Presentation Outlines for Meeting #2

September 16, 2014
Clatsop Community College, 1651 Lexington Ave, Astoria
310 Towler Hall

10:00 AM Presentations and discussion. Landscape system responses to climate change
Forests: Forest communities, terrestrial habitats, wildfire
Watersheds: Hydrology, flooding, aquatic systems and watershed changes
Coastal shorelands: Coastal flooding, erosion; estuaries; shoreline change

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Presentation Outline: **Climate Change Adaptation: Planning for Climate Change at the Landscape Scale for Clatsop and Tillamook Counties, Oregon**

Dr. Dominique Bachelet; senior climate change scientist at Conservation Biology Institute, associate prof. senior research at Oregon State University.

1. Climate projections from the latest IPCC (5th Assessment Report 2013) show consistent trend upward for all seasonal <u>temperatures</u>

   <u>Reality check</u>: Since the 1930s where summer temperatures were the lowest of the 20th century in Astoria, the trend has been upward.

   <u>Social/Economic Response to Observed Change</u>: seed zone in western Oregon has changed.

2. Projected forest response:
   a. large scale model (based on process) shows decrease in the dominance of evergreens, switch to a mixed type forest, expansion of subtropical types (common in coastal California) northward.
   b. species distribution models (based on correlations) show increased habitat restrictions, possibility of maladaptation of existing species.

   Despite the fact existing trees are expected to have a long term legacy, <u>disturbance</u> can make the changes occur sooner rather than later.
   a. fire is such disturbance: large scale model simulating potential vegetation response to changes in climate project more frequent fire occurrence mostly in the 2nd half of the 21st century (not if but when).

   BUT it could happen earlier because of forest condition. The coast range includes private lands with even age monospecific forests prone to allow fire spread (remember the Tillamook). Old growth enclaves on federal land will be at risk due to their proximity.

   Note: <u>old growth</u> provides many ecosystem services - cultural (tribal and local history), esthetic and touristic, but also ensuring long term carbon sequestration (climate regulation), decoupling from regional heat in the understory (wildlife habitat). Its diversity of species and age gives it some insurance against destruction by disturbance.

b. insect outbreaks are likely: endemic insects and/or pathogens could profit from changes in climate and cause havoc just like they did in British Columbia. Some scientists have been looking at the pathogen for Swiss Needlecast as a potential problem in the making.

The perfect storm - forest condition due to landuse and changes in climate (direct and indirect effects ie drought stress on trees as well as drying of fuels or enhancement of reproductive cycle of insects for ex - can create changes that are extensive and abrupt. Do not expect chronic linear predictable changes. Prepare now and monitor closely.

3. Projections of precipitation are uncertain because 1) it is difficult to measure (sometimes it is snow, sometimes it is drizzle or fog that does not accumulate and thus cannot be measured yet has large effect on plants, sometimes the wind makes it hard to measure also) so there are few reliable datasets available to calibrate the models (also not all met stations have instruments yet all measure temperature; technology has also evolved so long term records need reconciling are prone to error); 2) natural climate variability (El Nino, Pacific decadal oscillation) affect the amount of precipitation over (multi)decadal periods yet the cause in shifts for ex. between La Nina and El Nino years is not known - sea surface temperature changes can be measured and projected for the short term but what causes the shift in sea surface temperatures is the object of research.

   Reality check: less precipitation observed in the last decade.

   Projections of extremes: while uncertainty is large, more intense Fall and winter events have always been projected by several climate models.

   Reality check: We have seen such extremes occurring in the last decade.
   These are important for the hydrological cycle of forested areas. Soil erosion, landslides (another disturbance allowing for shifts during recovery period), affect stream network and water quality for communities downstream.

4. Riparian areas are important components of PNW forests.
   They provide fish/wildlife habitat, recreation venues, water quality and provision.
   Municipal watersheds provide water to coastal cities through stream network.

   Projections: most common species (alder) may become less adapted to warmer drier conditions if (natural or human) disturbance causes loss of watershed integrity. Look for southern riparian species to start moving in.

5. Remember that human activities may mask but also exacerbate climate change effects: pollution, introduction of invasive exotics, fragmentation affecting naturally moist cool microclimate, more sources of fire ignition due to more recreation as population centers along the coast (and in the whole state) expand, increasing demand from coastal populations for resources -including water.

