

Setting the Stage:

Ideas for Safeguarding Washington's Fish and Wildlife in an Era of Climate Change

NATIONAL WILDLIFE FEDERATION | 2009



An Imperative Need

Washington is one of the most ecologically rich places in America. The state is home to an incredible diversity of fish and wildlife, from the greater sage-grouse and pygmy rabbits that rely on the shrub-steppe habitats of the Columbia Plateau, to the songbirds and black bears that inhabit the mountain forests of the Cascades and Olympics; from the iconic salmon and steelhead that spawn in our rivers, to the shorebirds, sea otters, orcas, and fish that flourish off the coasts of Puget Sound and the Pacific Ocean. Washington's unique array of habitats and the species they support are invaluable to our economy, culture, and quality of life, which is why restoring and protecting these precious resources have been important goals for Washingtonians.

Washington's ambitious *Comprehensive Wildlife Conservation Strategy (CWCS)*, which was developed by the Washington

Department of Fish and Wildlife as a framework for activities funded under the federal Wildlife Conservation and Restoration Program and the State Wildlife Grants Program, provides a critical blueprint for achieving the goal of safeguarding our wildlife and natural habitats in the face of growing pressures from urban development, agriculture, industry, and invasive species.¹ Climate change is exacerbating and intensifying many of these existing problems and will result in new sets of impacts and stressors that pose a tremendous threat to the health of our ecological systems, even with aggressive reductions in greenhouse gas emissions. Accordingly, it is imperative that efforts to cope with climate change play an important role in the implementation of the CWCS as well as the Washington Biodiversity Conservation Strategy (WBCS) and other conservation strategies across the state and region.²



WILDLIFE ACTION PLANS: A PLATFORM FOR CLIMATE CHANGE ADAPTATION PLANNING.

To make the best use of federal funds provided through the Wildlife Conservation and Restoration Program and the State Wildlife Grants Program, Congress charged each state and territory with developing a state wildlife action plan, also called a “comprehensive wildlife conservation strategy.”

The primary goal of the plans is to proactively protect all of the respective state’s fish, wildlife, and natural areas before they become endangered (i.e., to keep “common species common”). States are required to update their wildlife action plans by 2015 to build on conservation successes to date as well as incorporate new information that might affect their conservation goals.

With the growing recognition that climate change is playing an increasingly significant role in the fate of our fish and wildlife resources, states have an opportunity during this revision process to assess the vulnerability of the species and habitats targeted under the action plans and incorporate additional measures to ameliorate the impacts. Using these action plans as a platform to address climate change is an efficient and effective way to go, for several reasons: 1) the development and implementation of the action plans is collaborative across a range of stakeholders, which will be critical for addressing the additional challenges brought by climate change; 2) in developing the action plans, states have already taken important steps to help define conservation goals and targets and identify priority management actions; and 3) the action plans will continue to be an important vehicle for receiving federal funding.



The Association of Fish and Wildlife Agencies has recently developed a comprehensive guidance document that identifies a suite of voluntary measures to help states incorporate climate change into their state wildlife action plans and other relevant conservation strategies.³

The Challenges Before Us

Given current trends, the environment in which our living resources – humans, plants, and animals alike – will exist in the future will be profoundly different from the one we have experienced over the past century during which our conservation traditions evolved.⁴ For example:

- **Higher temperatures** and shifts in precipitation patterns will mean that some native plants and animals will no longer be able to thrive in their current ranges.⁵
- **Increased disturbances** such as insect outbreaks and wildfires will facilitate expansion of invasive species.⁶
- **Significant declines** in average snowpack will mean lower streamflows and less water for fish and wildlife in summer months, when water resources are already stretched thin by competing uses.⁷

- **Rising sea levels** will inundate beaches, marshes, and other coastal habitats, particularly where bulkheads and other structures impede their movement inland.⁸
- **Increased acidification** of our ocean waters will harm shellfish and other invertebrates that are fundamental to the marine food web.⁹

As the climate changes, wildlife will not be the only sector that feels the negative effects. The fishing and shellfishing industries will suffer if their stocks decline. With sea-level rise, saltwater intrusion into some low-lying aquifers will contaminate freshwater supplies.¹⁰ More-extensive wildfires will contribute to declines in timber values and present risks to human health and property. The economic costs associated with just some of these impacts are estimated to reach hundreds of millions of dollars by the 2020s.¹¹ Moreover, recent trends indicate

that these changes are already underway across the region, which underscores the urgency to confront them while we can.¹²

Ultimately, the fate of Washington's wildlife and wild places will depend on steps we begin to take now to help them survive in the face of a changing climate – a strategy commonly referred to as climate change adaptation. Integrating climate change adaptation measures into state wildlife action plans such as the CWCS has become a priority for fish and wildlife agencies across the country, and numerous efforts are underway to review and revise these plans through collaborative, stakeholder-driven processes. The National Wildlife Federation is working with a number of other partners to help build capacity and support for these efforts through a project funded by the Wildlife Conservation Society and the Doris Duke Charitable Foundation, starting with pilot efforts in Virginia, Florida, New York, and Washington, and expanding to other states around the country.

