Quantifying disturbance and global change impacts on multi-decadal trends in aboveground biomass and land cover across Arctic-boreal North America

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Research Objective

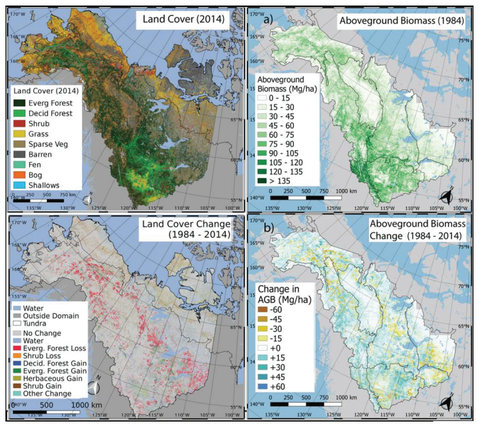
Ecosystem composition and structure in the northern high-latitudes are changing due to intensifying global change and disturbance, but such changes are difficult to characterize due to a lack of high-quality data at high resolution. In a new Terrestrial Ecology (ABoVE Phase 3) project, we are mapping annual (1984-2023) land cover and aboveground biomass (AGB) across Canada and Alaska with field data and remote sensing to ask three questions:

How are aboveground biomass and land cover changing across Arctic-boreal North America?

What drives changes in aboveground biomass and land cover across Arctic-boreal Noth America?

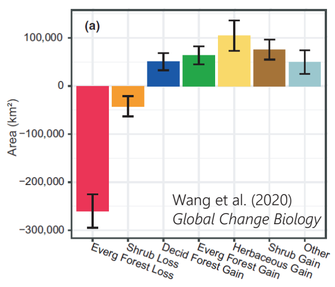
Can differences in carbon budgets derived from models, national inventories, and remote sensing be reconciled?

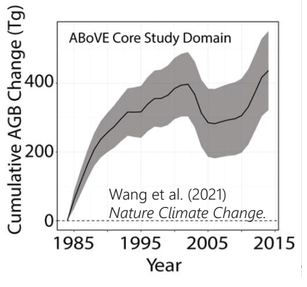
Background



Previously, we mapped annual land cover and AGB (1984-2014) at 30m resolution in the ABoVE domain (left, top row) with Landsat, ICESat, and DigitalGlobe data.

Changes in land cover and AGB were pervasive, patchy, and stark, reflecting the impact of fires and post-fire recovery (left, bottom row)





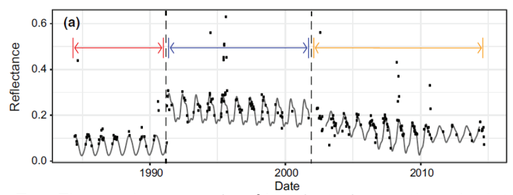
Left: Fires drove evergreen forest losses and successional gains of deciduous forest. Tundra shrub cover increased.

Right: Fires suppressed AGB accumulation across ABoVE core domain. Hard to compare to national inventories because data does not cover whole countries.

We now aim to create 30 m maps of land cover and AGB across all of Canada and Alaska for each year from 1984-2023 to quantify how recent warming and severe fires alter succession, woody cover, and carbon fluxes.

Mapping Land Cover

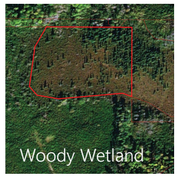
Land cover and changes mapped using "Continuous Change Detection and Classification" algorithm (Zhu et al., 2014) on time series of Landsat Collection 2 surface reflectance:

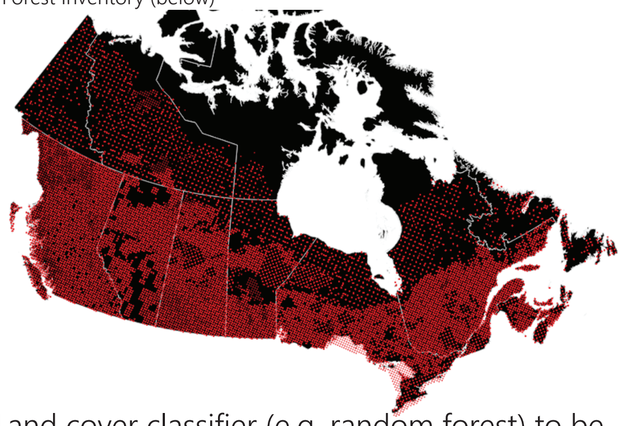


Top: Time series example of Landsat observations (points), fitted models (lines), and estimated breaks (dashed lines). Segments of stable land cover shown in colored lines.

