Panther Creek Project
Projecting Future Vegetation Condition Under Alternative Scenarios of Climate Change and Land Management

Project Partners: Portland State University, Environmental Protection Agency, Bureau of Land Management

Background

Forest sustainability is of paramount importance in the Pacific Northwest region of the US, since forests provide important ecosystem services including timber production, carbon sequestration and wildlife habitat. These ecosystem services, however, face multiple potential threats from climate change including pathogens (Kurz et al. 2008), wildfire (Westerling et al. 2006) and shifting ranges of important tree species (Bachelet et al. 2001). The issues surrounding the long-term sustainability of ecosystem services are highly contentious in the Pacific Northwest, where the spotted owl remains the iconic symbol of the tension between land conservation and timber harvesting.

Forest management in the Oregon Coast Range over the past century removed substantial amounts of timber, but in the 1980s environmental concerns caused significant reduction in timber harvesting on public lands. However, timber harvesting is still a common practice on private lands, with short rotation harvests (~40 year) of stands primarily composed of Douglas-fir (Pseudotsuga menziesii). Future forest management on public and private lands has the potential to affect the sustainability of forest ecosystems, given that timber harvesting affects productivity, carbon sequestration in the vegetation and the soils, and species composition. These trajectories of growth and carbon sequestration after harvesting may be altered by climate change and changing disturbance regimes.

As concerns about climate change increase over time, scientists and policy makers are looking towards forests as a potential source of green, renewable fuel source for electricity generation. In fact, a limited number of power plants are currently using “hog fuel,” which is wood left after logging or salvage operations to produce power. It has been shown in certain cases that forest productivity declines with repeated timber harvesting as a result of soil disturbance, lost soil carbon and removed nutrients (Bormann et al. 1968, Kimmins 1976, Johnson et al. 1982). The consequences, however, of more intensive, short-rotation harvesting and removal for the production of biomass fuel are less understood.

Objectives

We propose to use the LANDIS-II model of forest succession and disturbance to address multiple questions in the Panther Creek watershed and the Oregon Coast Range, including:

- How will timber harvesting affect the sustainability of forest vegetation and soils?
- How will harvesting of woody biomass for power generation alter sustainability?
• How will the trajectories of sustainability be altered due to anticipated changes in climate?
• Which potential disturbance interactions (e.g., wildfire, Swiss needle cast) could exacerbate the effects of climate change?
• Can forest harvesting (both for timber and woody biomass) be used to reduce long-term carbon losses and/or mitigate greenhouse gas emissions under predicted changes in climate and disturbance regimes?
• What are the largest sources of uncertainty regarding our forecasting of long-term changes in forest sustainability?

Approach

The first phase of the project will use the Panther Creek Watershed in the Oregon Coast Range Mountains as a case study to simulate the effects of different timber harvesting regimes and bioenergy harvest on forest sustainability (Figure 1). The Panther Creek Watershed is ideally suited for research on climate change effects on forest ecosystem carbon. Panther Creek is extensively instrumented with 36 mini-meteorology stations, one complete meteorology station and extensive carbon inventories have been conducted for 35 soil pits and 42 vegetation plots. LiDAR data have been assembled and these data are being used to estimate vegetation (Kazakova and Moskal 2012) and soils (Maynard and Johnson In prep) within the watershed and regionally.

The second phase will expand the study site to include the entire Oregon Coast Range (Figure 1), while focusing on the same goal of forecasting how different timber harvesting regimes (including biomass removal for energy production) will affect forest sustainability under different climate change and disturbance scenarios. We will engage landowners and stakeholders throughout the Coast Range to develop management scenarios that are useful and relevant for a variety of landowners and land managers.
Methods

To predict how climate change, disturbances (e.g., pathogens, wind, wildfire), and forest management will affect tree species composition and carbon sequestration in the Oregon coast range, we propose to use LANDIS-II, a model of forest dynamics that has been optimized for large-scale spatial dynamics and incorporates landscape-scale sources of variability (Scheller et al. 2007, Figure 2). LANDIS-II emphasizes the interactive effects of climate change, disturbances, and management that overlap in space and time (Sturtevant et al. 2009, Gustafson et al. 2010, Ravenscroft et al. 2010, Syphard et al. 2011b). LANDIS-II simulates individual tree species whose regeneration, growth, and mortality are dictated by life history attributes (e.g., fire tolerance, seed dispersal distance) (Mladenoff 2004) and physiological attributes (e.g., C:N ratios of wood, leaves, and roots) (Scheller et al. 2011). The model operates on a spatial grid that is aggregated by soil type, fire regime, ownership, etc., dependent upon the ecological process being simulated by each of many model components (or ‘extensions’).

