

Assessing Climate Impacts on Washington's Fish and Wildlife Workshop Summary

Held February 13th, 2009
Evergreen State College Longhouse in Olympia, WA

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I. Introduction

The National Wildlife Federation, in partnership with Washington Department of Fish and Wildlife and Washington Biodiversity Council, held a workshop on February 13th, 2009 to assess how wildlife and wildlife habitats in Washington State are being affected by climate change. The workshop brought together scientists, resource managers and policy specialists to assess the impacts of climate change on wildlife and natural systems and to identify management actions we should take to help safeguard wildlife in a warming world. This workshop represents one of many steps necessary to understand the impacts of climate change on biodiversity and develop climate-smart approaches to conservation and natural resources management.

Featured speakers at the workshop included Senator Phil Rockefeller, Honorable Peter Goldmark, Commissioner of Public Lands for Washington State Department of Natural Resources, and Phil Anderson, Interim Director of Washington State Department of Fish and Wildlife.

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A. Purpose of the Workshop

The purpose of this workshop was to engage key people in a dialogue to assess climate change impacts on wildlife and to identify high priority actions that should be taken to help safeguard wildlife under changing climate conditions. The workshop was structured to: 1) inform participants of researchers' current understanding of climate change impacts on aquatic and terrestrial systems in Washington State; and 2) allow participants to share their knowledge and make suggestions for future directions. The results from this workshop reflect the information and insights of those present and are not expected to be comprehensive. The findings will be further developed through additional research and expert consultation.

The expected outcomes of the workshop were to:

- Identify the most significant impacts, stressors, or threats to habitat and wildlife in Washington State.
- Review the current list of *Species of Greatest Conservation Need* and identify other climate sensitive species that should be added to that list.
- Identify potential near term, “no-regrets” adaptation strategies¹ and management actions.
- Identify information gaps to help guide research that can fill those gaps.
- Provide a mechanism for individuals across agencies and organizations to meet others involved in wildlife adaptation work in an effort to build bridges for collaboration.

B. Workshop Structure

The workshop agenda is provided in Appendix III. Three presentations were given at the beginning of the workshop to provide participants with the current state of research and a common platform upon which they could add their own knowledge. These presentations were given by scientists in their field of expertise:

- Josh Lawler of the University of Washington College of Forest Resources gave an overview of climate change projections, vulnerability, and adaptation

¹ These “no-regret” actions are actions that, even given the current state of imperfect knowledge, are reasonably certain to lead to benefits for the targeted species or habitat. These are actions that should be taken now.

- Jessica Halofsky, a research ecologist with Pacific Wildland Fire Sciences Lab, spoke on the projected responses of terrestrial systems including forests, woodlands, shrublands and grasslands
- Nate Mantua of the University of Washington Climate Impacts Group presented on salmon, coastal, and freshwater aquatics vulnerability to climate change.

After the expert presentations, participants were divided into four breakout groups with each group focusing on a specific habitat type:

- Freshwater aquatic and riparian habitats
- Marine and coastal habitats
- Forest and woodland habitats
- Grassland and shrubland habitats

Each participant chose the group they felt they would be able to contribute to the most and they remained with that group throughout the remainder of the workshop.

The breakout groups were split into a morning session and an afternoon session. The goal of the morning breakout session was to identify the most significant climate-related impacts to species and habitats. This information became the basis for the afternoon breakout session, where participants were asked to identify possible management actions that could be taken to help wildlife adapt to the impacts identified in the morning session. Near the end of each breakout session, each group prioritized their top five results (i.e., significant impacts; priority near-term, “no regrets” actions). In addition, participants were also asked to list major information gaps.

C. Workshop Participants

Approximately 100 individuals attended this invitation-only workshop. Invitees were drawn from federal, tribal, state, and local governments and agencies; academia and research centers; and conservation organizations. They were a mix of scientists, resource managers, and policy specialists working at the nexus of climate change and natural resource conservation.

Workshop speakers and presenters included a state legislator (State Senator Phil Rockefeller), heads of state agencies (Phil Anderson from WDFW and Peter Goldmark from WDNR), scientists (Josh Lawler, Nate Mantua, and Jessica Halofsky), resource managers (Rocky Beach from WDFW) and a conservation advocate (Doug Howell from National Wildlife Federation). This mix of presenters and participants reflects the breadth of those seeking to understand climate change impacts and develop mechanisms to safeguard our natural world from its effects. Appendix II provides a list of participants.

II. Highlights and Overarching Themes

Climate change affects each species, habitat, and natural system in unique ways. However, the workshop revealed numerous impacts and management responses that overlapped across multiple habitat types.

The most common significant impacts across the four habitat breakout groups are as follows:

- **Invasive species:** Climate change has the potential to increase the number and diversity of invasive species that a system faces. Climatic changes may also alter the relationships between species thereby reducing or increasing the effects of invasives on native species and systems. Invasive species across all habitat types will possibly outcompete native species, disrupting the balance of the ecosystem. Invasive species could even eradicate a keystone species, which would severely alter the ecosystem.
- **Changes in phenology:** Phenology, or the timing of key life stages, may be altered due to the effects of climate change. Altered timing of flowering and the abundance of key pollinators, for example, could lead to the extinction of certain plant species as they are dependant on their pollinators, which may be absent during the time of peak flowering. Changes in phenology could decouple predator – prey relationships which could result in changes in the food web.
- **Changes in the food web:** Changes in the food web can be affected by climate-driven changes in phenology or by the distribution or abundance of species. If a traditional food source is no longer available at crucial times or historical density, species will be forced to switch predation to a non-traditional food source. This could disrupt predator-prey relationships and have cascading effects on populations and systems.
- **Changes in disturbance regimes (fire, flooding, and drought):** Severe weather events will be exacerbated by climate change. Some areas will experience increased drought while others will have increased flooding. Forest fires will likely increase in severity due to increased evaporation rates, reduced soil moisture, and increased disease and pest infestations. Changes in the frequency and intensity of these disturbance regimes will make it more difficult for ecosystems to recover from large disturbances and may alter the species composition of systems.
- **Altered hydrology:** Climate change will disrupt the timing and extent of snowmelt and rainfall, which will impact the hydrology of rivers and streams. Increased intensity of rainfall, especially in winter, will increase the flow and turbidity of rivers, thus leading to the scouring of riverbeds and increased nutrient loading. Reduced snowpack and increased droughts will affect upland species as well as marine species due to reduced quantity and quality of fresh water in these systems, especially in summer.
- **Changes in seasonal patterns:** Seasonal patterns, including timing of snowmelt, wind patterns, and timing of droughts and floods, will likely be disrupted. Changing seasonal patterns will affect hydrology and the timing of disturbance regimes, changes to which some species will have a hard time adapting. Changes in wind patterns, for example, may affect migration routes which, in turn, may affect food webs.
- **Habitat fragmentation:** Habitat fragmentation is caused by both humans and climate change. Land development will continue to isolate patches of land for wildlife, making it more difficult for species to migrate in response to climate change. Additionally, increased temperatures will effectively isolate cold-weather dependant species as they migrate up mountains to remain in cooler temperatures.

As with the top impacts, many priority management actions were consistent across the four breakout groups. The common priority management actions included the following:

- **Educate and involve the public:** Public understanding and support will enhance the success of any management action across all four habitat types. Educating the public about the necessity for migration corridors or changes in land use practices will be more likely to encourage the public to

cooperate. Simply forcing private landowners to change their agricultural practices will most likely result in resistance to change. Involving the public will benefit research needs through “citizen science” such as Audubon’s Christmas and spring bird counts.

