Regional Mapping, Modelling, and Monitoring of Tree Aboveground Biomass Carbon

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Objectives and Overview of Approach

– Develop a Carbon Monitoring System (CMS) that uses Random Forests (RF) to map aboveground biomass (AGB) at two scales:
  • Landscape level, with following input data:
    – Field plot measures of AGB
    – Light Detection and Ranging (LiDAR) metrics
  • Regional level, annually, with following input data:
    – Landscape-level AGB maps
    – Landsat based detection of trends in disturbance and recovery (LandTrendr) metrics
    – Shuttle Radar Topography Mission (SRTM) 30-m topographic metrics
      » Except elevation
    – Physiologically relevant climate variables

– Develop a Validation Protocol for Monitoring, Reporting, and Verification (MRV)
  • Aggregate annual, regional AGB maps to county level
  • Compare against annual, county-level Forest Inventory and Analysis (FIA) estimates of AGB available nationally, calculate biases
Light Detection and Ranging (LiDAR) point cloud at the scale of a 400 m² forest inventory plot in northern Idaho.
Height Metrics

LDV - VI 63 - USDA Forest Service - Pacific Northwest Research Station

Maximum Canopy Height
95th percentile

Mean Canopy Height

Height Cutoff (1.37 m)
Height Metrics

Density Metrics

Returns in stratum s

Total returns

X 100

“Living” Database of Project-Level Reference Plots

P. A. Fekety
Predict Attributes at Unsampled Locations

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M. J. Falkowski, P. A. Fekety
Landscape-Level Approach

Regional-Level Approach
LandTrendr (LT) data

- LandTrendr - Landsat based detection of trends in disturbance and recovery algorithm (Kennedy et al., 2010)
- Input: Annual Landsat images stacked from 1984-2012
- Output: Trajectories describing trends for each 30-m pixel from multiple spectral variables
- Primary predictors we are using for annual AGB prediction are the tasselled cap indices:
  - Brightness
  - Greenness
  - Wetness
- Other important LT metrics:
  - Magnitude of greatest disturbance
  - Time since disturbance

http://landtrendr.forestry.oregonstate.edu/content/how-landtrendr-works
Landscape-Level Random Forests (RF) Model

LiDAR Project-Level RF Model

- ELEVSTRATA1000TO2000RETURNPROPORTION
- PERCENTAGEFIRSTRETURNSABOVE137
- ELEVSTRATAABOVE3000RETURNPROPORTION
- mmin_tenths
- ELEVSTRATA2000TO3000RETURNPROPORTION
- ELEV50
- ELEV95
- ELEVSTDDEV
- ELEVVAR
- ELEVDISTANCE
- mmin tenth
- ELEVVAR
LiDAR Project-Level RF Model

R^2 = 0.659
Uncertainty in 30-m ABG (Mg/ha) Map Cells Predicted from LiDAR

One Landscape (Moscow Mt.)

All N. Idaho Landscapes
Regional-Level Random Forests (RF) Model

Regional-Level RF Model

SSinAsp
sprp
MagOfLastDisturb
globRadEquinox
w_t
b_t
g_t
mapdd5
map

%IncMSE

w_t
b_t
sprp
SSinAsp
g_t
globRadEquinox
mapdd5
map
MagOfLastDisturb

IncNodePurity
Note: Green labels are ecoregion identifiers
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Conclusions, Next Steps

• Workflow has been developed to predict AGB across large spatial extents from historical Landsat images, using LiDAR-mapped 30-m AGB pixels as reference observations, and 30m pixels without lidar as target observations.

• Current annual predictions are higher than annual county-level FIA reports. Why?
  – Disturbance dynamics
    • Include LandTrendr time-since-last disturbance metric, delta metrics
  – What is “forest” vs “non-forest”?
    • Include tree cover mapped from high resolution airborne imagery
    • Landsat-based National Land Cover Database (NLCD) map has local inaccuracies
      – Gaps within forest matrix (commission errors)
      – Tree islands within non-forest matrix (omission errors)
  – FIA doesn’t inventory non-forest trees... but they’re out there!
Acknowledgements

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