Using LiDAR for Multi-scale Restoration

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New Challenges in Public Lands Management

Resilience

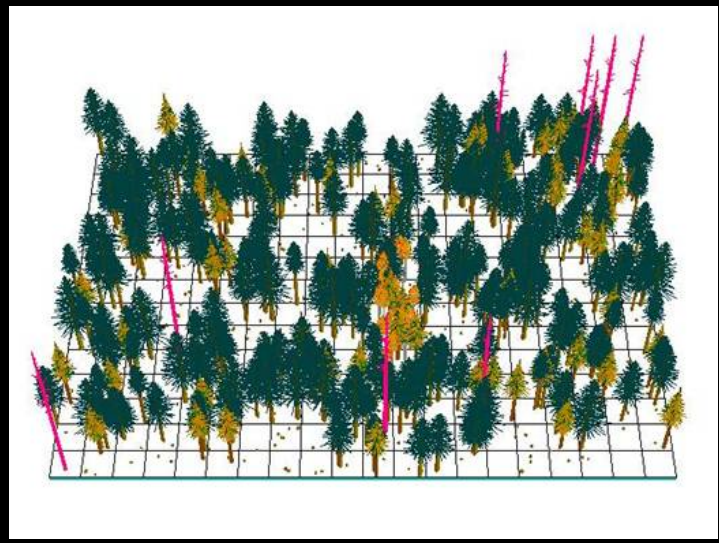
- Restoration
- Resistance to disturbance
- Climate adaption

Ecosystem services:

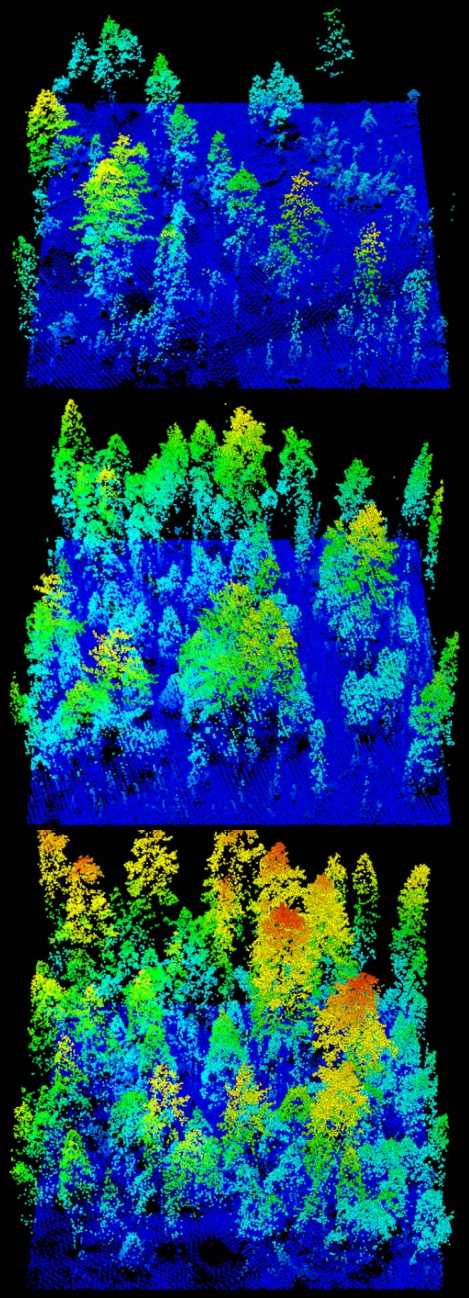
- Provisioning
- Regulating
- Cultural

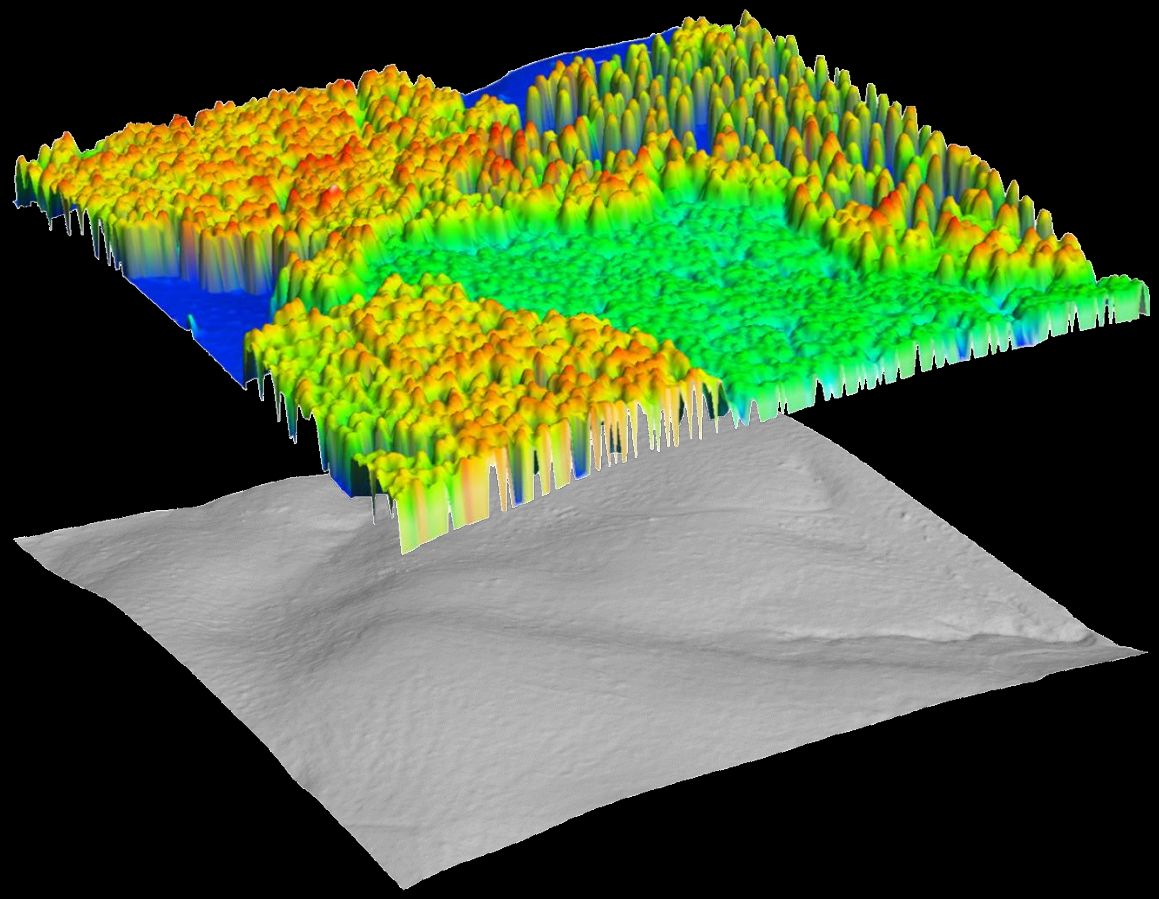
Manage at “Multiple Scales”

Manage for Pattern Linked to Desired Functions

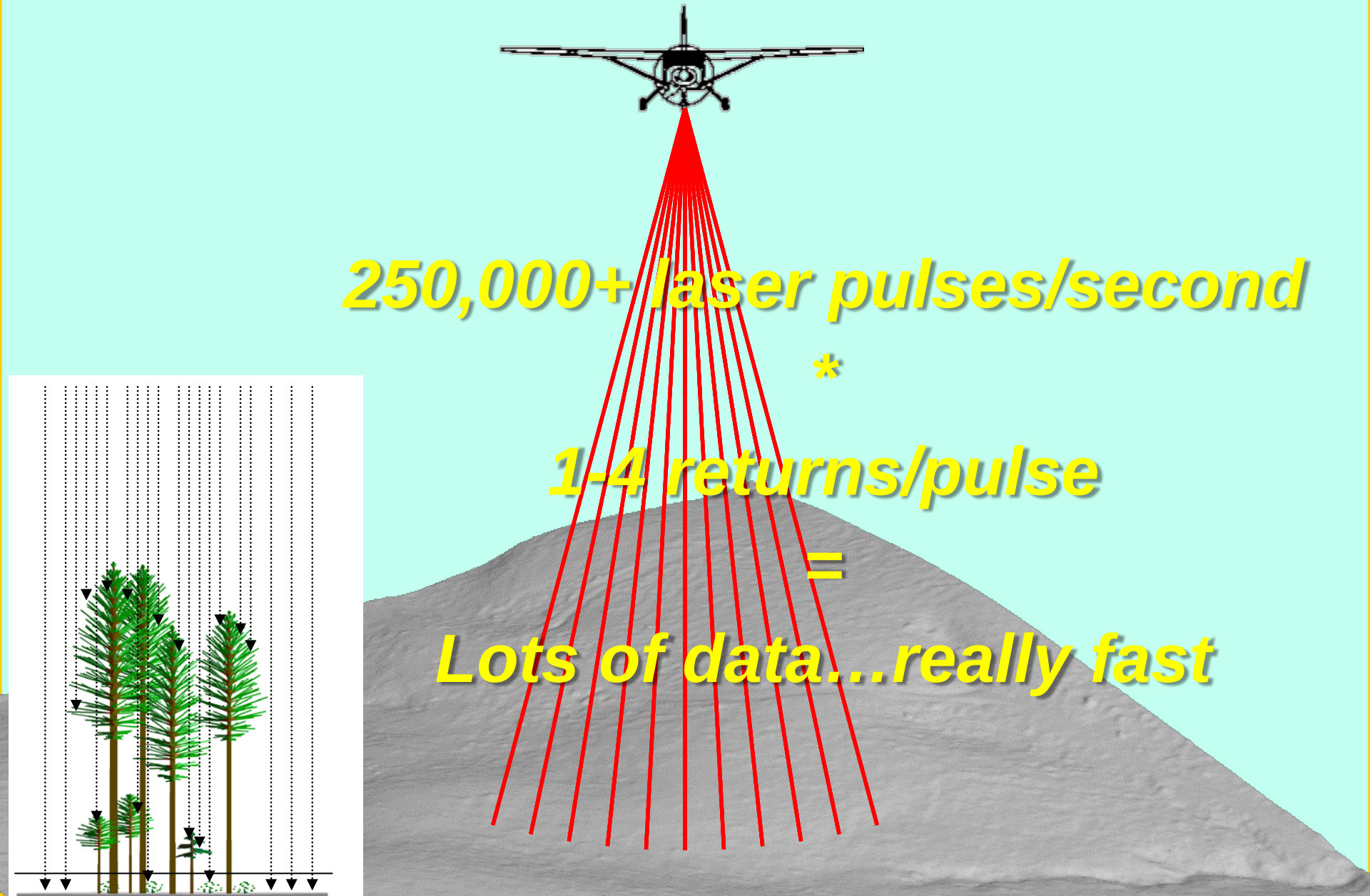


LiDAR: the Ultimate Multi-Scale Dataset





Airborne laser scanning



250,000+ laser pulses/second

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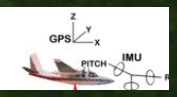
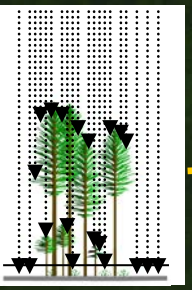
1-4 returns/pulse

=

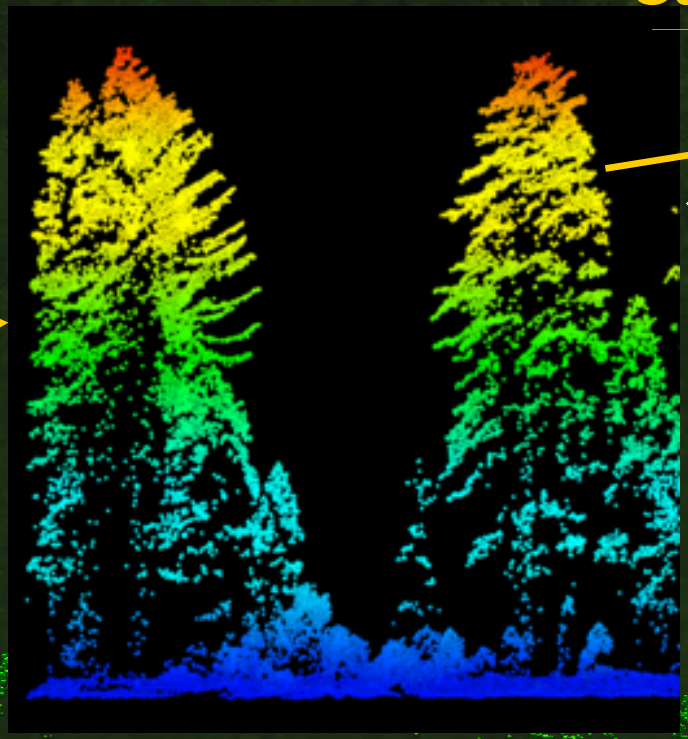
Lots of data…really fast

LiDAR: the Ultimate Multi-Scale Dataset

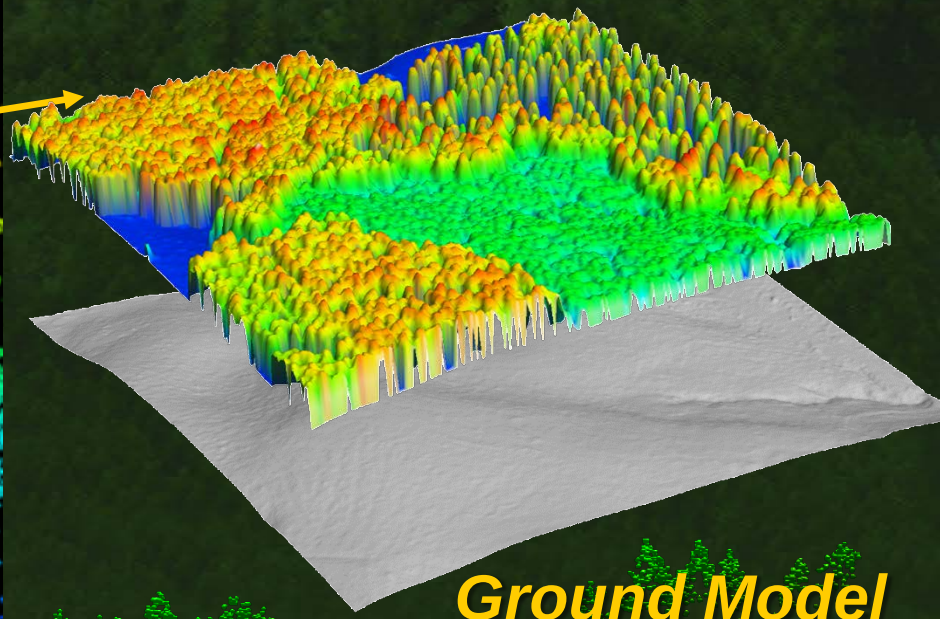




Point Cloud Data



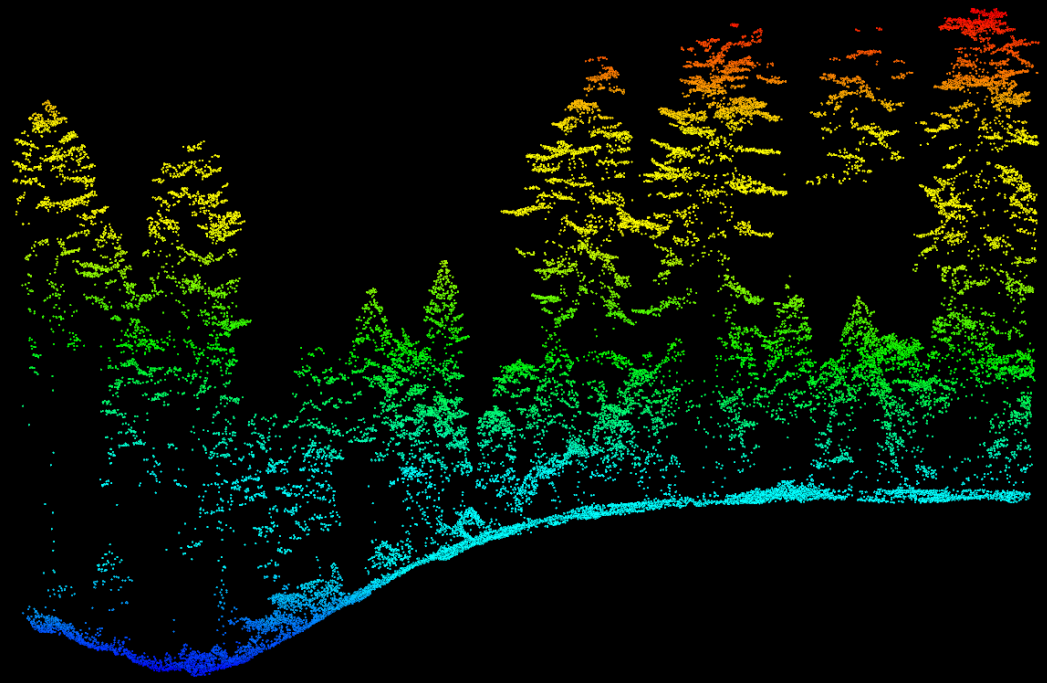
Canopy Height/Surface Model

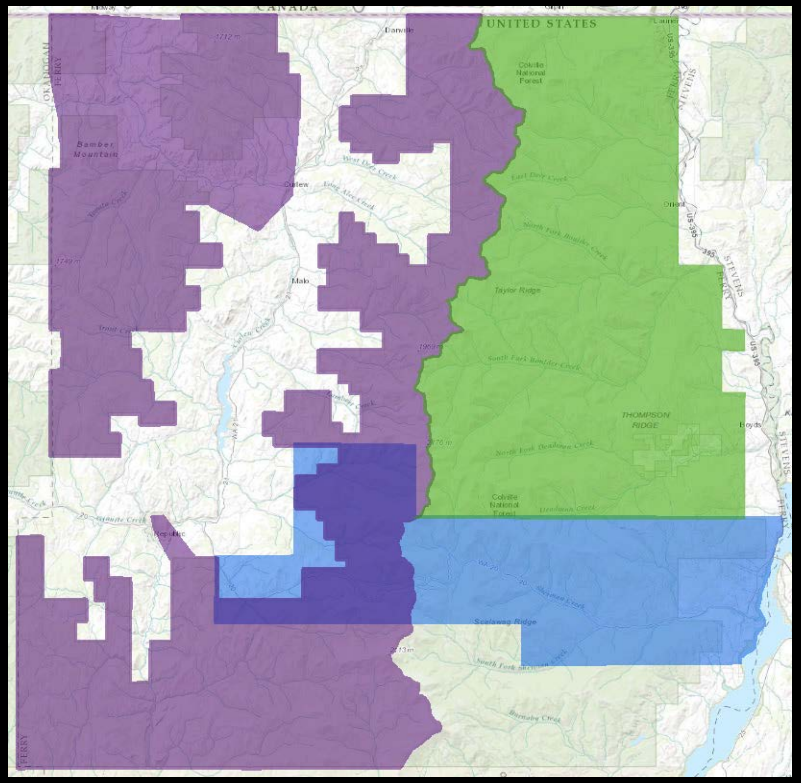


Ground Model

Challenge of LiDAR: Too Much Information!

