[a,b,*], Carolyn H. Sieg[a], Andrew J. Sánchez Meador[b], Peter Z. Fulé[b], José M. Iniguez[a], L. Scott Baggett[c], Paula J. Fornwalt[c], Michael A. Battaglia[c]

Sprouting species





Ecological Applications, 26(2), 2016, pp. 346–354
© 2016 by the Ecological Society of America

Influences of prior wildfires on vegetation response to subsequent fire in a reburned Southwestern landscape

Jonathan D. Coop,[1,3] Sean A. Parks,[2] Sarah R. McClernan,[1] and Lisa M. Holsinger[2]

(c) Oak Scrub—Plot 9656

(d) Ruderal—Plot 9622

Bark beetle epidemics

Mountain Pine Beetle infestation probabilities in uneven-aged stands

Basal area of trees >10 inch dbh
< 26 ft2/ac

Prob infestation
(6%)

Basal area of trees >10 inch dbh
> 26 ft2/ac

Prob infestation
(55%)

SDI< 203;
RD<45%

SDI> 203;
RD>45%

Prob infestation
(32%)

Prob infestation
(68%)

Negron and others 2008

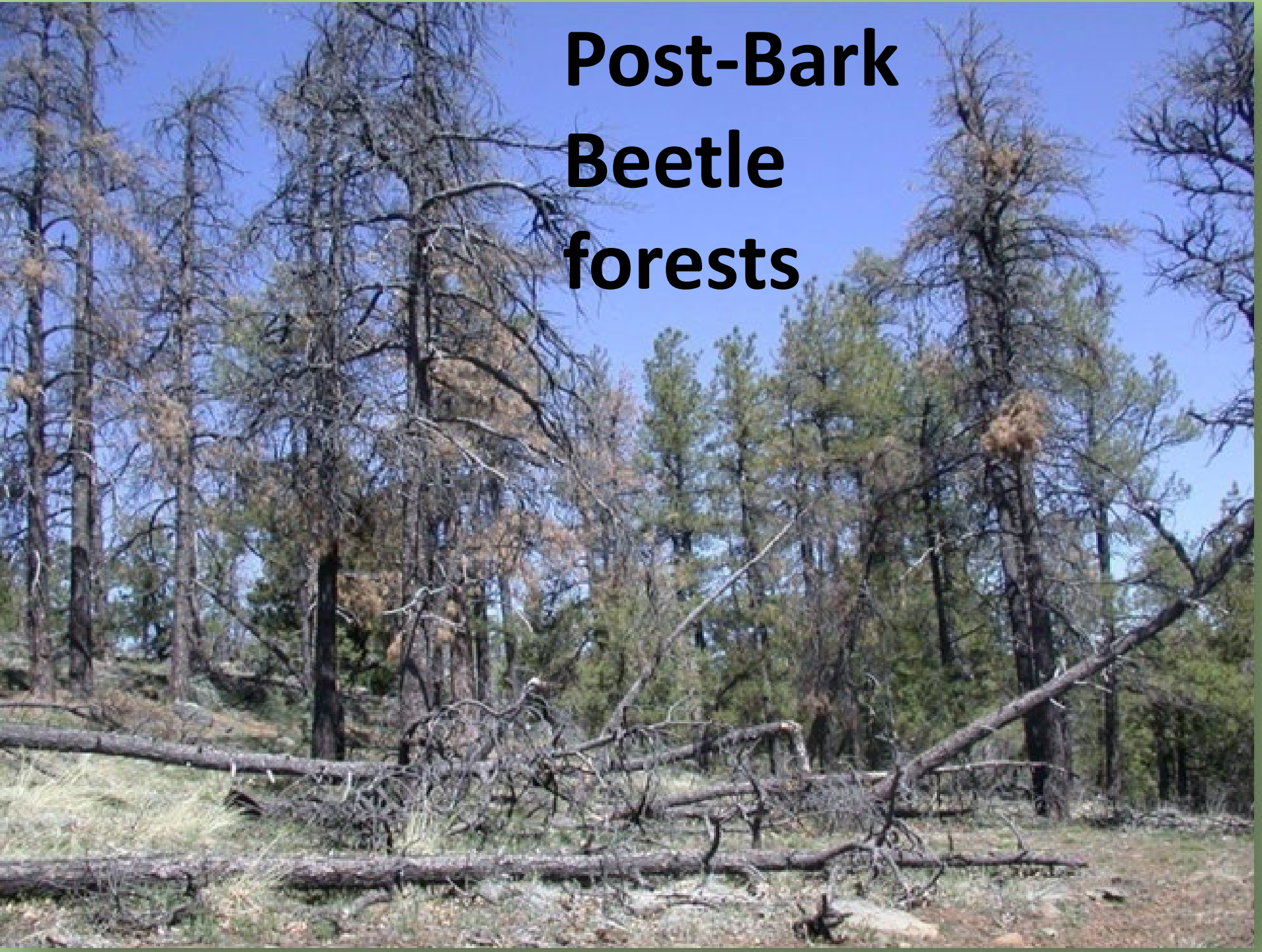
Long-term data sets: MPB Susceptibility Rating developed

- **High hazard: >80 ft²/ac**

- **Low hazard: <60 ft²/ac**

Roundheaded pine beetle

- Higher stand density stands have higher infestation rates (Negron et al. 2000)
- If 5-yr Periodic annual increment <0.26 inch there was a 95% probability of infestation in New Mexico
- 72% probability of infestation in stands with basal area > 105 ft^2/ac in Utah (Negron et al. 2000)


Post-Bark
Beetle
forests

CSIRO PUBLISHING

International Journal of Wildland Fire **2012**, *21*, 306–312
http://dx.doi.org/10.1071/WF11019