Right: Tentative land cover classification legend. Adapted from previous mapping project and classifications made in Canadian National Forest Inventory (below)

Unvegetated
Water
Permanent Snow/Ice
Barren
Vegetated
Deciduous Broadleaf Forest
Evergreen Needleleaf Forest
Mixed Forest
Woody-Wetland
Shrubland
Herbaceous
Non-treed Wetland
Bryoid
Agriculture
Land Use
Urban Land and Resource Extraction
Agriculture

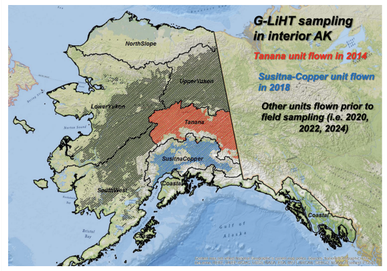


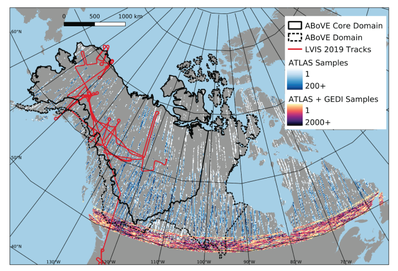


Land cover classifier (e.g. random forest) to be trained on n = 750k Canadian National Forest Inventory Photo Plot manually labelled polygons (top, red points). Zoomed examples to left. Will be augmented in tundra and AK by analyzing Maxar imagery and leveraging a MEaSURES project that will map land cover globally.

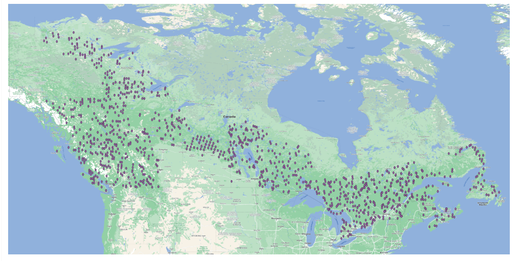
Mapping Aboveground Biomass

Will be mapped using a machine learning algorithm with Landsat reflectance trained and validated on AGB estimated from allometric equations, lidar, and forest inventory field data





Left: Goddard's Lidar, Hyperspectral, and Thermal Imager (G-LiHT) flight lines in Alaska. Right: Airborne lidar (LVIS) in red lines, satellite lidar (ICESat-2 ATLAS & GEDI) in points, indicating sample density, across study domain.



Left: Ground plot data from Canadian Forest Inventory (with precise coordinates) across managed forest. USFS FIA field plots in AK to be included soon.

Current Status

We started January 2023. By the end of the year, we aim to have preliminary land cover maps and have gained access to AK field plot data. We have precise Canadian plot data and will be developing a prototype AGB algorithm soon.

We acknowledge NASA TE grant 80NSSC23K0140 for support.
We seek a postdoc scholar! email jon.wang@utah.edu for info

References

Wang, J. A., Sulla-Menashe, D., Woodcock, C. E., Sonnentag, O., Keeling, R. F., & Friedl, M. A. (2020). Extensive land cover change across Arctic–Boreal Northwestern North America from disturbance and climate forcing. Global Change Biology, 26(2), 807-822.
Wang, J. A., Baccini, A., Farina, M., Randerson, J. T., & Friedl, M. A. (2021). Disturbance suppresses the aboveground carbon sink in North American boreal forests. Nature Climate Change, 11(5), 435-441.
Zhu, Z., & Woodcock, C. E. (2014). Continuous change detection and classification of land cover using all available Landsat data. Remote Sensing of Environment, 144, 152-171.

Datasets

Previous datasets are publicly available:
Land cover: https://doi.org/10.3334/ORNLDAAC/1691
AGB: https://doi.org/10.3334/ORNLDAAC/1808