Global Climate Change

Climate change (also called global warming) is a regional or global-scale alteration in average temperature and weather patterns, especially storm activity over a time scale ranging from decades to centuries. The term refers to both natural- and human-caused differences in climate over a long period. Current science suggests a link between climate change over the last century and human activity, particularly the burning of fossil fuels (NRC 2006; Karl and others 2006; Intergovernmental Panel on Climate Change (IPCC) 2007; PBS 2008).

It is important to distinguish between climate change (the long-term trend), climate variability (year-to-year or decade-to-decade variations), and weather (the daily to seasonal changes with which we are all familiar). Pacific Northwest events — storms, floods, winters that seem colder and summers that seem hotter — need to be put in an appropriate context and time frame. Such events can be associated with climate, but only over many years — a single flood, back-to-back snowy winters, or an extended drought don't necessarily signal a change in climate over longer time frames (Littell and others 2009).

Why Is Climate Change a Concern?

Since the late 1980s, scientists have identified a worldwide trend toward global warming, demonstrated through changes in patterns of climatic occurrences such as El Niño and La Niña, typhoons, and disturbances like forest fires (Ecology 2008). The Intergovernmental Panel on Climate Change (IPCC 2007) reported the "warming of the climate system is unequivocal," and it is more than 90 percent likely that the accelerated warming trends of the past half-century are due to human contributions. As the science continues to develop, scientists have stressed that climate change has very site-specific effects that present both positive and negative impacts to the environment and to the cultures and economies tied to the resources they produce.

Researchers (Stewart and others 2005; Hamlet and others 2007; Mote 2003; Mote and others 2005; Barnett and others 2008; IPCC 2007; Oregon Wild 2007; McNulty and Aber 2000; EPA 1998; van Mantgem and others 2009; Littell and others 2009) predict that a warming in the western mountains means more rain during winter months, decreased snowpack, earlier snowmelt and runoff, and reduced summer flows which will consequently lengthen the period of summer drought. Increased rainfall during winter months also may contribute to greater flooding and soil erosion. Drier weather and increased temperatures during the summer could mean less water in streams and lakes and drier soils as evapotranspiration increases, causing an additional threat to ecosystem health.

Projected 21st century changes in temperature and precipitation will affect forests differently depending on their elevation and proximity to the coast. The main impacts will be changes in tree growth, changes in establishment and regeneration, changes in disturbance regimes (fire, pests, disease), and eventually, changes in species composition and range (Ecology and others 2008, EPA 1998). Some of these changes have already been observed and are consistent with observed increases in temperature.

A recent study by van Mantgem and others (2009), suggests that regional warming (0.5° to 0.7° F per decade from the 1970s to 2006) may be the dominant contributor to increases in tree mortality rates. In the Pacific Northwest, the tree mortality rate is one of the highest in the nation and on a trajectory to double in the next 17 years (van Mantgem and others 2009) although there most likely will be an increase in tree growth and establishment at higher elevations.

Running (2006) suggested that earlier snowmelt, higher summer temperatures, longer fire seasons, and expanded areas of vulnerable high-elevation forests were contributing to larger, more intense fires in the west. Forest fires threaten thousands of acres of DNR-managed lands annually and contribute greenhouse gases into the atmosphere; however, very few acres burn annually within the OESF due to seasonally wet conditions. If annual temperatures continue to increase, the moisture levels of plants, down woody debris, and soils may decrease and could result in more frequent forest fires.

Both plant and animal species will respond individually to climate change, with some species responding negatively and others positively. Species may respond to both direct (changes in temperature and precipitation) and indirect (changes in habitat availability, timing of life history, availability of prey, species interactions) effects of climate change. Climate change could move current plant and animal communities toward the poles and up to higher elevations, but it appears that the rate of climate change will eventually outpace the ability of some species to adapt to changing conditions (Aitken and others 2008). As climates have changed slowly, species have migrated or adapted—a circumstance scientists call 'species drift' (Sherry and others 2007; Hanson and others 2001). These drifts could change relationships between pollinators, predators, and prey as well as other important species interactions (Sherry and others 2007). Many species are not able to move fast enough and are overtaken by more adaptable, non-native species (EPA 1998).

Although published research on the effect of climate on northern spotted owls is lacking, their populations, for example, could be strongly affected by climatic variables. Franklin and others (2000) showed through modeling that temporal variation in owl populations is driven primarily by annual variation in climate (temperature and precipitation). Their 30-year forecast shows that the northern spotted owl "may experience periods of decline caused solely by climatic variation. In models of northern spotted owl demography, seasonal variations in temperature and precipitation accounted for 38 percent of the variation in owl productivity (Olson and others 2004). A link between poor weather conditions and northern spotted owl demographic performance was discussed by Anthony and others (2006). In the OESF, the northern spotted owl has specific life history habitat requirements. Climate change may affect the northern spotted owl indirectly through its effect of forest conditions, such as alteration of fire regimes, increased climatic stress, susceptibility to insect outbreaks, and changes in geographic patterns of forest productivity (Littell and others 2009).