- **Work across barriers and increase interagency interactions:** A healthy ecosystem depends on the wellbeing of its surrounding habitats. An agency that focuses on forest ecosystems, for instance, will benefit from working with an agency that focuses on riparian habitats as forests are dependant on water availability. Increasing interaction between agencies will not only ensure the success of ecosystem recovery, but also decrease the amount of replicated work each agency will complete.
- **Change land management practices:** Changes in current land management could occur through a revision of current management policies like the Shoreline Master Program, or through changes in current practices. A major shift in agricultural practices is necessary for water conservation and decreasing habitat fragmentation. Allowing prescribed disturbance events like burns and floods will decrease the potential destruction of unplanned forest fires and flooding events while simultaneously controlling invasive species. Changes in current practices will result in a more sustainable land management ethic.
- **Acquire lands for conservation:** The acquisition of land for conservation purposes was raised by all four groups. Setting aside land specifically for wildlife will ensure the land is used primarily with wildlife in mind and without conflicts of interest. Providing corridors for northward or upward migration will aid species survival. Planning for habitat transitions will be especially important for nearshore habitats, where estuaries will become inundated and uplands should be protected today to provide for future nearshore habitats. Expanding current reserves will create connectivity and redundancy between wildlife areas, making it possible for wildlife to migrate across large expanses and mitigating for habitat loss due to fragmentation.
- **Restore habitat to increase resiliency:** Habitat restoration on both public and private lands is necessary to increase the resiliency of degraded ecosystems. Land that remains privately owned can serve dual purposes, for example providing prime grazing habitat through a sustainable means while simultaneously encouraging wild species to reside in or migrate through the area. Because such projects on privately owned land require the approval and engagement of the landowner, education, outreach, and incentives for restoration are key for these projects to be effective.

Information gaps in each habitat area primarily focused on the need for more information. Most groups stated the need for research on ecological processes like phenology and thresholds, as ecosystems are very complex and current science can not yet identify all the interactions. Better monitoring and increasing data availability at the micro-level were two other primary information gaps shared across the four habitat types, with specific emphasis on downscaling information to the local level.

Table 1 displays the significant impacts, priority management actions, and information gaps identified by each of the four breakout groups.

Table 1: Significant Impacts, Priority Management Actions, and Key Information Gaps

	<i>Marine</i>	<i>Freshwater</i>	<i>Grassland</i>	<i>Forests</i>
Impacts	Beach erosion Hydrological changes Changes in the food web Coastal and marine fish industries Infrastructure infiltration	Increased water temperature Reduced base flows/increased peak flows Increased erosion/sedimentation Reduced snowpack/glacial melting Decreased forest cover	Hydrology Fire Invasive species Changes in land use Loss of endemics and species biodiversity	Frequency of storm events Forest fires Exotic species Loss of high elevation habitats Carrying capacity, disease, and pine beetles
Management Actions	Acquire lands Revise existing policies Create incentives for restoration Public outreach Link conservation efforts	Water conservation Acquisition of land and water Public education Provide species access to the most resilient areas Understand human dimensions to climate change	Increase efficiency Restoration projects Change agricultural practices Changes in land use Raise public awareness	Engage the private sector Increase interagency collaboration Vulnerability assessment Acquire land Changes in land management
Information Gaps	Research ecological processes (thresholds, etc) Better access to micro-level data Better communication strategies between scientists and land use planners	Better monitoring, like of soil temps, species, etc Better research of thresholds to water temperature	Research on species interactions Research around post-fire ecosystems	Changes in vegetation not understood Research needed to understand phenology

III. Summary of Breakout Session Findings

A. Marine and Coastal Habitats

Table 2: Marine and Coastal Habitats: Significant Impacts, Priority Management Actions, and Information Gaps

Key Impacts	Priority Management Actions	Information Gaps
<ul style="list-style-type: none"> • Habitat erosion/inundation • Altered hydrology • Changes in the food web • Effects on coastal and marine fish industries • Inundation of coastal infrastructure 	<ul style="list-style-type: none"> • Acquire lands for coastal buffers, wetlands, and protected areas • Review and revise existing policies and regulations • Public outreach: awareness and education • Create incentives for restoration • Link terrestrial, coastal, and marine conservation efforts 	<ul style="list-style-type: none"> • Research ecological processes: thresholds, etc • Better access to micro-level data • Better communication strategies between scientists and land use planners

1. Key Impacts

Habitat Erosion/Inundation: Much of the breakout discussion focused on sea-level rise, which will affect coastal habitats across the region. NWF’s recent Sea Level Rise report provided a basis for this discussion.² Sea-level rise will change the extent, composition, and distribution of nearshore habitats. These habitats will essentially begin to move inland as the water level rises. For example, many of today’s beaches will become tide flats and today’s tide flats will become shallow water. Participants noted that current land use practices, such as development in coastal areas, have already altered the natural shoreline and this problem will become exacerbated as the water level rises. Shoreline armoring will prevent the nearshore habitats from migrating inland, resulting in shoreline habitat being pushed up against manmade structures. This prevents species from being able to move inland and results in the loss of wetland habitat. For instance, many estuaries in the Puget Sound area will cease to have tide flat exposure as manmade structures and armoring prevent the tide flats from moving inland. The resulting lack of tide flats will affect migrating birds that use these flats as a stopover along the Pacific flyway. Thus, the inability of the habitat to move inland as the sea level rises will eliminate key habitat areas and diminish the ability of some wildlife to adapt to climate change.

Changes in the Food Web: Climate change will alter the marine food web, affecting biodiversity throughout the region. Of particular concern is the fact that climate change will exacerbate other stressors such as algal blooms and invasive species. For example, as the water temperature rises, warm water species will begin colonizing cold water areas and competing with native fish. Several participants noted that climate change may already be exacerbating competition between introduced American shad and native salmon populations.

Altered Hydrology: Changes in the timing and extent of precipitation and snowmelt due to global warming will alter the hydrology of the region’s coastal areas, contributing to problems such as flooding, nutrient loading, altered salinity, and changes in sediment deposition. Increased frequency and intensity of flooding in estuarine areas will result in the scouring of mudflats, which will cause changes in the

² In 2007, NWF released *Sea-level Rise and Coastal Habitats in the Pacific Northwest*. This report used the Sea Level Affecting Marshes Model (SLAMM) to project the impacts of sea-level rise on several Northwest habitats under different climate change scenarios. Download the report at: <http://www.nwf.org/sealevelrise/pdfs/PacificNWSeaLevelRise.pdf>.

physical structure of habitats. An increase in freshwater runoff after extreme storm events will also lead to changes in salinity levels and deposition of excess nutrients and other pollutants in estuarine waters. These and other changes will affect food abundance, the timing of life cycle events, and predator-prey interactions.

Coastal and Marine Fish Industries: Climate change is likely to have a significant impact on the region's important fisheries. Shellfish, in particular, are vulnerable to ocean acidification, which results in reduced calcification rates for bivalves. Ocean acidification is more of a problem in colder waters because calcium dissolves more readily at lower water temperatures. Acidification also results in shifts in phytoplankton diversity and changes in the food web, which has implications for the overall biodiversity of the ecosystem. There is the potential for acidification to change the fitness and survival rate of ocean species, although additional scientific research is necessary to better understand this process.

Inundation of Coastal Infrastructure: The final major impact noted by the group was the inundation of coastal infrastructure due to sea-level rise, which has both human and ecological implications. With a rising water level and an increase in the frequency of flooding events, waste water treatment plants could overflow, spilling raw sewage into waterways. This causes a serious habitat concern with ecological consequences, such as algal blooms and dead zones.

