An Update to the Spatial Database Representing Age Structure and Legacy of United States Forests

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Introduction: Disturbance and stand age play a key role in determining the carbon content and fluxes of forest resources throughout North America and the world. The first attempt to compile a stand age map including recent disturbance data for North America was made by Pan et al. (2011) by combining a stand age map for Canada (dated 2004) and a newly developed map for the United States (dated 2006). An update to this original map covering and now including the entire state of Alaska is presented here along with a new map for 2011. Many new forms of spatially based disturbance data sets have become available since the release of the 2006 map for the United States. For instance, several insect and drought disturbances occurred after 2006. These caused diebacks of some forests in the Southwestern US and are reflected in the new map. The original 2006 dataset was made at 1 km resolution, the new datasets are made at 250 m to match the US National forest type map. The forest stand age data has been increasingly used in large-scale carbon modeling, both for land-based biogeochemistry models and atmosphere-based inversion models, in order to improve the spatial accuracy of carbon cycle simulations.

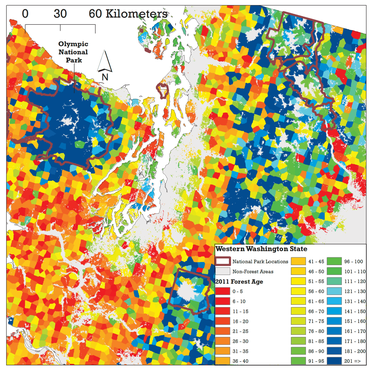
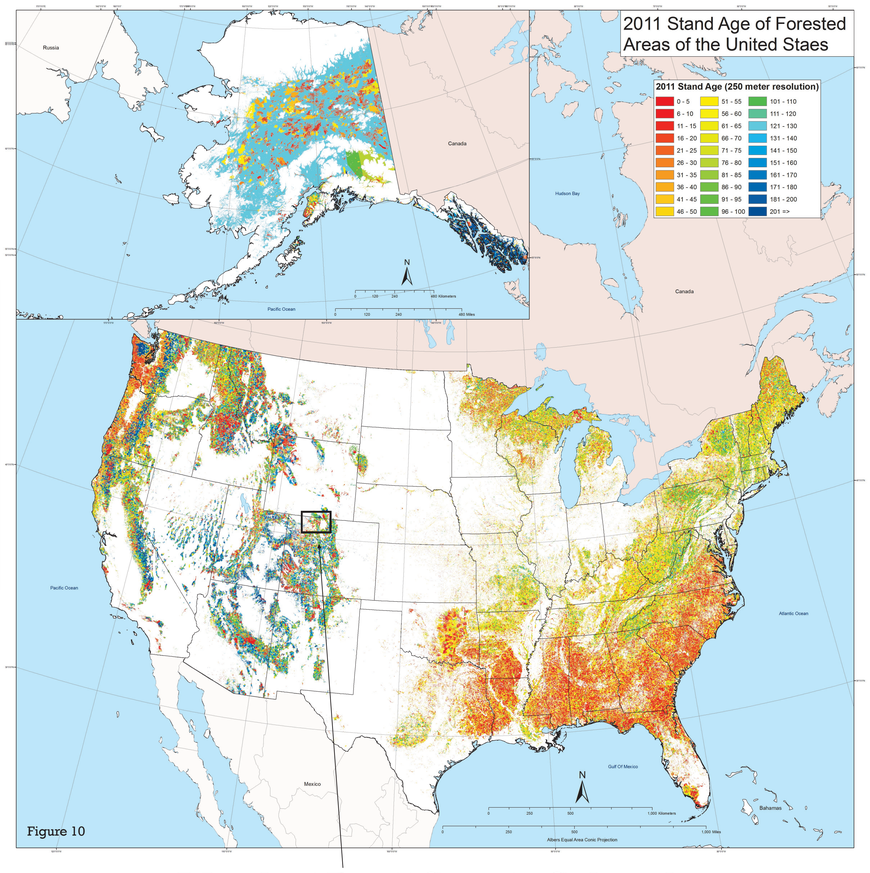


Figure 1. The Voronoi polygons for Western Washington state as based on the FIA data. Notice the variation between the Olympic National Park and the areas outside its boundary.

FIA Data: All available FIA data from the public website are used as a base layer for the stand age map. The appropriate inventory year is determined for each state, and the average age for each plot is adjusted to 2006 or 2011. Anomalous plots are removed leaving over 100,000 plot points for the U.S.

Various spatial modeling techniques were tried to determine to best method to extrapolate FIA plot age to non-sampled forested areas. Voronoi polygons appear to provide an adequate solution of the large scale modeling problem for the U.S., which operate by forming polygons so that all locations in that polygon are closest to its central point (in this case the FIA plot center) and not any other point (Fig. 1).



Forest Health Technology Enterprise Team (FHTET) Photo Interpreted Data: (1997-2011)

The FHTET gathers yearly data of mortality and damage from insects and other pests from the aerial detection survey (ADS) and other sources. The agents that were thought to cause stand clearing or mortality events were used to model stand age. The data is mapped at the polygon level and converted to 250 m resolution as raster layers (Fig 5.).