Point Cloud Data ➔ Metrics useable at larger extents

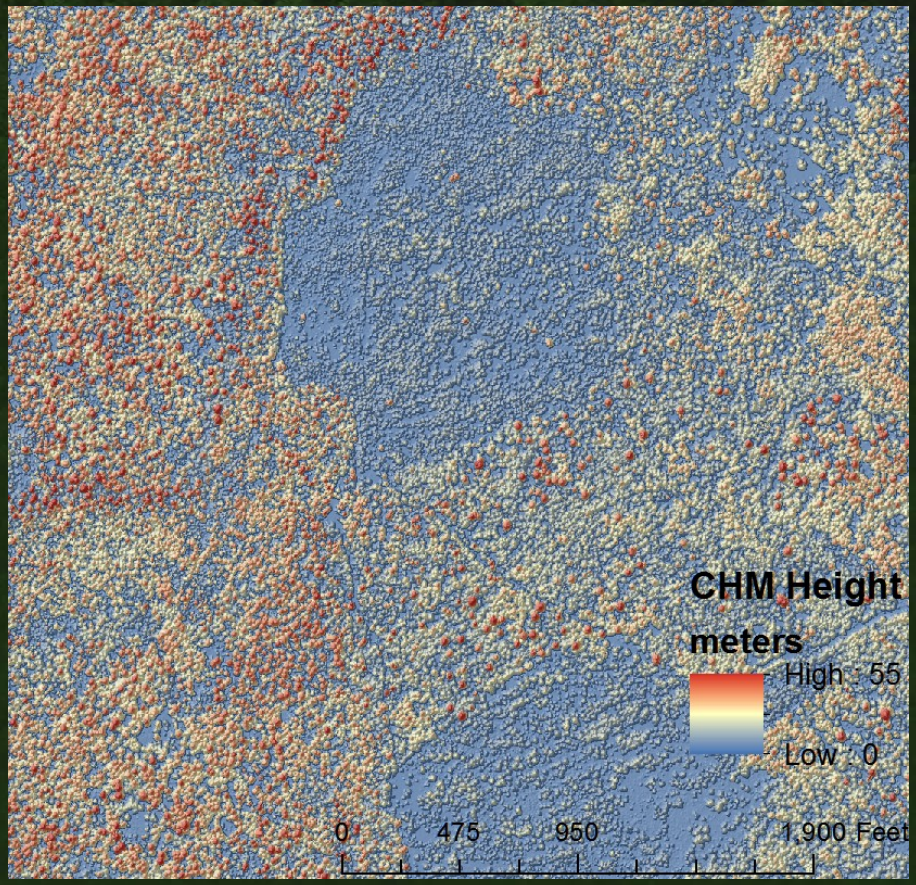




LiDAR Products

1. Point Cloud Data:

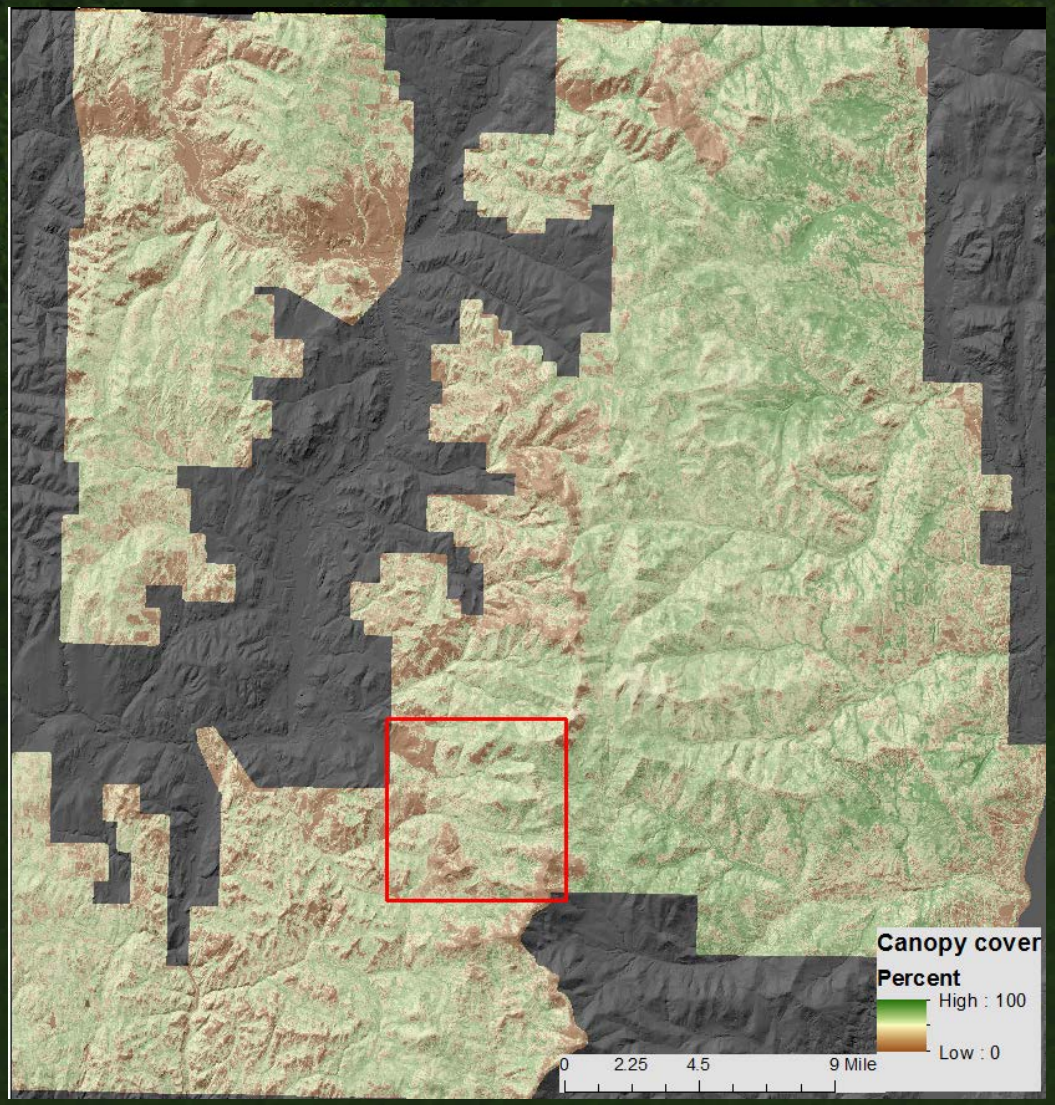
2. Direct: Surface Models (1-2m rasters)
   - Canopy surface model
   - Ground model
   - Hillshades



CNF LiDAR Products

1. Point Cloud Data:
2. Direct: Surface Models

3. Direct: 30m rasters:
   - Canopy cover
   - Height: P95 & P25
   - Cover by strata
   - Many others…

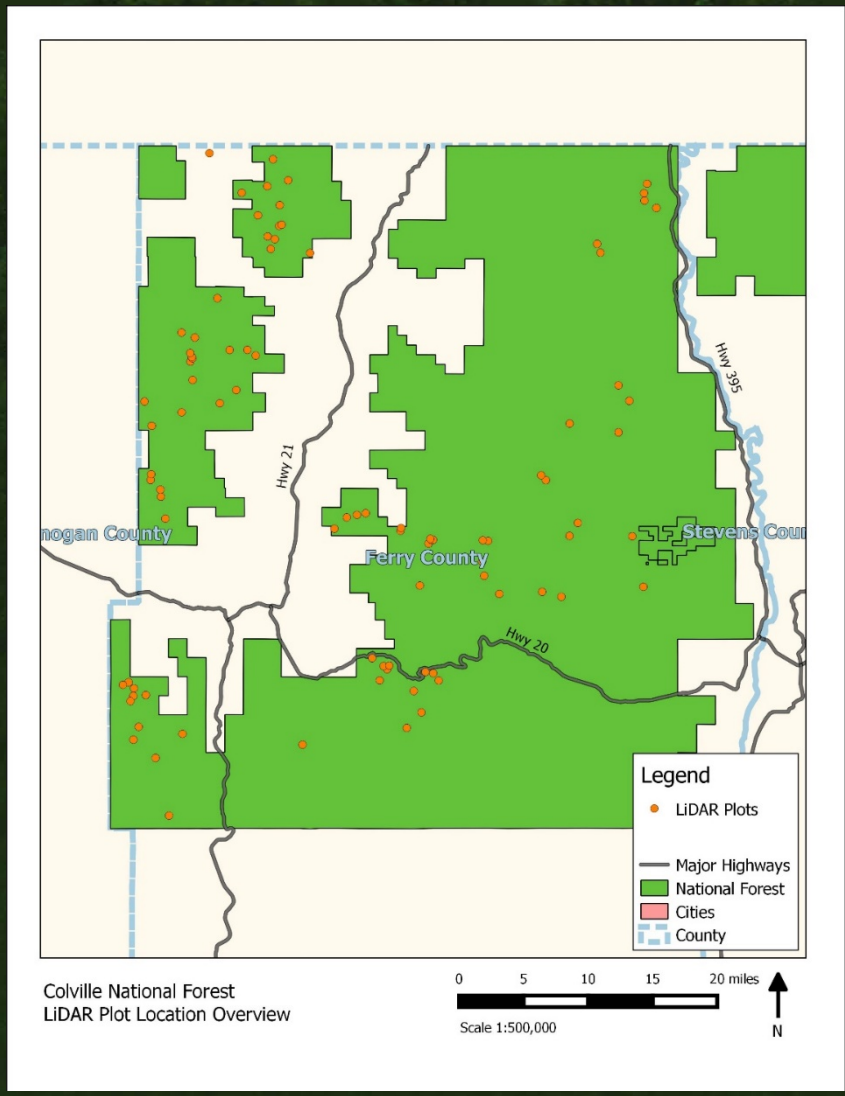


LiDAR Products

1. Point Cloud Data:
2. Direct: Surface Models
3. Direct: 30m rasters:
4. Direct: Topo metrics

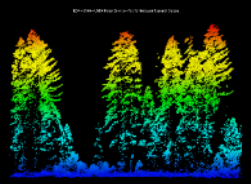
5. Derived/Modeled from plot data:

- Basal area, volume
- QMD, TPA
- TPA>21”

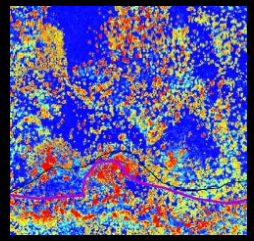


LiDAR as a Scalable Information Set

Level
Local landscapes: Watersheds
Stand Neighborhood – Project Area
Successional – Topo Patches
Tree Neighborhoods

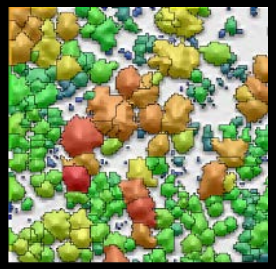


Point Cloud & Intensity Data

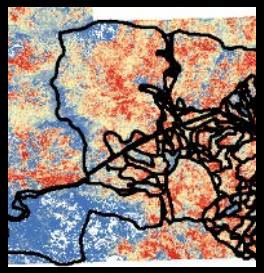


1-2m Pixels

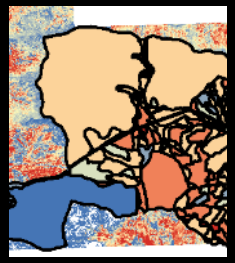
Canopy Surface Model



Tree-Clump-Opening Segments



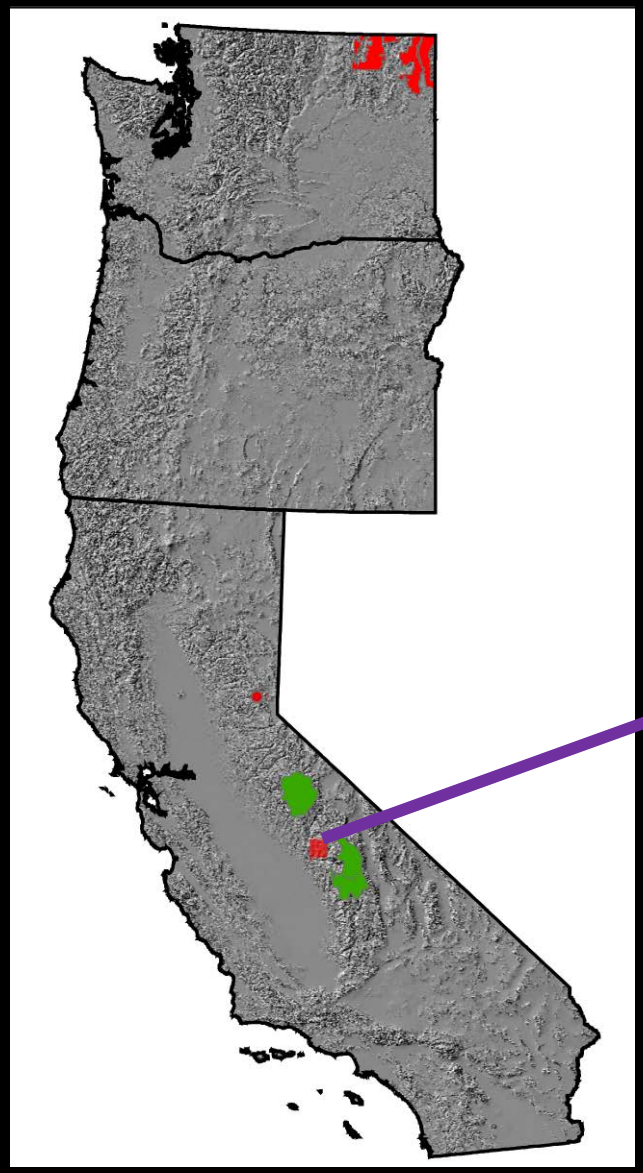
10-30m Pixels:



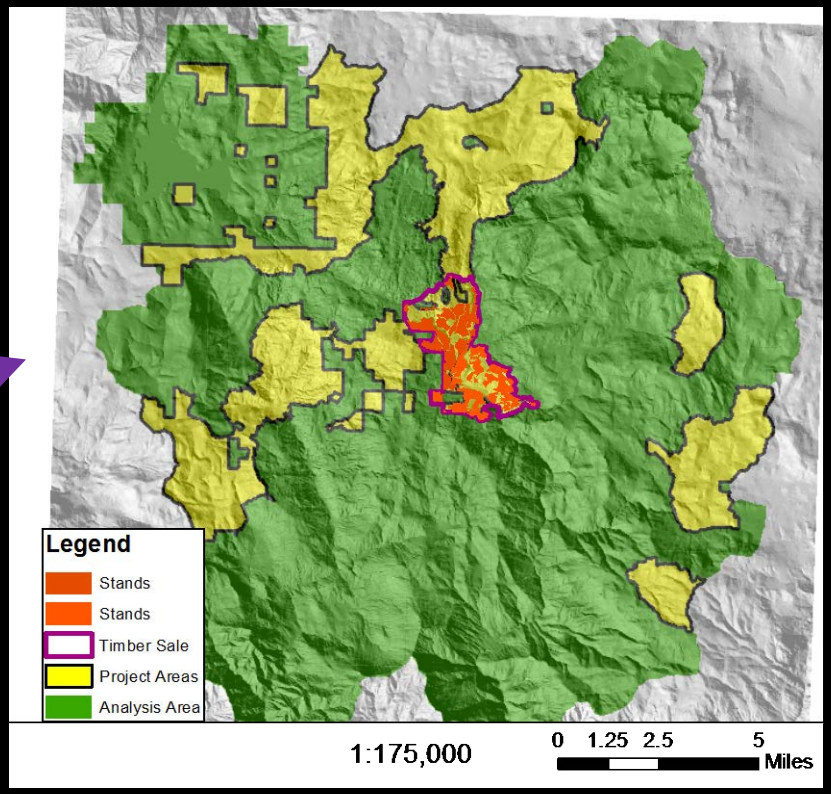
Polygon:

Case Studies of LiDAR Applications

Dinkey CFLRA: Sierra National Forest

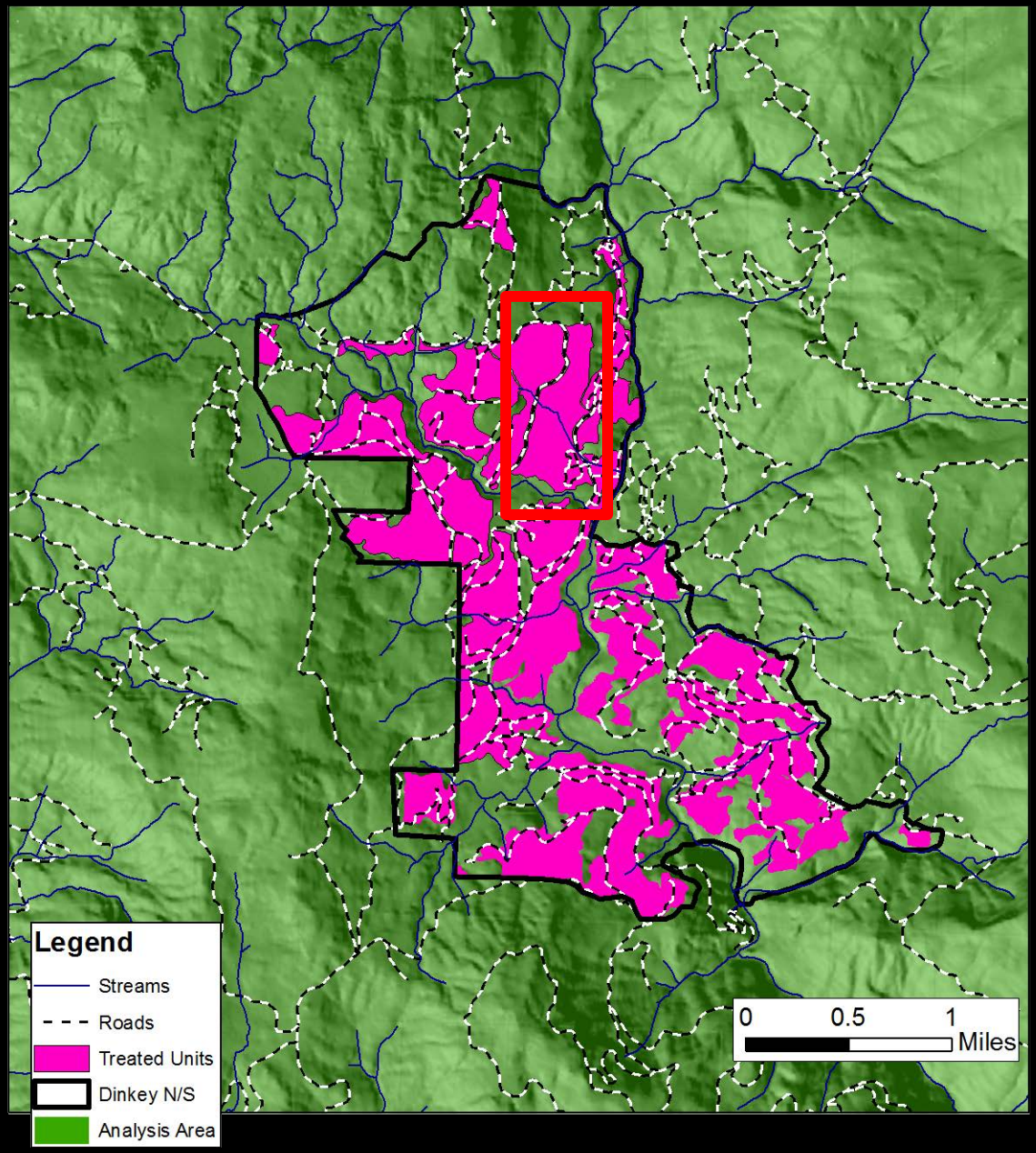


GTR 220
Monitoring with LiDAR



Dinkey Monitoring Results

- Dinkey North/South Project
- Total Area: ~ 3300 Acres
- Treatment units: 1690 Acres
-
- LiDAR Flights: 2010 & 2012
- Forest Structure & Heterogeneity
- Project Level: all acres
- 40 Treated units: stand level
- Unit 245