2. Priority Management Actions

Acquire Lands for Coastal Buffers, Wetlands, and Protected Areas: Pre-emptively protecting land areas that will be needed for coastal habitat as sea levels rise was identified as a key strategy for addressing nearshore habitat loss in an era of climate change. Purchase of conservation easements and other land protection mechanisms along the coast and wetlands are especially important to create a buffer between human development and the waterfront to enable habitats to migrate upland as sea level rises. In addition to setting land aside, it is important to ensure that both new and existing development and other land use practices do not negatively impact estuaries and other coastal areas.

Review and Revise Existing Policies and Regulations: State regulations such as the Shoreline Master Program (SMP), the Growth Management Act (GMA), and other existing policies should be updated to incorporate climate change impacts like sea-level rise. Revising these policies with sea-level rise in mind will allow alternative management practices and will allow a critical reconsideration of typical shoreline armoring. For example, certain areas of wetland could be inundated through the removal of levees to allow flooding. This will create a more natural landscape and may reduce the risk of flooding elsewhere, protecting other developed areas.

Public Outreach, Awareness and Education: Public support and understanding will be necessary for new policies and regulations to be effective. Getting the public involved and interested can be accomplished through town hall meetings and other public discussions that bring together diverse members of the community. In addition to larger meetings, it is also necessary to have smaller group discussions and even one-on-one dialogue to explain to the public why action is important in protecting our ecosystems.

Create Incentives for Restoration: Policies that use incentives or compensation to encourage landowners to use the land in a way that promotes habitat protection creates greater public support and also benefits the landowner. Discussing the economic costs of inaction tends to grab the public's attention, so discussing how climate change will affect key industries in Washington (such as sportfishing, tourism, and the shellfish industry) will help encourage Washingtonians to protect these resources.

Link Terrestrial, Coastal, and Marine Conservation Efforts: Finally, the group made the point that, while marine ecosystems do require specific management actions, they are not completely isolated from terrestrial ecosystems. Conservation efforts should be linked so that there is a system level approach and that conservation programs are not created in isolation.

3. Information Gaps

Ecological Processes: Ecological processes are complex and further research is needed to comprehensively understand the extent of climate change impacts. For example, thresholds, keystone species, and the cost of delay are not known for each habitat. The length of time required for the ecosystem to be restored and recovered is also unknown for each habitat.

Information flow: There is currently an information flow problem from scientists to policy makers. Better communication strategies need to be developed between conservation scientists and land use planners in order to establish more deliberate planning.

Local-scale assessments: Better access to micro-level data is needed for local scale vulnerability assessments. Information that is already known needs to be downscaled to the local level. This will allow cities or counties to find out what impacts are relevant to where they live.

B. Freshwater Aquatics and Riparian Habitats

Table 3: Freshwater Aquatics and Riparian Habitats: Significant Impacts, Priority Management Actions, and Information Gaps

Key Impacts	Priority Management Actions	Information Gaps
<ul style="list-style-type: none"> • Increased water temperature • Reduced snowpack and glacier shrinking • Reduced base flows and increased peak flows • Increased erosion and sedimentation • Decreased forest cover/buffer zones/riparian areas 	<ul style="list-style-type: none"> • Water conservation • Acquisition of surface and groundwater and protection of hydrological diversity and habitat • Education and involvement in all management actions • Provide species access to the most resilient areas • Understanding human dimensions of climate change 	<ul style="list-style-type: none"> • Better monitoring, like of soil temperatures, species, etc • Inventory for cold water refugia • Species responses to temperature increase

1. Key Impacts

Increased Water Temperatures: Higher water temperatures in the region’s lakes, rivers, and streams were identified as one of the primary impacts of concern. During the 20th century, temperatures in the Pacific Northwest rose 1.5 ° F. which has contributed to increased water temperatures as well. Future projections show extended periods where the weekly average water temperature in many of the region’s rivers and streams will exceed 69.8° F, which is a threshold temperature because water temperatures above that level become lethal for salmon and steelhead. Four specific impacts were identified by the breakout group as particularly concerning:

- The timing of key life stages, or phenology, will be altered. For example, the timing of the emergence of salmonids to feed and migrate may change so that it no longer coincides with an abundance of food for them to eat. Shifting phenology can result in a decoupling of predator and prey relationships, thus leading to a change or reorganization of the food web. If salmonids cannot feed on their traditional primary food source, they will most likely find a different food source.
- Increased water temperatures result in habitat constriction as coldwater species can no longer survive in their traditional range and are confined to a smaller section that continues to have

colder water. The confinement of a population to a smaller habitat has implications for faster disease transmission as individuals are more densely packed. A smaller habitat also changes the spatial access of interaction between predator and prey.

- Changes in water temperature may lead to changes in bioenergetic demands and metabolism development. Ecosystems could feel a decrease in productivity, resulting in ecosystems reaching their carrying capacity at a decreased threshold.
- Consistently higher temperatures may produce a thermal barrier to salmon migration as the salmon will not be able to survive the increase in temperature. For example, Lake Washington's Ship Canal is projected to have chronically high summer water temperatures at the same time adult sockeye and summer Chinook salmon migrate to spawn.

Reduced Snowpack and Glacier Shrinking: There are currently three basic streamflow patterns: rain-dominated, transient (early winter peak from rainfall, spring peak from snowmelt), and snow-melt dominated (streamflow peaks in late spring and early summer). Climate change will result in changes in these streamflow patterns as glaciers retreat and low elevation and springtime snowpack declines. Many of today's snowmelt-dominated rivers will become transient basins; current transient basins will become rainfall dominated rivers. The decrease in glacial and snow melt timing will result in hydrology habitat survival schemes that favor rainfall dominated systems instead of snow melt dominated systems.

Reduced Base Flows and Increased Peak Flows: Due to the decline in average snowpack and timing shifts in snowmelt runoff, summer base flows are projected to decrease from 5 to 50% for most streams in western Washington and the Cascades. The prevalence of flow beyond the base flow is projected to decrease in snowmelt and transient rivers as streamflow patterns become more rain dominated, resulting in reduced rearing habitat. More winter flooding with increased peak flows will occur in sensitive transient streamflow river basins that are common in the Cascades. This will likely reduce the survival rates for incubating eggs due to stream scouring. These changes in seasonal stream flow morphology patterns will restrict some species while simultaneously offering benefits to others. Invasive species may be among the species that benefit.

Increased Erosion and Sedimentation: Another concern is that increased peak flows will lead to increased erosion in rivers as well as the deposition of excess sediments in streambeds, which could scour and/or bury salmon nesting sites.

Decreased Forest Cover/Buffer Zones/Riparian areas: The disruption of seasonal water patterns due to climate change is yet to be determined, but will likely result in an excess of water and severe flooding in winter and less water during the summer months. These extreme weather events will alter the cycle of water available for wetlands and other riparian areas, leading to spatial and temporal changes in habitat availability for wildlife as reduced water availability impacts certain habitats differently than others. Climate change impacts interact with changes in land cover due to land use practices that affect hydrology. Decrease in forest cover due to population expansion and development decrease buffer zones along riparian areas, which are necessary for decreasing the severity of extreme weather events, such as flooding. Losing these buffer zones means losing species and habitat as well as causing more damage due to flooding.

2. Priority Management Actions

Water Conservation: The infrastructures of reservoirs and hydropower systems need to be updated to ensure water conservation. Greater flexibility is needed in the operations of reservoirs to ensure that water remains in rivers when fish and wildlife need it.