Educating key constituencies about wildlife action plans and climate change adaptation is an important part of this work. This report, which is intended to help raise public awareness of the issues at hand, draws from information shared at a February 2009 stakeholder workshop as well as research conducted by the National Wildlife Federation. It marks just one step in what will be a continuing effort in Washington and across the region to build on the CWCS and other important conservation plans to develop a meaningful climate change adaptation strategy for our fish and wildlife.

Overarching Management Principles for Climate Change Adaptation

Coping with climate change will require fundamental shifts in the way conservation and natural resource management are carried out.¹³ While many of our conservation tools and principles will remain the same, it is likely that some of our goals and priorities will need to change as we look at protecting fish and wildlife through a climate change lens. Parks, wildlife refuges, and other protected areas, for example, may no longer provide viable habitat for managed species such as waterfowl. This bolsters the importance of developing habitat buffers and improving connectivity with habitats outside of refuge borders. Promoting biological diversity may become more effective than managing habitats for individual species of concern. In addition, the traditional approach of using past conditions and trends as a benchmark and goal for conservation will become increasingly problematic in a rapidly changing environment.

Although the details of climate change strategies for specific places and resources across the state will no doubt vary considerably, several overarching adaptation principles are likely to apply broadly. In many cases, these activities are likely to be beneficial regardless of climate change – in other words, they are “no regret” actions:¹⁴

- **Reduce non-climate stressors.** Climate change will exacerbate many existing threats to our wildlife and natural ecosystems, such as the loss of habitat and spread of invasive species. Reducing non-climate stressors will be critical to promoting ecosystem resilience. Nonetheless, climate change will require us to be strategic in identifying which existing problems are most important to address.
- **Manage for ecological function and biological diversity.** Healthy and biologically diverse ecosystems will be better able to withstand or bounce back from some of the impacts of climate change. Strengthening the region's and nation's network of protected lands and waters will be essential for maintaining strongholds of wildlife populations and sustaining the full array of species, ecosystems, and their human benefits.
- **Improve habitat connectivity.** Improving habitat connectivity to facilitate species migrations and range shifts in response to changing climate conditions will be increasingly important. Connecting core habitat areas by establishing buffers and wildlife corridors can reduce or prevent barriers such as urban development, roads, and levees that might otherwise limit a species' ability to inhabit new areas.
- **Implement proactive management and restoration.** Efforts that actively facilitate the ability of species, habitats, and ecosystems to accommodate climate change – for example, adding sediments to assist with marsh accretion and perhaps even translocating species to new areas – may be necessary to protect highly valued species or ecosystems when other options are insufficient.
- **Embrace uncertainty.** Although uncertainty exists regarding the severity of future climate shifts and the ecological impact of these changes, such uncertainty can no longer be an excuse for inaction. Instead, resource managers must learn to embrace uncertainty by adopting agile management approaches and monitoring ecosystem conditions and responses.



PROMOTING HABITAT CONNECTIVITY: A CONSERVATION PRIORITY FOR WASHINGTON.

Washington's CWCS has identified habitat loss through conversion to other uses, fragmentation, and degradation as the most serious statewide threat to native fish and wildlife. Accordingly, maintaining and restoring habitat connectivity has become an important conservation priority for the state and region, supported by programs such as Washington's collaborative Wildlife Habitat Connectivity Working Group and the Western Governors' Association Wildlife Corridors Initiative.¹⁵ The threat of climate change has now created an additional justification for this approach, although new guidelines and criteria will be necessary to promote plant and animal movement into areas that may be outside of their historic or current range but that are more likely to provide viable habitat as the climate changes. Initial efforts have been underway in Washington to bring key stakeholders and decision-makers together with scientists to help develop important guidance for addressing climate change in ongoing efforts to restore and protect habitat connectivity across the state and region.