Patch → Tree Neighborhood

Level
Local landscapes: Watersheds
Stand Neighborhood – Project Area
Successional – Topo Patches
Tree Neighborhoods

Point Cloud & Intensity Data

1-2m Pixels

Canopy Surface Model

Tree-Clump-Opening Segments

10-30m Pixels:

Direct, Derived, Combined

Polygon:

Summarized Direct, Derived, Combined Metrics

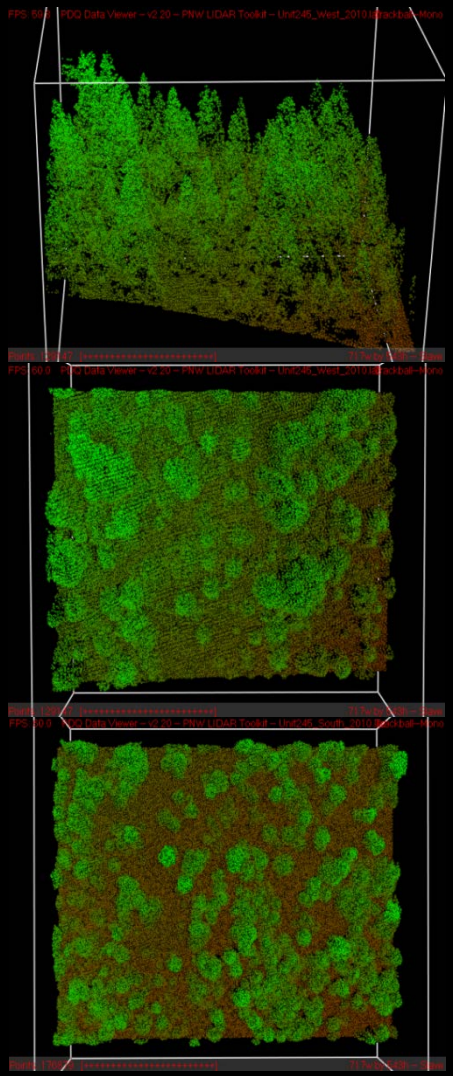
Tree Neighborhood Pattern in Frequent-Fire Forests

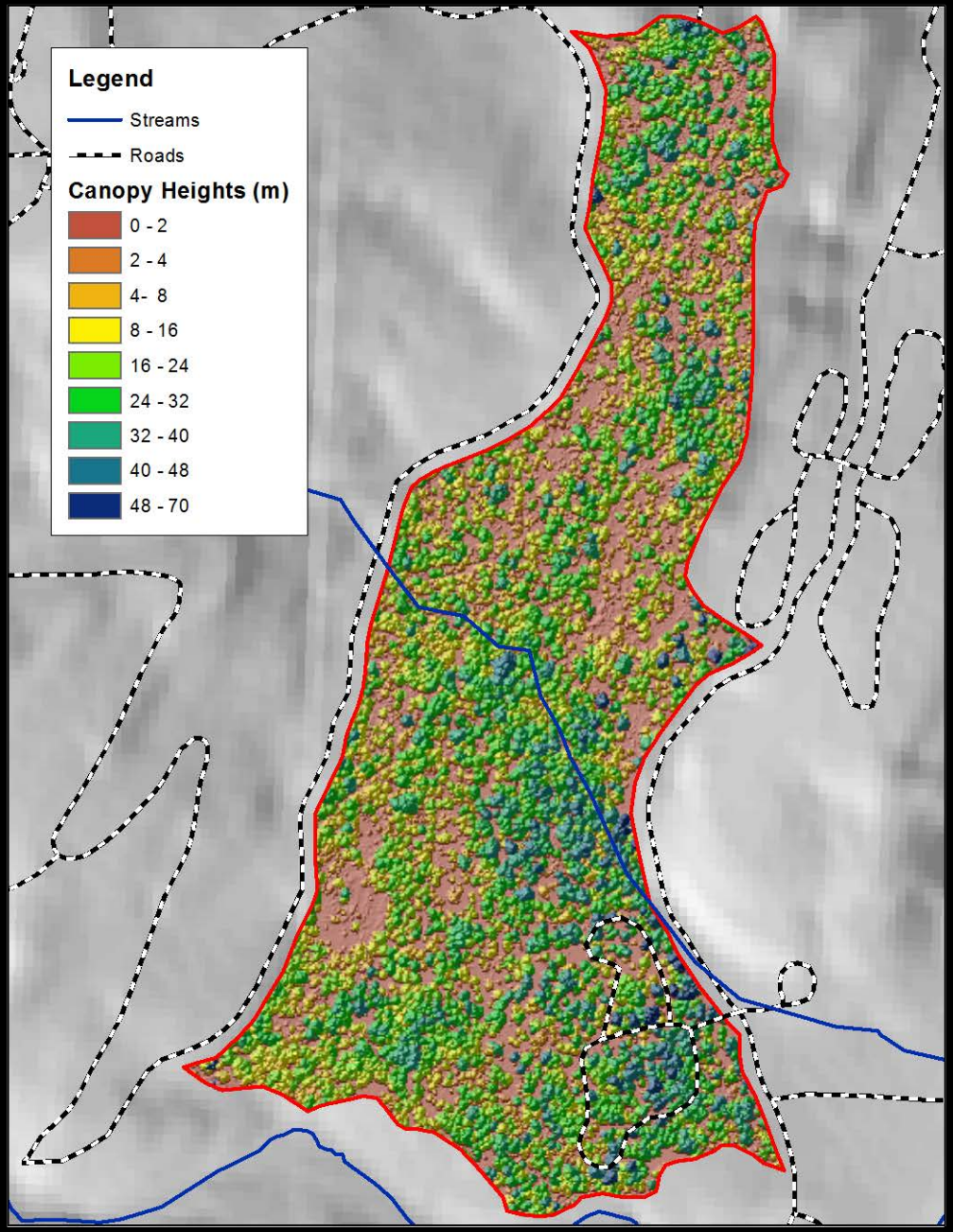
Figure 2—An example of the clumped tree distribution and canopy gaps produced by an active fire regime. The photograph is an aerial view of the Beaver Creek Pinery, which has experienced very little fire suppression.

Photo by Carl Skinner, from: North, M. et al., 2009. An Ecosystem Management Strategy for Sierran Mixed- Conifer Forests. *USDA Forest Service: Pacific Southwest Research Station. General Technical Report*, PSW-GTR-220.

Treatment Unit Comparison

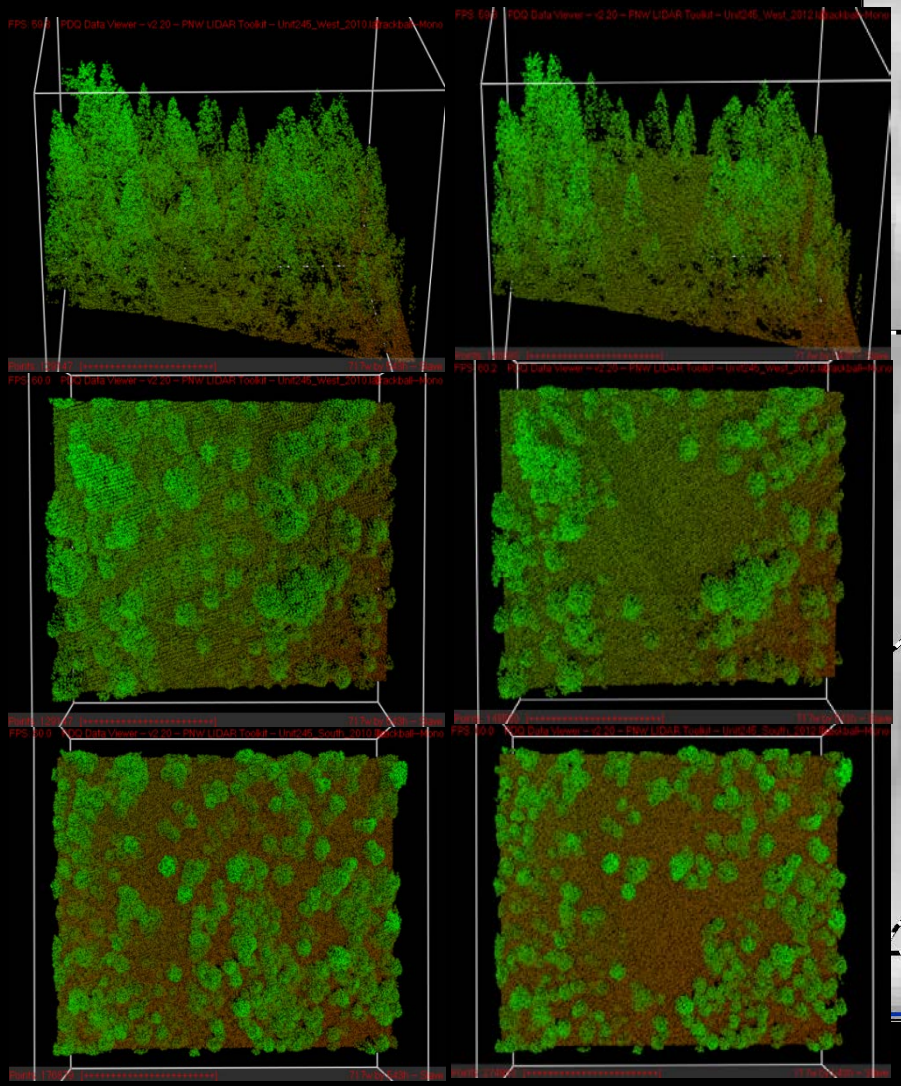
Unit 245: Pre-treatment

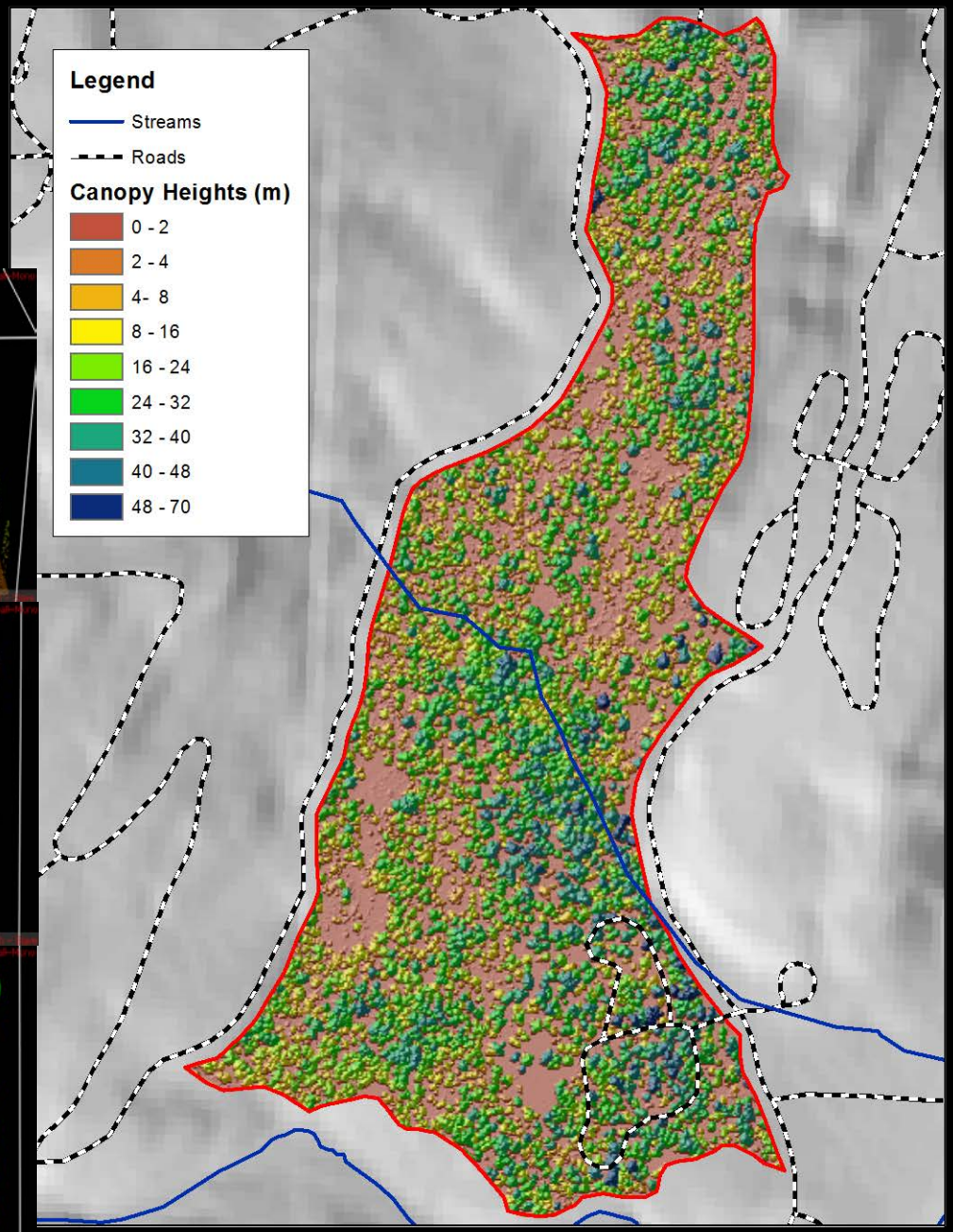




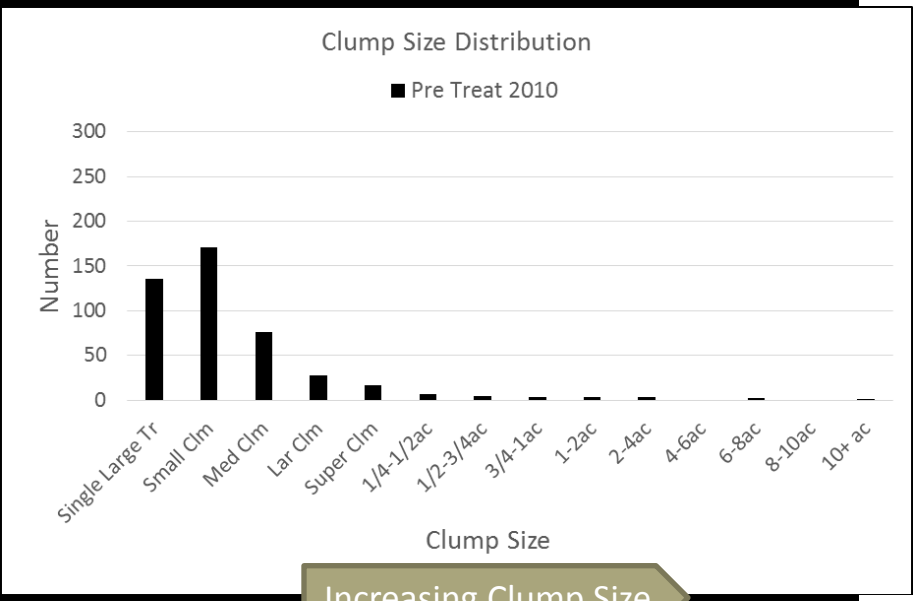
Treatment Unit Comparison

Unit 245: Post -treatment



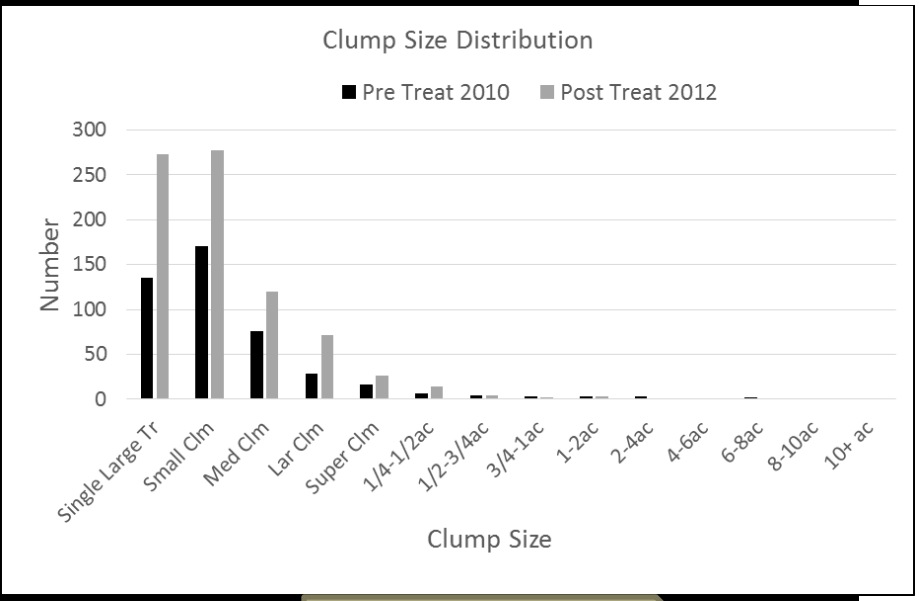


Unit 245: Stand Level Heterogeneity
Clump Size Distribution
Pre- Treatment



Increasing Clump Size

Clump Size Distribution Post Treatment



Increasing Clump Size

Project Area → Patch

Level
Local landscapes: Watersheds
Stand Neighborhood – Project Area
Successional – Topo Patches
Tree Neighborhoods