Acquisition of Surface and Groundwater and Protection of Hydrological Diversity and Habitat: Conservation efforts should not focus solely on riparian areas that are already in jeopardy, but also on clean, untarnished water sources and habitats. These sources should be identified, protected, and (in the case of impacted areas) restored to their natural form. Protecting hydrological diversity is necessary in preserving the resiliency of the water resource. In some cases restoration can be accomplished through

the acquisition of riparian areas, but this requires additional funding. Introducing incentives to increase riparian areas on privately owned lands may be a less costly way to protect wetlands.

Education and Involvement in All Management Action: The past is no longer a good indicator of future scenarios and cannot be relied upon as the basis for management actions. Historic management approaches cannot be depended upon for the future of conservation, leading to the need for new management actions. For these new management strategies to be effective, the public must be brought into the discussion. Education of the public is a key underlying component for the success of all new management actions. The public must be educated about the issue and involved in next steps in order to sway representing policy makers to make decisions with wildlife adaptation in mind. It is necessary to change the operation of existing water management to incorporate climate change impacts and the public sector must be involved in this change.

Provide Species Access to the Most Resilient Areas: Vulnerability assessments are necessary to determine which habitats will be in most resilient watersheds under various scenarios of climate change for the region. Those habitats that will be most resilient to climate change impacts are the ones that have maintained their biodiversity. Preserving the genetic diversity of species is key to promoting healthy areas for wildlife. Land management practices should preserve life history and the genetic diversity of species. For example, salmon hatcheries and shellfish industries could diversify their stock. Likewise, mono-crop agriculture could shift towards poly-crop agriculture, creating diversity within a controlled landscape. Tied to maintaining biodiversity is the control of invasives that can outcompete native species.

Understanding Human Dimensions of Climate Change – Human Responses by Integrating Social and Natural Resource Management: Humans will be negatively impacted by climate change as well as wildlife. It is important to understand the human dimension in an attempt to predict human responses. The lack of adequate water and agricultural shifts may cause the relocation of human populations, resulting in the migration of people in response to uncertainties. Integrating social science and anthropology is paramount in predicting human changes in response to a changing climate, and how these human changes will impact wildlife and habitat.

3. Information Gaps

Monitoring data: Soil temperatures for upland forest systems as well as water temperature need to be reported at a better resolution in order to monitor changes.

Inventory for cold water refugia: An inventory for cold water refugia is needed to better understand what species and how many are currently residing in these cold water areas.

Species responses to temperature increase: It is not entirely understood how water temperature affects species, but temperature and species interactions need to be better studied as these interactions are not linear and there may be an unknown threshold.

C. Grassland and Shrubland Habitats

Table 4: Grassland and Shrubland Habitats: Significant Impacts, Priority Management Actions, and Information Gaps

Key Impacts	Priority Management Actions	Information Gaps
<ul style="list-style-type: none"> • Altered hydrology including floods and drought • Increasing Fires • Expansion of invasive species • Changes in land use • Loss of endemics and species diversity 	<ul style="list-style-type: none"> • Increase water use efficiency • Protect and restore habitat • Change agricultural practices to reduce the need for water • Change land use management • Raise public awareness 	<ul style="list-style-type: none"> • Migration Patterns • Species interactions • Post-fire ecosystem restoration

1. Key Impacts

Altered Hydrology: Permanent and seasonal changes in water abundance will have impacts on grassland and shrubland habitat. Floods and droughts are already ecosystem stressors and they will become more frequent with climate change. There is likely to be both more flooding in the winter and more droughts in the summer. Ephemeral pools and year round reservoirs will no longer adequately supply the ecosystem with the water it requires to sustain growth and proliferation. Drought will interact with other stressors, such as fire and insects, to further increase grassland vulnerability.

Increasingly Frequent and Severe Fires: As droughts become more common, wildfires will become more frequent and more severe. Changes in the natural balance of fires could result in the loss of even the fire dependant species if fires become too hot, severe, and frequent. With the increased frequency of disturbance due to wildfires, wildlife corridors must be protected through redundancy and connectivity of habitat and migration routes.

Expansion of Invasive Species: One of the primary concerns for grassland and shrubland habitats is the expansion of invasive species, which are already a significant problem for these systems. As temperatures increase, species will tend to migrate northward where possible in an effort to adapt to changing climate conditions. In addition, many invasive plant species will be able to take advantage of systems that have been weakened by extreme events such as wildfires. These introduced species may outcompete native species and will cause a shift in ecosystem balance as well as alter the food web. The new species may bring with them diseases to which native species are susceptible, decimating native populations. In addition to the introduction of new species, current invasive species may be able to expand their range.

Changes in Land Use: Existing habitat is becoming more fragmented as eastern Washington communities expand and the land is converted to hardscape development. Possible human migration north due to changes in climate will cause further development and further habitat fragmentation. Habitat loss due to fragmentation poses a problem for species that need to migrate in adaptive response to climate change impacts. Current grazing practices and mono-crop agriculture are causing changes in the biological elements of the soil. Soil is the underlying basis of everything else, so problems and changes in the soil can impact the whole ecosystem.

Loss of Endemics and Species Diversity: Shifts in phenology can result from changes in temperature and this in turn impacts wildlife through food availability, timing of emergence, and disease. These impacts can result in changes in the food web and result in broken or altered predator – prey relationships. Phenologic shifts can also result in species extinction through the inability of some species to adapt. For

example, the uncoupling between the time plants flower and the emergence of their pollinators can result in the extinction of the plant if their pollinator does not disperse the pollen.

2. Priority Management Actions

Increase Water Use Efficiency: Irrigation infrastructure should be updated to conserve water more efficiently. Water storage needs to be sited and managed properly to provide the maximum benefit to humans and wildlife.

Protect and Restore Habitat: A number of restoration projects were suggested to mitigate for climate change impacts on hydrology, fire, invasive species, changes in frequency disturbance, and loss of endemics. The overarching theme was to research sites and determine which areas will have the fewest negative impacts in order to prioritize the healthiest areas where conservation efforts will be most effective. Setting aside these lands for wildlife through acquisitions and easements will allow conservation efforts to focus on improving hydrology connectivity, reseeding areas after fires, and prescribing burns to control invasive species.

Change Agricultural Practices to Reduce the Need for Water: Converting agricultural practices to be less water intensive will reduce the quantity of water diverted from rivers and streams. The most water consumptive crops should be identified and those fields prioritized for conversion to less water intensive crops. There is the potential for a big wave of crop conversion, however this requires incentives to farmers.

Change Land Use Management: Land protection through conservation easements will facilitate the restoration of riparian and grassland habitat and will allow conservation measures that aggressively control and monitor invasive species. Easements will enable planned disturbances like prescribed fires and flooding events. Prescribed fire management would allow seasonal brush control to prevent larger fires and aggressively control invasives while simultaneously promoting fire dependant natives. Pre-planned flooding events would decrease damage due to erosion by planting ahead of time. Allowing certain areas to become temporarily inundated would encourage natural flow regimes. Long-term monitoring and study would be needed to evaluate the success of pre-planned flooding and prescribed burns.

Raise Public Awareness: Each of the above proposed changes in land use management requires public support for its success. The public must be educated about the benefits of prescribed burns and pre-planned flooding events in order to gain public support and involvement. In addition to education, incentives will be required to encourage farmers and cattle ranchers to participate in conservation measures on agricultural and grazing land.

3. Information Gaps

Migration patterns: Due to the complexity of ecosystems, it is not fully understood how climate change will affect species migrations from the south. New species will expand their range northward and it is not known which species those will be or what impact they will have.