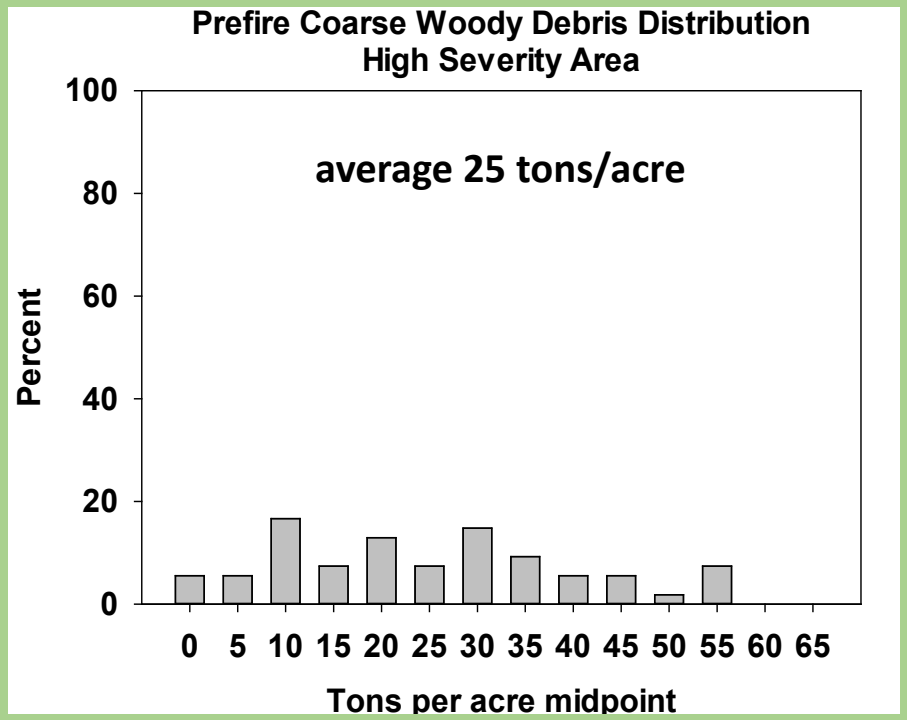
Fuel loadings 5 years after a bark beetle outbreak in south-western USA ponderosa pine forests

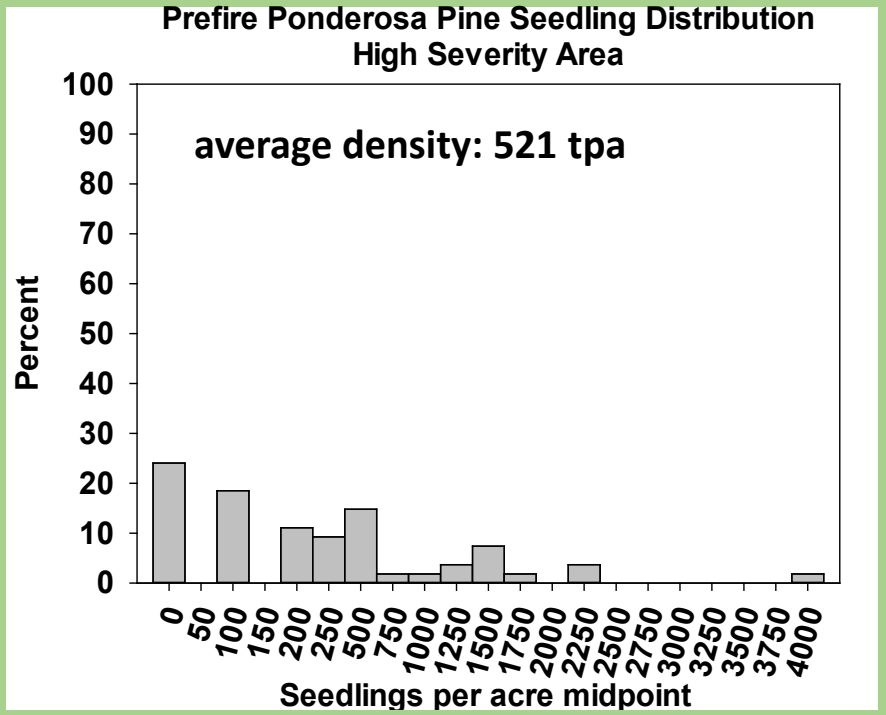
Chad M. Hoffman[A,E], *Carolyn Hull Sieg*[B], *Joel D. McMillin*[C] *and Peter Z. Fulé*[D]

- Pre-outbreak BA: 117 ft^2/ac
- Post-outbreak BA: 28 ft^2/ac
- Total coarse woody fuels: 12 t/a
  - 2.5 times higher than non-impacted stands
  - **5 years post-beetle only 48% of killed trees had fallen**
- Needle litter depth doubled

