

**PACIFIC NORTHWEST CLIMATE IMPACTS RESEARCH CONSORTIUM  
(CIRC)  
ANNUAL PROGRESS REPORT 2015**

- 1. Award Title:** Pacific Northwest Climate Decision Support Consortium (CDSC)
- 2. Performance Period** (from previous progress report through May 30, 2014): May 2014 – May 2015

**3. Who are your team members?**

Co-PI Leads

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Principal Investigators

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- Jeffrey Bethel, OSU, Assistant Professor, College of Public Health and Human Sciences [Jeff.Bethel@oregonstate.edu](mailto:Jeff.Bethel@oregonstate.edu)
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- Susan Capalbo, OSU, Department Head, Agricultural and Resource Economics [Susan.Capalbo@oregonstate.edu](mailto:Susan.Capalbo@oregonstate.edu)
- David Hulse, UO, Envision, Department of Landscape Architecture [dhulse@uoregon.edu](mailto:dhulse@uoregon.edu)
- Bart Nijssen, UW, hydrology, Department of Civil & Environmental Engineering [nijssen@uw.edu](mailto:nijssen@uw.edu)
- Peter Ruggiero, OSU, coastal issues, Department of Geosciences [ruggierp@geo.oregonstate.edu](mailto:ruggierp@geo.oregonstate.edu)
- David Turner, OSU, vegetation modeling, Department of Forest Ecosystems & Society [david.turner@oregonstate.edu](mailto:david.turner@oregonstate.edu)

**Other participants**

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- John Stevenson, OSU, Regional Extension Climate Specialist  
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#### **Post-Docs**

- Katherine Hegewisch, UI [khegewisch@uidaho.edu](mailto:khegewisch@uidaho.edu)
- Julie Vano, OSU [jvano@coas.oregonstate.edu](mailto:jvano@coas.oregonstate.edu) - supported by NSF fellowship

#### **Graduate Students**

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4. What are your **new areas of focus or partnerships** that have begun this past year? Please provide some context for why you are expanding into this area or partnership.

#### **PACIFIC NORTHWEST DROUGHT**

Regional drought status May 2015:

- Oregon: drought is unavoidable in most of the state, drought declarations covering 20 of 36 counties as of July 2015
- Washington: statewide drought emergency, although Governor notes that Seattle, Tacoma, Everett water utilities are not currently heavily drought impacted
- Idaho: five counties declared drought emergencies

What did CIRC do on drought in the last year?

- 2014: monthly update webinars
- 2015:
  - Boise pre-scoping meeting for National Integrated Drought Information System (NIDIS) drought early warning system
  - Monthly drought updates in *The Climate CIRCulator* newsletter starting in May
  - Interviews with stakeholders by RECS
  - State level work in OR (mostly funded by state funding, some overlap with CIRC)  
<http://www.oregon.gov/owrd/pages/wr/drought.aspx>
  - Significant media attention on drought in region to which CIRC responded

(See also Drought Monitoring System for the Pacific Northwest in Section #9 on NIDIS-Coping with Drought)

#### **TRIBAL**

- Tribal cultural dimensions of climate change: a Northwest Climate Science Center-funded postdoc who is a Native American (Siletz tribe) interviewed elders of three Northwest tribes to determine cultural impacts of climate change; CIRC provided funding to continue the work after the NW CSC funding ended.

## **WILLAMETTE WATER 2100**

- Interacting with various stakeholders in the Willamette Water 2100 project that models water scarcity under climate change in the Willamette Basin - **see research results matrix (attached)**

## **NORTH COAST ADAPTATION PROJECT (NCAP)(Tillamook/Clatsop Counties):**

- Developed regional adaptation framework that identified priority risks, management options, and opportunities for implementation.
- Reliance on building network among landscape managers and resource/climate experts

For questions 5-7, you can combine these questions for each of the main projects you are highlighting, if it makes sense to do so.