Species interactions: There are too many variables in ecosystems to accurately predict all of the keystone species and how they will be affected by a changing climate. Likewise, plant/animal and predator/prey relationships will change in response to climate change and more research is needed to predict what these changes will be.

Post-fire ecosystem restoration: Research around post-fire ecosystem restoration is needed to properly manage prescribed burns in a climate friendly manner. Long-term monitoring of prescribed burns and flooding is necessary to determine changes in soils and ecosystems in order to identify the success and failure of new management practices.

D. Forest and Woodland Habitats

Table 5: Forest and Woodland Habitats: Significant Impacts, Priority Management Actions, and Information Gaps

Key Impacts	Priority Management Actions	Information Gaps
<ul style="list-style-type: none"> • More frequent storm events • Increased forest fires • Expansion of invasive species • Loss of high elevation habitats • Carrying capacity, disease, and pine beetles 	<ul style="list-style-type: none"> • Engage the private sector • Increase interagency collaboration • Conduct vulnerability assessments and monitor species • Acquire land for habitat conservation • Change land management 	<ul style="list-style-type: none"> • Vegetation community responses • Phenology and species inter-relationships

1. Key Impacts

More Frequent Storm Events: It is predicted that there will be an increase in the frequency and severity of storm events and this will have an effect on forests. Increased wind events can become detrimental with current forest practices. Increased intensity in wind storms will decrease the ability of forests to regenerate after the storm. An increase in blow down from wind storms will primarily affect riparian areas, rendering riparian areas less suitable for wildlife habitat.

Increased Forest Fires: Higher temperatures and more frequent droughts will lead to longer, more-severe wildfire seasons. Forest fires were traditionally considered an eastern Washington problem, but climate change will cause more frequent wildfires in western Washington as well. The Olympic Peninsula has already seen the onset of fires earlier in the year, and the fire season is projected to continue to arrive earlier than it has historically. Fires that have occurred on the west side of the Cascades have historically been rather large. If there are increases in droughts it is projected that there could be two to four times the area burned as historical levels.

Expansion of Invasive Species: Changes in carbon dioxide concentrations and temperature are likely to cause invasive vegetation to expand its range. It is unknown what ecological consequences will result from the invasion of exotic species, although it is likely that ecosystems will be dramatically altered.

Loss of High Elevation Habitats: High elevation areas, such as alpine wetlands and meadows, will be at serious risk due to warming temperatures. Increases in temperature will shrink high elevation habitat and may eventually cause it to disappear. As these habitats shrink the connectivity between high elevation areas will disappear, making it difficult for species dependant on these areas to adapt through migration. Snow-dependant species such as the wolverine and lynx will be at greatest risk as snowpack declines and their habitats become fragmented by rising temperatures.

Carrying Capacity, Disease, and Pine Beetles: As habitats begin to shrink in size, individuals in a population increase contact, creating a higher chance of disease transmission. Decreases in habitat size mean a decrease in carrying capacity, thus altering the bioenergetic needs of the ecosystem. Changes in historic temperatures affect the survival rates of not only diseases but also pests, such as the pine beetle which is killing increasing numbers of trees in western forests. All of these concerns affect both the biodiversity of an ecosystem and the genetic diversity of a species.

2. Priority Management Actions

Engage the Private Sector: Establishing a forum that brings in multiple sectors such as local land trusts, tribes, the private sector, etc would help individuals work across barriers and decrease information gaps. Engaging the private sector would increase the amount of land managed with conservation measures in mind. Creating conservation incentives for private landowners is necessary for establishing habitat connectivity.

Increase Interagency Collaboration: In addition to engaging the private sector, forest conservation requires more interagency collaboration. Both resource and non-resource agencies must be involved in conservation discussions so their work can be integrated and so multiple agencies do not duplicate each other's work. It is also important to think about forest management as a regional issue. Developing strategies that are not confined to state borders is necessary for effective conservation projects.

Conduct Vulnerability Assessments and Monitor Species: Completed vulnerability assessments will be paramount in establishing which species are at greatest risk from climate change impacts and which species will most benefit from conservation efforts. The list of SGCN should be re-evaluated to keep in mind climate change impacts to wildlife, plant species, and ecosystems. The vulnerability assessment should also include the monitoring of species to study the long-term shifts in habitat and species.

Acquire Land for Habitat Conservation: Acquiring lands for conservation allows expansion of current natural reserves. It is important to ensure that there is sufficient land area that if a species has to migrate there is enough protected land for them to migrate to. Building redundancy and connectivity in wildlife land areas is key to mitigating for changes in range.

Change Land Management: The largest limiting factor for public agencies to manage land is staffing and adequate funds. Having said that, participants agreed that it is necessary for public agencies, such as the U.S. Forest Service and DNR, to work with each other and with private landowners to make land management more feasible. Conservation areas should be designed with resiliency, habitat connectivity, and an adequate size for wildlife migration in response to disturbance in mind.

3. Information Gaps

Vegetation community responses: Changes in vegetation community types are not fully understood and need further research. Approaches to conservation usually come from the wildlife point of view, but vegetation may shift and conservation measures need to take this into account. If an entire pine forest ecosystem shifts, where will it move and how does that affect the species that live there?

Phenology and species inter-relationships: More research is needed to highlight the importance of phenology and ecological events. How stressors will affect the relationship between pollinators and their plant species are not understood.

IV. Workshop Evaluation

Thirty six workshop evaluations were received. The results show that nearly all participants found the workshop highly valuable, with 86% giving it a 7 or higher on a scale of 1-10. When asked for suggestions for improvement and next steps, many suggested that the subject was too big and complex to get very far in a single day, and thus the breakout sessions were too short to accomplish the requested tasks. Some had expertise in many habitat types and wanted to participate in more than one breakout group. Many wanted to hold more workshops like this with more time to go into greater detail.

There was also strong interest in developing other opportunities for information sharing about climate change impacts on biodiversity and adaptation strategies. Suggestions included a clearinghouse or website with information about recent and ongoing research, and more effective use of existing resources, such as UW Climate Impacts listserv.

V. Next Steps

This workshop represents an initial step toward prioritizing landscape level changes resulting from climate change and developing policy and management strategies that will safeguard wildlife and habitats in a warming world. Through this and other activities, we intend to compile scientifically defensible information that will be used to incorporate climate change impacts into Washington's Comprehensive Wildlife Conservation Strategy, and be a widely available resource for other conservation action plans in Washington State, such as the Wildlife Habitat Connectivity Analyses, and the Biodiversity Conservation Strategy.

To improve our understanding of climate impacts and appropriate responses, National Wildlife Federation, Washington Department of Fish & Wildlife, and Washington Biodiversity Council will continue working together with workshop participants and others. Future activities may involve compiling research and conservation initiatives, developing a white paper on the current state of knowledge (based on research and expert interviews), additional expert workshops focusing on a single habitat type at a time, further development of response strategies, further assessment by researchers and academics, completion of a vulnerability assessment, and a follow-up workshop to present and refine our findings and engage a broader set of people on the issue. Ultimately, we plan to develop scientifically sound response strategies to safeguard our natural heritage from global warming and develop the necessary support and funding for implementation.

Appendix I: Conservation Planning and Climate Change

A. State Wildlife Action Plan

Washington's State Wildlife Action Plan (SWAP) is known as the *Comprehensive Wildlife Conservation Strategy* (CWCS) and was published by Washington Department of Fish & Wildlife in 2005. Every state in the nation completed a similar plan in order to qualify for funds allocated through the federal State Wildlife Grants program.

