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

* 

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
1. Point Cloud Data:

2. Direct: Surface Models (1-2m rasters)
   - Canopy surface model
   - Ground model
   - Hillshades
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
Polygon: Summarized Direct, Derived, Combined Metrics

10-30m Pixels: Direct, Derived, Combined

Tree Clump Opening Segments

1-2m Pixels

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Patch → Tree Neighborhood
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.

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

Clump Size Distribution
- Pre Treat 2010

- Number
- Clump Size
Clump Size Distribution
Post Treatment

Clump Size Distribution

- Pre Treat 2010
- Post Treat 2012

Number

Clump Size

Increasing Clump Size
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- **Point Cloud & Intensity Data**
- **Canopy Surface Model**
- **1-2m Pixels**
- **10-30m Pixels**
Did forest treatments significantly alter canopy cover?

Treated Units

4-16% reduction in CC
Structure Classes

Class 1  Class 2  Class 3  Class 4

Class 5  Class 6  Class 7  Class 8  Class 9

Height breaks
meters

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

Differ in cover & dominant tree height
Structure Classes

Legend
- Major Streams
- Dink_Treat_units
- Owl PAC

Structure Class 2010
- Open
- Large Tr - Mod Cvr
- Med Large Tr - Mod Cvr
- Small Tr - High Cvr
- Large Tr - High Cvr
- Med Tr - High Cvr
- Large Med Tr - High Cvr

Structure Class 2012
- Open
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- Large Med Tr - High Cvr
**Conclusions:**

- **CSO class largely unchanged**
Conclusions:

• Fire prone class reduced
Total Area

Connectivity

Mean patch size

Conclusions:

• Fire resistant class increased
**Total Area**

**Connectivity**

**Mean patch size**

**Conclusions:**

- Open class increased
Reference Areas

Legend
2012 Structure Classes
1 Short Dense
2 Sparse
3 Multistory - Mod
4 Med/Lar - Low
5 Multi - Dense
6 Med/Lar - Mod
7 Med/Lar - Dense
8 Large - Mod

Proportion of Watershed

Proportion
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4

0
0.5
1
Miles

Short Dense
Sparse
Multi-Mod
Med-Lar Low
Multi-Dense
Med-Lar Mod
Med-Lar Dense
Large Mod
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

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
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Polygon:
Summarized Direct, Derived, Combined Metrics

Project Area ➔ Patch
Structure Class 3
Structure Class 5
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 (Flammmap modeling)
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 ("brightness")

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

Anderson (1982)

Scott & Burgan (2005)

Kopper et al. (in prep.)

draft only - Kopper et al. (in prep.)
LiDAR: Multiscale Information Set

Level

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Stands/Patches

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Conclusions & Caveats

What LiDAR does not measure well:

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

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