6. In summary:
   - while SE timber production will be at risk from sea level rise and drought, the demand on PNW forest land will likely increase: however, climate may affect productivity directly through species sensitivity to increased temperatures and evaporative demand causing some maladaptation problems, as well as indirectly through the increased likelihood of large scale disturbance (fires, pest outbreaks). Solutions are being discussed by foresters: including the use of adapted

genotypes (new seed sources), introduction of new species, longer rotations, increased species diversity, thinning/less dense plantations.

- Large disturbances will affect carbon sequestration potential (climate regulation), water capture and retention (more runoff and less ground water recharge). They will also affect recreation and cultural values especially from the few remnant old growth patches in a patchwork of tree farms. Coordination between landowners (private, federal, state) to optimize landuse is important. Scenario planning for large scale disturbance (ex. large fire followed by extreme rainfall) in the region would help coordinate efforts and raise the level of preparedness.
- Riparian habitats are at risk from a variety of disturbance and this will affect fish habitat, water quality and provision to municipalities. Protecting critical areas of watersheds should allow for resilience to change.
- Current wildlife will be affected by changes but new or less common species may form new assemblages taking advantage of dead snags, abundance of beetles etc …

Presentation Outline: **Climate Change effects on Watersheds in Clatsop and Tillamook Counties**

Jennifer McAdoo; Hydrographer. Oregon Water Resources Department.
David Jepsen; Research Project Leader. Oregon Department of Fish and Wildlife.

Hydrologic Change under Climate Change

This talk will outline the ways in which climate change in Tillamook and Clatsop Counties could affect water resources there. Specific water resource characteristics discussed in the talk include: minimum summer flows, groundwater, peak flows, storage, sedimentation, and water quality.

Emphasis will be placed on understanding the natural water system, how climate variables interact with it, and how other components of the water system could mediate or exacerbate climate-driven change to water resources.

Projected changes to the climate will be taken from the OCCRI report for Tillamook and Clatsop Counties.

Published findings, which include Tillamook and Clatsop counties, project:

- **Decreased spring and summer stream flow**, due to projected decreases in spring and summer precipitation and possible decreases to snow in the upper elevations
- **Slightly increased and earlier winter stream flow**, due to projected increase in fall and winter precipitation and possible decrease to snow pack in the upper elevations

Preliminary local findings suggest ***possible***:

- **Slight increase or increased variability in peak flows**, due to increased winter precipitation, possible decrease in snow pack, and possible, periodic vegetation loss due to increased chance of forest fire

Gaps in peer-reviewed, local analysis include the following ***possible*** changes:

- **Saltwater intrusion into groundwater** resource in low elevation areas, due to possible increased groundwater pumping and sea level rise
- **Periodic increase in erosion** in steeper areas, corresponding to possible **increased sediment deposition** in flatter areas due to possible increases in forest fire and peak flows
- **Increased inundation** in highly localized areas, due to possible peak flow increases, possible sediment deposition in flatter areas, and sea-level rise in estuaries
- **Increase or increased variability in water temperature** due to increases in forest fire, decreases in snow pack in high elevations, and possible changes in groundwater level in the low areas

Outline projected watershed conditions (scenarios) given current understanding of change in climate drivers (air temperature, precipitation), and the probable watershed responses that we need to plan for.:

- Changes in precipitation patterns will lead to changes in stream hydrology and sediment regimes
    - **More frequent and protracted low flow conditions** in summer might affect municipal and rural water availability
    - More intense storm events (peak flows) might lead to **greater frequency and magnitude of flooding**
    - More intense storm events (peak flows) might lead to **greater stream scour and more frequent debris flows**
- Increases in air temperature will lead to several watershed-level responses, including:
    - Drier soils, greater evapotranspiration, and more frequent and intense fire regimes, leading to **changes in forests composition** (see Dominique's presentation)
    - The combination of higher air temps, lower summer precipitation, and vegetative response will **lead to higher water temperatures**, potentially impacting cold-water adapted animals.