Development of the CWCS was an important step in setting a direction for fish and wildlife conservation in Washington. This strategic document established a biological foundation and planning framework and identified the Species of Greatest Conservation Need as well as the Habitats of Conservation Concern. At the time, the document considered conservation of wildlife in a nontraditional way – that is, to think of wildlife conservation with concepts like biodiversity and ecosystems in mind instead of a single-species approach. A single-species framework is still necessary for certain issues such as endangered or keystone species. However, this approach is unrealistic when considering the conservation of all of Washington's wildlife. As a result of this new framework, WDFW developed the following guiding principles to aid in the creation of a CWCS that incorporated these nontraditional concepts.

1. Guiding Principles

- 1) Address conservation of species and habitats with greatest conservation need, while recognizing the importance of keeping common species common.
- 2) Build the Washington CWCS from a large body of existing work, including eight ongoing ecoregional assessments.
- 3) Strengthen conservation partnerships with other conservation agencies, local governments, Indian tribes, nongovernmental organizations, and the private sector.
- 4) Incorporate recommendations of the Washington Biodiversity Council's Conservation Strategy Report.
- 5) Link the Comprehensive Wildlife Conservation Strategy (CWCS) to the goals of the WDFW strategic plan.
- 6) Create a document that is attractive, readable, and understandable to a wide range of public citizens and stakeholders.
- 7) Use the CWCS to draw attention to important wildlife conservation issues – for Congress, the Washington Legislature, the media and the public.

In order to be eligible for future State Wildlife Grants, Congress requires that SWAPs must meet the following eight essential elements. Washington's CWCS currently meets or surpasses the required elements, however it is important to make sure the updated SWAP also meets this requirement.

2. Eight Essential Elements

- 1) Include information on the distribution and abundance of priority wildlife species that reflect the diversity and health of state wildlife.
- 2) Identify the extent and condition of wildlife habitats and community types essential to the conservation of priority species
- 3) Identify problems that may adversely affect priority species or their habitats.
- 4) Determine actions to be taken to conserve priority species and their habitats.
- 5) Provide for periodic monitoring of priority species and habitats, as well as the effectiveness of conservation actions.
- 6) Coordinate all stages of the CWCS with federal, state, tribal, and local agencies.
- 7) Incorporate opportunities for public involvement into the development, revision, and implementation of the CWCS.
- 8) Provide for review of the CWCS and appropriate revision at intervals of not more than 10 years.

3. SWAP as a Platform for Climate Change Adaptation Planning

SWAP is the current framework for receiving money from federal legislation and it is a logical model for the allocation of additional dedicated funding that might result from national climate change legislation. Washington's SWAP must be updated to incorporate climate change impacts and guide the use of funding to help safeguard Washington's fish and wildlife. The SWAP was chosen as the vehicle for establishing the need for funding for several reasons.

- Because the SWG is a nationwide program, all 50 states have a SWAP. Each state's SWAP must incorporate the eight essential elements required by Congress. This makes it easier to divide natural resource funding across the nation as each state has a similar document that has common themes for conservation planning.
- SWAPs can be adapted to include game or fish that are not considered species of greatest conservation need (SGCN). This allows conservation planning to include not only wildlife that is considered rare, but also species that are common, sometimes even common enough to be hunted or fished.
- SWAPs provide a framework for assessing the vulnerability of fish and wildlife species and their habitats to anthropogenic stressors, including climate change.
- SWAPs require agencies to collaborate with one another across the nine different ecoregions in Washington. This multi-agency collaboration will be critical to meeting the additional conservation challenges brought by climate change.

In addition to providing a basis for the use of natural resource funding, updated SWAPs are a way to understand the scope and detail of necessary adaptation measures and will help make the task of helping wildlife adapt more manageable. The workshop held on February 13th 2009 was intended to raise an understanding of this task among relevant stakeholders and to develop a process for next steps.

B. Teaming With Wildlife

In 1998, the Teaming With Wildlife (TWW) coalition was formed to document the need for wildlife funding and to secure funds that would finance state-level fish and wildlife recreation, education, and conservation programs. Today, TWW is a 6,000 member nationwide coalition with more than 100 member organizations in Washington. National Wildlife Federation and the Washington Wildlife Federation are currently rebuilding TWW membership through a grant provided by the Doris Duke Foundation. The current goal is to provide funds to safeguard wildlife through climate legislation. The aim is to pass state and federal climate legislation with 100% auction of revenues on a cap-and-trade program with a portion of the auction revenue being dedicated for natural resource adaptation funding. Given the significant threat climate change poses to Washington's fish and wildlife, additional sources of dedicated funding will be necessary to help wildlife adapt. National Wildlife Federation and WDFW believe that updating Washington's SWAP with the impacts of climate change on wildlife is the best way to provide a framework for the use of any natural resource funding that will emerge from a national climate change policy.

C. Washington Biodiversity Conservation Strategy

The Washington Biodiversity Council was chartered by governor's executive order to develop a long-term, landscape approach to conserving Washington's remarkable biological diversity. The Council, a public private partnership, published the Biodiversity Conservation Strategy in late 2007. At the heart of the strategy are three major initiatives – (1), guiding conservation investments through the use of a new tool which maps areas of high biodiversity value and those at risk of future development, (2), improving landowner incentives and developing conservation markets, and (3), engaging citizens and scientists in monitoring and tracking our progress.

The Council has been working on integrating future climate change impacts into its reports and in tools to guide future conservation investment. The Council is particularly focused on developing information

and approaches that take into consideration a full range of biodiversity, including insects, reptiles, mammals and plant communities as well as the important ecosystem services generated by healthy biodiversity.

For more information on the Council, please visit our website at www.biodiversity.wa.gov.

Appendix II: Workshop Participants

American Rivers

Michael Garrity

Cascade Land Conservancy

Nicole Hill

Chelan-Douglas Land Trust

Neal Hedges

Conservation Northwest

Joe Scott

Environmental Protection Agency

Burney Hill

Elaine Somers

Linda Storm

Defenders of Wildlife

Sara O'Brien

Ducks Unlimited

Mark Petrie

Gifford Pinchot Task Force

Lisa Moscinski

King County Government

Elizabeth Wilmott

National Oceanic and Atmospheric Administration

Tami Black

Lisa Crozier

Gayle Kreitman

National Wildlife Federation

Dan Siemann

Patty Glick

Robyn Carmichael

Nic Callero

Becky McIntire

Doug Howell

Lydia Moore

The Nature Conservancy

Cathy Baker

Kara Nelson

Brad McRae

North Pacific Coast Lead Entity

Cathy Lear

Oregon State University

Dominique Bachelet

Pacific Education Institute

Margaret Tudor

Pacific Shellfish Institute

Dan Cheney

Pacific Wildland Fire Sciences Lab

Jessica Halofsky

People for Puget Sound

Doug Myers

Puget Sound Regional Council

Yorik Stevens-Wajda

Robin McClelland

Puget Sound Partnership

David St. John

Recreation and Conservation Office

Dominga Soliz

Rocky Mountain Elk Foundation

Wayne Marion

Salmon Recovery Office

Lloyd Moody

Trust for Public Land

Pater Dykstra

Tulalip Tribe

Preston Hardison

UNM Center for Wildlife Law

Ruth Musgrave

University of Washington

Josh Lawler

Nate Mantua

Dave Beauchamp

Karen Raegan

US Fish and Wildlife Service

Kate Benkert

Carrie Cook-Tabor

James Michaels

Joanne Stellini

US Forest Service
Kim Mellen-McClean
Carol Aubry

Washington Biodiversity Council
Lynn Helbrecht

Washington Department of Ecology
Kathy Taylor
Angie Frederickson
Jeanne Koenings

Washington Department of Fish and Wildlife
Phil Anderson
Rocky Beach
Jeff Davis
Charles Gibilisco
Mathew Vander Haegen
Michael O'Malley
Bill Ritchie
Dave Price
Elizabeth Rodrick
Dayv Lowry
Robert Fimbel
Nicole Ricketts
Dayv Hays
Joe Buchanan
Mara Zimmerman
Gary Bell
Chris Sato
Jane Banyard
Tim Quinn
Bob Everitt