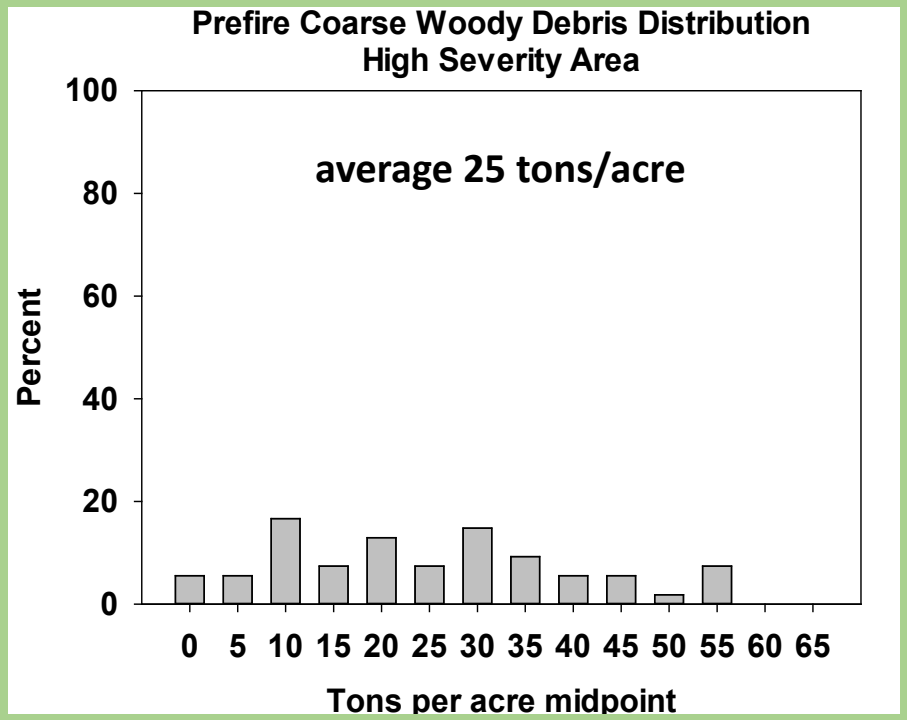
Post-wildfire fuel profile – 10 yrs

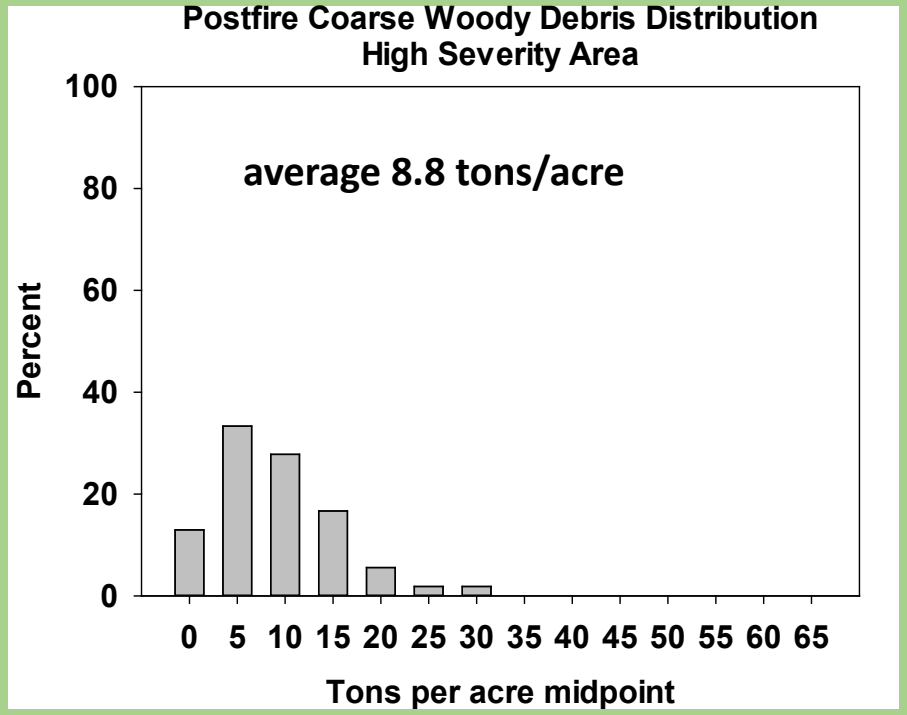
Black Hills, SD


Prefire Coarse Woody Debris Distribution
High Severity Area
average 25 tons/acre
Percent
100
80
60
40
20
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65
Tons per acre midpoint

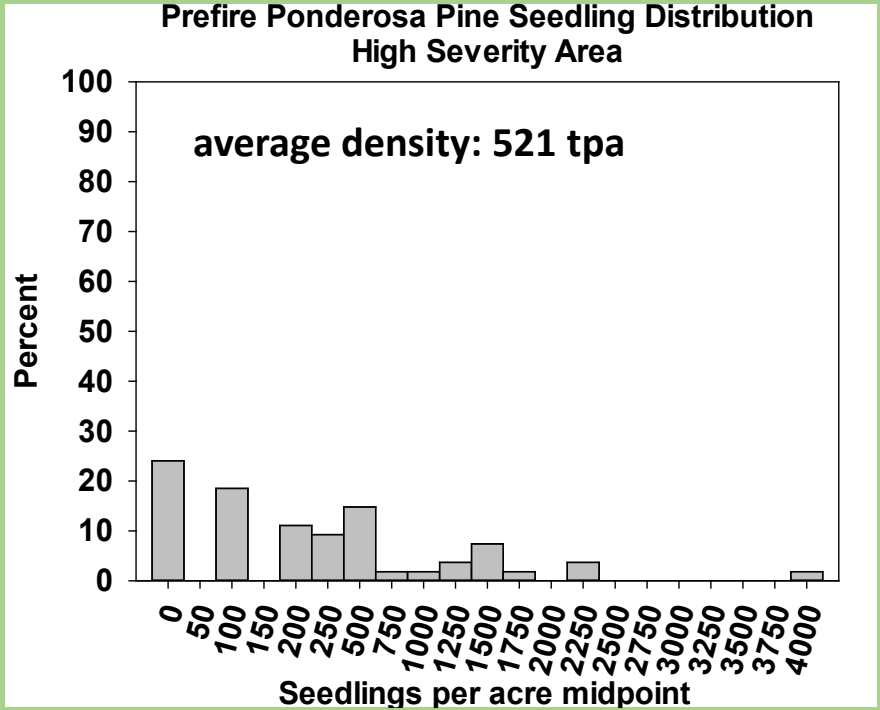

Prefire Ponderosa Pine Seedling Distribution
High Severity Area
average density: 521 tpa
Percent
100
90
80
70
60
50
40
30
20
10
0
0 50 100 150 200 250 500 750 1000 1250 1500 1750 2000 2250 2500 2750 3000 3250 3500 3750 4000
Seedlings per acre midpoint

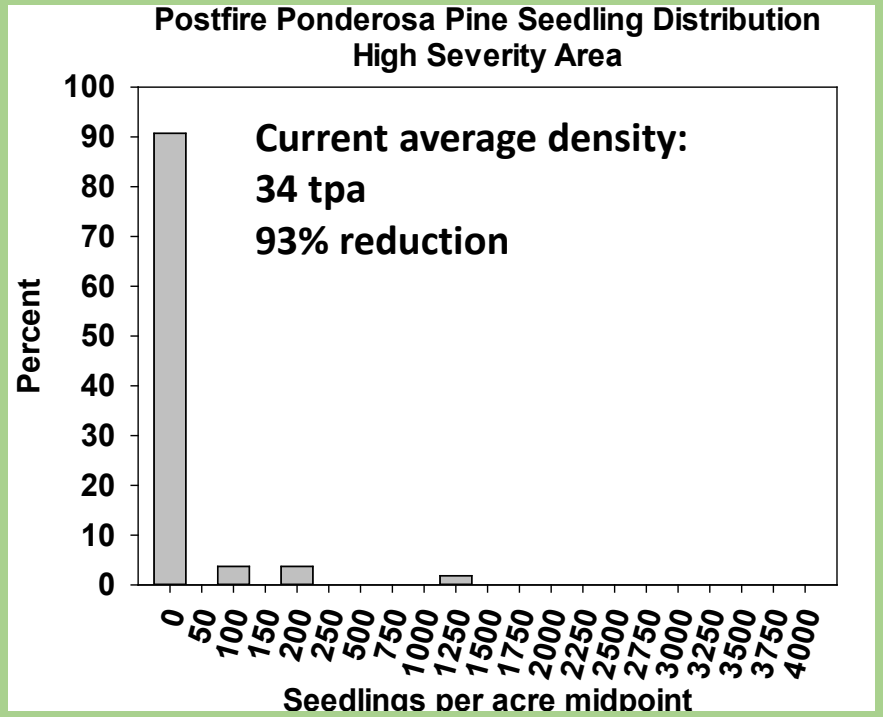
09/30/2011


Prefire Coarse Woody Debris Distribution
High Severity Area
average 25 tons/acre
Percent
100
80
60
40
20
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65
Tons per acre midpoint


