FOREST DYNAMICS IN THE TEMPERATE RAINFORESTS OF ALASKA: FROM INDIVIDUAL TREE TO REGIONAL SCALES

Tara M. Barrett

Abstract—Analysis of remeasurement data from 1079 Forest Inventory and Analysis (FIA) plots revealed multi-scale change occurring in the temperate rainforests of southeast Alaska. In the western half of the region, including Prince William Sound, aboveground live tree biomass and carbon are increasing at a rate of 8 (± 2) percent per decade, driven by an increase in Sitka spruce. In the Alexander Archipelago, western red cedar is increasing, as is overall biomass on gentler slopes and in higher latitudes. These increases, which occurred during a warmer period of the Pacific Decadal Oscillation, correspond well with regional predictions of forest change in a warming climate. In the 180 thousand ha of managed forests on the Tongass National Forest, aboveground live tree carbon was found to be stable between the two inventory periods. And at the regional level, analysis of FIA data showed no significant change in the yellow-cedar population, despite widespread publicity for a 'decline' in this species. While FIA remeasurement data provides insight at a variety of scales, alterations in forest definition and other inventory methods complicated analysis.

Northern latitudes are expected to have the largest temperature increases from global climate change (IPCC 2014). With fire absent or extremely rare, fire suppression has had almost no impact on the forests of southeast Alaska, and timber harvesting or other forms of vegetation manipulation have also been absent from large expanses of the forest. Thus these forests provide an ideal environment for monitoring early detection of change associated with climate.

To examine whether changes were occurring, a combination of forest inventory and remote sensing data was used to examine growth, mortality, and net change in southeast Alaska's temperate rainforest.

METHODS

The study area included the whole temperate rainforest region of Alaska (figure 1), with the exception of national forest wilderness and Glacier Bay National Park. Plots were initially installed between 1995 and 2003, and then remeasured between 2004 and 2010. Stratification with remote sensing data (NLCD) and other spatial information was used to account for different sampling intensity on Kodiak Island, population boundaries that varied between inventories, and missing data (inaccessible plots) that occurred primarily on forested land. Individual tree data were reconciled to Time 1 measurements, with analysis limited to subplots that were fully forested at both measurements due to a change in definition of 'forest' that occurred between inventories. Growth and mortality were converted to average annual values and then compiled to population level estimates using standard national methods (Bechtold and Patterson 2005). Detailed description of methods can be found in Barrett (2014).

RESULTS

Within-forest live tree biomass is increasing in the western portion of the Alaska temperate rainforest, where the Chugach National Forest is found. Estimated rate of change was an average annual increase of 0.8 ± 0.2 percent (p-value < 0.001). This change is primarily driven by an average annual increase in Sitka spruce live tree biomass of 0.9 ± 0.3 percent. Increases also occurred in paper birch and cottonwood in that region.