Bridget Moran
Craig Busack
Peter Birch
Janet Sutter
Brodie Cox
Hal Beecher
Greg Bargmann
Joanne Schuett-Hames

Washington Department of Natural Resources
Hon. Peter Goldmark
Richard Gelb
John Gamon
Pene Speaks

Washington Department of Transportation
Ken Risenhoover
Kelly McAllister

Washington Rivers Conservancy
Lisa Pelly

Washington State Legislature
Senator Phil Rockefeller

Washington Wildlife Federation
Kyle Smith
Mark Heckert

Washington Wildlife and Recreation Coalition
Jill Wasberg

Appendix III: Workshop Agenda



Washington
Department of
**FISH and
WILDLIFE**



WASHINGTON
BIODIVERSITY COUNCIL
CONSERVATION | EDUCATION | STEWARDSHIP

Assessing Climate Impacts on Washington's Fish and Wildlife

February 13, 2009
Longhouse, Evergreen State College

Workshop Objectives

- Identify climate change impacts on Washington's species, habitats, and natural systems.
- Identify priority management and policy changes needed to safeguard fish, wildlife and natural systems under future climate conditions and begin estimating the scale of needed adaptation funding.
- Contribute information and insights to a 3-state vulnerability assessment and to an update of the state's Comprehensive Wildlife Conservation Strategy.
- Identify gaps in knowledge and develop a process for gathering needed information.
- Connect leading scientists and policy experts working at the nexus of climate change and natural resource conservation.

Agenda

8:30 Continental Breakfast

8:45 Welcome

Doug Howell, Regional Executive Director, National Wildlife Federation
Phil Anderson, Interim Director, Washington Department of Fish & Wildlife
Hon. Peter Goldmark, Commissioner of Public Lands, Washington State
Department of Natural Resources

9:30 Washington's Comprehensive Wildlife Conservation Strategy and
Teaming with Wildlife

Rocky Beach, Wildlife Diversity Division Manager, Washington Department of Fish
& Wildlife

9:45 Presentations on climate change, vulnerability and adaptation

Introduced by **Lynn Helbrecht**, Executive Coordinator, Washington Biodiversity
Council

Josh Lawler: College of Forest Resources, University of Washington
Overview of climate change projections, vulnerability and adaptation
Nate Mantua: Climate Impacts Group, University of Washington
Salmon, coastal and freshwater aquatics vulnerability
Jessica Halofsky: Research Ecologist, Pacific Wildland Fire Sciences Lab
Projected responses of forests, shrublands, and grasslands

11:15 Breakout group discussions, **Part I**

Participants will be grouped around habitat types:

- **Freshwater aquatic and riparian habitats** (lakes, rivers, wetlands, floodplains)
- **Marine and coastal habitats** (bays, estuaries, nearshore, beaches)
- **Forest and woodland habitats**
- **Grassland and Shrubland habitats**

Discussion during Part I will focus on:

1. What impacts have already occurred or are anticipated to occur as a direct or indirect consequence of climate change?
2. What are the most significant impacts to species, habitats and ecosystems expected to occur during the periods 2040-2069 and 2070-2099? (Consider type of impact, geographic location, and key species affected.)

12:30 Lunch (provided)

Senator Phil Rockefeller, Keynote Speaker

1:00 Breakout group discussions, **Part II**

Participants will remain in same groups to continue discussion, focusing on:

3. What are possible “no-regrets” management or policy actions that could be taken to address the significant impacts identified in #2 above?
4. What are the most significant information gaps and how can they be filled?
5. What mechanisms could be developed to share information among participants and others interested in biodiversity adaptation?

Groups will list their top five items from topics 2, 3, 4, and 5 to report back to the larger group.

2:20 Break

2:30 Large Group: Reports from breakout groups on top 5 items from topics 2, 3, & 4.

3:30 Synthesis of breakout group results and next steps

Josh Lawler: Science and vulnerability assessment
Rocky Beach: Policy and WDFW response

4:00 Adjourn

Appendix IV: Reports Related to Conservation and Climate Change in Washington

Workshop participants were asked to list reports addressing conservation and climate change in Washington State that may not be in the published literature. Below is a compilation of items they identified.

Audubon Washington. *State of the Birds 2009. Birds and Climate Change: Washington's Birds at Risk.* 2009.

Climate Impacts Group, UW. *The Washington Climate Change Impacts Assessment.* February 2009. <http://cses.washington.edu/cig/files/waccia/wacciafullreport.pdf>

Climate Impacts Group, UW. The Climate Impacts Group has published a series of reports on climate change impacts on Washington's habitats. The reports can be easily perused by topic, such as aquatic systems, coastal ecosystems, forest ecosystems, water resources, human health, etc. These reports can be found on the CIG website: <http://cses.washington.edu/db/pubs/allpubs.shtml>

Climate Impacts Group, UW. *Uncertain Future: Climate Change and Its Effects on Puget Sound.* October 18, 2005 <http://cses.washington.edu/cig/outreach/files/psat1005.shtml>

Defenders of Wildlife and Oregon Department of Fish and Wildlife. *Preparing Oregon's Fish, Wildlife, and Habitats for Future Climate Change: A Guide for State Adaptation Efforts.* http://www.defenders.org/programs_and_policy/global_warming/wildlife_and_global_warming/oregon_adaptation_efforts.php

Department of Ecology Climate Action Team. *Leading the Way: Implementing Practical Solutions to the Climate Change Challenge.* November 2008. http://www.ecy.wa.gov/climatechange/2008CATdocs/ltw_app_v2.pdf

Department of Ecology. *Growing Washington's Economy in a Carbon Constrained World: a Comprehensive Plan to Address the Challenges and Opportunities of Climate Change.* December 2008. <http://www.ecy.wa.gov/climatechange/2008CompPlan.htm>

Independent Scientific Advisory Board (ISAB). *The Impacts of Climate Change on Columbia River Basin Fish and Wildlife* <http://www.nwcouncil.org/library/isab/isab2007-2.htm>

Independent Scientific Advisory Board (ISAB). *The Impacts of Human Population on Columbia River Basin Fish and Wildlife* <http://www.nwcouncil.org/library/isab/isab2007-3.htm>

National Wildlife Federation. *A Great Wave Rising: Solutions for Columbia and Snake River Salmon in the Age of Global Warming.* <http://www.nwf.org/GlobalWarming/pdfs/AGreatWaveRising.pdf>

National Wildlife Federation. *Fish Out of Water: A Guide to Global Warming and Pacific Northwest Rivers.* March 2005. <http://www.nwf.org/globalwarming/pdfs/FishOutOfWaterReport.pdf>

National Wildlife Federation. *Sea Level Rise and Coastal Habitats in the Pacific Northwest.* July 2007. <http://www.nwf.org/sealevelrise/pdfs/PacificNWSeaLevelRise.pdf>

National Wildlife Federation. *A New Era for Conservation: Review of Climate Change Adaptation Literature.* February 2009. <http://www.nwf.org/globalwarming/pdfs/NWFClimateChangeAdaptationLiteratureReview.pdf>

This purpose of this manual is to provide information for natural resource managers on how to protect natural areas from the impacts of climate change.