Postfire Coarse Woody Debris Distribution
High Severity Area
average 8.8 tons/acre
Percent
100
80
60
40
20
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65
Tons per acre midpoint

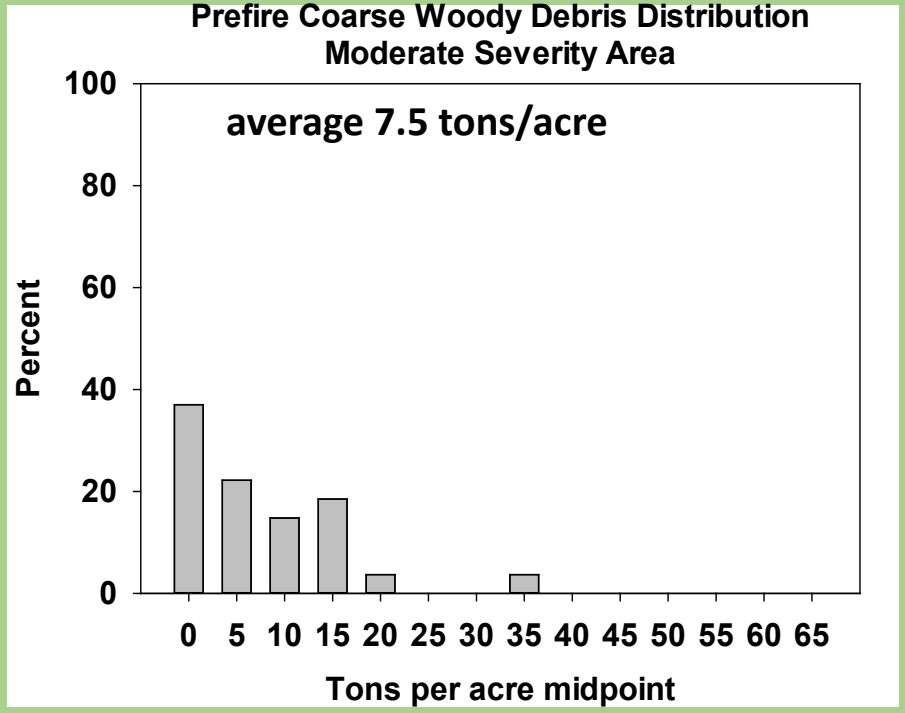
REBURN

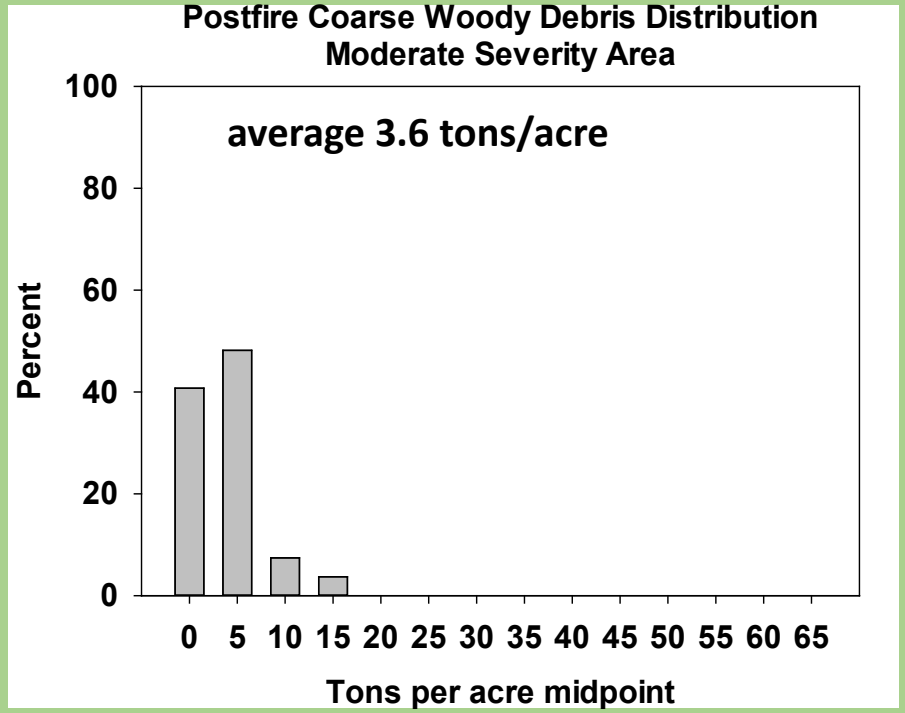

Prefire Ponderosa Pine Seedling Distribution
High Severity Area
average density: 521 tpa
Percent
100
90
80
70
60
50
40
30
20
10
0
0
50
100
150
200
250
500
750
1000
1250
1500
1750
2000
2250
2500
2750
3000
3250
3500
3750
4000
Seedlings per acre midpoint

