Appendix B – NW CLIMATE SCIENCE CENTER: SCIENCE AGENDA FOR 2012-2016

Key Science Needs

Identifying key science needs is a fundamental step in developing climate science for natural- and cultural-resource managers, Tribes, and other stakeholders in the Northwest. The key science needs that have been identified to date are organized below into seven interrelated Research Themes that broadly reflect the scale of the relevant processes and the flow of information. The science themes are not intended to represent any hierarchy of importance, need, or order of effort. The NW CSC will work in cooperation with the ESAC to prioritize the key science needs. Prioritization will reflect the needs of LCCs and other stakeholders, and consider ongoing efforts and identified science and information gaps. Once priorities have been identified, it is anticipated that priority science needs under multiple themes will be addressed in parallel.

1. Climate Science and Modeling – Continue development of climate science and modeling capabilities to provide resource managers and researchers across all disciplines reliable and defensible information on the range of probable future climate conditions and associated uncertainty in the Northwest.

a. Coordinate with and leverage efforts at the national level to advance techniques of analyzing and downscaling global and regional climate models as appropriate for the Northwest, including the understanding, quantification, and characterization of climate model uncertainty.
b. Connect with and leverage efforts at the national level to advance the understanding of nonlinear behavior of climate systems, and feedbacks between climate systems and other physical and biological systems, including development and application of coupled regional models suitable to this task.
c. Develop a data infrastructure for documentation, storage, and dissemination of a well-vetted set of future climate scenarios including multimodel ensembles, along with guidance regarding appropriate interpretation, use, and uncertainty.
d. Identify metadata standards for model data sets to ensure data are properly documented and appropriate for specific uses.

2. Response of Physical Systems to Climate Change – Characterize and model the response of physical systems (for example hydrologic, atmospheric, and earth-systems) to historic and future temperature and precipitation, taking into consideration the effects of uncertainty. Key among these processes is the hydrologic response, which directly influences streams and groundwater resources, ecosystems, historical and cultural resources, and ecosystem services.

a. Advance understanding of the response of hydrologic systems to future climate, including changes in snow hydrology, alpine glaciers, streams (both perennial and intermittent), lakes (both lotic and lentic systems), groundwater systems, wetlands, water temperature, water quality, and extreme events. This need relates to effects on aquatic habitat, as well as the timing and amount of water available for agricultural and municipal use, recreation, wildlife and stock use, and power generation. The hydrologic response also affects understanding of drought, flood risk, reservoir operations, and land management.
b. Advance understanding of changes in physical and chemical processes in marine systems, including sea level rise, salinity, acidity, circulation patterns, nutrients, dissolved oxygen, intensity of storm events, and shoreline erosion.
c. Advance understanding of atmospheric fluxes of carbon dioxide, other greenhouse gases, and water, as well as other of atmospheric processes, such as acid and nutrient deposition, airborne dust, and other contaminants.

d. Improve understanding of erosion, mass wasting, and sediment transport processes (including both wind and water) resulting from changes in precipitation and stream flow, sea level rise, and glacier retreat, particularly as they relate to hazards, water quality, aquatic habitat, cultural resources, and infrastructure.
e. Quantify probable changes in soil moisture and energy, particularly as they relate to vegetation, evapotranspiration, and hydrologic budgets. This need includes effects to irrigated agriculture (*e.g.,* soil suitability, water consumption rates, and cropping patterns).
f. Advance understanding of probable changes in air and water temperatures, and develop projections of the potential impacts to affected physical and biological systems.

3. Response of Biological Systems to Climate Change – Characterize and model the response of biota, terrestrial and aquatic ecosystems, and biogeochemical systems to changing climate, specifically including the effects of uncertainty. Characterization may include analysis of historic data, field research, and model analysis, as well as other approaches. The efforts in Research Theme 2 complement and provide the physical template for understanding the biological systems in this theme. The elements of this theme have importance to biodiversity, biotic components of culturally-important landscapes, as well as ecosystem services.

a. Characterize the response of species, populations, and ecosystems to climate change.
b. Improve understanding of threats to habitat connectivity and potential for fragmentation of terrestrial, aquatic, marine, and nearshore habitats.
c. Continue to advance understanding and modeling of changes in fire regimes.
d. Continue to develop understanding of the ecology and potential impacts of invasive species, plant and animal diseases, harmful algal blooms, pathogens, and epidemic insect infestations.
e. Enhance understanding of carbon cycling, biological carbon sequestration, and carbon emissions, particularly as they relate to land management, mitigation, and adaptation strategies.
f. Improve understanding of potential changes in phenology (relative timing of physical and biological cycles) and related monitoring needs.
g. Improve understanding of the feedback between biological systems and processes, and physical systems and processes (including climate).