A Framework for Developing a Climate Change Adaptation Strategy for Fish and Wildlife

The following steps provide a general framework for developing a climate change adaptation strategy to help safeguard Washington's fish and wildlife:

- 1. Select conservation targets/goals.** An important initial step in developing and prioritizing conservation actions is the selection of a conservation target or set of targets, such as the protection of a species, ecosystem, or specific location. Washington's CWCS has identified 193 Species of Greatest Conservation Need as well as 20 associated priority habitats within Washington's nine ecoregions as the plan's primary focus. Based on these targets, a broad range of stakeholders have been working to evaluate and synthesize ongoing conservation efforts and develop new strategies to address what has been defined under the plan as the state's greatest conservation challenges. Now, with climate change emerging as the primary, overarching threat to Washington's fish and wildlife, we must also begin to factor the impacts of climate change into our conservation plans, including revising the CWCS. Reengaging the stakeholders who were involved in the development of the CWCS will serve as a cost-effective and efficient mechanism to identify concerns and articulate the conservation actions needed to address climate change.
- 2. Assess climate change impacts and vulnerability of conservation targets.** For each conservation target, it will be necessary to use the best available information about current and projected climate impacts to assess their *vulnerability*, which will help us develop and prioritize appropriate and effective management actions. Vulnerability refers to the extent to which a species, habitat, or ecosystem is susceptible to climate change impacts – more vulnerable species and systems are more likely to be affected by climate change; less vulnerable systems are less likely to be affected. There are a number of different approaches for a vulnerability assessment, from conducting reviews of existing literature and drawing on expert opinion through workshops and other forums, to conducting complex ecological modeling. Because the results of a vulnerability assessment may lead to revision or reprioritization of conservation targets and goals, these first two steps should be well coordinated.
- 3. Evaluate management options and develop management responses.** Once the conservation target and its vulnerability to climate change have

been identified, stakeholders should evaluate various management options available and develop management responses. Management options should include existing conservation tools, programs, and laws, as well as adaptation-specific options necessary to supplement where the available tools are insufficient. The evaluation of management options will need to consider the technical feasibility of potential solutions and the capacity to respond, along with the social, economic, political, and cultural factors contributing to threats or representing opportunities.

4. Implement management and monitoring strategies. Implementation of the management strategies will

need to be accompanied by appropriate monitoring strategies to help determine the effectiveness of the conservation actions and track the status of key indicators. Education and outreach to key stakeholders will also be an important aspect of the implementation phase.

5. Review and revise. The regular review of each step that informed the development of the management strategy and appropriate revisions will be critical to success. Such an adaptive management approach is commonly discussed in conservation efforts, but it will need to be even more central in climate change adaptation as the levels of understanding about the impacts of climate change and the effectiveness of management options improve over time.

ASSESSING THE VULNERABILITY OF FISH AND WILDLIFE IN THE PACIFIC NORTHWEST.

Recognizing the need to better understand which ecosystems and habitats in Washington are susceptible to harm from climate change, the Washington Department of Fish and Wildlife recommended, as a supplement to the *Recommendations of the Preparation and Adaptation Working Groups* under Governor Chris Gregoire's *Climate Change Challenge*, that the state invest in several targeted vulnerability assessments – including an assessment of key species in Washington, Oregon, and Idaho.¹⁶ Toward this end, a team of researchers, natural resource managers, and conservation planners (including the University of Washington, the University of Idaho, the Washington Department of Fish and Wildlife, the Oregon Department of Fish and Wildlife, the Nature Conservancy, the U.S. Geological Survey, the National Park Service, and the National Wildlife Federation)

are conducting a multi-phased vulnerability assessment for the Pacific Northwestern U.S. that involves two major components. These include: 1) building a climate sensitivity database for all of the region's ecosystems, and 2) downscaling projected future climate change scenarios in terrestrial systems, projecting potential shifts in major vegetation types, and forecasting potential shifts in the distributions of individual terrestrial species. The assessment is scheduled to be completed in 2012. The results of this and other vulnerability assessments will play an important role in helping the region shape meaningful climate change adaptation strategies. However, it is important to recognize that there are many actions that

we can and should undertake in the meantime, based on already-existing knowledge and tools, to prepare for and cope with the impacts of climate change. In an effort to support collaborative scientific assessments of climate change and wildlife and inform adaptation or management of fish and wildlife in the face of climate change, the U.S. Geological Survey has established a National Climate Change and Wildlife Science Center (NCCWSC), with regional hubs across the country. For more information, go to <http://nccw.usgs.gov/>.



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Planning Under Uncertainty

A primary barrier to climate change adaptation in the conservation arena has been concern about uncertainty in terms of both how our climate will change and how those changes will affect fish and wildlife species and their habitats.¹⁷ Certainly, resource managers and other relevant decision makers need information about the more regional and localized consequences of climate change, as well as the vulnerability of species and ecosystems, in order to develop effective solutions. As the science of climate change has progressed over the past few decades, our understanding of climate change as well as its impacts (both those that have already occurred and those that are projected for the future) has increased considerably. Significant improvements in “downscaled” climate models and research on impacts to natural systems and species already offer a tremendous amount of useful information, and investments in additional research will ensure that our body of knowledge will continue to grow.