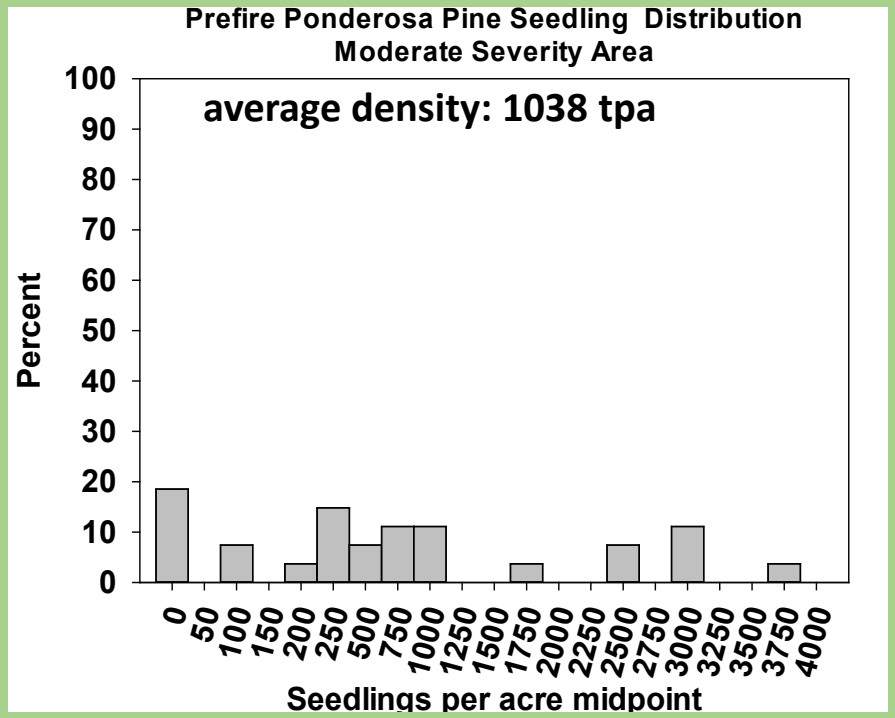

Postfire Ponderosa Pine Seedling Distribution
High Severity Area
Current average density:
34 tpa
93% reduction
Percent
100
90
80
70
60
50
40
30
20
10
0
0
50
100
150
200
250
500
750
1000
1250
1500
1750
2000
2250
2500
2750
3000
3250
3500
3750
4000
Seedlings per acre midpoint

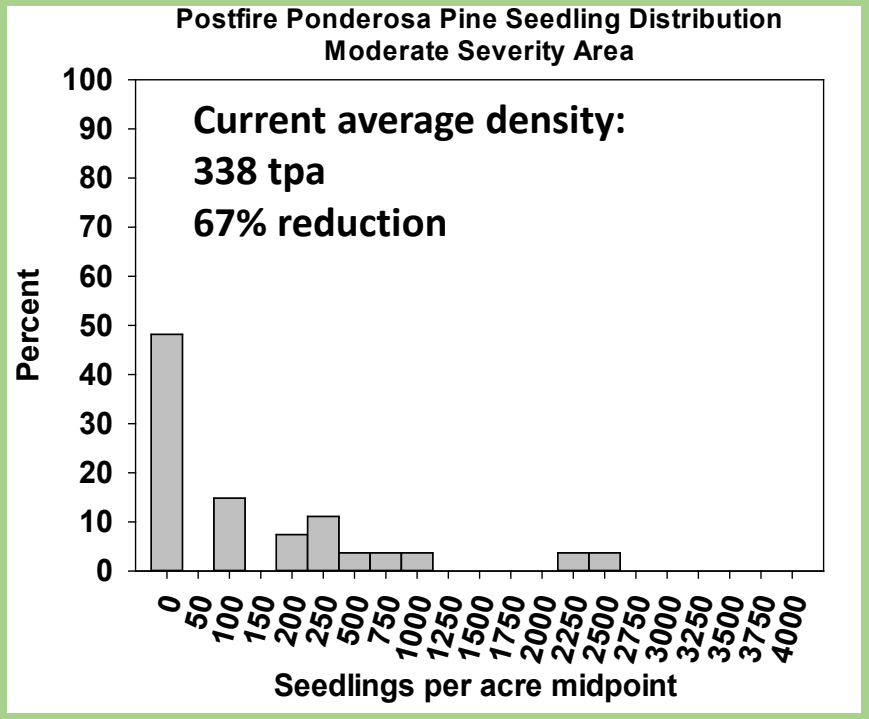
REBURN

Basal areas around 25 to 40 ft^2/acre


Prefire Coarse Woody Debris Distribution
Moderate Severity Area
average 7.5 tons/acre
Percent
100
80
60
40
20
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65
Tons per acre midpoint


Postfire Coarse Woody Debris Distribution
Moderate Severity Area
average 3.6 tons/acre
Percent
100
80
60
40
20
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65
Tons per acre midpoint


Prefire Ponderosa Pine Seedling Distribution
Moderate Severity Area
average density: 1038 tpa
Percent
100
90
80
70
60
50
40
30
20
10
0
0
50
100
150
200
250
500
750
1000
1250
1500
1750
2000
2250
2500
2750
3000
3250
3500
3750
4000
Seedlings per acre midpoint


Postfire Ponderosa Pine Seedling Distribution
Moderate Severity Area
Current average density:
338 tpa
67% reduction
Percent
100
90
80
70
60
50
40
30
20
10
0
0
50
100
150
200
250
500
750
1000
1250
1500
1750
2000
2250
2500
2750
3000
3250
3500
3750
4000
Seedlings per acre midpoint

USDA

United States Department of Agriculture

Forest Service

Rocky Mountain Research Station

General Technical Report RMRS-GTR-310

September 2013

Restoring Composition and Structure in Southwestern Frequent-Fire Forests:

A science-based framework for improving ecosystem resiliency

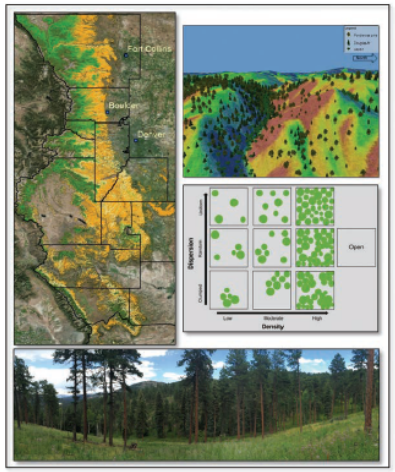
Richard T. Reynolds, Andrew J. Sánchez Meador, James A. Youtz, Tessa Nicolet, Megan S. Matonis, Patrick L. Jackson, Donald G. DeLorenzo, Andrew D. Graves

USDA

United States Department of Agriculture

Principles and Practices for the Restoration of Ponderosa Pine and Dry Mixed-Conifer Forests of the Colorado Front Range

Robert N. Addington, Gregory H. Aplet, Mike A. Battaglia, Jennifer S. Briggs, Peter M. Brown, Antony S. Cheng, Yvette Dickinson, Jonas A. Feinstein, Kristen A. Pelz, Claudia M. Regan, Jim Thinnes, Rick Truex, Paula J. Fornwalt, Benjamin Gannon, Chad W. Julian, Jeffrey L. Underhill, Brett Wolk