4. Vulnerability and Adaptation – Identify vulnerabilities of specific physical systems, ecosystems, human health, cultural resources, and infrastructure to climate change, and identify actions or practices that may improve prospects for adaptation. This theme complements understandings developed in Research Themes 2 and 3.

a. Assess the vulnerabilities (as well as resiliencies) of terrestrial, aquatic, and near-shore marine ecosystems, as well as individual species and populations, to climate change and non-climate-change stressors.
b. Identify vulnerabilities of physical and biological systems and landscape characteristics critical to Native American Tribes. These efforts must consider the unique relation between Tribes and the landscape, and the large degree to which Tribes rely on the landscape for their economic well-being and cultural identity.
c. Assess climate-related increases in vulnerability of threatened and endangered species or other species of concern.
d. Identify vulnerabilities of freshwater resources, particularly as they relate to ecosystem needs, cultural and historical resources, human needs, infrastructure, and shifting demands.
e. Develop adaptation strategies for vulnerabilities identified at the full range of spatial scales.

5. Monitoring and Observation Systems – Evaluate, enhance, develop (if necessary) new programs for monitoring and observation of key physical and biological systems, and develop systematic methods for analyzing, storing, and serving information. This theme centers on the need for data (including traditional knowledge) required to quantify physical and biological processes, track changes, and evaluate effectiveness of adaptation and mitigation measures.

a. Inventory and evaluate existing monitoring networks, expand and modify networks as necessary, and, where feasible, integrate efforts across agencies. Ensure monitoring and observation efforts inform understanding of physical and biological systems, and inform assessment and modification of adaptation efforts.
b. Develop new metrics for tracking the response of physical systems, ecosystems, and individual biota to climate change, and establish new monitoring and observation systems where needed.
c. Use models, where applicable, to evaluate data from and guide design of monitoring networks.

6. Data Infrastructure, Analysis, and Modeling – Improve methods for data analysis and storage, modeling, forecasting, and decision-support. This cross-cutting theme relates to science application across the full range of disciplines, processes, and scales. Efforts related to decision support systems should be coordinated with the CDSC.

a. Expand retrospective analyses of the response of physical and biological systems to historic climate and advance paleoclimate research. This effort needs to occur at a range of scales and, where possible, incorporate traditional knowledge.
b. Continue development and application of a set of coherent and well-vetted models of regional climate, physical and biological systems, using best practices and employing multimodel ensembles. Develop standard methods for evaluating model application, calibration, and uncertainty.
c. Incorporate models into decision support systems.
d. Characterize and, where possible, quantify uncertainty. Develop methods to include uncertainty in decision making and to characterize and assess risk associated with action or non-action.
e. Improve existing (or develop new) data management practices and, as appropriate, infrastructure to ensure common standards for data collection and processing, formatting, quality assurance, storage and archiving, and data sharing.

7. Communication of Science Findings – Develop strategies for communicating results and current thinking to the full range of agencies, stakeholders, and the general public. Efforts under this theme relate to all other science themes and should be coordinated with other major efforts such as the LCCs and the NOAA-funded Pacific Northwest Climate Impacts Research Consortium (CIRC), as appropriate. Because of the importance of communication of science findings to society at large, particular attention should be paid to communication of science findings to non-science agencies, agency staff, and the general public.

a. Develop an information infrastructure that allows on-the-ground resource managers and non-technical decision makers ready access to current, thoroughly peer reviewed syntheses of climate science, future climate projections, assessments of uncertainty, responses of physical and biological systems, and vulnerabilities. The overall goal of such an effort would be to enable users to have a single source of information they need for resource management and decision support.
b. Translate and transfer scientific information and data to scientists, resource managers, stakeholders, and the general public in a manner appropriate to target audience. Utilize as appropriate the full range of tools and techniques, such as factsheets, websites, webinars, seminars, workshops, and training courses.