Marbled murrelet demography appears to be influenced by oceanic variability linked to climate (Peery and others 2006; Becker and others 2007). However, empirical evidence of how climate change affects oceanic processes is lacking.

What Factors Affect Climate Change?

Rising greenhouse gases (carbon dioxide, methane, and others) continue to produce increasingly warmer temperatures. Additional upward or downward detours come from other important sources of climate variability. For example, an extremely strong tropical El Niño event helped make 1998 a record warm year, not to be matched until 2005, a year with a mild El Niño event. The 2008 La Niña event produced temporary global cooling, but even so, the National Climatic Data Center still ranked 2008 as the 8th warmest year globally on record. Local cold snaps or heat waves, tell us nothing about global factors in climate like the effects of rising greenhouse gases (Littell and others 2009).

Although the climate record is dominated by natural variability, natural causes cannot explain the rapid increase in global temperatures in the last 50 years. Scientists have searched for other explanations – heat from the ocean, solar variability, cosmic rays, instrumental error – and have used sophisticated statistical techniques, and nearly every study concludes that the rising temperature is a result of rising greenhouse gases. Laboratory tests, ground-based instruments, and satellite instruments show that adding greenhouse gases to the atmosphere warms the surface (Littell and others 2009).

How Do Forestlands Counteract the Negative Influences of Climate Change?

Photosynthesis and respiration trap carbon dioxide and release oxygen into the atmosphere; through these processes, forestlands have the capacity to absorb large quantities of carbon dioxide emissions and sequester carbon for potentially long periods of time (Binkley and others 1997).

The rate and magnitude of carbon sequestration depends on tree growth and mortality. Newly planted forests accumulate carbon rapidly for several decades and then sequestration declines as trees mature and growth slows, resulting in less wood being produced each year. Old forests can release more carbon from decay than they sequester in new growth. It can take several decades or longer for large trees to decay and old forests generally store considerable amounts of carbon on the forest floor. While old forests can maintain a large amount of stored carbon, they reach a point, however, at which they no longer add additional carbon to their stockpile of stored carbon (DNR 2004).

Forest management is one of the few human activities that can create biological carbon sinks to help mitigate the accumulation of carbon dioxide in the atmosphere (Kurz and others 2002).

Forests have the potential to store a great deal more carbon than they currently do (Harmon 2001); which, in turn, may temporarily slow the increases of atmospheric carbon dioxide concentrations. Although studies have shown that intensive forest management can lead to increased rates of carbon dioxide sequestration (Schroeder 1992; Binkley and others 1997), other research suggests that not all forestry-related projects are equally likely to sequester carbon dioxide and that some may actually release carbon to the atmosphere (Harmon 2001).

Possible ways to increase carbon storage include increasing the forested area, lengthening harvest rotations (Haswell 2000), or increasing carbon density through active management. Long-term terrestrial storage of carbon dioxide through carbon sequestration has been hypothesized to help reduce the effects of climate change.

A detailed analysis of carbon sequestration was not completed for this document. However, a brief summary is provided here. On average, about 77 million metric tons of carbon dioxide[1] (equivalent to 21 million metric tonnes of carbon) are currently stored on DNR-managed lands within the OESF. Both alternatives project higher levels of carbon storage at the end of the planning horizon: 104 million (36 percent increase from current conditions) and 94 million (22 percent increase) metric tonnes of carbon

[1] Carbon storage can be reported in terms of carbon dioxide equivalents, the quantity that describes the amount of greenhouse gas (the amount of CO_2) that would have the same potential for climate change when measured over a specified time scale, generally 100 years. This value is typically reported in the literature using metric units (metric tonnes).

dioxide equivalents for the No Action and Landscape Alternatives, respectively.

Additional ways forests may counteract effects include regulating localized microclimates by reducing wind and limiting surface cooling which will maintain current species and vegetation coverage, as discussed above.

What Is DNR Doing to Address Climate Change?

Washington and other western states are participating in a federal grant to examine how the 2.1 million acres of forested state trust lands and 8.5 million acres of private forestland could be used to offset the greenhouse gas, the use of fossil fuels to generate electric power, and other carbon dioxide sources.