Forest Service

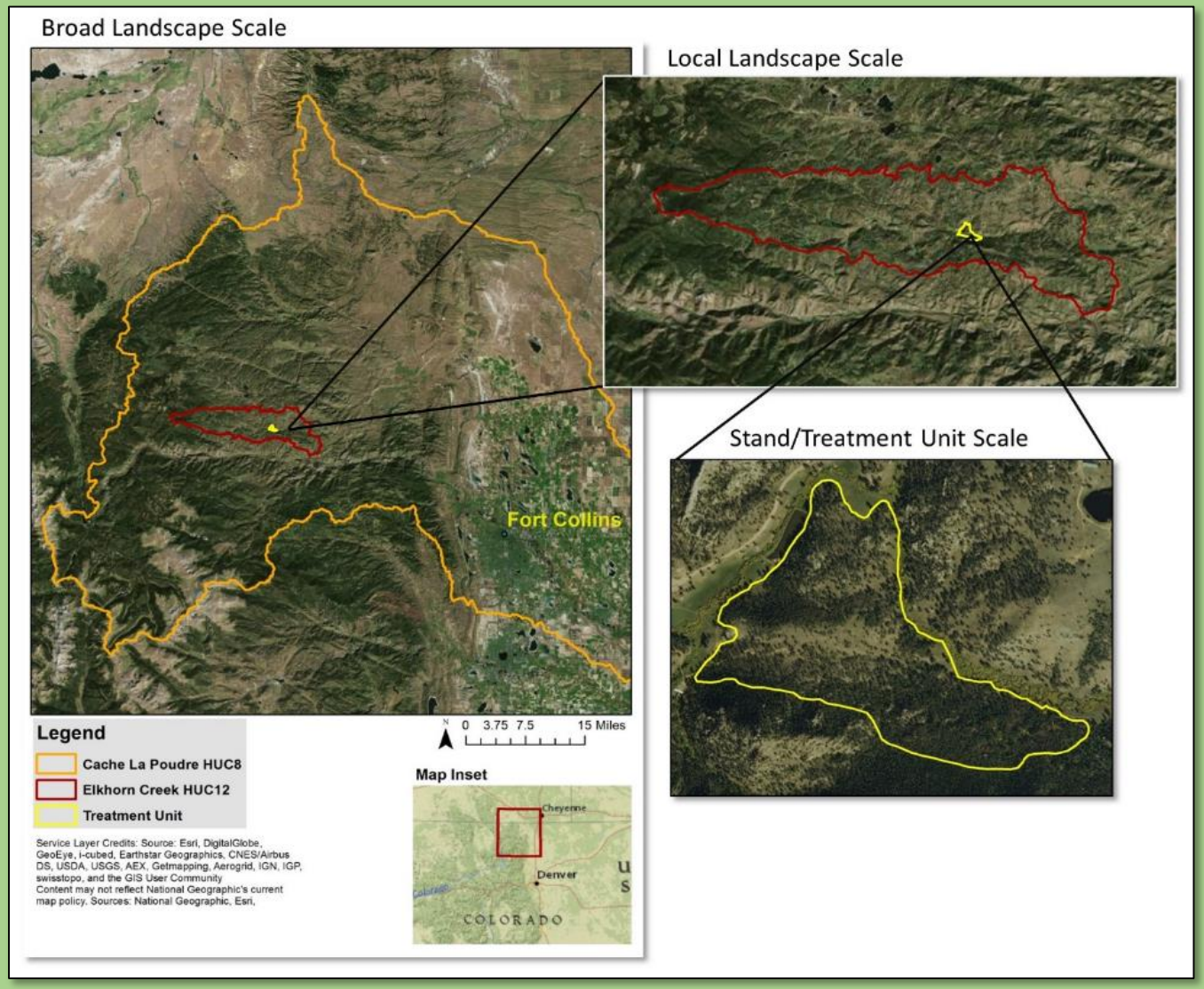
Rocky Mountain Research Station

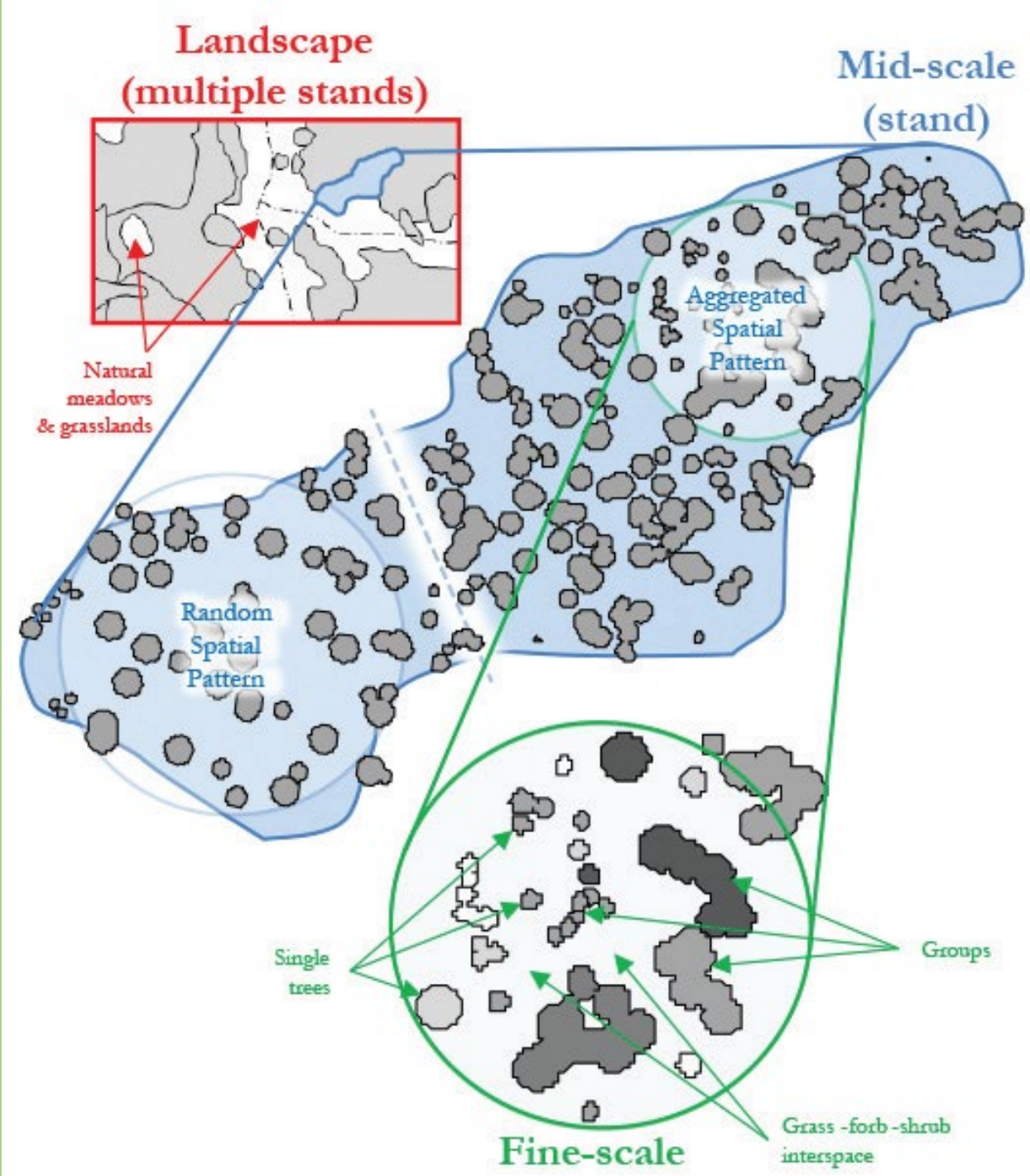
General Technical Report RMRS-GTR-373

January 2018

Principles for restoration

Spatial scale provides an important organizational framework for restoration





USDA

United States
Department
of Agriculture

Forest Service

Rocky Mountain
Research Station

General Technical