Point Cloud & Intensity Data

1-2m Pixels

Canopy Surface Model

Tree-Clump-Opening Segments

10-30m Pixels:

Direct, Derived, Combined

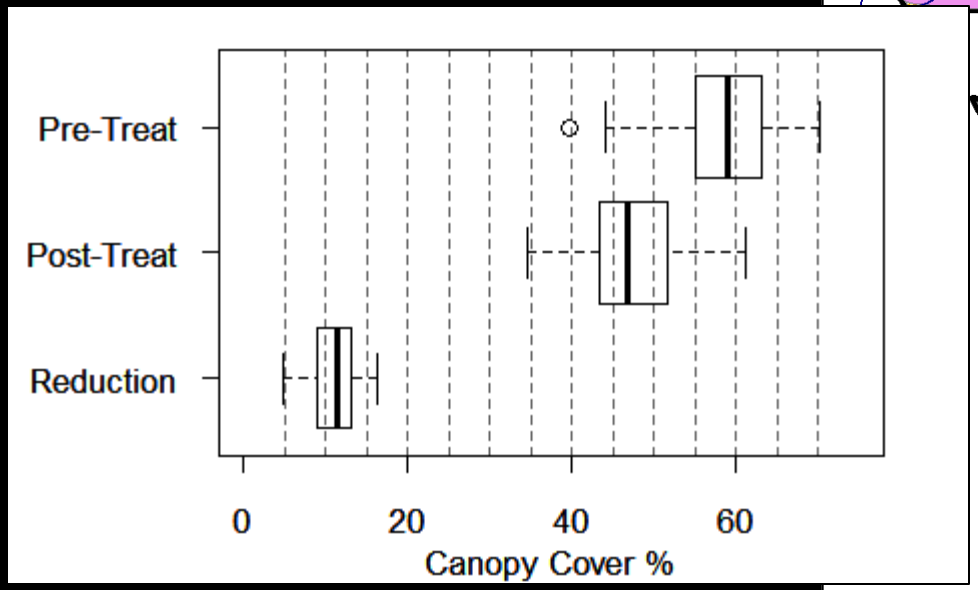
Polygon:

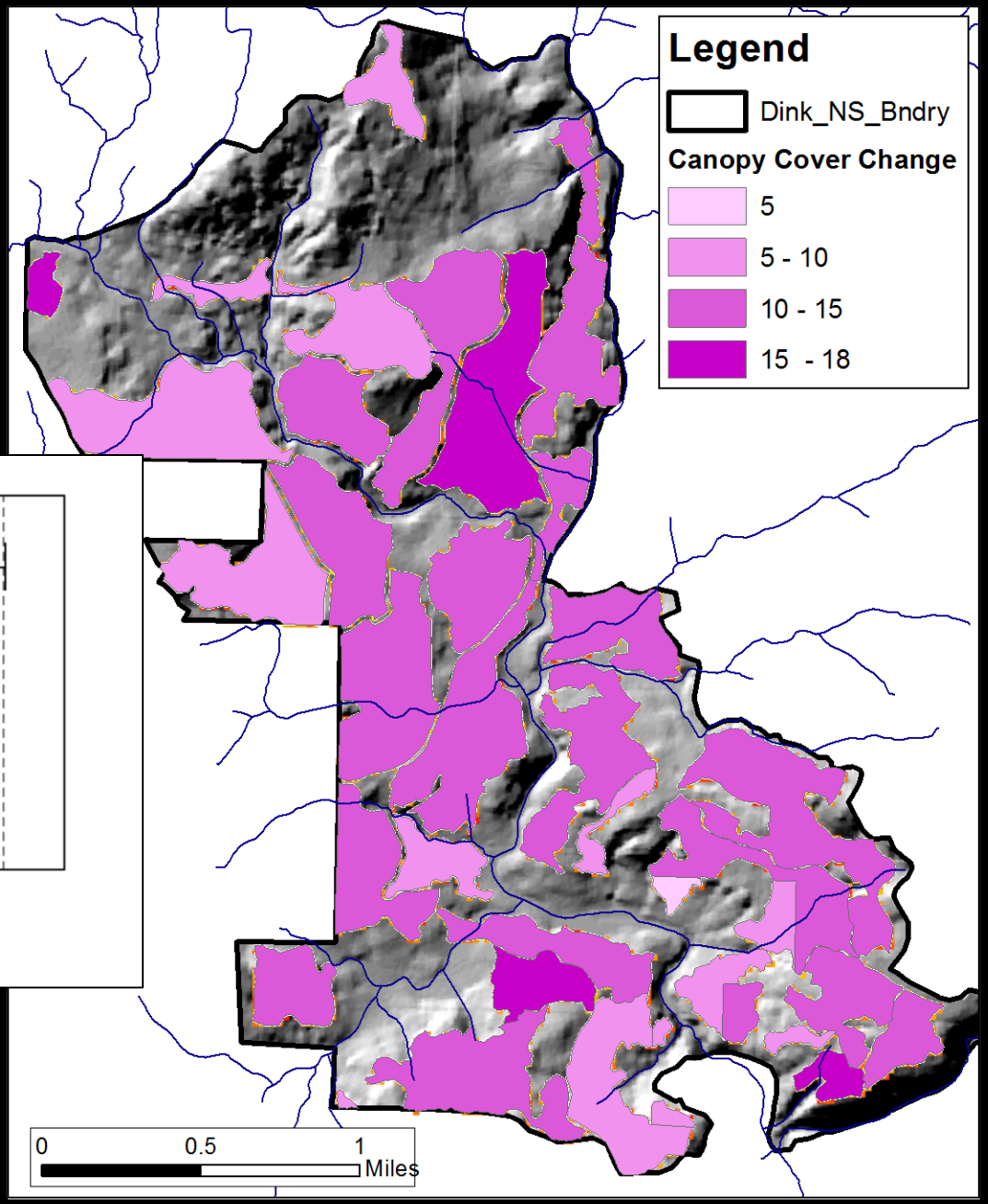
Summarized Direct, Derived, Combined Metrics

Canopy Cover

Did forest treatments significantly alter canopy cover?