5. Please provide a list of up to 5 **research findings** – Please try to include examples that span disciplinary and interdisciplinary work. Examples might be: a) dust-on-snow reduces Colorado River runoff by 5%, or b) analysis revealing the presence or absence of adaptive capacity in legal and policy frameworks for managing resources.
  - A. Climate model evaluation reduced the range of projected temperature change in the northwest; specifically, low rates of warming were ruled out.
  - B. Knowledge to Action Network (KTAN) approach showed value of alternative futures in determining KTAN development outcomes.
  - C. Big Wood Basin, Idaho:
    - a. Talking about climate adaptation (as opposed to climate change attribution) is effective even in deeply conservative communities
    - b. Management and policy affects water use and availability more than climate
  - D. Agricultural and urban uses are not in conflict so agricultural water use and production can be expanded because of overall inefficiencies in system allocations.
  - E. *Envision* modeling and planning tool is an effective way to put climate, water, and coastal hazards in context with other community challenges and priorities via visualizations and narratives, proving its ability to stimulate stakeholders to think deeply and interact productively regarding the decisions they have to make and the potential impacts of those decisions.

6. Please provide a list of up to 5 **outreach activities** that you have undertaken in the past year. OPTIONAL: If applicable, please share the outcomes of these activities.

## **PRESENTATIONS**

### **2015**

- May 28, Kathie Dello: Western States Water Council and California Department of Water Resources meeting, San Diego, California. It's not just California's drought.
- May 28, Peter Ruggiero: Tillamook Futures Council, "Envisioning Coastal Futures: Exploring alternative scenarios for Tillamook County coastlines." Coastal CIRC.
- May 7, Adell Amos: Lecture series at University of Oregon School of Law. Legal context for the recent drought declarations in California and Oregon, and the impacts on urban and rural water use and the role of modeling efforts in Willamette Water 2100.
- April 22, Adell Amos: Sustainability and Climate lecture series at Oregon State University. Developing the Law of the River: The Integration of Law and Policy into Hydrologic and Socio-Economic Modeling Efforts in the Willamette River Basin Law.
- April 20, Phil Mote: American Planning Association, Seattle, Washington. Partnerships for Climate Resilient Communities.
- April 1, Kathie Dello: Oregon Water Resources Department, Salem, Oregon. Drought and climate change.
- April 1, Phil Mote: Lewis and Clark Law School, Northwest Environmental Defense Center. Synopsis of Northwest Climate Assessment Report.
- March 2, Kathie Dello: Eastern Oregon drought forums. Drought, climate, and climate change.
- February 20, David Rupp: River Management Joint Operating Committee Workshop, Portland, Oregon. Integrated Scenarios project: Selecting climate scenarios and evaluating Global Climate Models.
- January 23, Kathie Dello: Salem City Club, Salem, Oregon. Northwest Chapter of the National Climate Assessment.
- January 8, Darrin Sharp: Confederated Tribes of the Umatilla (CTUIR), Pendleton, Oregon. Climate Change Impacts on First Foods.

### **2014**

- December 8, Phil Mote: Idaho Environmental Forum. National Climate Assessment (included Idaho's Lieutenant Governor Brad Little)
- November 19, Dave Turner: Willamette Water 2100 Advisory Group. Climate Change Impacts on Upland Forest Dynamics over the Willamette River Basin
- November 12, Kathie Dello: American Institute Architects, Committee on Environment, Portland, Oregon. Climate change in the Northwest.
- November 5, Peter Ruggiero: Tillamook County Commissioners Meeting. Coastal CIRC.

- November 5, Dave Turner: Willamette Water 2100 webinar series. Climate Change Impacts on Upland Forest Dynamics over the Willamette River Basin.
- October 31, Phil Mote: Seminar for Institute of Ecology and Evolutionary Biology, University of Oregon. Climate science update.
- October 24, Phil Mote: Climate change & electric utilities conference. Northwest climate science.
- October 22, Phil Mote: Portland General Electric Board Meeting. Climate 101.
- October 22, Phil Mote: Water for Food Conference, Seattle, Washington. Climate data and models.
- September 25, Phil Mote: Oregon Ground Water Council, Portland, Oregon. Observed climate trends in the Northwest, and National Climate Assessment
- September 16, Phil Mote: Webinar, EPA Group on Climate and Materials. National Climate Assessment in Northwest and Southwest.
- September 2, Phil Mote: Institute for Tribal Environmental Professionals tribal training, Portland, Oregon. Climate 101 and Northwest impacts.
- September 24, October 24, November 19, and December 18, 2014; and March 19, 2015, Dave Hulse: Five Willamette Water 2100 Technical Advisory Group Stakeholder Meetings. Two future scenarios for modeling alternative land and water use futures in the Willamette Basin.
- August 27-28, Phil Mote: San Juan Islands. Climate impacts and resilience.
- June 3, Josh Foster: Benton County Board of Commissioners, Benton County Climate Change Adaptation Plan Meeting. Local climate impacts.
- June 12 Kathie Dello: American Meteorological Society Applied Climate Conference, Denver, Colorado. 2014 drought.
- June 12 Kathie Dello: American Meteorological Society Applied Climate Conference, Denver, Colorado. CIRC and Bureau of Land Management drought work.
- May 23, Phil Mote: Union of Concerned Scientists webinar. Northwest climate assessment.
- May 14, Phil Mote: National Tribal Forum. Regional climate efforts.
- May 13, Phil Mote: Seattle City Council, Seattle Public Utilities Committee. National Climate Assessment
- May 12, Phil Mote: Institute for Tribal Environmental Professionals (ITEP), Anacortes, Washington. United States climate change.