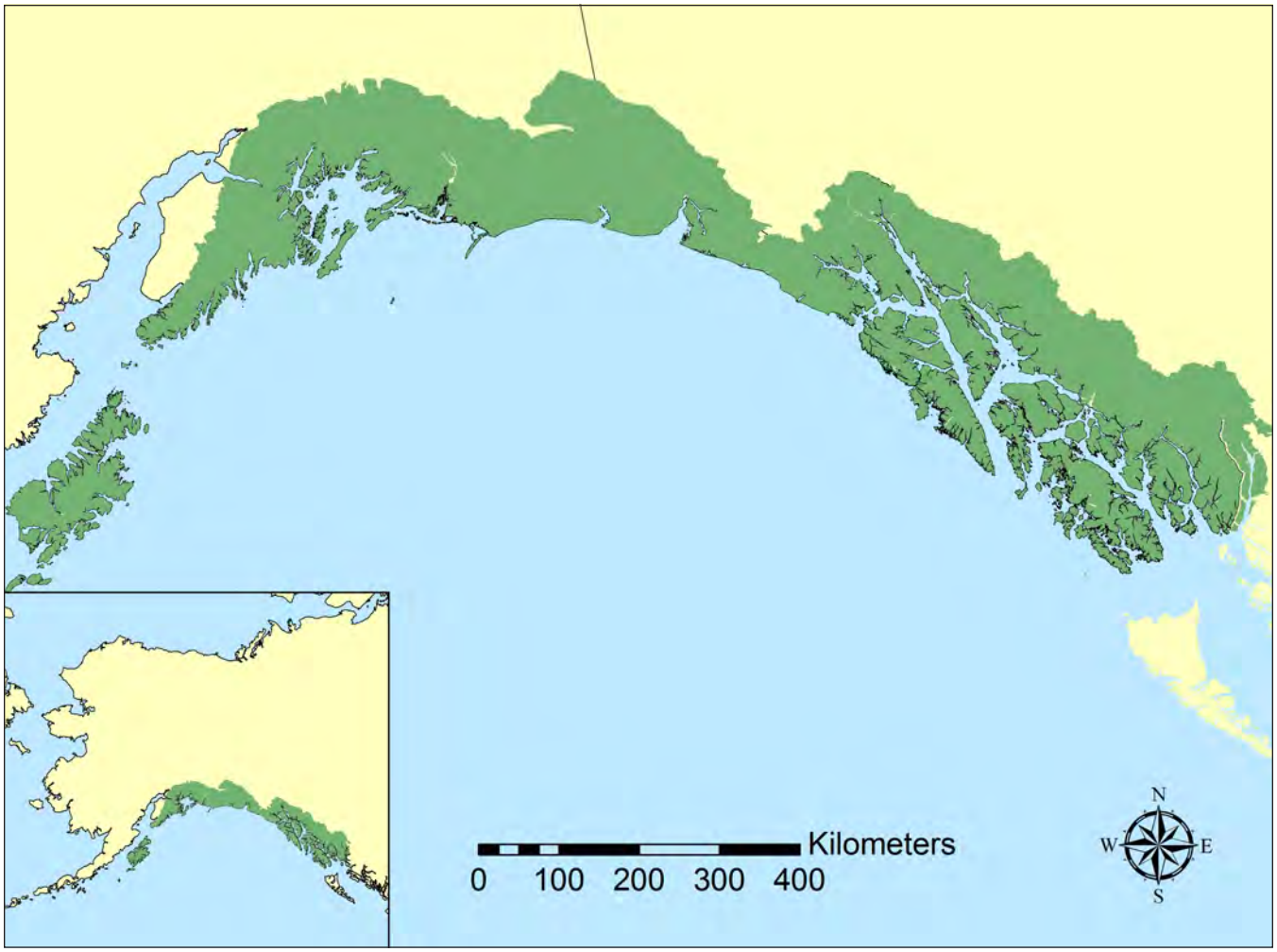

Figure 1—The study area included the temperate rainforest region of Alaska.

In the eastern region of the temperate rainforest, including the Alexander Archipelago, western redcedar is increasing in biomass (average annual increase of 0.6 ± 0.1 percent) and there is some evidence for a decrease in shore pine live tree biomass (-0.31 ± 0.19 percent). Although substantial research has focused on yellow cedar decline, the population outside of wilderness areas appears to be stable overall; the 95 percent confidence interval for live yellow-cedar average annual biomass change was from -0.04 percent to +0.29 percent of initial biomass.

Shifts in species composition and carbon storage and flux differed between managed and unmanaged forest. Areas of the Tongass National Forest that had past silvicultural treatments ("managed" forest) had higher log density and lower live tree and snag density than unmanaged forest (Figure 2a). Managed forest also had greater carbon turnover (Figure 2b) than did areas of unmanaged forest.

DISCUSSION

Procedural changes between the two inventories greatly complicated analysis. Procedural changes included a shift in forest definition from tree cover to tree stocking, alterations in which species were considered trees, the exclusion of Krumholtz forest in the first inventory, altered rules used to decide whether a tree was in or out of a subplot, shifting boundaries for the non-inventoried national forest wilderness, different sampling intensities, altered interpretation