Given the above set of watershed-level responses, the presentation will use coastal salmon species to outline some scenarios of aquatic habitat and biotic responses that we may need to plan for:

- reduced stream flows and water depth in spring/summer/fall increases water temperatures, which changes habitat availability/distribution, and **leads to greater habitat fragmentation**, and potentially to greater continuous exposure to conditions affecting adult salmon mortality
- increased storm intensity leads to greater channel scour, more stochastic spring flows, and warmer spring water temperatures, which in turn **subjects juvenile life stages to greater occurrence of discreet mortality events**.
- Increase in summer air temperatures leads to late summer/early fall flow declines, and more severe and frequent drought events. This leads **to greater probability of juvenile salmonid mortality.**
- Flow declines in combination with other factors lead to increase water temperatures, decrease dissolved oxygen, and **less habitat and altered timing for juveniles transitioning to salt water**.

Presentation Outline: **Erosion and Flood Hazards on the Northwest Oregon Coast due to Earth's Changing Climate**

Jonathan Allan; Coastal Geomorphologist. Oregon Department of Geology and Mineral Industries

The Oregon coast is 366 miles long from the Columbia River to the California border. The coastal geomorphology of this landscape reflects a myriad of geomorphic features (Figure 1) that range from plunging cliffs (in regions 1, 4, & 5), rocky shorelines and shore platforms (regions 1, 3, 5, & 6), wide and narrow sandy beaches backed by both dunes (regions 2, 5 & 6) and cliffs (regions 3 & 4), gravel and cobble beaches backed by cliffs (regions 1, 5 & 6), barrier spits (regions 2, 4 & 5), and estuaries (regions 1-6). Cliffed or bluff-backed shorelines make up the bulk of the coast accounting for 58% of the coastline, the remainder being dune-backed. Geomorphically, the coast can be broken up into a series of "pocket beach" littoral cells (Figure 1) that reflect resistant headlands (chiefly basalt) interspersed with short to long stretches of beaches backed by both less resistant cliffs and dunes (e.g. Lincoln and Tillamook Counties (regions 3 & 5 in Figure 1). The headlands effectively prevent the exchange of sand between adjacent littoral cells. Sediment inputs are considered to be negligible such that the littoral cells have a finite volume of sand. Some beaches form barrier spits, creating estuaries or bays behind them (e.g. Nestucca and Netarts Spits). About 75.6% of the coastline consists of beaches comprised of sand or gravel backed by either dunes or bluffs, while the remaining 24.4% of the coast is comprised of a mixture of rocky cliffs (including headlands) and shores. Of the 18 littoral cells on the Oregon coast, the largest is the Coos cell, which extends from Cape Arago in the south to Heceta Head in the north, some 62.6 miles in length.

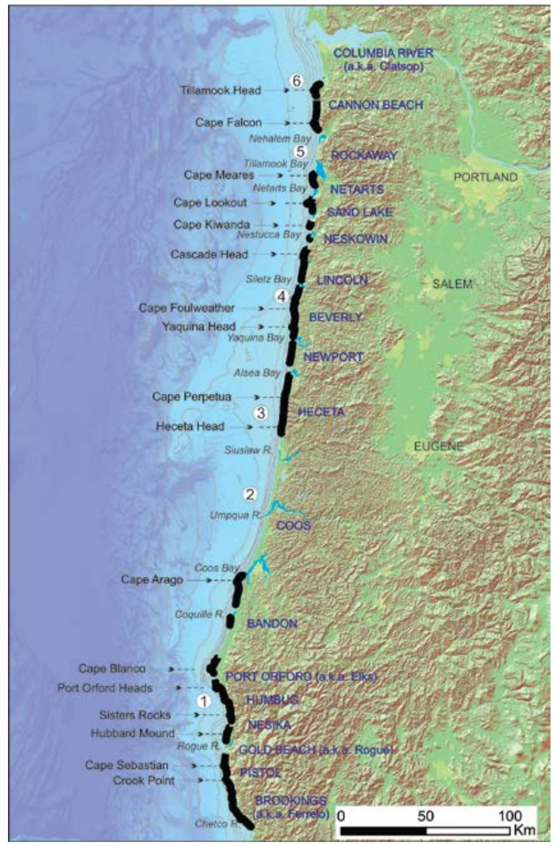

Figure 1: The coastal geomorphology of the Oregon coast, including a break-down of Oregon littoral cells. Bold black lines denote the locations of cliffs and rocky shores. Numbers indicate regional coastal geomorphic features: plunging cliffs (1, 4 & 5), rocky shorelines and shore platforms (1, 3, 5 & 6), wide and narrow sandy beaches backed by both dunes (2, 5 & 6) and cliffs (3 & 4), gravel and cobble beaches backed by cliffs (1, 5 & 6), barrier spits (2 & 5), and estuaries (1-6).