## **NEWSLETTER**

- Communications Outreach: Each month since April 2012, CIRC's newsletter, *The Climate CIRCulator*, has summarized 5-7 climate science publications and findings relevant to the Pacific Northwest, Open rate and readership tends to be above industry standard for publication type. Oregon Governor's office interested in increasing *CIRCulator* distribution among state agencies. CIRC has co-developed with the North Pacific Landscape Conservation Cooperative and the NW CSC *Northwest Climate Magazine*, a yearly magazine-style publication written for a more general audience. The intent of the publication is to provide a

platform to detail CIRC and partners' science and adaptation work. CIRC continues to engage stakeholders and increase outreach via social media.

### **PARTNERSHIPS & TOOLS (WITH OUTREACH COMPONENTS)**

- U.S. Forest Service (USFS) Adaptation Projects - building on earlier USFS work in western Washington, this project aims to:
    - Increase the institutional capacity of Pacific Northwest public land managers to adapt current management practices to regional climate change and
    - Transfer knowledge gained from successful partnerships to a wider audience including Northern Rockies Adaptation Partnership (NPAP) and Blue Mountain Adaptation Partnership (BMAP)
  - North Coast Alignment Project (NCAP)
    - Develop regional adaptation framework that identified priority risks, management options, and opportunities for implementation.
    - Reliance on building network among landscape managers and resource/climate experts
  - Association of Natural Resource Extension Professionals (ANREP) Climate Science Initiative:
    - Building capacity of natural resource extension professionals around climate science and clientele communications
    - In service trainings, webinars
  - Downscaled climate data portal at University of Idaho: continued development to increase accessibility and knowledge for place-based climate change in the Northwest, and blending of associated hydrologic and vegetation datasets:
    - <http://maca.northwestknowledge.net>
    - <http://climate.nkn.uidaho.edu/IntegratedScenarios/>
  - AgClimate.net:
    - Online aggregator of information related to PNW agriculture and climate
    - Weekly blog posts
  - See NIDIS Section for Engagement on Drought
7. Please provide a list of **key publications** from the past year - We are seeking ~ 5 publications, give or take a few, to be highlighted on the CPO webpage. These can be either non-peer reviewed or peer-reviewed. For peer-reviewed publications, please list either **published** or in **press**, but **not** "in review". For non peer-reviewed publications, please provide a hyperlink or webpage wherever possible. (You may include a more comprehensive list of publications as an appendix.)
- Abatzoglou, J.T., D.E. Rupp and P.W. Mote, 2014, Questionable evidence of natural warming of the northwestern United States, Proceedings of the National Academy of Sciences, doi:10.1073/pnas.1421311112.  
<http://www.pnas.org/content/111/52/E5605>
  - Abatzoglou J.T., R. Barbero, J.W. Wolf, Z. Holden (2014), Tracking interannual streamflow variability with drought indices in the Pacific Northwest, US, *Journal of Hydrometeorology*, 15, 1900-1912.  
<http://renaudbarbero.weebly.com/uploads/2/1/5/5/21555380/hydromet.pdf>