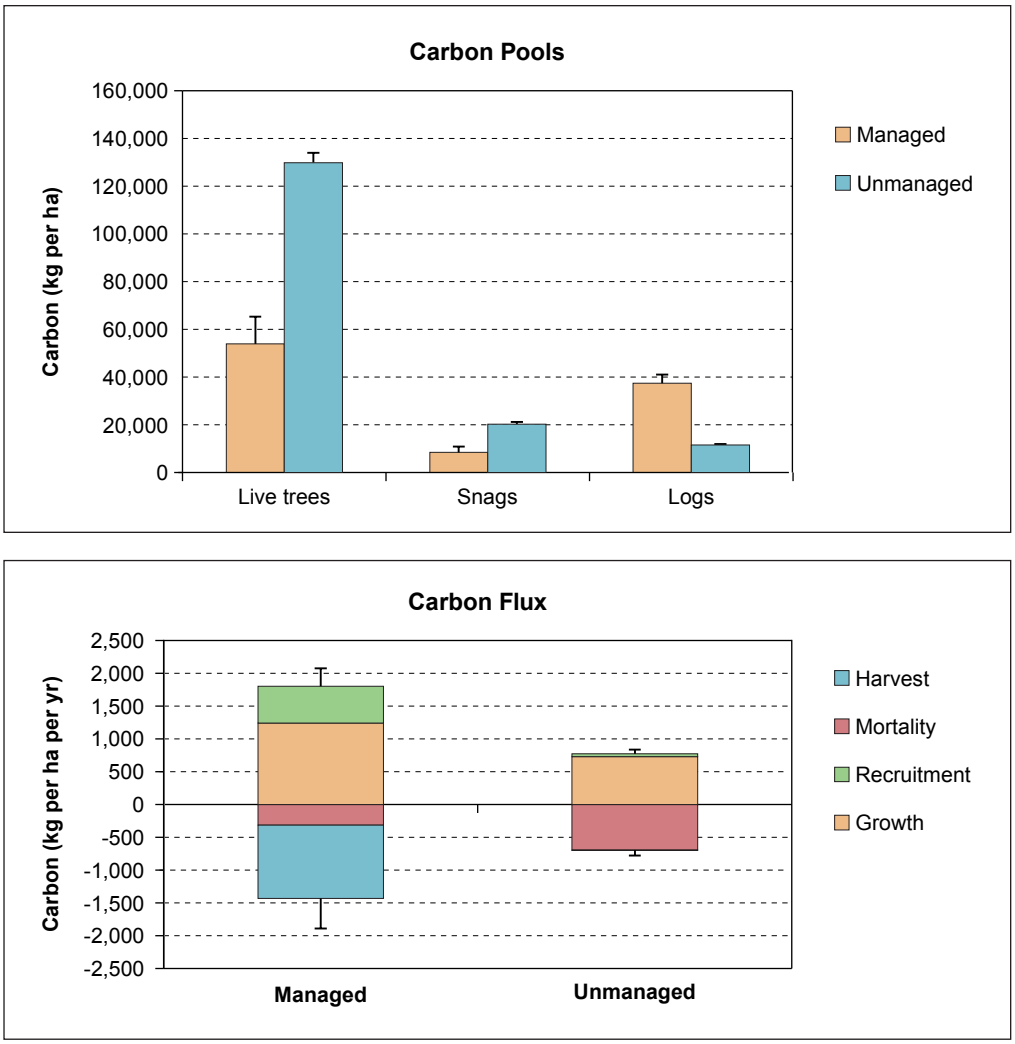

Figure 2—Aboveground tree carbon (a) density and (b) flux in managed (180,000 ha) and unmanaged (2,547,000 ha) forest of the Tongass National Forest. (Does not include forest in wilderness areas.)

of decay classes and crown classes, and a variety of other changes. The impact of the procedural changes is greater than actual change in many cases, with the result that unsuspecting users of the two data sets from the national web site are likely to make erroneous conclusions from a *prima facie* comparison.

While the change in forest definition prevented reliable estimates of deforestation or afforestation, using an approach based on remote sensing data suggests gains are outpacing losses, with forest increasing in northerly aspects, lower elevations, and higher latitudes (Buma and Barrett 2015).

Given the absence of fire and other large disturbances, the changes observed in the unmanaged portions of the temperate rainforest seem likely to be associated with climate or atmospheric changes. The remeasurement period largely coincided with a warmer period of the Pacific Decadal Oscilliation, and so may be an earlier indicator of trends under climate change. Future monitoring will help to detect whether the observed changes continue into the future.

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