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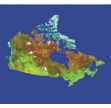
Mapping forest biomass and composition across the managed forests of Canada using MODIS imagery and k-NN imputation



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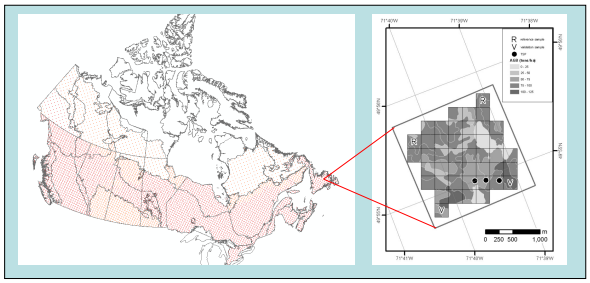
CONTEXT: Forests help regulate climate through their capture, storage and release of carbon from their various organic pools, but also through dynamic radiative and latent energy exchanges with the atmosphere. Accurate mapping of forest properties is key to evaluating potential effectiveness of management measures, or potential impacts of change, on climate.

METHODS: We have generated maps of forest biomass and of species composition for all of Canada's managed forests at 250m resolution. Our reference sample data (N = 21037) of biomass and composition (the "Y" variables) were obtained from the 1% photo-plot systematic sampling network of Canada's National Forest Inventory (NFI), rasterized to the 250m MODIS pixel grid.



The spatial interpolation was based on a set of spatially-continuous ancillary variables (the "X" variables), including *ca* 2001 winter and summer mosaics of top-of-atmosphere corrected MODIS multi-spectral data processed by Canada Centre for Remote Sensing, along with climatic and topographic variables. The non-parametric "*k-Nearest Neighbour*" method (*k*=6) was used to perform the imputation beyond the 1% NFI systematic sample.

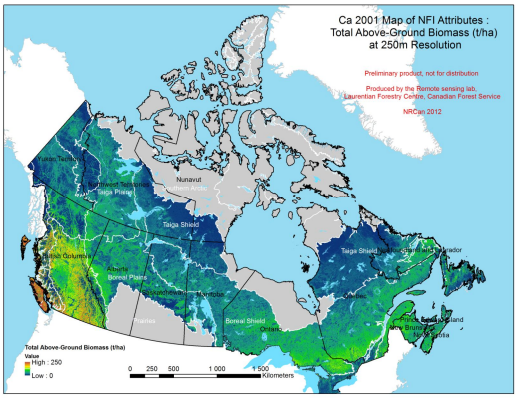
31 "X" variables

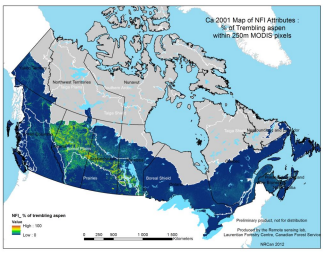
- 18 *ca* 2001 MODIS spectral bands & indices (summer & winter)
- 9 bioclimatic (related to temperature, precipitation, moisture and radiation)
- 3 topographic (altitude, slope, aspect)
- 1 land cover (water proportion)

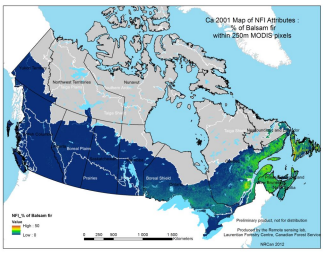
123 "Y" variables

- 4 land cover proportions: veg/non-veg, treed/non-treed
- 11 structure : **biomass (total and by compartment),** total and merchantable volumes, tree height and age, density
- **108 species composition** : conifers and broadleaves + 106 individual species

RESULTS: The resulting maps reveal strong and expected trends in biomass and species composition across Canada, as well as more subtle patterns associated with topography, surficial deposits and disturbance patterns (harvest, fire). Accuracy for pixel-level biomass estimates relative to the validation data set (N=9055) was of 68 % relative RMSE with overall low bias of -0.8 tons/ha and R^2 of 0.62. The RMSE was cut to about 34% when map resolution was aggregated to a 1.5 km resolution.







CONCLUSION: Inherent to the k-NN is the maintenance of the co-variance structure among imputed variables so that, for example, percent composition of all species for a given pixel will sum to 100%. Studies are under way to determine how changes in disturbances regimes might feedback to climate.