- Amos, A., 2014: Developing The Law of the River: The Integration of Law and Policy into Hydrologic and Socio-Economic Modeling Efforts in the Willamette River Basin” 62:4 Kansas University Law Review, May 2014  
[http://law.ku.edu/sites/law.drupal.ku.edu/files/docs/law\\_review/v62/7%20KLR%20Site%20Amos\\_Final%20Press%20with%20Figure.pdf](http://law.ku.edu/sites/law.drupal.ku.edu/files/docs/law_review/v62/7%20KLR%20Site%20Amos_Final%20Press%20with%20Figure.pdf)
  - Lute, A.C, J.T. Abatzoglou, and K.C. Hegewisch, 2015, Projected changes in snowfall extremes and interannual variability of snowfall in the western U.S, Water Resources Research, doi: 10.1002/2014WR016267.  
<http://onlinelibrary.wiley.com/doi/10.1002/2014WR016267/abstract>
  - Serafin, K. and Ruggiero, P., 2014. Simulating extreme total water level events using a time-dependent, extreme value approach, Journal of Geophysical Research – Oceans, 119, 6305-6329, doi: 10.1002/2014JC010093.  
<http://onlinelibrary.wiley.com/doi/10.1002/2014JC010093/abstract>
  - Piloting Utilities Modeling Applications (PUMA): Seattle Public Utilities Climate Impacts Assessment. December 2014. A Synthesis Report to Seattle Public Utilities Prepared by The Pacific Northwest Climate Impacts Research Consortium (CIRC)(no online reference)
  - **(publication by partners about one of our projects:)** Actionable Science in Practice: Co-producing Climate Change Information for Water Utility Vulnerability Assessment. Final Report of the Piloting Utility Modeling Applications (PUMA) Project (February 2015)  
[http://www.wucaonline.org/html/actions\\_publications.html](http://www.wucaonline.org/html/actions_publications.html)
  - Vano, J. A., B. Nijssen, and D. P. Lettenmaier (2015), Seasonal hydrologic responses to climate change in the Pacific Northwest, Water Resour. Res., 51, 1959–1976, doi:10.1002/2014WR015909.  
<http://onlinelibrary.wiley.com/doi/10.1002/2014WR015909/full>
8. Please provide up to 3 narrative **examples** from the past year of plans, policies, strategies, tools, agreements, etc. that were proposed, adopted, and/or implemented as a result of RISA work.
- Tillamook County passed the Neskowin Adaptation Plan, currently under appeal to Land Use Board of Appeals (LUBA)
  - Increased capacity of Seattle Public Utilities (SPU) and Portland Water Bureau (PWB) to do in-house climate impact assessments: both created intra-departmental technical working groups on climate, and increased connectivity with other city departments
  - Big Wood River Basin (Idaho) water managers developed more comprehensive view of urban, recreational, and agricultural connectivity, trade-offs, and where water management efficiencies might be realized relative to climate change and other drivers (e.g. demographic change and development)

9. How are you measuring the overall impact of your RISA team on decision-making in your region? For instance, how do you know what your program-level impact is?
- CIRC initiated an evaluation of Knowledge to Action Network (KTAN) lessons learned and effectiveness with findings to be included in Final Report.
  - Tillamook County: CIRC has been using an engagement and modeling approach with measureable success in Tillamook County, Oregon. For example, Tillamook County Commissioner Mark Labhart recently said *“Peter [Ruggiero’s] work at OSU has been astronomically helpful and I am sure we are going to be relying on him in the future as we move forward with these big policy issues that face us about what to do along our coastline”* after PI Ruggiero’s presentation at the Tillamook County Board of Commissioner Meeting on 5 November 2014. At an earlier Tillamook County-KTAN meeting Commissioner Labhart also described our Envision modeling efforts *“... I think it’s going to be a powerful tool for us to use to make major decisions that are going to affect people’s lives. So we thank you very much for your efforts and students you did a good job today.”* The Tillamook County Community Development Office (Planning Department) has been attending our KTAN meetings as well. Recently, Director Bryan Pohl offered *“I think there are larger implications than just informing the conversation... I mean, there are extremely important central policies and outcomes from this... it’s still going to hopefully be the genesis for some policy changes.”*
10. For teams that receive NIDIS-Coping With Drought funds for work on the NIDIS Regional Drought Early Warning System: Please describe how the research contributed to drought early warning technique or capabilities in the region and/or methodologies that advance the early warning systems. Areas could include improvements in monitoring, forecasting, impact assessment, identification of vulnerability and risks, aligning capabilities with planning and preparedness (e.g. indicators, thresholds,) evaluation of early warning, and improving awareness and communication about drought and drought response.
- Developed a high resolution, regional version of Continental US (CONUS) wide drought monitor providing added regional detail.  
[http://www.hydro.washington.edu/forecast/monitor\\_west/](http://www.hydro.washington.edu/forecast/monitor_west/)
  - 2014:
    - Ad hoc drought briefings for water managers in Oregon in 2014
    - Monthly update webinars for the Pacific Northwest
  - 2015:
    - 2015 active participation in drought calls with Oregon and Washington state water managers
    - Boise pre-scoping meeting for NIDIS drought early warning system
    - Monthly drought updates in *CIRCulator* newsletter starting in May
    - Interviews with stakeholders by RECS
    - State level work in Oregon (mostly funded by state funding, some overlap with CIRC). <http://www.oregon.gov/owrd/pages/wr/drought.aspx>
    - Significant media attention on drought in region to which CIRC responded