Report RMRS-GTR-310

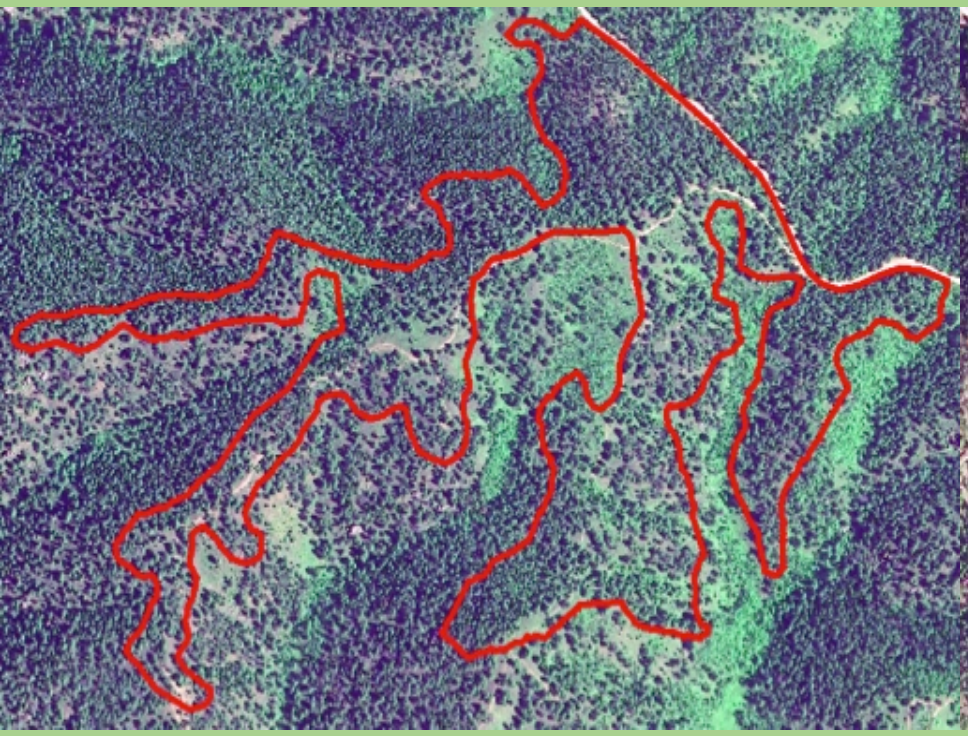
September 2013

Restoring Composition and Structure in Southwestern Frequent-Fire Forests:

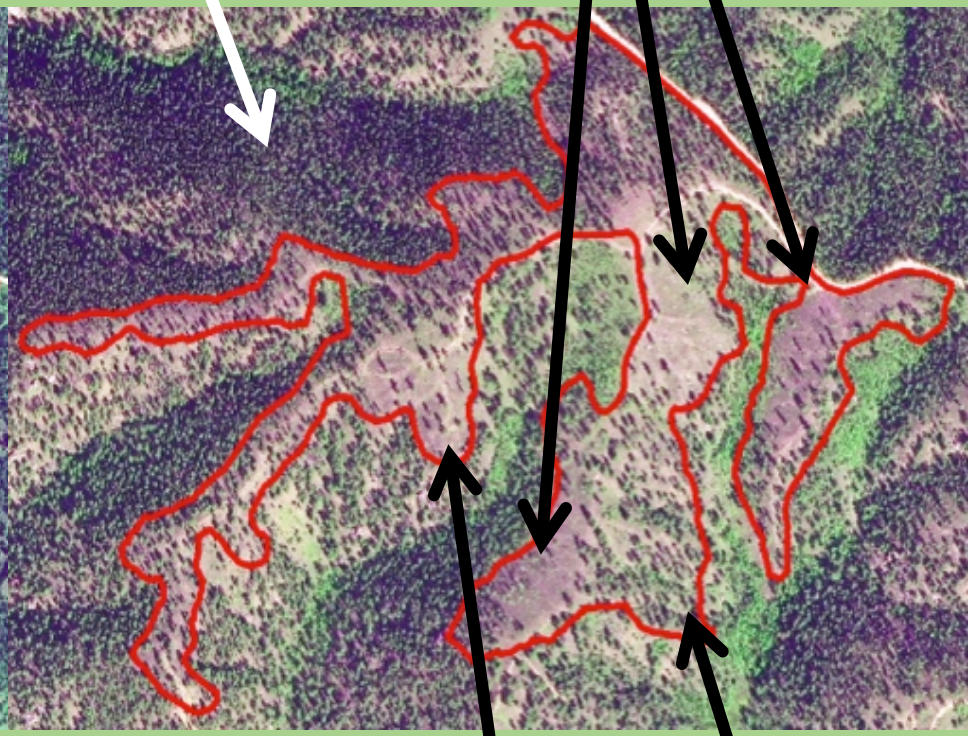
A science-based framework for improving ecosystem resiliency

Richard T. Reynolds, Andrew J. Sánchez Meador, James A. Youtz,
Tessa Nicolet, Megan S. Matonis, Patrick L. Jackson,
Donald G. DeLorenzo, Andrew D. Graves