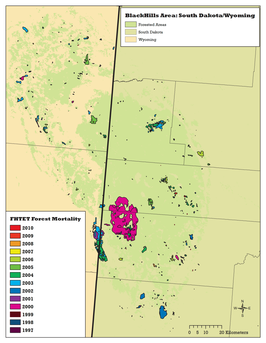


Figure 5. The resulting mortality data for every year for the Black hills Region of South Dakota and Wyoming.

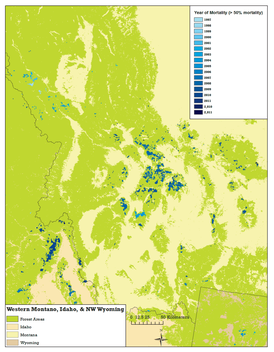


Figure 6. The areas that have over 50% of crown mortality by year as caused by the Bark Beetles.

Western FHTET Mortality Data Caused by Bark Beetles as Processed by Meddens: (1997-2011)

Meddens et al. (2012) took the FHTET mortality data for many different Bark Beetles and processed it for the Western United States. They converted it to 1 km pixels to estimate low, middle and high estimates of the damage caused by the different Bark Beetles. The middle estimates are used here to help determine stand age along with a 50% cell cover mortality threshold (Fig. 6).

Monitoring Trends in Burn Severity (MTBS):

(1984-2011) Only the high Burn Severity categories were used: Moderate and High (Fig. 2). The areas in these categories were presumed to be stand clearing events. All of the MTBS data is delivered at 30 m resolution. All of the appropriate data was converted to 250 m resolution to match the rest of the data used. Each year of MTBS data was processed separately.

(Image Source: MTBS website at http://www.mtbs.gov/index.html)

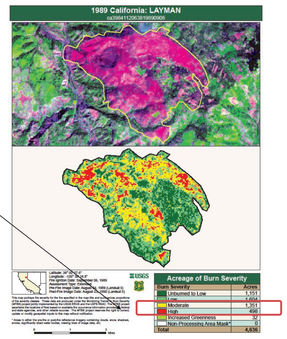


Figure 2. MTBS Sample Image with moderate and high burn severity

Alaska Fire History and FIA sampling of Alaska:

(1942-2011) Alaska has been mapping large fires since 1942. All fire boundaries before 1984 are thought to be stand clearing events and are mapped as such. For 1984 and onward the MTBS product is used.

Another problem with Alaska is due to its vast size and remoteness. The FIA program only samples the Southern coastal portion of the state, leaving a vast majority of the forested part of the state with no spatial FIA data (Fig. 7). A standard stand age is assumed for these areas (Fig. 10).

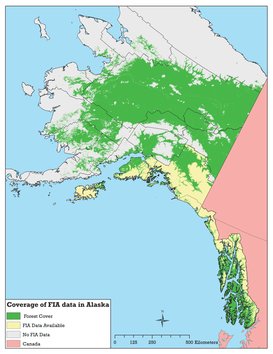
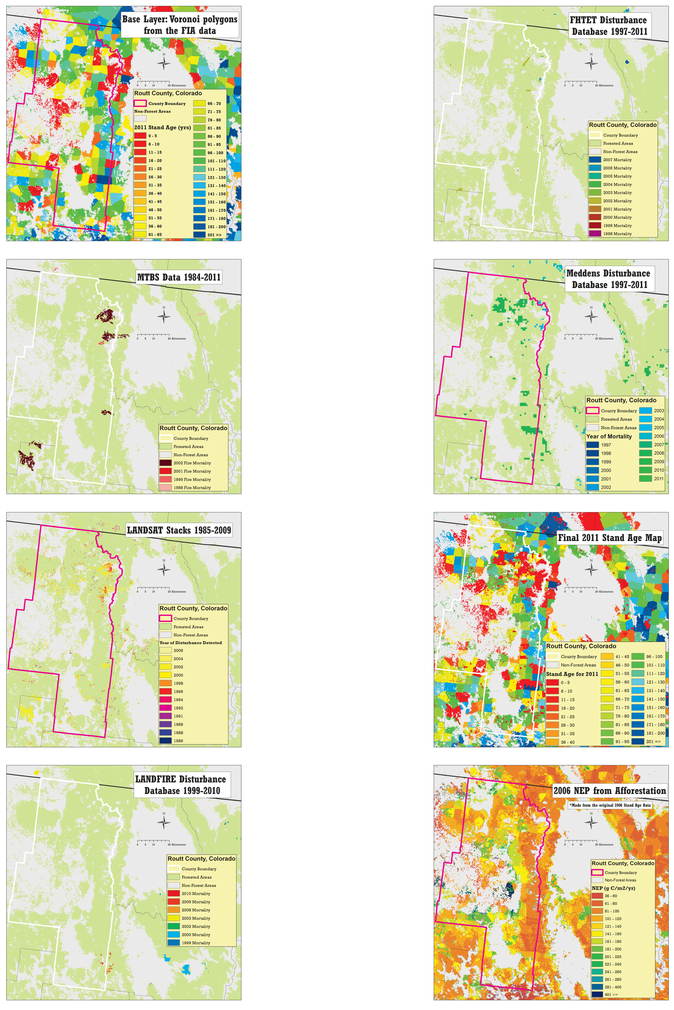


Figure 7. The FIA plot and forest coverage for Alaska.