Along the Oregon coast, coastal communities are increasingly under threat from a variety of natural hazards, including coastal (wave-induced) erosion (both short and long-term) and flooding, sand inundation, and potentially catastrophic tsunamis generated by the Cascadia subduction zone. Over time, these hazards are gradually being compounded, in part due to the degree of development that has evolved along the Oregon coast in recent decades. A particular concern is that the local geology and geomorphology of the region have restricted development to low-lying areas, chiefly along dunes, barrier spits, or along coastal bluffs present along the open coast that are subject to varying rates of erosion, and to low-lying areas adjacent to the numerous estuaries that make up the coast (Allan and others, 2009). All of these sites are highly susceptible to increased impacts as erosion processes and flood hazards intensify, driven by rising sea level and increased storminess.

Beaches and dunes are particularly susceptible to the occurrence of large storms coupled with high ocean water levels. Along the Tillamook County coast, coastal erosion hazards have been especially acute over the past 15 years due to the occurrence of several major storms, coupled with the occurrence of the 1997-98 El Niño. Collectively such events have resulted in extensive erosion in several communities (e.g. Neskowin, Tierra Del Mar, and Rockaway[1]), leading to the proliferation of coastal engineering structures in order to protect backshore properties from the erosion hazard. Although scientists are now beginning to gain an understanding of the short to long-term patterns of Oregon coastal change (e.g. Allan and Hart, 2008; Ruggiero et al. 2013), the most significant erosion and flood events are forced by major storms (e.g. January 1939) or storms-in-series (e.g. 1998-99 winter). In all cases, it is the combination of large waves, low atmospheric pressure, strong onshore directed winds, coupled with high tides, which produces high total water levels[2] along the coast and causes the most significant erosion and flood hazards. A case in point is the extreme 1998-99 winter, which was characterized by the equivalent of five 100-year (1%) events over a two month period and led to the removal of ~1.4 million m^3 of sand in the Rockaway sub-cell. At the time, the calculated extreme storm wave was 10 m. Following those major events, the 1% event was revised upward to ~14-15 m. Following periods of storminess it can take beaches years to decades to fully recover and in some cases recovery may not be possible due to the removal of sand into deeper water. Along much of the Tillamook County coast this is essentially the situation with many beaches remaining in a degraded state. As a result, coastal communities are vulnerable today to major storms let alone from the effects of future climate change.

Although the same sets of processes are important for driving coastal erosion and flood hazards in Clatsop County, the impacts have not been as severe. This is in large part due to the local geomorphology (mostly homes built on marine terraces that are somewhat resistant to erosion) and anthropogenic effects such as the construction of the Columbia River jetties, which have strongly influenced the development of the Clatsop Plains. The latter has seen significant accretion and shoreline progradation since the early 1900s. However, there is some suggestion that this process may be reversing along the northern end of the Clatsop Plains (north of the Peter Iredale), where erosion processes are now beginning to drive the overall coastal response.

Due to the prevalence of sandy beaches and dunes along the Tillamook and Clatsop County coast, coastal erosion and flood hazards will almost certainly increase in the future due to projected regional increases in sea level. Global sea level has risen approximately 20 cm during the 20th century at an average rate of ~1.75 mm/yr (Holgate, 2007). The rate of sea level rise (SLR) has accelerated over the last few decades, reaching rates of 2.8-3.4 mm/yr, determined from satellite altimetry (Cazenave and Llovel, 2010), although some of this probably reflects steric (temperature and salinity) variations due to interdecadal ocean cycles. On the Oregon coast, historic rates of relative sea level change vary from a decrease of -0.62 ±0.35 mm/yr at Astoria on the northern Oregon coast, to an increase of +1.33 mm/y (±0.79 mm/y) on the central coast, and a decrease of -1.10 mm/y (±0.5 mm/y) on the northern California coast at Crescent City (Komar et al, 2011). Differences in the response between these sites (and others) reflect the effects of regional tectonics, such that the southern Oregon coast (south of

[1] http://www.oregongeology.org/nanoos/data/img/lg/Rck4_EDA.png

[2] Total water level reflects the combined effect of wave runup superimposed on the measured tides

about Coos Bay) is presently an emergent coast as tectonic uplift outpaces sea level rise, while the central to northern Oregon coast (including Tillamook County) is gradually being submerged (i.e. sea level rise exceeds tectonic uplift).