The *Global Climate Change Initiative* (signed by President Bush, February 14, 2002) studies carbon sequestration, the process by which trees remove carbon from the air as part of their natural biological respiration process and store the carbon in the wood as standing trees or once harvested, in structural lumber. As part of this initiative, greenhouse gas emitters would purchase carbon credits from owners of forestland.

In association with the *Western Climate Initiative* and in response to the 2008 Engrossed Second Substitute House Bill 2815 Section 4(3)(g), DNR teamed with Ecology and other state agency representatives to create the *Forest Sector Workgroup—Climate Action Team*. The group provided a forum for stakeholders to develop proposals for reducing greenhouse gas emissions from the forestry sector to achieve Washington greenhouse gas reduction goals. In addition, the team worked on developing a secondary goal—implementing a market-based system of incentives to maintain forestlands for carbon storage and develop methods for measurement, accounting, and verification (refer to the *Forest Sector Workgroup on Climate Change Mitigation Final Report* (2008) for more information on this topic).

DNR also supports the Taskforce on Adapting Forests to Climate Change whose mission is to provide public and private managers with science-based management tactics for different climate scenarios for a variety of objectives. For up-to-date information on the taskforce, visit http://tafcc.forestry.oregonstate.edu (last visited April 22, 2010).

In February 2009, the Commissioner of Public Lands launched an effort to create jobs, increase renewable energy approaches, and promote healthier forests by using woody biomass from our state's forests. Washington's forests have an abundant, renewable supply of woody biomass, and using some of this material for liquid transportation fuel, heating, and electrical power generation will play an important role in Washington's emerging green economy and help to address climate change.

Removing biomass from forests in ecologically sustainable ways can improve forest health by reducing elevated forest fuel loads from past fire exclusion, and thereby reduce the risk of forest fires and the carbon emissions that result from then. Encouraging an industry for forest biomass can provide a market for products that come from forest health treatments (materials that are currently burned or left to decay). This will not only reduce the greenhouse gas emissions from burning, but can also incentivize treatments that many forests in our state need. Forest treatments are often left undone because economics don't support them.

In 2009, the Washington State Legislature passed the Biomass Energy Bill[2] authorizing

[2] House Bill 2165

DNR to implement forest biomass-to-energy pilot projects —one customized to eastern Washington and another for western Washington—to demonstrate the use of existing biomass conversion technology in the field. In January 2010, four projects were selected to move forward in the first phase of biomass-to-energy projects in the state. DNR supports innovative and emerging biomass harvesting and processing technologies that can contribute to the bio-fuel industry. Additionally, the DNR sees biomass as playing a key supporting role to other energy needs in the state: grid-power and on-site residential and industrial heating.

What Are the Current Indicators of Climate Change?

Because climate change is a relatively new science, there are no indicators defined by state or national policies or generally accepted in the scientific community for measuring climate change at the scale of the OESF. As DNR learns more about the changes that are taking place and as methods become standardized, DNR will be able to measure the effects of adaption and mitigation and compare them to current or past conditions.

How Does DNR Mitigate for Climate Change?

DNR uses several tactics which may help with moderating climatic changes. These include maintaining genetic diversity within local populations including operation of breeding, testing, and seed selection programs; planting multiple species (not necessarily on every acre); and cultivating stands with moderate densities.

Some studies (O'Neill and others 2008; Aitken and others 2008) have supported the idea of assisted seed migration (planting tree seedlings adapted to future climates) to help crops move into appropriate geographic locations (along latitudinal and elevational gradients) to maintain similar levels of productivity in the future. DNR scientists are currently investigating forest tree seed zone migration due to climate change.

DNR may need to consider more aggressive strategies in the future, if the more severe climate changes occur. Long-range seed movement may be used as a method to overcome temperature changes across elevations and latitudes where the local climate has changed (van Mantgem and others 2009). This seed movement would likely be more beneficial if the same species were planted from a different seed source in similar climatic conditions than if the species composition were being changed on the site. Altering species composition away from historical mixes can have impacts on the ecological interactions in the area. Some studies suggest planting at higher densities to absorb expected losses; however, if projections were inaccurate, these high densities could increase individual plant stresses, decrease forest health, or increase thinning costs. Other studies suggest using shorter rotations to allow for more rapid changes to species composition and choosing appropriate seed sources to keep up with changing climate conditions.

As the scientific community gains more confidence in climate modeling and acquires a better understanding of the science of species interactions, DNR will continue to identify new tactics for continued sustainable land management. DNR will closely monitor the rapidly evolving science of climate change and make changes as necessary. DNR's existing management framework, particularly adaptive management, is designed to allow management flexibility and adjustments for new information.