A Look at Routt County, Colorado



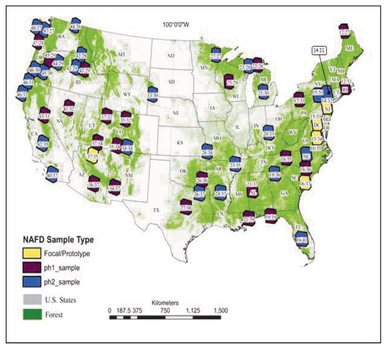


Figure 3. The areas covered by NAFD data stacks

NACP North American Forest Dynamics Project (NAFD): Forest Disturbance and Regrowth Data: (1985 -2009)

It uses the results from the Vegetative Change Tracker (VCT). The VCT works on Landsat Time Series Stacks (LTSS) and is able to discern annual forest disturbance (Fig. 3). The last year of disturbance scene was used for each image stack to represent the last year of disturbance or the year the forest was cleared/disturbed. These were assumed to be stand clearing events. The data was then adjusted to 250 m from 30 m resolution.

(Image Source: ftp://ftp.daac.ornl.gov/data/nacp/NAFD_Disturbance//comp/NAFD_Disturbance_guide.pdf)

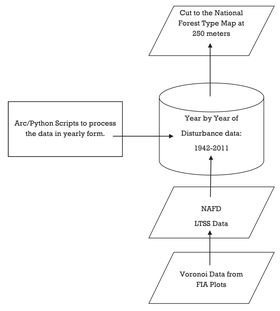


Figure 9. How the map was made.

Assembling the Final Product:

The Voronoi map is used as the base layer, which is then cut to match the forest type group map at 250 m resolution. Next, the NAFD LTSS data are applied scene by scene. Then rest the data is layered by year from oldest year to newest year. All of the data is processed and pieced together by way of custom built python/arc scripts (Fig. 9). No field validation of the map product is done but cost of the constituent data sets have been independently validated or checked for errors.

LANDFIRE Public Events Database: (1999-2010)

It covers all available public land areas for Alaska and the continental United States. It attempts to record all disturbance events on all public lands (federal, state, local and private organizations) into one database. Only the most severe events are used (High Severity = >80% above-ground biomass removed) to map stand age (Fig. 4).

An example of this data can be seen on the right. This map shows the New Jersey Pinelands area. All of these events are prescribed fire events by the New Jersey Forest Fire service.

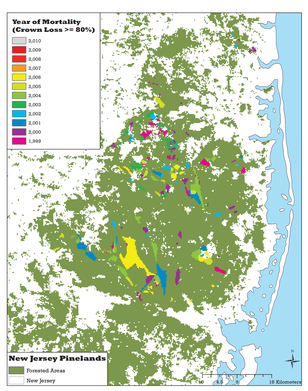


Figure 4. An example of the LANDFIRE data, showing the central New Jersey Pinelands area. All of these events are prescribed fires events by the New Jersey Forest Fire service.

Uses for the Final Stand Age Map, an Example:

The stand age can be applied and used many ways. For instance, we have used the age data to estimate net ecosystem productivity (NEP) of U.S. forests (Pan et al. (2011).

The stand age data has been combined with the forest type group map and regional NEP-age equations derived from the Smith et al. (2006) to calculate NEP by way of afforestation and reforestation for the entire U.S. (Fig. 9).

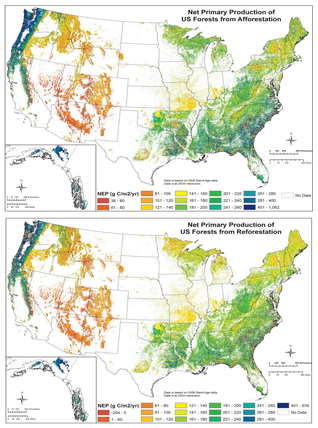


Figure 9. The NEP results for the United States for the original 2006 stand age map at 250 m.

References:

Meddens, Arjan J. H., Jeffrey A. Hicke, and Charles A. Ferguson 2012. Spatiotemporal patterns of observed bark beetle-caused tree mortality in British Columbia and the western United States. Ecological Applications 22:1876–1891

Pan, Y.; Chen, J.M.; Birdsey, R.; McCullough, K.; He, L.; Deng, F. 2011. Age structure and disturbance legacy of North American forests. Biogeosciences. 8(3): 715-732.

Smith, James E.; Heath, Linda S.; Skog, Kenneth E.; Birdsey, Richard A. 2006. Methods for calculating forest ecosystem and harvested carbon with standard estimates for forest types of the United States. Gen. Tech. Rep. NE-343. Newtown Square, PA: USDA NE-343. 216 p.

Coming Soon to : http://www.fs.usda.gov/rds/archive/ Also available an updated 2006 map for the U.S.