In December 2010, state and federal agencies on the US West Coast commissioned a sea level change study by the National Academies of Sciences with the expressed purpose of deriving future projections of SLR in 2030, 2050, and 2100. Importantly, a major component of the study was to incorporate such factors as regional tectonics, glacial isostatic adjustments, and tide gauge information in order to constrain the estimates to the regional level (NRC, 2012). Results from the NRC study were published late in 2012 and for the central Oregon coast they indicate that mean sea level is projected to increase by +7 cm (-4 to +23 cm range) by 2030, +17 cm (-2 to +48 cm range) by 2050, and +63 cm (+12 to +142 cm range) by 2100 (NRC, 2012). These projections are presented conceptually in Figure 2, which demonstrates the effect of these increases under a range of mean sea level conditions (summer, winter and El Nińo effects) typical of the Oregon coast, forecast for the next 85 years.

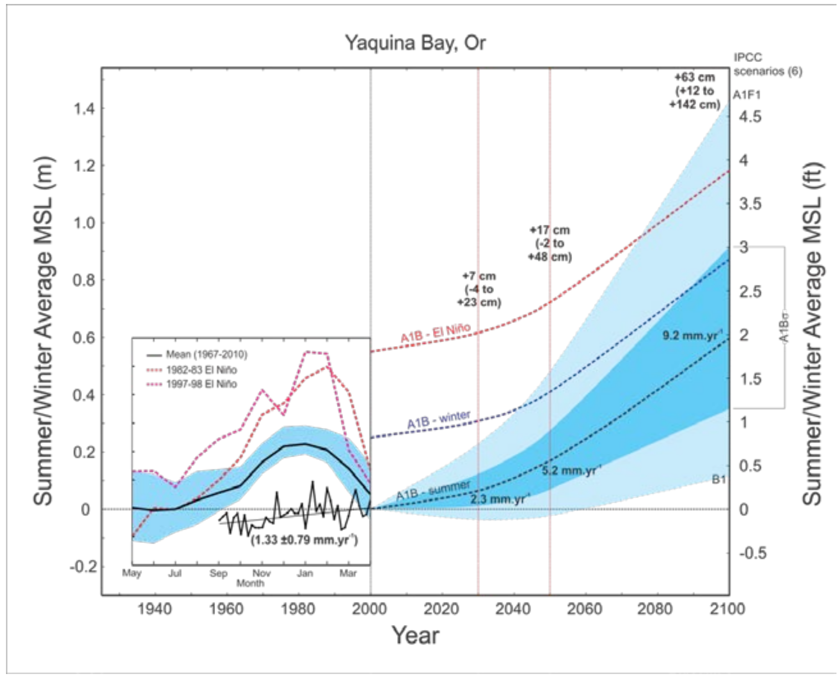

Figure 2: Projections of future sea level rise for the central Oregon coast. Dashed lines reflect the mid-range (A1B) estimate. Darker shading depicts the uncertainty for the A1B scenarios, while the lighter shading reflects the uncertainty for all global climate models. Insert figure depicts the seasonal and El Nińo cycle in monthly mean sea levels along with the historical rate of sea level rise determined for the Newport tide gauge.

To improve our understanding of the effects of climate change on the northern Oregon coast, researchers are now focusing their attention on a variety of climate change issues. This includes (but not limited to) the effects of coastal erosion and flood hazards due to storms and SLR (Ruggiero et al, 2011; Stimely and Allan, 2014, ongoing), analyses of extreme wave overtopping and flood effects (Allan and Ruggiero, ongoing) SLR on tidal hydrodynamics, ecology and flooding in estuaries (Hill, Hacker and Allan, ongoing), and ocean acidification (Hales, ongoing). Ocean acidification, which reflects a change in the chemistry of the ocean due to the ocean's absorption of carbon dioxide from the atmosphere, is of particular concern in the Pacific Northwest due to its potential effect on the shellfish industry. In 2012, scientists in Oregon found evidence that higher levels of carbon dioxide in the Pacific Ocean were responsible for the failure of oyster larvae to survive in 2005 at Whiskey Creek Shellfish Hatchery on Netarts Bay.