Model Components

1. **Forest Succession**: We will use the Century succession extension to LANDIS-II (Scheller et al. 2011), which is principally derived from the CENTURY model (Parton et al. 1983, Parton et al. 1993). The extension simulates establishment and succession for all potential tree species, their growth rates, competitive abilities, and ability to establish at a given location. The extension estimates above- and below-ground net primary production (NPP), heterotrophic respiration (Rh), and net ecosystem exchange (NEE). NPP, Rh, and NEE are sensitive to changes in climatic factors, (e.g., temperature and soil water availability). It also tracks multiple pools of live biomass, including leaf, wood, fine root, coarse root, multiple detrital pools, and three soil pools with both C and N: fast, slow, and passive (Parton et al. 1983). This extension allows disturbances, such as fire and harvesting, to alter the temporal and spatial pattern of succession among sites.

2. **Forest Management**: Forest management (including timber harvesting and harvesting for woody biomass energy generation) will be simulated using the Biomass Harvesting extension for LANDIS-II (Gustafson et al. 2000). The extension was designed to simulate a wide variety of management activities (including thinning) and allows complex rules to be applied based on stakeholder inputs. Timber production will be measured as the amount of C removed.

3. **Pathogens**: Pathogen outbreaks and resulting species mortality will be simulated using the LANDIS-II Defoliation extension (Sturtevant et al. 2004, Foster et al. In prep), which simulates the spread, tree growth-reductions and mortality as a function of pathogen host preferences, outbreak frequency and spread functions. The extension uses information about the likelihood of defoliation given recent outbreaks within the dispersal-defined neighborhood and the frequency and duration of
pathogen outbreaks. The proposed project will leverage data resources from existing projects where applicable (e.g., Townsend et al. 2004, Foster et al. In prep).

4. **Wildfire**: We will use the Dynamic Fire and Fuel System extension (Sturtevant et al. 2009) to model fire events and fire regimes (e.g., Syphard et al. 2011a). The extension simulates fires dependent upon fuels, weather conditions, slope and topography, and fire duration. The fire extension will interact with the defoliation extension, since defoliation and mortality due to pathogen damage causes higher fuel loads (in the short term), which increase fire spread and severity.

**Data Sources**

Data used for this project include GIS, tabular, and text inputs used in our empirical analysis and to parameterize LANDIS-II. Other data will be found in the literature.

1. **Vegetation**: To initialize the LANDIS-II model with current forest conditions by species-age cohorts, we will use the Landscape Ecology, Modeling, Mapping & Analysis (LEmma) Gradient Nearest Neighbor (GNN) maps (Ohmann and Gregory 2002).

2. **Soil**: Site-specific soil characteristics (e.g., water holding capacity) and climate (i.e., temperature and precipitation) will be used to aggregate the landscape into ecoregions with homogenous soils and climate. We will use the soil carbon and nitrogen values from a soil LiDAR project (Maynard and Johnson In prep) in Panther Creek along with soil county surveys (compiled in the Natural Resources Conservation Service SSURGO database) for the Coast Range to initialize the soil conditions.

3. **Climate**: We will use the Parameter-elevation Regressions on Independent Slopes Model (PRISM) 800m down-scaled temperature and precipitation data to characterize the historic climate and parameterize the Century extension. For climate change projections, we will access downscaled climate projections to 2100 from Dr. Katherine Hayhoe for selected climate scenario(s) from the USGS Geo Data Portal. We will likely use climate projections from a high emissions scenario (e.g., A2) and downscaled global circulation model(s) (GCM) that have been assessed for the Pacific Northwest (Mote and Salathé 2010).

4. **Wildfire and Defoliation**: Recent disturbances (1985-present) have been mapped and classified at high resolution in the LandTrendr (Kennedy et al. 2010) and Monitoring Trends in Burn Severity (MTBS) (Eidenshink et al. 2007) datasets. These data will be used to parameterize the fire and defoliation extensions.

**Products**

The project will inform land managers throughout the Coast Range about the potential long-term implications of varying management strategies. We will provide an assessment of the implications of biomass energy harvest and other timber harvesting strategies on forest sustainability and above-and below-ground carbon sequestration, as well as an analysis of the risk of forest change due to climate change and disturbance. These results can be used to reduce uncertainty about future forest condition and weigh the costs and benefits of management strategies for timber, energy production, climate change mitigation and other strategies. Results will be documented in a report and in peer-reviewed journal articles.
References


Foster, J., R. Scheller, B. Sturtevant, and D. Mladenoff. In prep. Forest insect defoliation and carbon dynamics: simulating multiple defoliator outbreaks in mixed deciduous landscapes with LANDIS-II.


Maynard, J. J. and M. G. Johnson. In prep. Scale-dependency of LiDAR-based terrain attributes in quantitative soil-landscape modeling: effects of grid resolution vs. neighborhood extent.


simulation model with flexible spatial and temporal resolution. Ecological Modelling 201:409-419.