Restoration Silviculture



Pre-treatment



Post-treatment

Fine-Scale Forest Structure

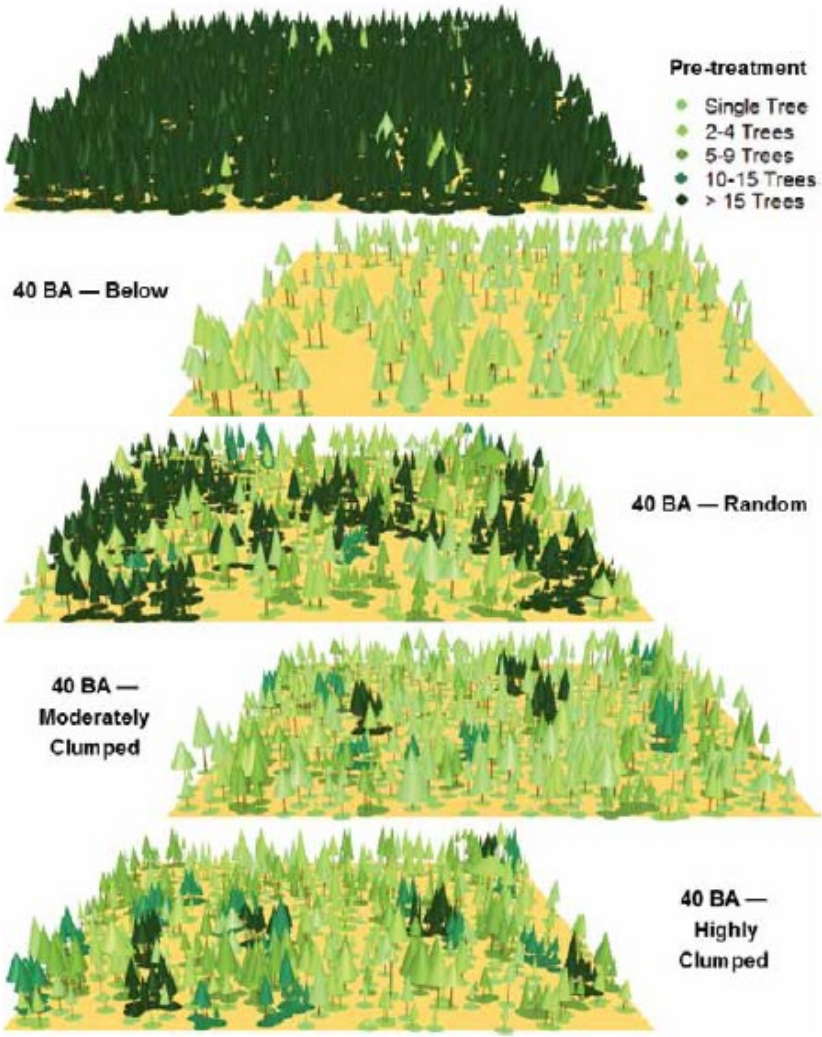
Principles for restoration

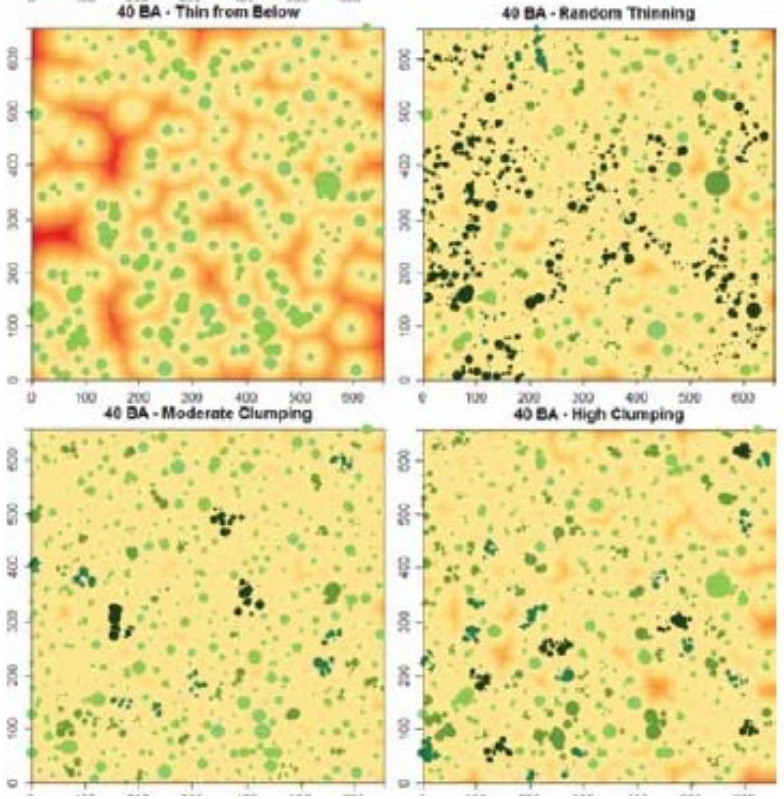
- Manage for diverse forest developmental trajectories

Principles for restoration

- Importance of restoring ecological processes such as fire

Fuelbeds produce different fire behavior

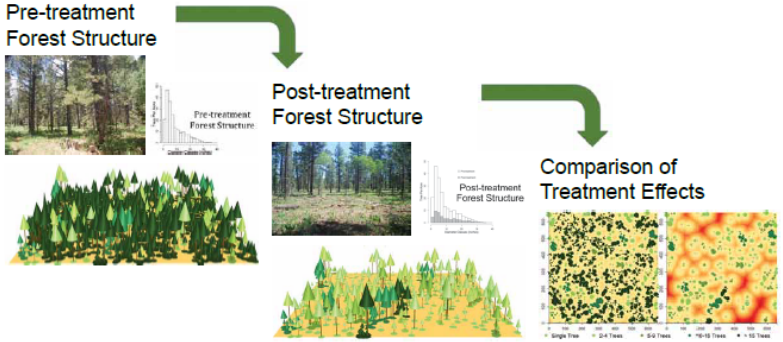




USDA United States Department of Agriculture

Visualization of Heterogeneous Forest Structures Following Treatment in the Southern Rocky Mountains

Wade T. Tinkham, Yvette Dickinson, Chad M. Hoffman, Mike A. Battaglia, Seth Ex, and Jeffrey Underhill



Forest Service Rocky Mountain Research Station General Technical Report RMRS-GTR-365 September 2017

Tinkham et al 2017. RMRS-GTR-365

Historical ponderosa pine forests

- Fire is an important process in ponderosa pine
- Basal areas and TPA were variable within and between regions
- Uneven-aged forest structures (stand and landscape)
- All size classes present but each size class typically had low TPA
- Upper diameter size varied with Region
- Groupy-clumpy spatial pattern evident