Treated Units

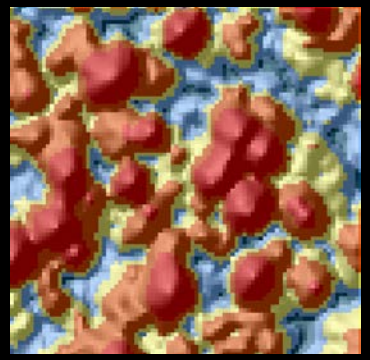




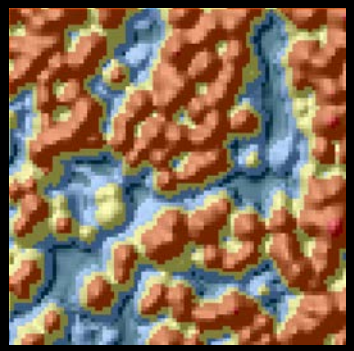
4-16% reduction in CC

Structure Classes

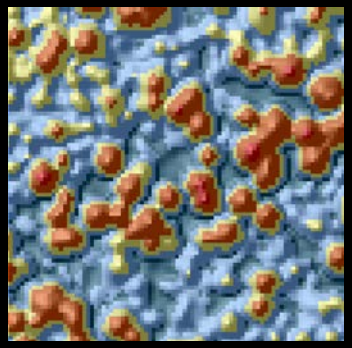
Class 1



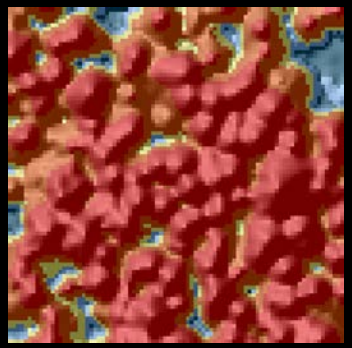
Class 2



Class 3



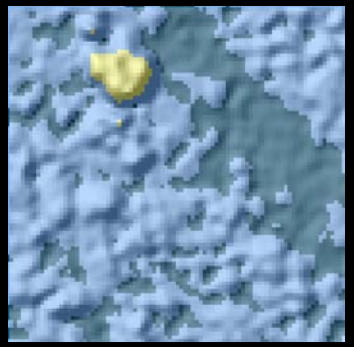
Class 4



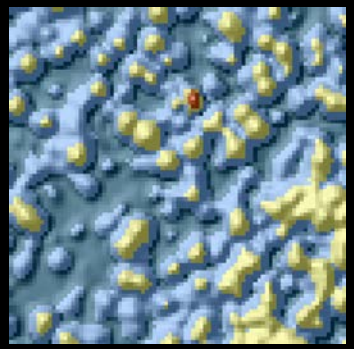
Height breaks meters

- 0 - 2
- 2 - 8
- 8 - 16
- 16 - 32
- 32 - 75

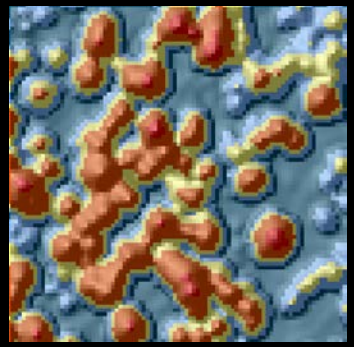
Class 5



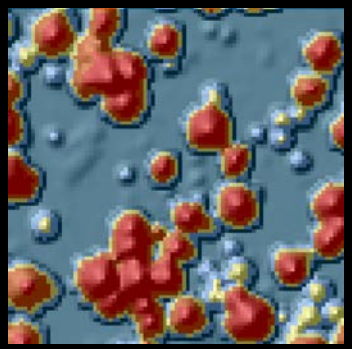
Class 6



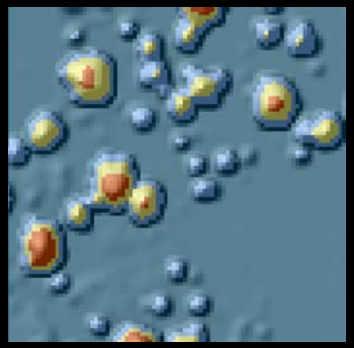
Class 7



Class 8

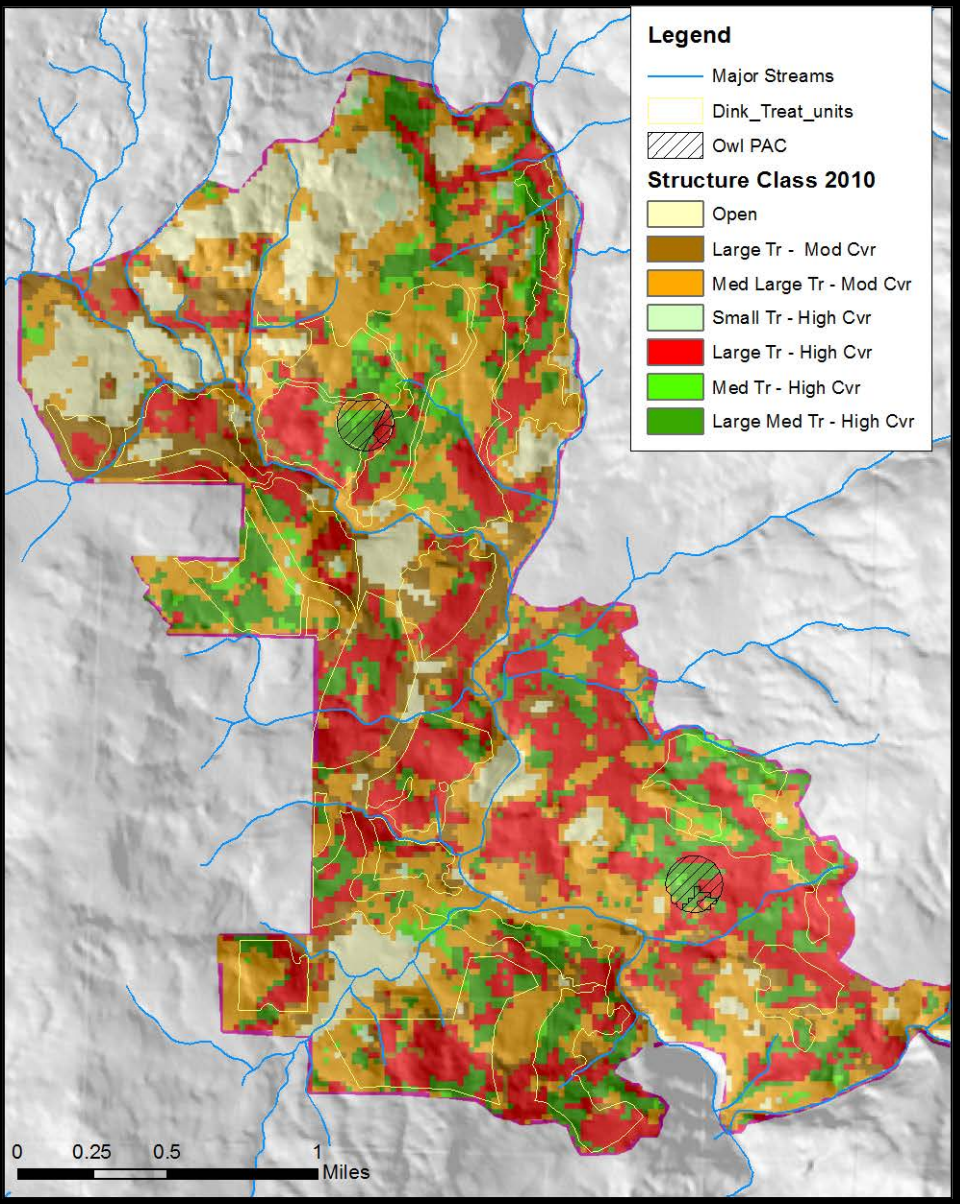


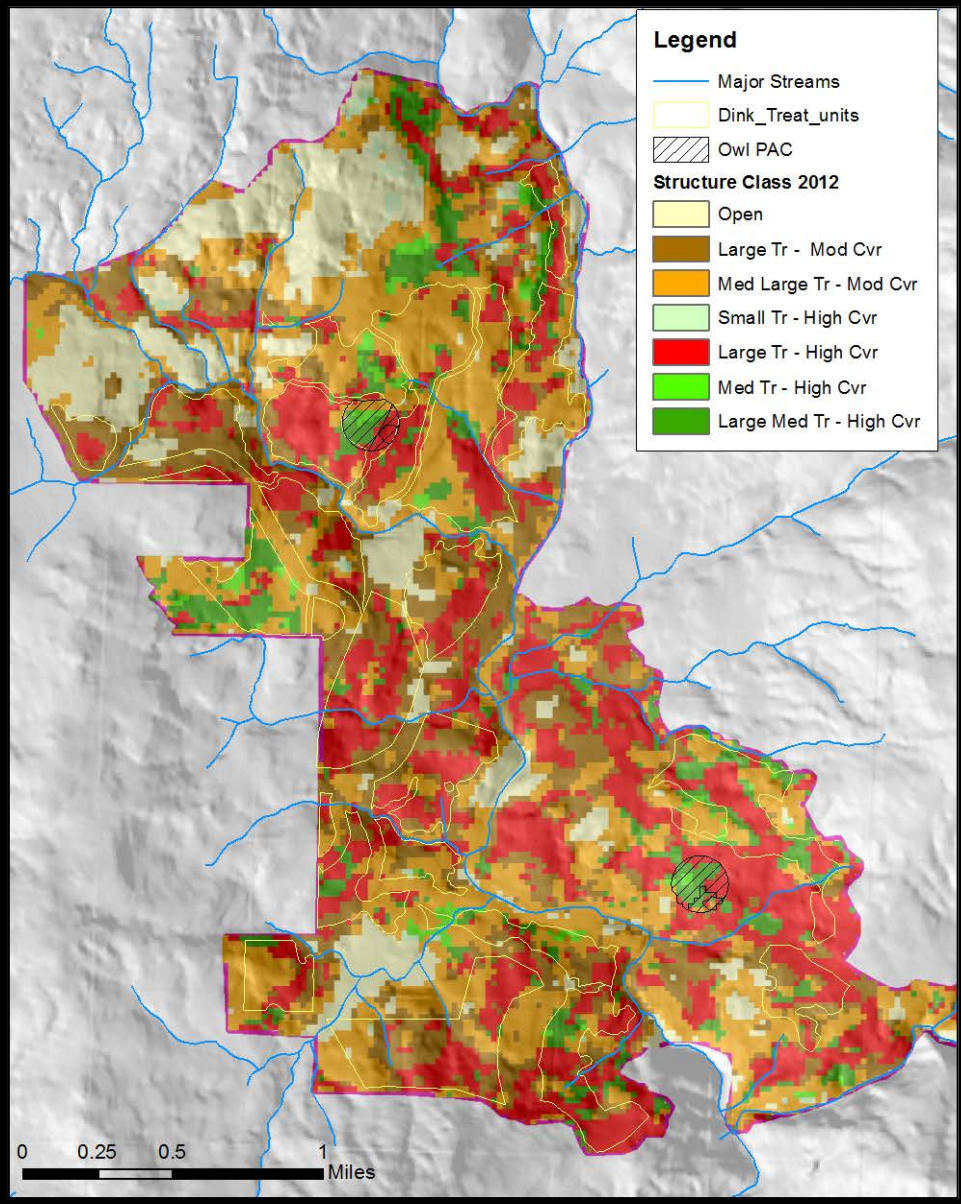
Class 9



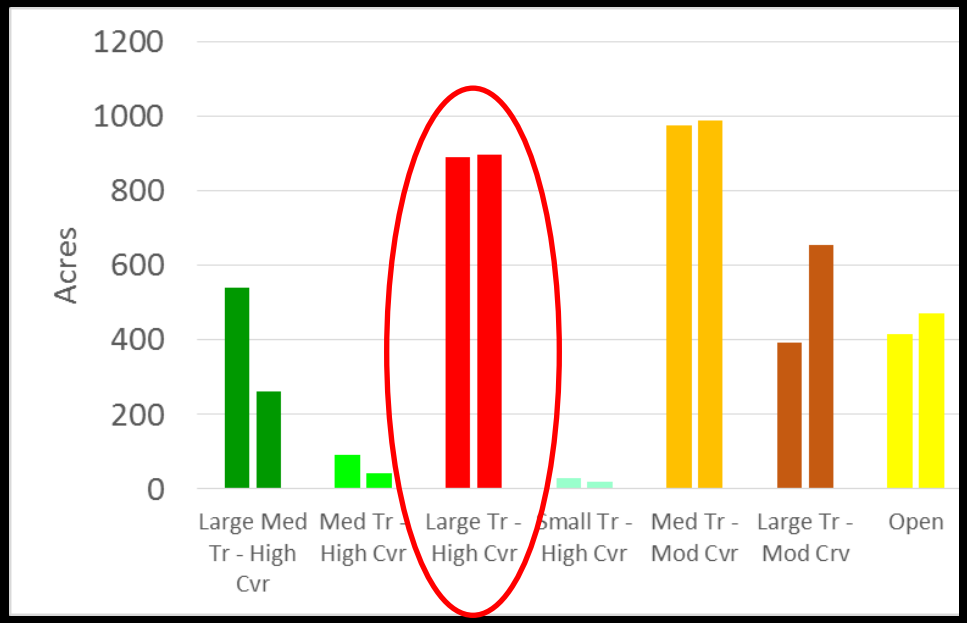
Differ in cover & dominant tree height

Structure Classes

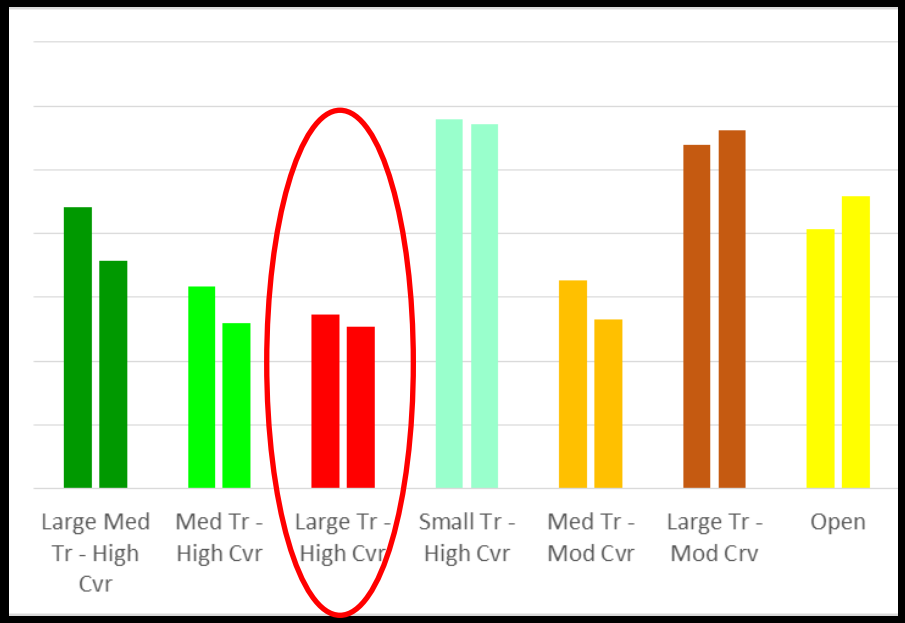




Total Area



Connectivity

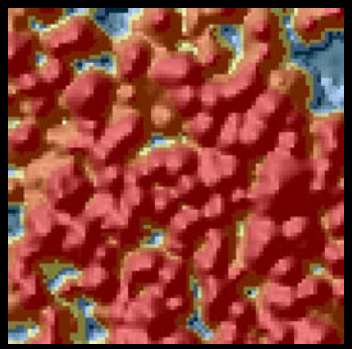


Proportion like adjacencies

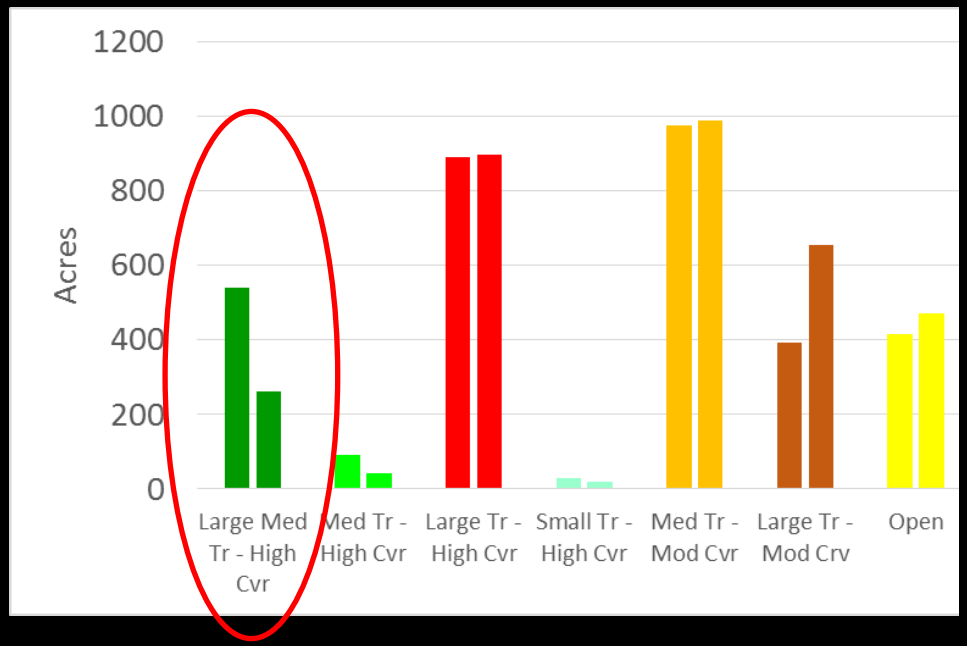
Mean patch size

Conclusions:

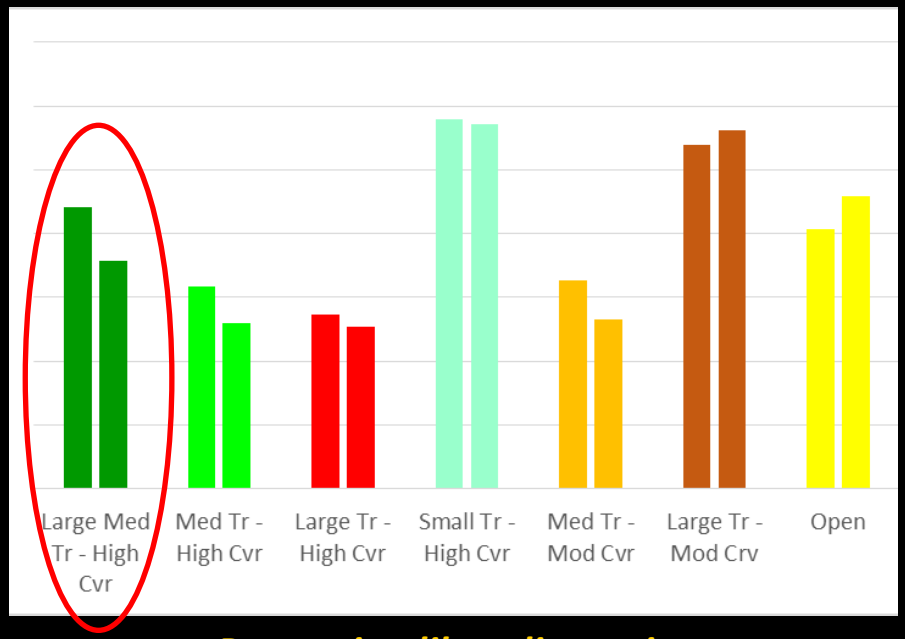
- *CSO class largely unchanged*



Total Area

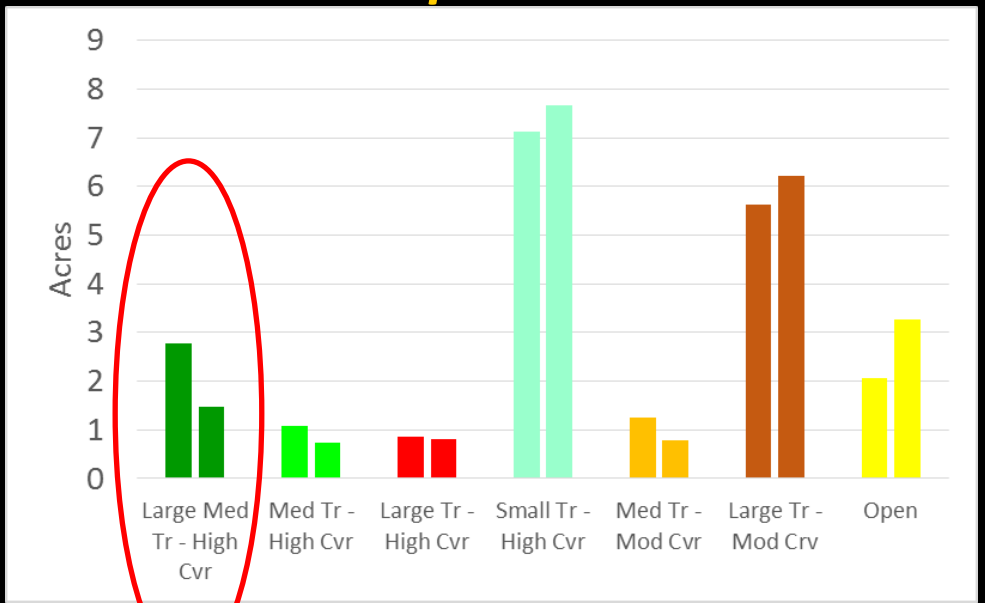


Connectivity



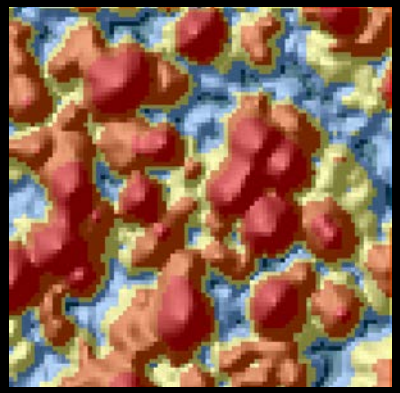
Proportion like adjacencies

Mean patch size



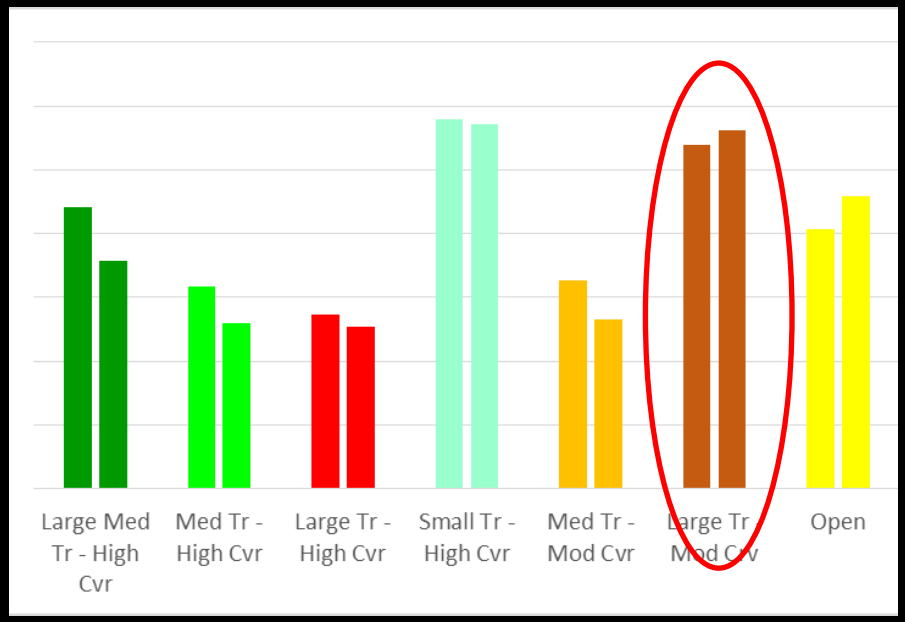
Conclusions:

- *Fire prone class reduced*



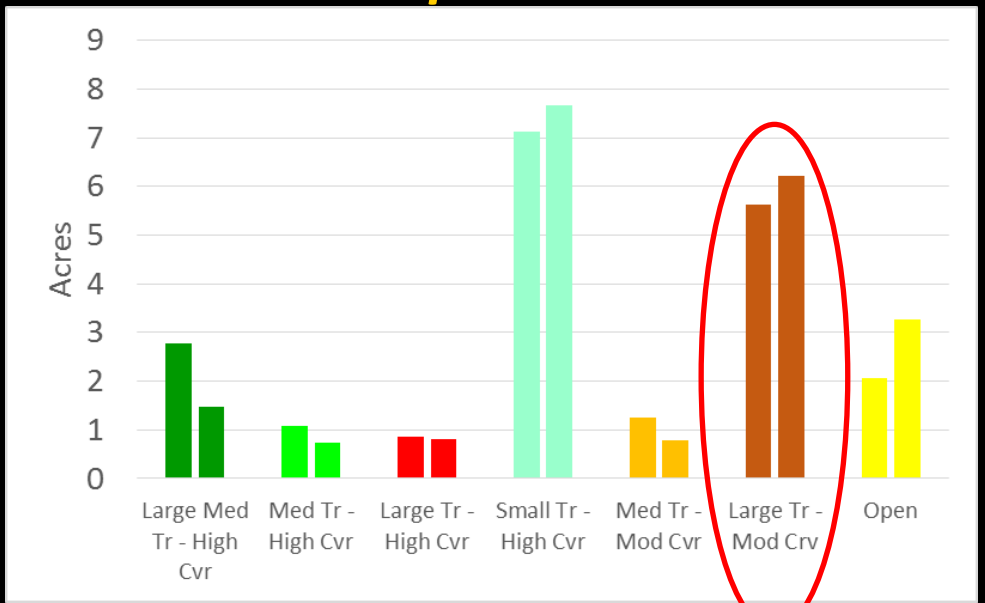
Total Area

Connectivity



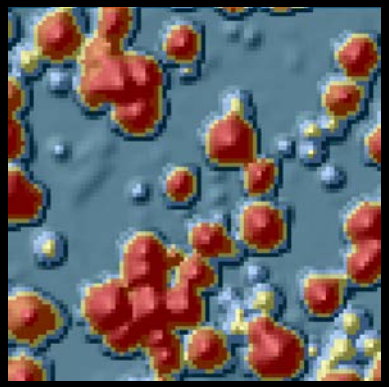
Proportion like adjacencies

Mean patch size

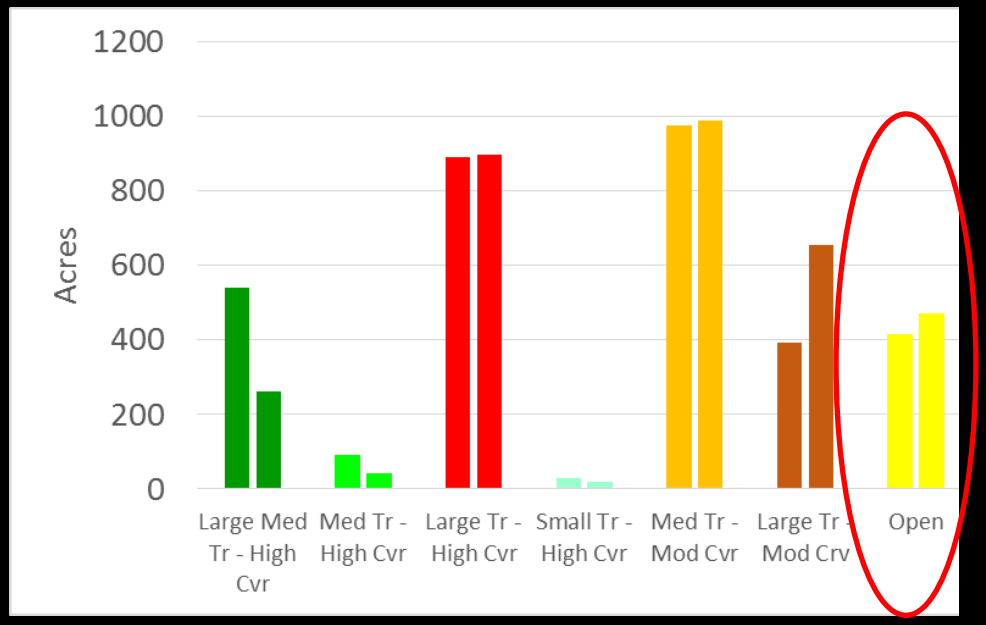


Conclusions:

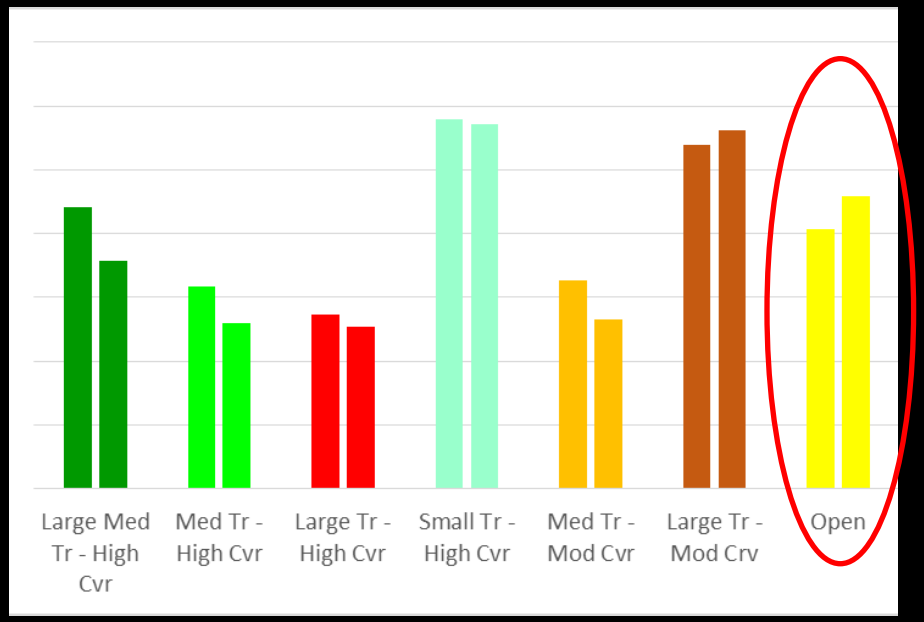
- *Fire resistant class increased*



Total Area

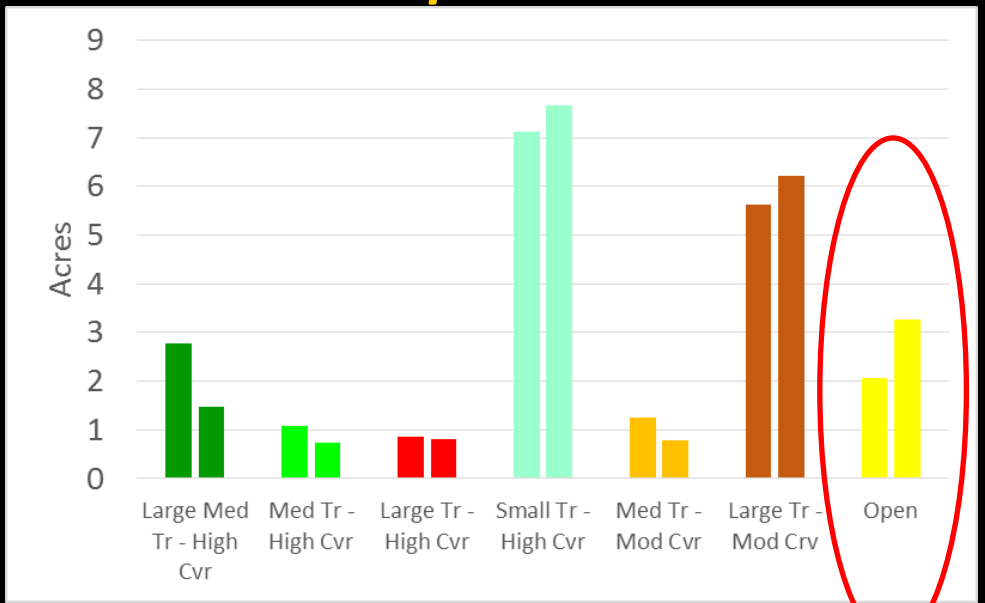


Connectivity



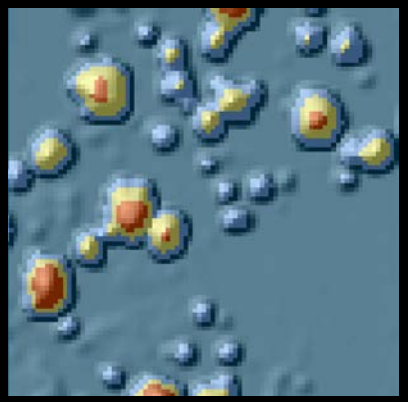
Proportion like adjacencies

Mean patch size

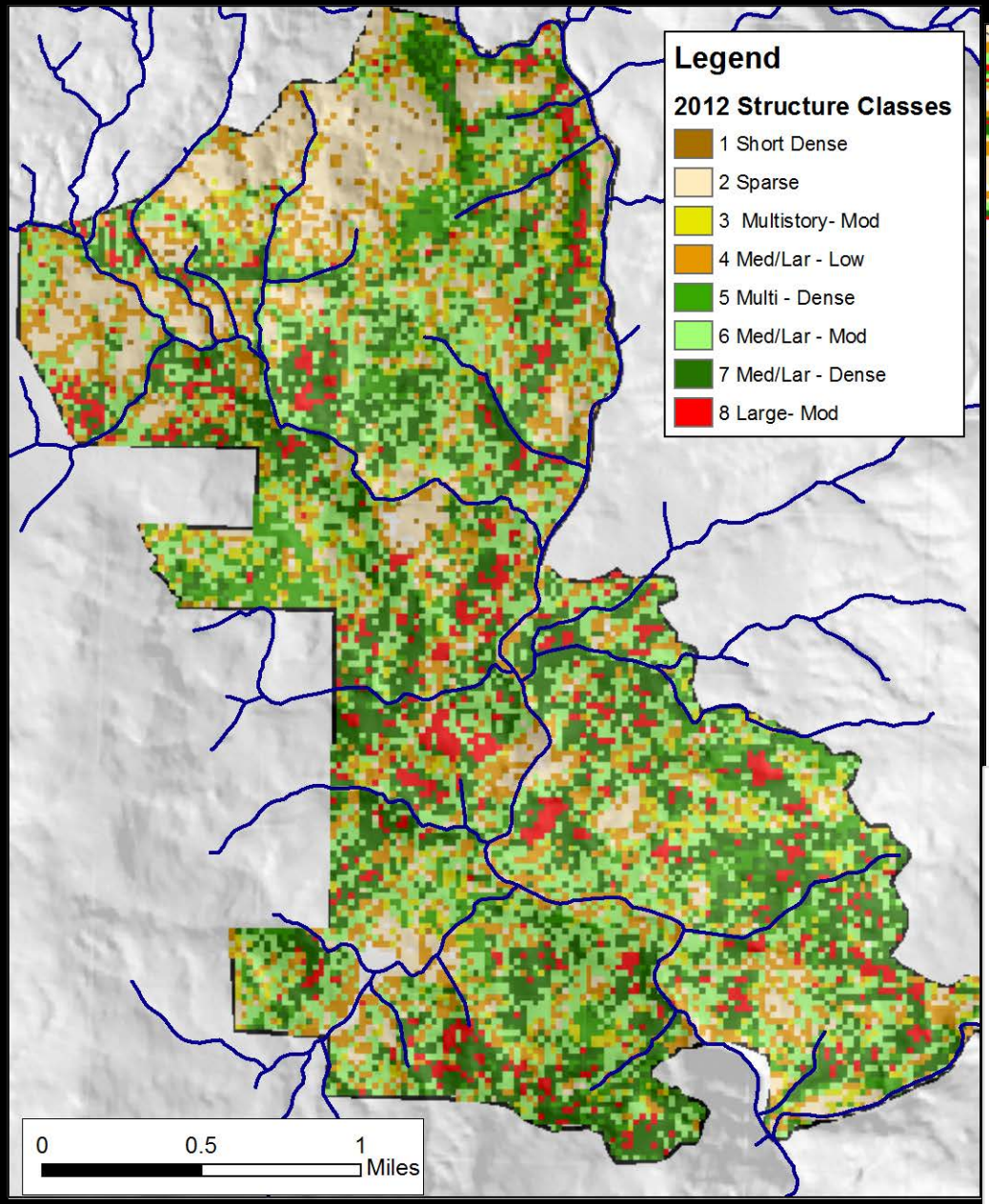


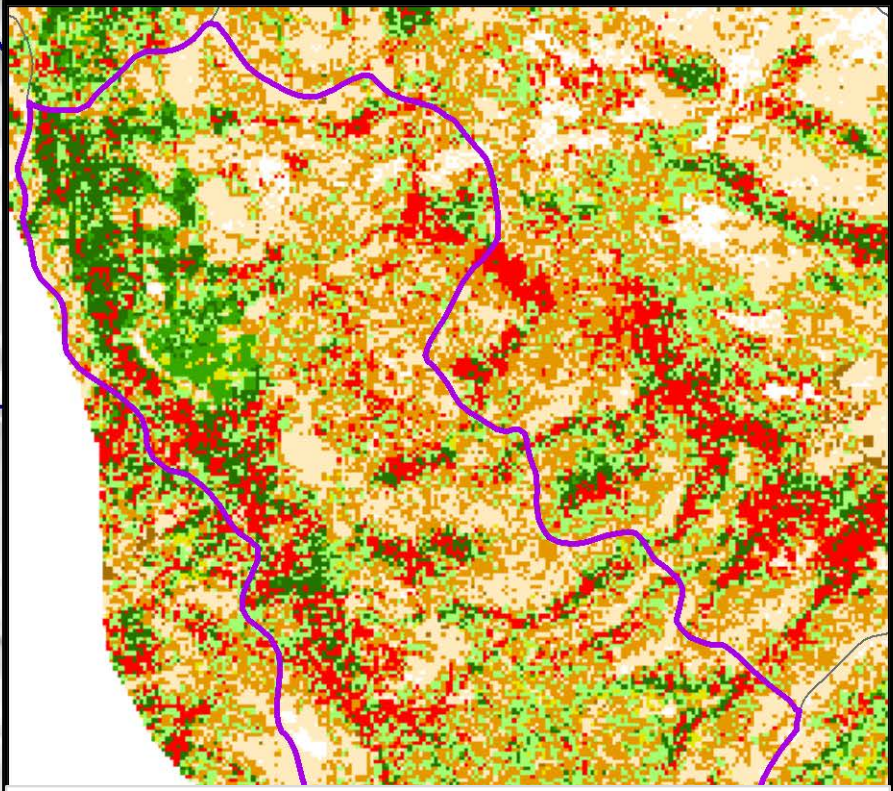
Conclusions:

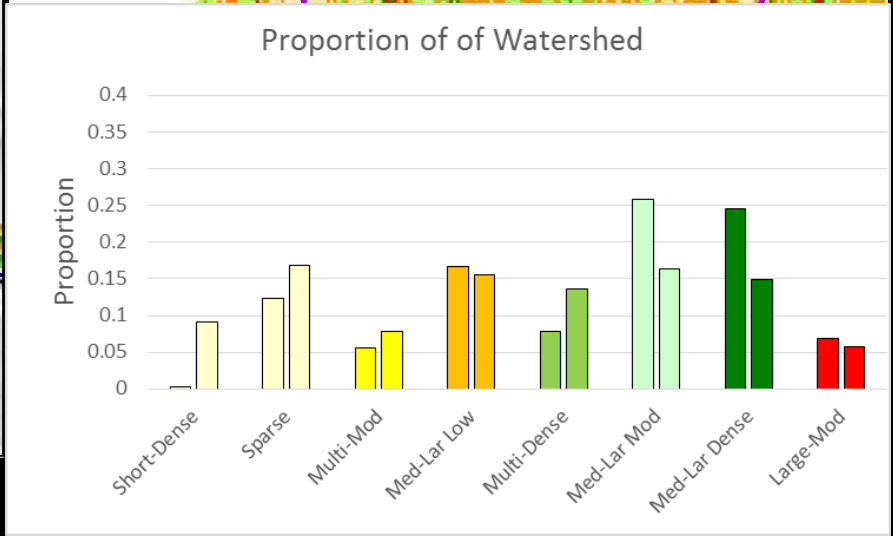
- *Open class increased*



Reference Areas

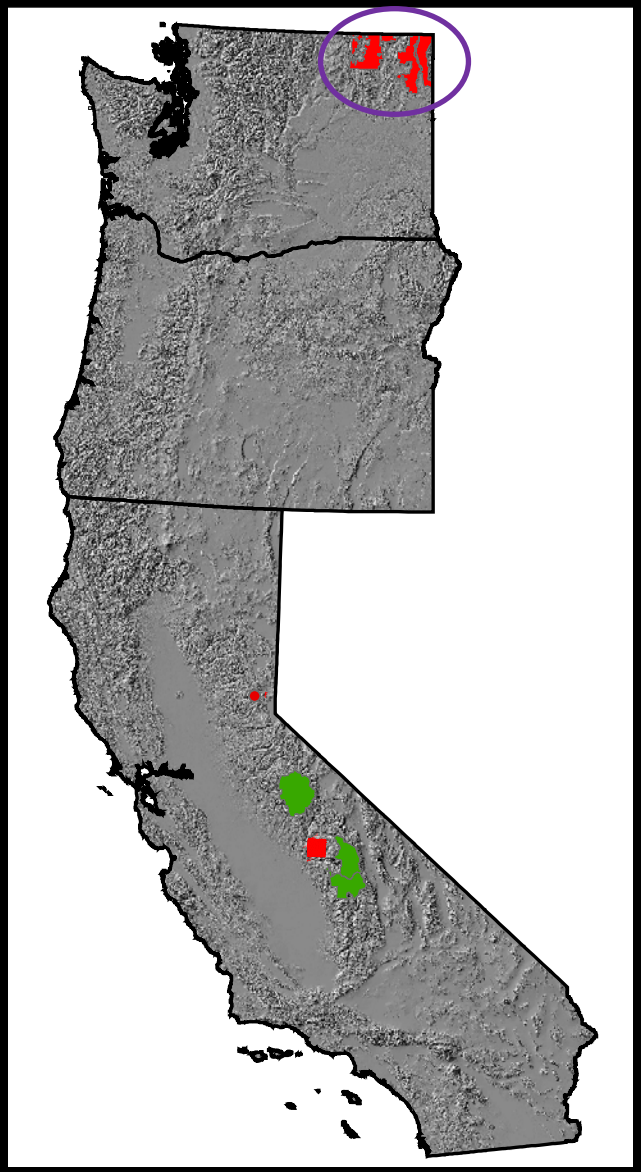






Case Studies of LiDAR Applications

Colville National Forest CFLRA



Integrate LIDAR with Landscape Evaluation:

➔ PI & Landscape Prescription

➔ Align forest structure with topography

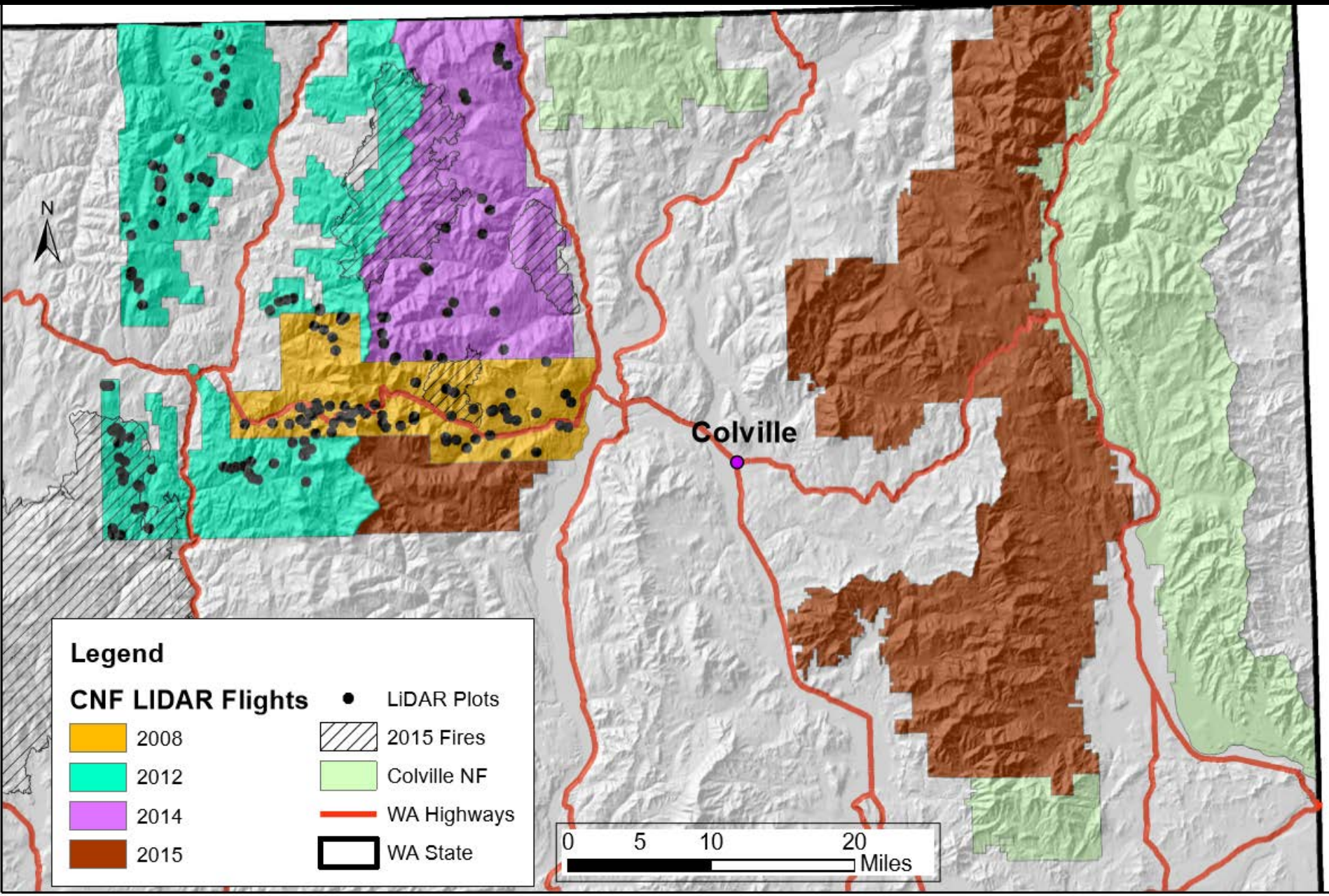
➔ No reference conditions for LiDAR

Landscape Ecol
DOI 10.1007/s10980-015-0218-0

REVIEW ARTICLE

Restoring fire-prone Inland Pacific landscapes: seven core principles

Paul F. Hessburg · Derek J. Churchill · Andrew J. Larson · Ryan D. Haugo · Carol Miller · Thomas A. Spies · Malcolm P. North · Nicholas A. Povak · R. Travis Belote · Peter H. Singleton · William L. Gaines · Robert E. Keane · Gregory H. Aplet · Scott L. Stephens · Penelope Morgan · Peter A. Bisson · Bruce E. Rieman · R. Brion Salter · Gordon H. Reeves


N
Colville
Legend
CNF LIDAR Flights
2008
2012
2014
2015
LiDAR Plots
2015 Fires
Colville NF
WA Highways
WA State
0
5
10
20
Miles

Project Area → Patch

Level
Local landscapes: Watersheds
Stand Neighborhood – Project Area
Successional – Topo Patches
Tree Neighborhoods

Point Cloud & Intensity Data

1-2m Pixels

Canopy Surface Model

Tree-Clump-Opening Segments

10-30m Pixels:

Direct, Derived, Combined

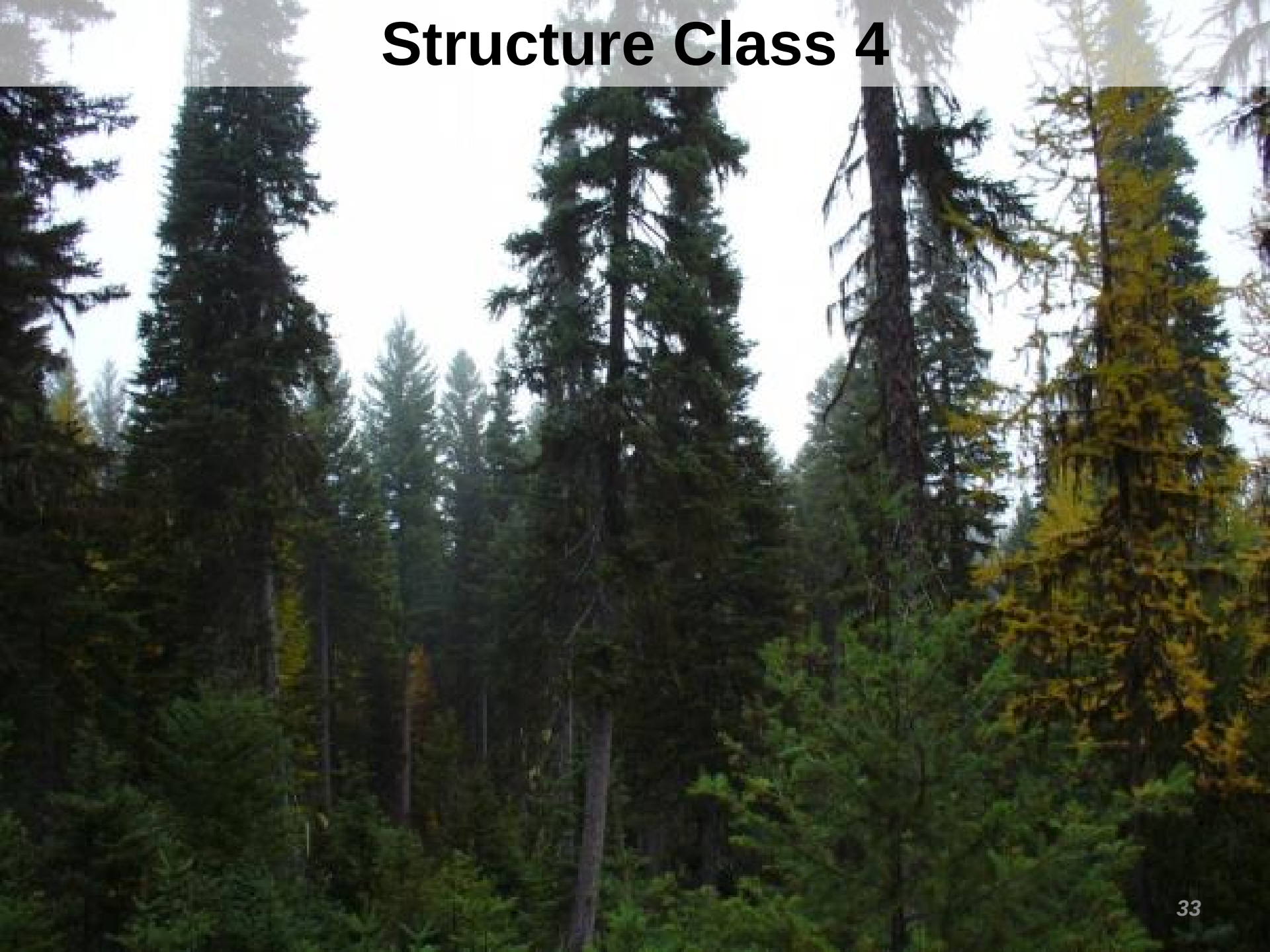
Polygon:

Summarized Direct, Derived, Combined Metrics

Structure Class 1

Structure Class 3

Structure Class 4



Structure Class 5

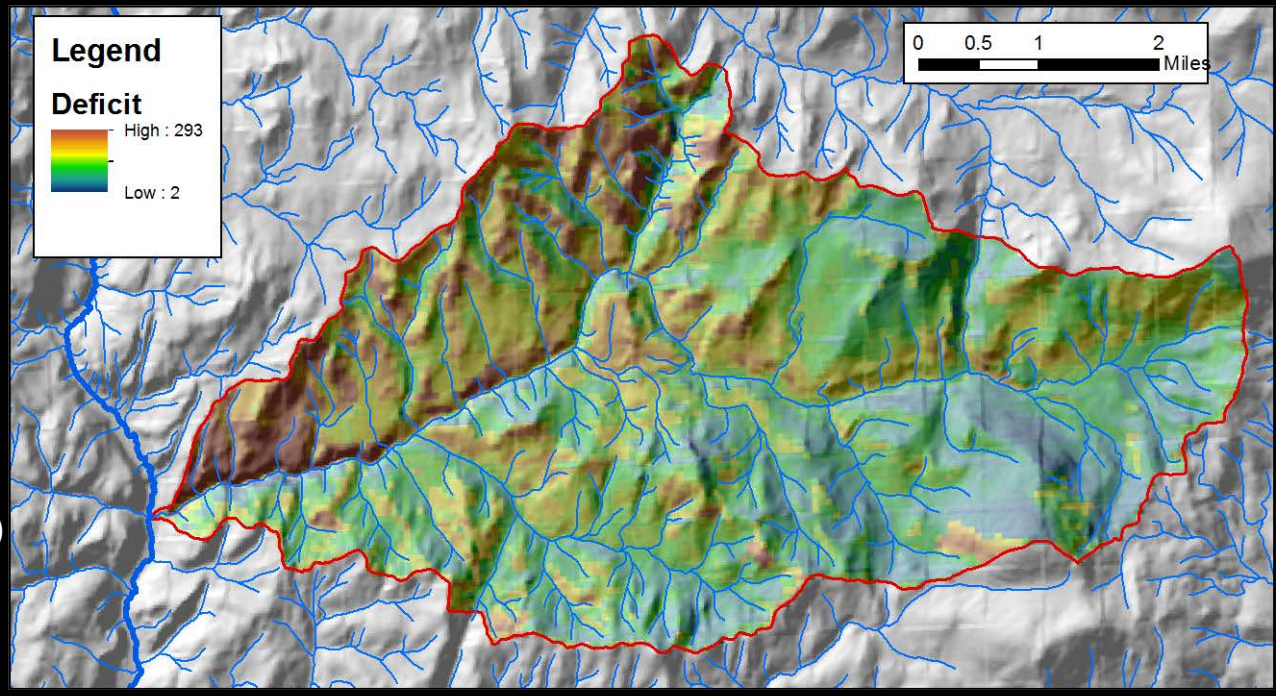
Structure Class 7

Align Forest Structure with

-Topography & biophysical conditions

Water Balance Metrics:
AET & Deficit

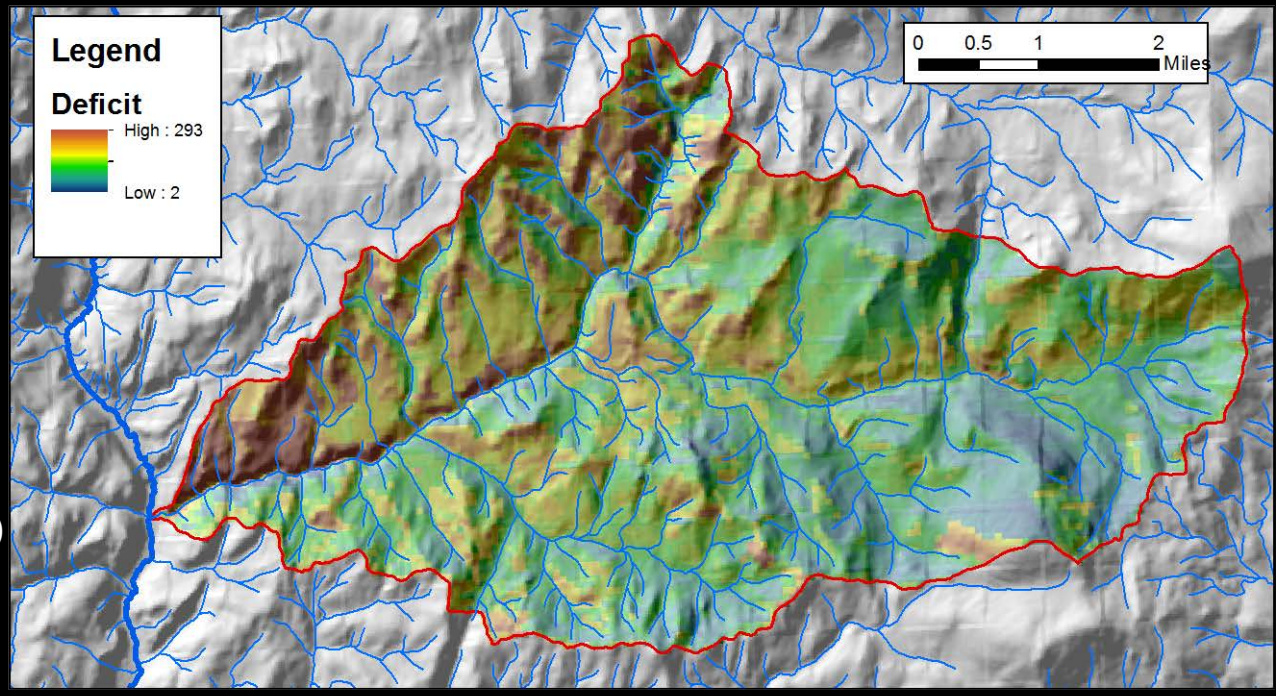
(Lutz et al. 2010, Churchill et al. 2013)



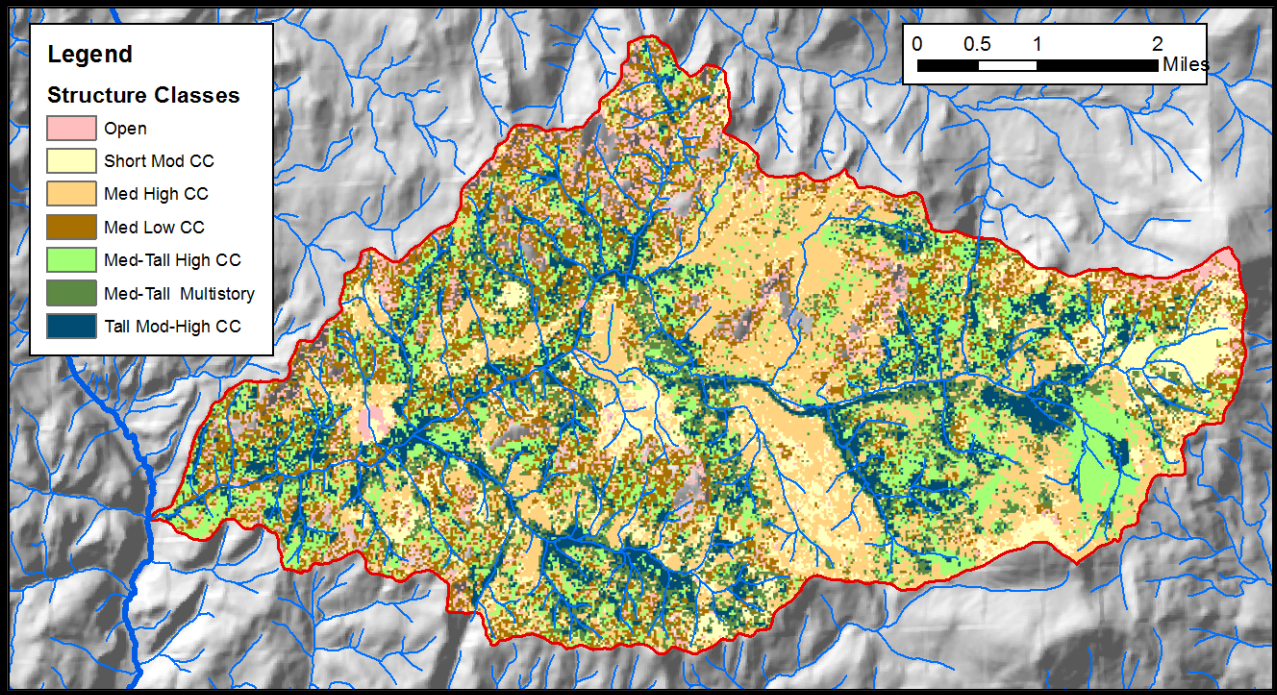
Align Forest Structure with topography & biophysical conditions

Water Balance Metrics: AET & Deficit

(Lutz et al. 2010, Churchill et al. 2013)



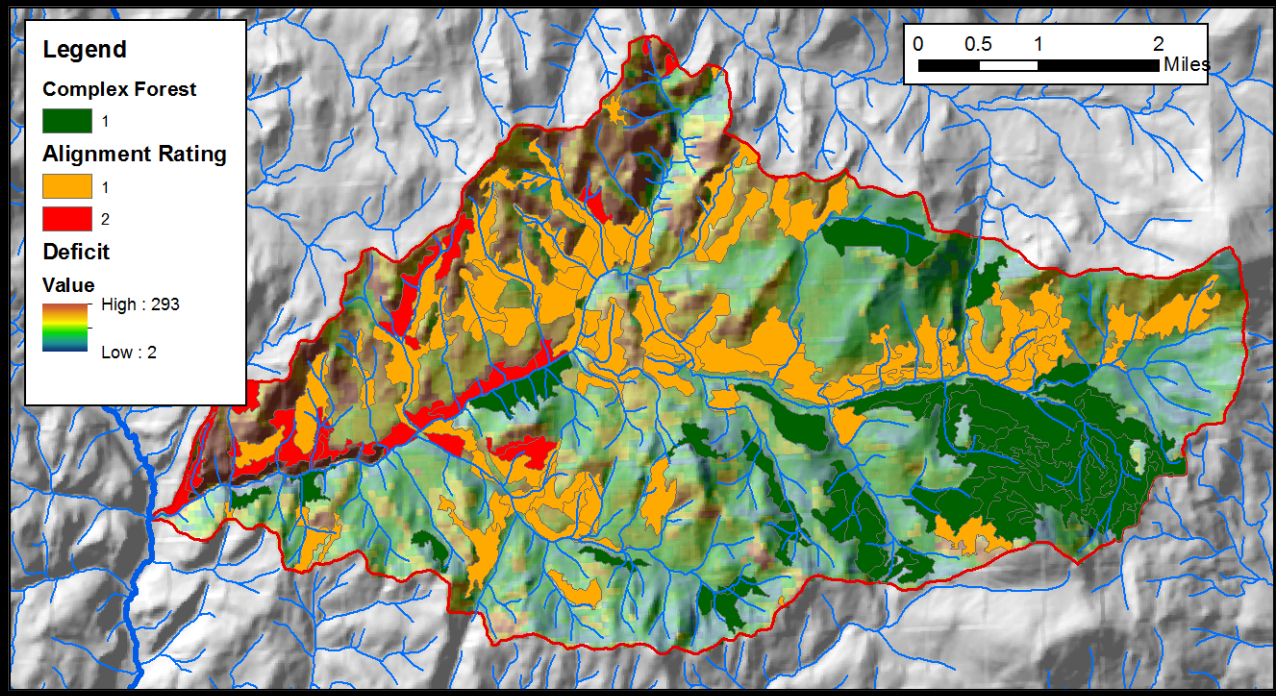
- Structure Classes

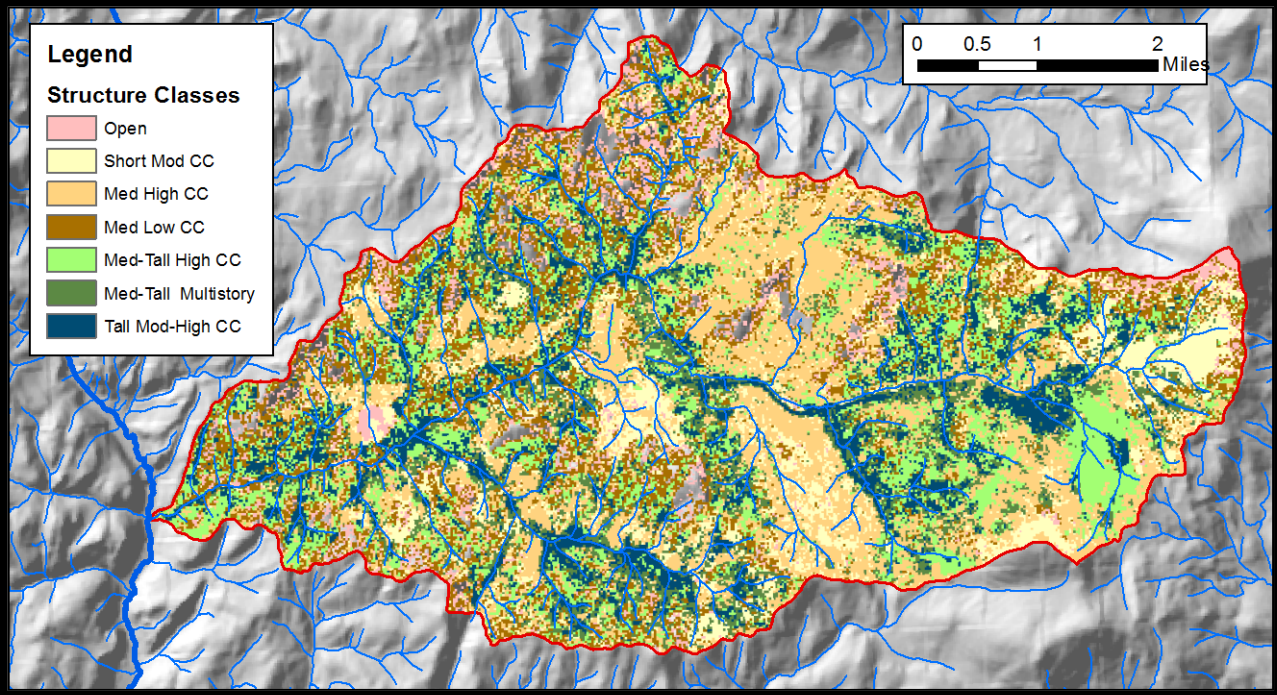


Locate areas:

-High biomass ➔ high deficit & low AET

- Complex structure ➔ Low deficit, higher AET

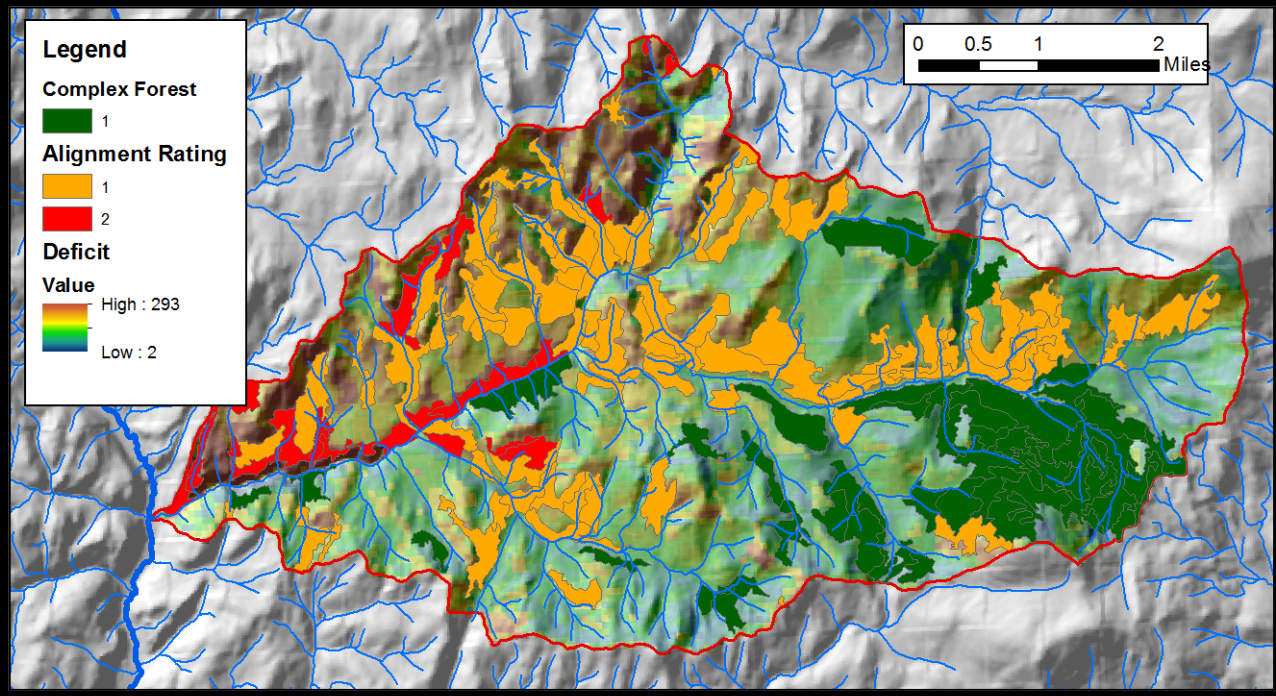


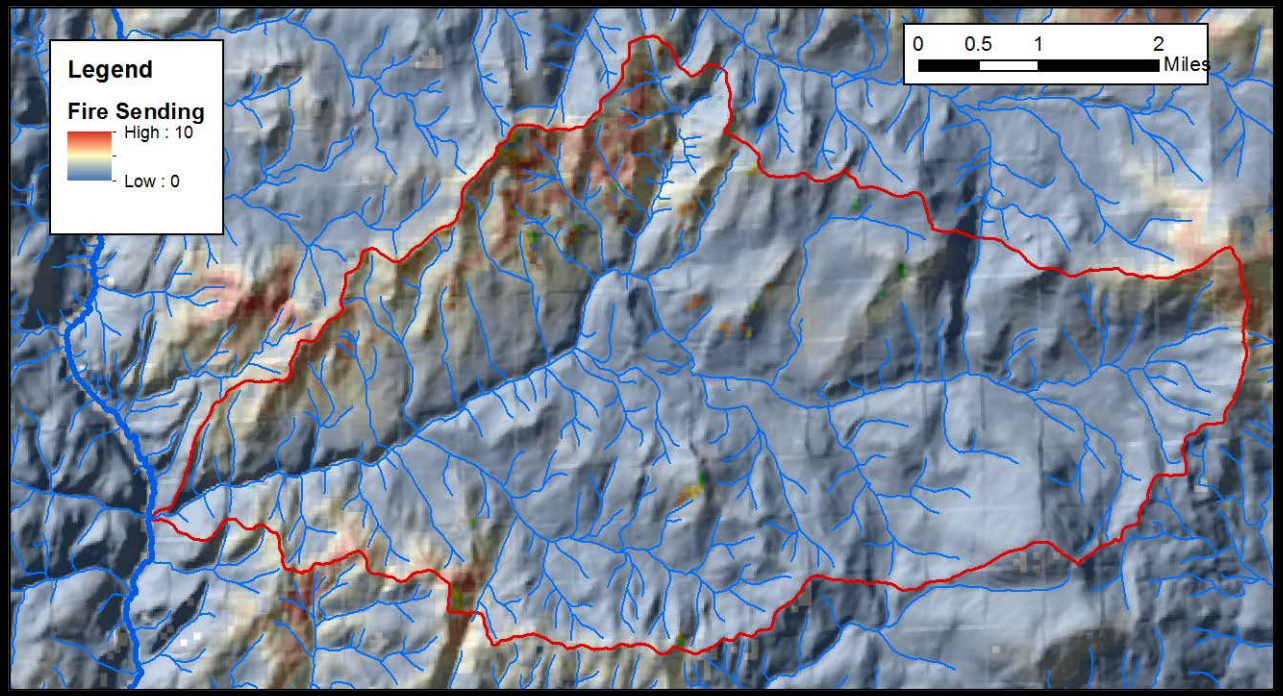


Align Forest structure with

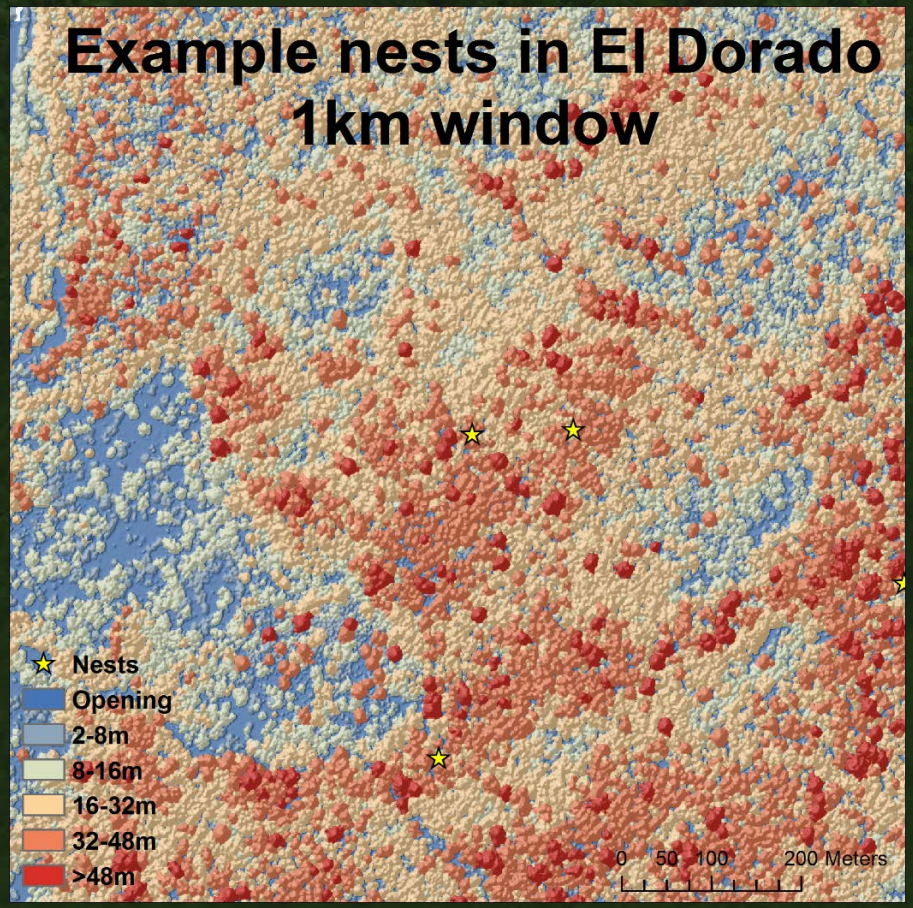
-Topography & biophysical conditions

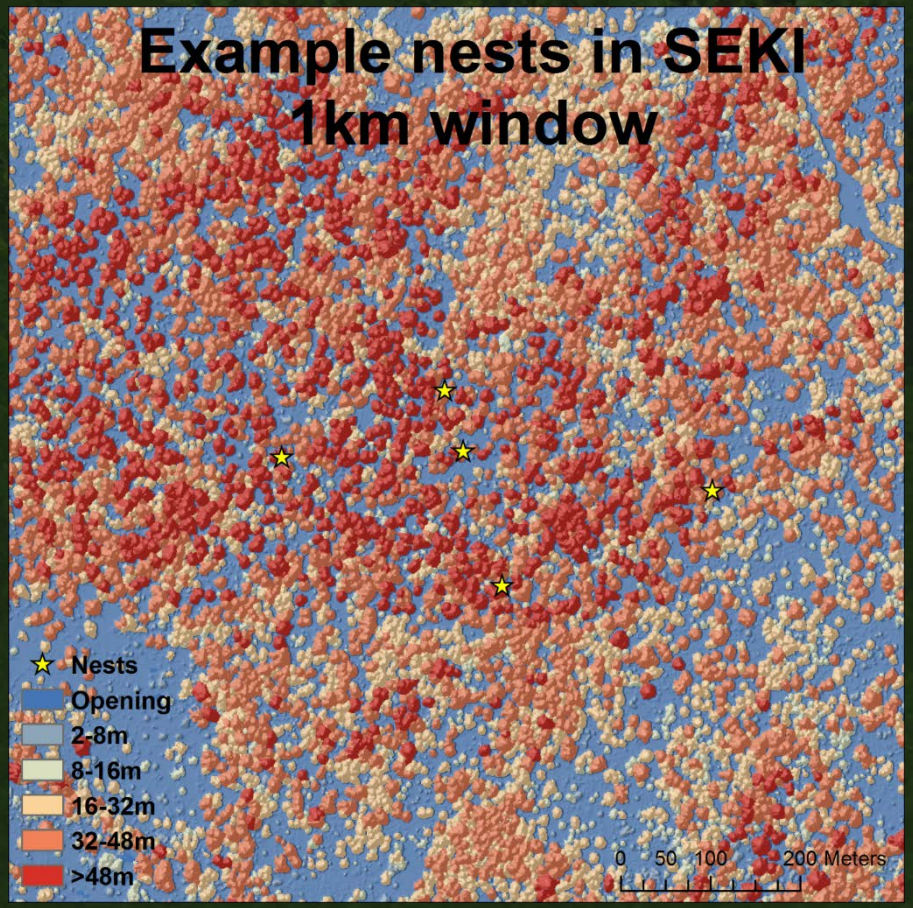
- Fire flow (Flammap modeling)





Mapping Habitat



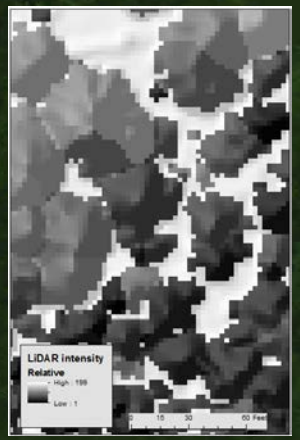


California spotted owls – select nest sites with high canopy cover from large trees, select against sites with high cover from short/medium height trees

Identifying Mortality

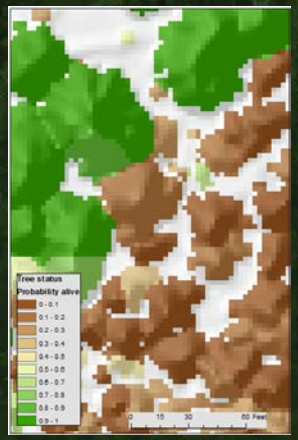
Identify living and dead trees from aerial images (training data)

Identify dominant trees/snags from LiDAR data
(Watershed segmentation)



Map trees/snags by LiDAR intensity (“bright-ness”)

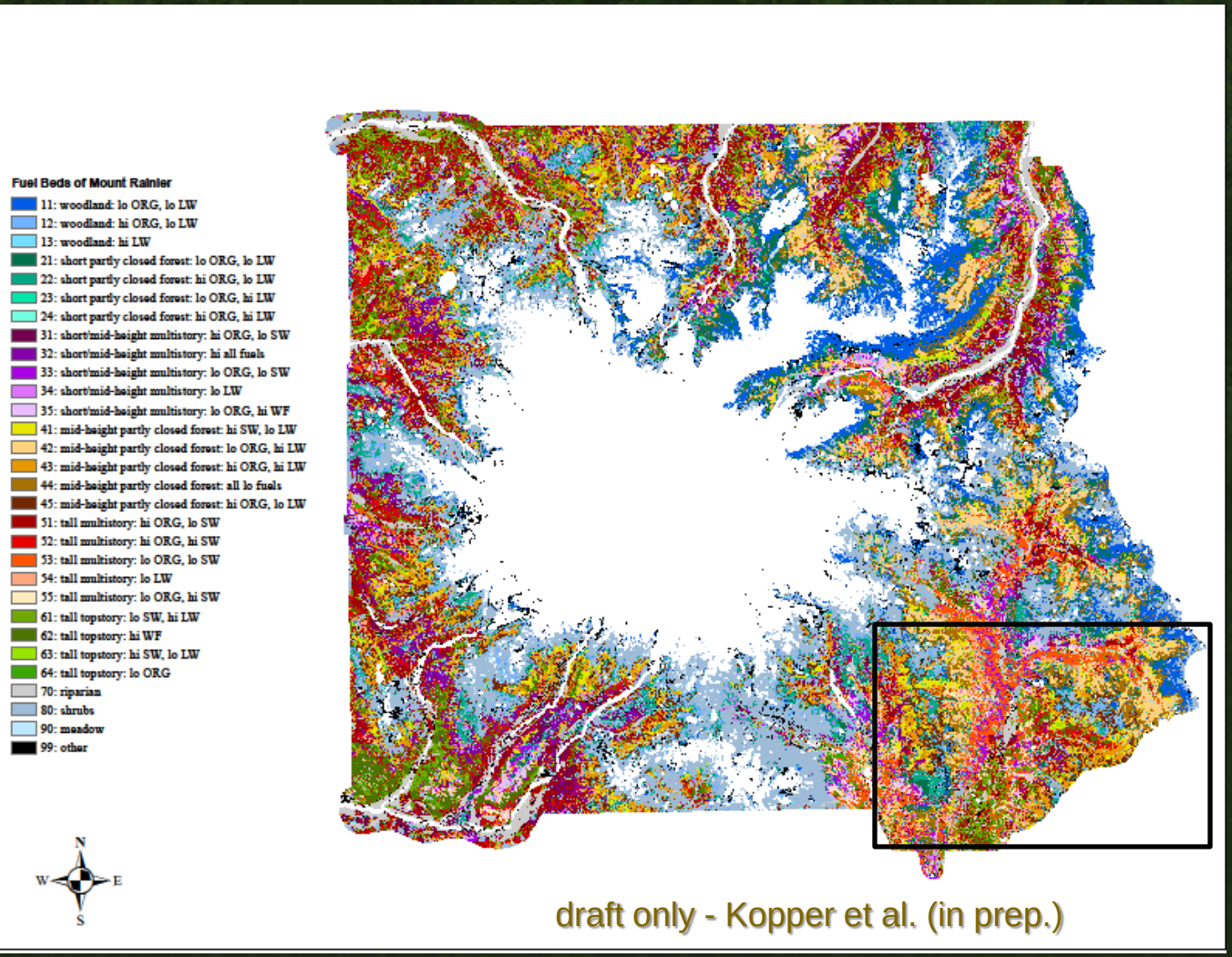
Map canopy cover for trees/snags with LiDAR



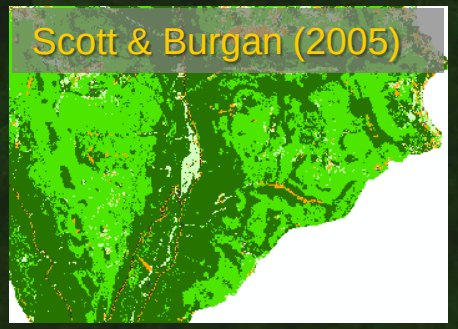
Model probability living vs dead

Accuracy
Alive = 95%
Dead = 87%
Kappa = 0.81

Mapping Fuels – Mt. Rainier

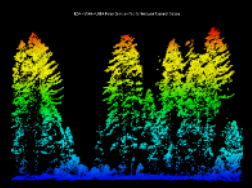


draft only - Kopper et al. (in prep.)

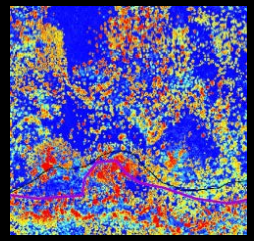


LiDAR : Multiscale Information Set

Level
Local landscapes: Watersheds
Stand Neighborhood – Project Area
Stands/Patches
Tree Neighborhoods

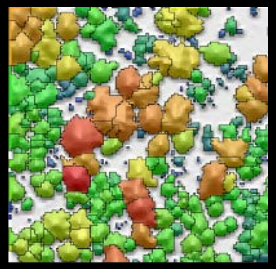


Point Cloud & Intensity Data

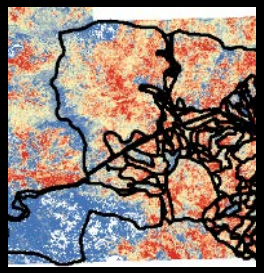


1-2m Pixels

Canopy Surface Model

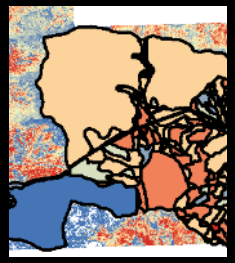


Tree-Clump-Opening Segments



10-30m Pixels:

Direct, Derived, Combined



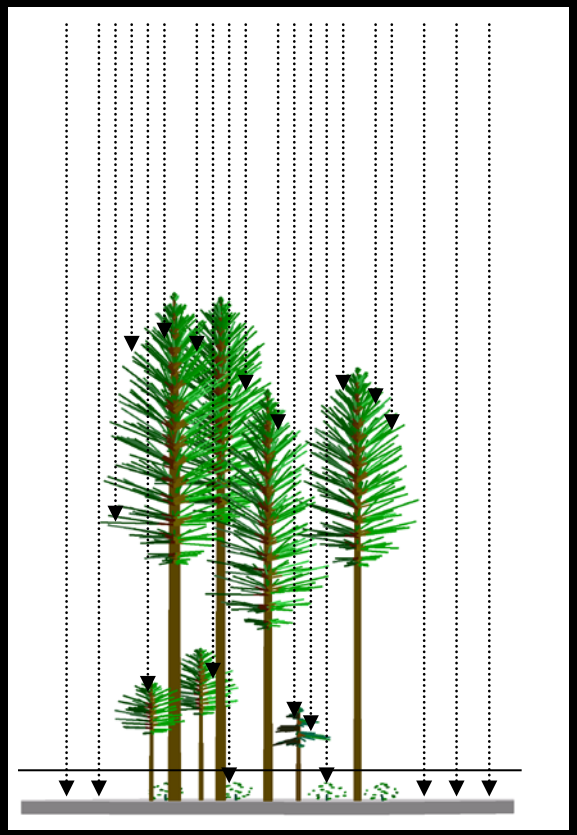
Polygon:

Summarized Direct, Derived, Combined Metrics

Conclusions & Caveats

<u>What LiDAR does not measure well:</u>

1. Species: high spectral imagery
2. Individual tree recognition
3. Understory components: shrubs, downed wood, snags



Conclusions & Caveats

LiDAR ➔ Landscape Restoration

1. Highly accurate information that is scalable to a variety of functions, critters, and processes.
2. Facilitates multi-scale approach
3. Monitoring change
4. LiDAR ➔ PI & Landscape evaluations

Thanks to our funders:

- US Forest Service: Region 5
- USFS: Pacific Northwest Research Station
- USFS: Colville National Forest