11. Please fill out the attached project database template for projects that meet all of the following criteria (NOTE: These criteria are generally a judgment call on the part of the Principal Investigator(s) and/or the Program Managers and do not require extensive analysis. Criteria should NOT be listed in database.):

- Core RISA projects – Determined by one or more of the following:
  - i. RISA investigator is leading the effort
  - ii. RISA is primary source of funding
  - iii. RISA capacity is critical to the project (e.g. Regional Chapters/Technical Inputs of the NCA)
- Current projects – Determined by one or more of the following:
  - iv. Recently completed (i.e. finished within the last six months)
  - v. Ongoing (i.e. initiated, but not completed)
  - vi. Planned (i.e. funded but not started)

## **12. PUBLICATIONS**

### **2014-2015 Publications**

- See above list.

**Willamette Water 2100 Modeling Scenarios – June 2015**

Scenario Name	Climate	Population & Income	Forest Disturbance	Urban Development	Reservoir Ops	Urban Water Demand & Pricing	Crop Choice and Irrigation	Water Claims	Environmental Flows
<b>REFERENCE CASE</b>									
<b>Reference Case – MIROC (Ref)</b>	MIROC - middle range climate change; 5.5°C (10°F) increase in PNW annual mean temperatures over century	county population projections to 2050 from OEA (2011) and income to 2040 from Woods & Poole (2011) with linear extrapolations to 2100; pop. in 2010 = 2.41M; 2100 = 5.37M; mean household income in 2010 = \$87.9K; 2100 = \$242K (in 2005 dollars)	wildfire suppression at historical rates; forest area burned per year increases from 0.2%/yr in 2010 to 0.6%/yr in 2100; harvest by clear cut at historical rates (8000 ac/yr on public lands + 29000 ac/yr on private lands); no harvest of protected areas; stand age for harvest >= 40 yrs on private land, 40-80 yrs on public lands	all development within UGBs; UGBs expand when 80% developed; growth of PDX Metro UGB confined to urban reserves through 2060	rule curves implemented as of 2011; reservoir refill begins Feb 1 with target to fill reservoirs by May	increase in water price 2011-2025 (1.5%/yr) to cover infrastructure backlog, then prices held near constant in real terms for city population size; resulting average per capita municipal demand = 118 gal/day in 2100	crop mixes similar to today; crop and energy prices do not rise in real terms; legal limits include max irrigation rate 1/80 <sup>th</sup> cfs/acre and duty 2.5 acre-feet/acre; about 2/3 of acres with water rights irrigated in an average year; result is about 280,000 acres irrigated initially	no new water rights and no new deliveries of stored water from the Willamette Project	includes instream water rights implemented as of 2010 and BiOp recommendations as of 2009 except selective withdrawal structure at Cougar; pulse flows in sub-basins not implemented
<b>CLIMATE SCENARIOS – vary only climate inputs</b>									
<b>Low Climate Change – GFDL (LowClim)</b>	GFDL - low climate change; 1.5°C (3°F) increase in PNW annual mean temp. over century	same as Ref	same as Ref; small decrease in forest area burned per year relative to historical rates	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref
<b>High Climate Change – Hadley (HighClim)</b>	Hadley - high climate change; 7.6°C (14°F) increase in PNW annual mean temp. over century	same as Ref	same as Ref; forest area burned per year increases 9X over historical rates	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref

Scenario Name	Climate	Population & Income	Forest Disturbance	Urban Development	Reservoir Ops	Urban Water Demand & Pricing	Crop Choice and Irrigation	Water Claims	Environmental Flows
<b>HUMAN DIMENSIONS SCENARIOS – vary one human or policy element at a time</b>									
<b>High Population Growth (HighPop)</b>	same as Ref	pop. growth rates within UGBs doubled relative to Ref; pop. in 2100 = 8.25M	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref
<b>Upland Wildfire Suppression (FireSuppress)</b>	same as Ref	same as Ref	fire suppression efforts increase to hold area burned per year to historical rates	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref
<b>Relaxed Urban Expansion (UrbExpand)</b>	same as Ref	same as Ref	same as Ref	UGBs expand when 70% developed; no urban reserves	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref
<b>Late Reservoir Refill (LateRefill)</b>	same as Ref	same as Ref	same as Ref	same as Ref	reservoir refill begins March 1, ramps up to Ref. rule curves between March and May	same as Ref	same as Ref	same as Ref	same as Ref
<b>Full Cost Urban Water Pricing (FullCost-Urb)</b>	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	15 yr increase in price to reach estimated long-run average cost (LRAC), which depends on pop. size; prices then continue at LRAC; resulting WB avg. per capita municipal demand = 108 gal/day in 2100	same as Ref	same as Ref	same as Ref

Scenario Name	Climate	Population & Income	Forest Disturbance	Urban Development	Reservoir Ops	Urban Water Demand & Pricing	Crop Choice and Irrigation	Water Claims	Environmental Flows
<b>Limited Irrigation Rates &amp; Duties (LimIrrig)</b>	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	legal max irrigation rate reduced from 1/80 cfs/acre to 1/100 cfs/acre; duty also reduced from 2.5 to 2.0 acre-feet/acre	same as Ref	same as Ref
<b>Higher Irrigation Usage (HighIrrig)</b>	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	avg. fraction of irrigation rights utilized in a given year increased from 2/3rds (Ref case) to 5/6th	same as Ref	same as Ref
<b>New Irrigation Rights (NewIrrig)</b>	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	new irrigation contracts and related rights introduced 2015-2044; probability of adding new rights reflect their profitability and account for pumping and conveyance costs and contract fees (\$9/acre); crop choice as in Ref	new contracts from Willamette Project added to satisfy demand for new irrigation demand	same as Ref
<b>New Instream Flow Rights (New-Instream)</b>	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	new instream water rights introduced 2015-2034 to reflect “recommended minimum flows for fish life.” <sup>1</sup>

<sup>1</sup> See reports including Hutchison, James M., Kenneth E. Thompson, and John D. Fortune Jr. *The fish and wildlife resources of the upper Willamette basin, Oregon, and their water requirements*. Basin Investigations Section, Oregon State Game Commission, 1966; Hutchison, James M., and Warren W. Aney. *The fish and wildlife resources of the* This document represents work in progress by Oregon State University, Portland State University, and the University of Oregon. **Please do not cite or distribute.**

Scenario Name	Climate	Population & Income	Forest Disturbance	Urban Development	Reservoir Ops	Urban Water Demand & Pricing	Crop Choice and Irrigation	Water Claims	Environmental Flows
<b>STAKEHOLDER DEFINED SCENARIOS – recombine multiple climate and human elements</b>									
<b>Extreme</b> extreme changes in climate and population combined with policies that emphasize resource use over conservation; assumes all sectors ‘share the pain’ in water deficit years	same as High Climate Change (Hadley) - 7.6°C (14°F) increase in PNW annual mean temp. over century	same as HighPop; pop. growth rates within UGBs doubled relative to Ref; pop. in 2100 = 8.25M	increase in wildfire suppression so that forest area burned per year increases from 0.2%/yr in 2010 to 0.8%/yr in 2100; harvest by clear cut at historical rates (8,000 ac/yr on public lands + 29,000 ac/yr on private lands); no harvest of protected areas; stand age for harvest >= 40 yrs on private and public lands	same as UrbExpand; UGBs expand when 70% developed; no urban reserves	reservoir refill begins March 1, ramps up to existing rule curves between March and May; 1% chance each year for one of the five biggest reservoirs to go offline for one calendar year; reservoir treated as “Run of the River” when offline	ratio of commercial to residential water demand increased 2015-2030 to reach the highest level observed in the WB in recent years	same as NewIrrig; new irrigation contracts and related rights introduced 2015-44; probability of adding new rights reflect their profitability and account for pumping and conveyance costs from the nearest reach below a federal reservoir; crop choice as in Ref	New claims of stored water (May-October)  Up to 233,060 acre-feet/yr for municipal uses  Up to 550,000 acre-feet for agricultural irrigation <sup>2</sup>	same as Ref