Washington Biodiversity Council. *Climate Change and the Future of Biodiversity in Washington: A Preliminary Assessment.* Josh Lawler and Molly Mathias. 2007. <http://www.biodiversity.wa.gov/documents/WA-CC-report-final.pdf>

Washington Biodiversity Council. *Washington Biodiversity Conservation Strategy: Sustaining Our Natural Heritage for Future Generations*. December 2007.

http://www.biodiversity.wa.gov/documents/EXECSUMMARY_FINALcomplete.pdf

Washington Biodiversity Council. *Washington's Biodiversity: Status and Threats*. January 2007.

<http://www.biodiversity.wa.gov/documents/WABiodiversityStatusThreats.pdf>

Washington Department of Fish and Wildlife. *Nearshore Assessment: Nearshore water quality of the central and western Strait of Juan de Fuca*. 2008. (This report studies the presence of American shad and juvenile salmonids in the Strait of Juan de Fuca.)

<http://www.pc.ctc.edu/coe/pdfs/ERC/Chapter9.Nearshore%20water%20quality%20of%20the%20central%20and%20western%20Strait%20of%20Juan%20de%20Fuca.pdf>

World Wildlife Fund. *Buying Time: A User's Manual for Building Resistance and Resilience to Climate Change in Natural Systems*. August 2003. <http://assets.panda.org/downloads/buyingtime.pdf>

Appendix V: Climate and Conservation Research, Projects, and Initiatives

Workshop participants were asked to identify on-going, planned or recently completed research, projects and initiatives that address conservation and climate change in Washington State and the Pacific Northwest. Below is a list of items they identified.

- **American Rivers and Sierra Club.** Identifying key freshwater and terrestrial habitats in the Puget Sound basin essential for adaptation. Lead Staff: Dr. Lara Hansen
- **Ducks Unlimited.** Modeling effects of sea-level rise on coastal wetlands, particularly in diked areas such as the Skagit. Lead Staff: Mark Petrie
- **NASA.** Simulating Pacific Northwest tree sustainability to endemic insects that could become problematic in future climate conditions. Lead Staff: Dick Waring and Nicolas Coop (BC).
- **National Wildlife Federation.** Assisting Washington Department of Fish & Wildlife to integrate future climate considerations into Comprehensive Wildlife Conservation Strategy. Lead Staff: Dan Siemann
- **National Wildlife Federation.** Working with FEMA to protect floodplains and integrate future climate conditions flood hazard maps related to the National Flood Insurance Program. Lead Staff: Dan Siemann
- **The Nature Conservancy.** Assessing the impacts of climate change on estuaries through the Port Susan Bay sea-level rise project.
www.nature.org/wherewework/northamerica/states/washington/misc/art26321.html
- **NatureServe.** Developing a Climate Change Vulnerability Index for species. Lead Staff: Bruce Young
- **NOAA – UW.** Conducting a large scale Synthesis of Climate Impacts on Salmon. Lead Staff: Mary Ruckelshaus and other federal and academic scientists
- **State of the Salmon.** Provides a website that offers data about Pacific Northwest salmon including interactive maps, an atlas of Pacific Salmon, and links to other data sites.
www.stateofthesalmon.org
- **University of Oregon.** Conducting a study to model effects of a variety of climate-driven changes in ecosystems in Willamette Valley, with particular interest in catastrophic wildlife and role of oak savanna restoration. Lead Staff: Bart Johnson, professor of landscape architecture
- **University of Oregon.** Conducting a study to understand potential threats to prairie ecosystems from climate change in OR and WA. Lead Staff: Scott D. Bridgham, ecologist
- **University of Washington.** Conducting a three-state vulnerability assessment to identify the aquatic and terrestrial species and habitats of concern that are most vulnerable to climate change. The study will develop and use high resolution climate and vegetation models. Lead staff: Josh Lawler, University of Washington
- **USFS.** Conducting studies on invasive species, tree mortality and tree thinning. Olympic National Forest and others. Lead Staff: Kathy O'Halloran
- **USFS.** West-wide climate initiative/Olympic Peninsula Climate change case study. High resolution climate vulnerability assessments on forests of Olympic Peninsula. With Olympic National Forest natural resources staff, Forest Service PNW Research Station and Climate Impacts Group. Lead Staff: Ron Nielson, Corvallis
- **USGS.** USGS National Climate Change and Wildlife Science Center. <http://nccw.usgs.gov/>
Robin_Schrock@usgs.gov; [Bruce Jones](#)

- ***WA Department of Fish and Wildlife et al.*** Washington Habitat Connectivity Working Group. Joanne Schuett-Hames, WDFW
- ***Western Governor's Association.*** Wildlife Corridors Initiative. The Western Governors' Association has created a new impetus for habitat connectivity planning, with an emphasis on planning that crosses state boundaries.
- ***Wild Fish Conservancy.*** Conducting research to evaluate baseline conditions in a variety of ecoregions and at varying scales to detect changes due to climate change. Lead Staff: Mark Hersh

Appendix VI: A New Era for Conservation: Review of Climate Change Adaptation Literature

The National Wildlife Federation, in conjunction with the National Council for Science and the Environment, wrote the report *A New Era for Conservation* to provide a summary of reports on climate change adaptation as it specifically applies to natural resource management and fish and wildlife conservation. The review starts with an overview of the concept of climate change adaptation, including overarching principles and barriers experienced to date in adaptation planning and implementation. It then provides specific examples of adaptation strategies for four broad habitat types: forests, grasslands and shrublands, freshwater systems, and coasts and estuaries.

The literature review found that climate change adaptation measures generally focus on the following five overarching principles:

- 1. Reduce other, non-climate stressors.** Addressing other conservation challenges—such as habitat destruction and fragmentation, pollution, and invasive species—will be critical for improving the ability of natural systems to withstand or adapt to climate change. Reducing these stressors will increase the resilience of the systems, referring to the ability of a system to recover from a disturbance and return to a functional state.
- 2. Manage for ecological function and protection of biological diversity.** Healthy, biologically diverse ecosystems will be better able to withstand some of the impacts of climate change. Ecosystem resilience can be enhanced by protecting biodiversity among different functional groups, among species within function groups, and variations within species and populations, in addition to species richness itself.
- 3. Establish habitat buffer zones and wildlife corridors.** Improving habitat “connectivity” to facilitate species migration and range shifts in response to changing climate condition is an important adaptation strategy.
- 4. Implement “proactive” management and restoration strategies.** Efforts that actively facilitate the ability of species, habitats and ecosystems to accommodate climate change—for example, beach renourishment, enhancing marsh accretion, planting climate-resistant species, and translocating species—may be necessary to protect highly valued species or ecosystems when other options are insufficient.
- 5. Increase monitoring and facilitate management under uncertainty.** Because there will always be some uncertainty about future climate change impacts and the effectiveness of proposed management strategies, careful monitoring of ecosystem health coupled with management approaches that accommodate uncertainty will be required.

Putting these overarching principles into action will require that agencies identify conservation targets, consider their vulnerability, evaluate management options, and then develop and implement management and monitoring strategies. Based on our review of the literature, we offer the following conceptual framework for developing and implementing adaptation strategies. It is important to note that the development and implementation of a successful climate change adaptation strategy for natural resources will need to employ an iterative adaptive management approach, incorporate significant stakeholder engagement, and promote sharing of knowledge among conservation practitioners and other experts.

Read the full publication at:

<http://www.nwf.org/globalwarming/pdfs/NWFClimatChangeAdaptationLiteratureReview.pdf>