*Lower Willamette Basin, Oregon, and their water use requirements.* Oregon State Game Commission, 1964; *The fish and wildlife resources of the middle Willamette basin, Oregon, and their water use requirements.* Report to the Oregon State Game Commission, Basin Investigations Section, 1963.

<sup>2</sup> Maximum claims based on Willamette Basin Reservoir Study Interim Report (USACE, 2000) and 1994 Application for Reservation (ODA, 1994 and League of Oregon Cities and Special Districts Association of Oregon, 1994)

Scenario Name	Climate	Population & Income	Forest Disturbance	Urban Development	Reservoir Ops	Urban Water Demand & Pricing	Crop Choice and Irrigation	Water Claims	Environmental Flows
<b>Managed</b> mid-range changes in climate and population with a continuation of recent trends in resource use and management; assumes all sectors 'share the pain' in water deficit years	same as Ref; middle range climate (MIROC)	same as Ref; pop. in 2010 = 2.41M; 2100 = 5.37M	differential increase in wildfire suppression on private and public lands; resulting increase in forest area burned on private lands from 0.2%/yr in 2010 to 0.3%/yr in 2100 and on public lands from 0.2%/yr in 2010 to 0.8%/yr in 2100; harvest by clear cut at historical rates (8000 ac/yr on public lands + 29,000 ac/yr on private lands); no harvest of protected areas; stand age for harvest >= 40 years on private and 40-80 years on public lands	same as Ref	same as Ref	municipal use declines to 100 gal/day/capita by 2050 then holds at that rate to 2100	same as Ref	new deliveries of stored water (May-October)  Up to 133,060 acre-feet/yr for municipal uses  Up to 385,000 acre-feet for agriculture	same as Ref

Scenario Name	Climate	Population & Income	Forest Disturbance	Urban Development	Reservoir Ops	Urban Water Demand & Pricing	Crop Choice and Irrigation	Water Claims	Environmental Flows
<b>COUNTER-FACTUAL SCENARIOS – hold one element constant or absent to determine model sensitivity</b>									
<b>Stationary Climate (StatClim)</b>	21 <sup>st</sup> century climate the same as 1950-2010 based on simulated historical MIROC	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref
<b>Zero Population and Income Growth (NoGrow)</b>	same as Ref	population and household income remain at 2011 levels throughout century	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref
<b>Run of the River (No-Reservoirs)</b>	same as Ref	same as Ref	same as Ref	same as Ref	modeled without federal reservoirs	same as Ref	same as Ref	same as Ref	same as Ref
<b>All Fallow (AllFallow)</b>	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	crop choice set to “fallow” for all agricultural lands (including trees and orchards); no irrigation	same as Ref	same as Ref
<b>HISTORICAL SCENARIOS – simulation period 1950-2010</b>									
<b>Historic Mid-Range Climate (HistoricRef)</b>	simulated historical climate based on MIROC global climate model	not modeled; landcover held constant with 2010 conditions	not modeled; landcover held constant with 2010 conditions	not modeled; landcover held constant with 2010 conditions	same as Ref	not modeled; landcover held constant with 2010 conditions	not modeled; landcover held constant with 2010 conditions	not modeled	same as Ref
<b>Historic High Climate (Historic-HighClim)</b>	simulated historical climate based on Hadley global climate model	not modeled; landcover held constant with 2010 conditions	not modeled; landcover held constant with 2010 conditions	not modeled; landcover held constant with 2010 conditions	same as Ref	not modeled; landcover held constant with 2010 conditions	not modeled; landcover held constant with 2010 conditions	not modeled	same as Ref