However, by its very nature, there will always be some degree of uncertainty about how, when, and where climate change will affect natural systems. Increased monitoring and research will help close the gap in knowledge, but we will never know exactly when and where we will experience the impacts. This does not mean we shouldn't act. Rather, the very fact that there is risk – and the potential for climate change to lead to irreversible damages, such as the extinction of species – necessitates precautionary action. It is prudent to consider actions we can take now that can reduce our vulnerability as well as incorporate useful measures of uncertainty into our decision making.

One approach to managing under uncertainty is scenario planning. The central idea is to consider a variety of possible futures that include many of the important uncertainties rather than focus on accurate prediction of a single outcome.¹⁸ In other words, the scenarios are not predictions or forecasts but, rather, a set of plausible alternative future conditions. The approach entails several steps:

1. Identify your conservation issue or goal through a collaborative process among stakeholders.
2. Assess the issue in the broader ecological and social context.
3. Identify alternative ways in which the system could evolve, focusing in particular on potential factors that are “uncontrollably uncertain” (e.g., changes in rainfall, as opposed to “controllable” factors such as development in floodplains).
4. Develop and test 3-4 plausible scenarios of future conditions (which could be based on modeled projections as well as expert opinion).
5. Identify and test potential management or policy measures under the different scenarios.

Scenario planning will be an important tool for developing climate change adaptation strategies under the CWCS, the WBCS, and other important conservation plans.





Washington's Habitats at Risk: What are Some Major Issues of Concern?

The National Wildlife Federation, in partnership with its state affiliate, the Washington Wildlife Federation, the Washington Department of Fish and Wildlife and the Washington Biodiversity Council, held a workshop on February 13th, 2009 to engage relevant stakeholders in a dialogue about the consequences of climate change for fish and wildlife conservation in Washington. The workshop brought together about 100 individuals, ranging from scientists, resource managers, and policy specialists working at the nexus of climate change and natural resource conservation, to assess the impacts of climate change on the state's wildlife and natural systems and to begin to identify potential management strategies.

The workshop was structured to:

- 1) inform participants of the current scientific understanding of climate change impacts on aquatic and terrestrial systems in Washington State; and
- 2) allow participants to share their own knowledge and make suggestions for future directions.

During the first half of the workshop, participants listened to presentations from several experts in their field on how climate change will affect fish and wildlife. Following the presentations, participants divided into four groups based on specific habitat types, including coastal and marine habitats, freshwater habitats, grasslands and shrublands, and forests, to identify key impacts, potential near-term management actions, and information gaps.

The results from this workshop, summarized below, reflect the information and insights of those present and are not intended to be comprehensive. The findings will be further developed in the coming months through additional workshops, targeted research, education programs, and other efforts to engage stakeholders in an ongoing, collaborative, and iterative process to build a meaningful and actionable adaptation strategy for Washington's fish and wildlife.



Coastal and Marine Habitats

Coastal and Marine Habitats		
Key Impacts <ul style="list-style-type: none"> Habitat erosion/inundation Changes in the food web Altered hydrology Effects on coastal and marine fish industries Inundation of coastal infrastructure 	Potential Management Actions <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 	Information Gaps <ul style="list-style-type: none"> Research ecological processes: thresholds, etc. Information flow Local-scale assessments

Key Impacts

- Habitat erosion/inundation.** Rising sea levels will increase erosion of beaches and inundate coastal marshes, tidal flats, and other important habitats for numerous species of fish and wildlife.¹⁹ Current land use practices, such as development in coastal areas and shoreline armoring, worsen the problem by reducing or preventing the ability of these habitats to move upland.
- 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 existing stressors such as algal blooms and invasive species.²⁰



- Altered hydrology.** Changes in the timing and extent of precipitation and snowmelt 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.²¹ These problems will affect food abundance, the timing of life cycle events, and predator-prey interactions.

- Effects on 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.²² Acidification also results in shifts in phytoplankton diversity and changes in the food web, which has implications for the overall biodiversity of the ecosystem.
- Inundation of coastal infrastructure.** Inundation of coastal infrastructure is possible due to sea-level rise, which has both human and ecological implications. A rising water level and increases in the frequency of flooding events may cause wastewater treatment plants to overflow, spilling raw sewage into waterways, which can lead to algal blooms and dead zones.²³

Potential Management Options

- Acquire lands for coastal buffers, wetlands, and protected areas.** Preemptively protecting land areas needed for future coastal habitat as sea levels rise is 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 inland 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, the Growth Management Act, and other existing policies should be updated to incorporate climate change impacts like sea-level rise. Revising these policies with climate change in mind will

allow alternative management practices and will allow a critical reconsideration of typical shoreline armoring. For example, certain wetland areas 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 is necessary for new policies and regulations to be effective. Getting the public involved 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 Washington's ecosystems.
- **Create incentives for restoration.** Policies that use incentives or compensation to encourage landowners to use land in a sustainable way creates greater public support while benefiting the landowner. Because discussing economic costs of inaction tends to grab the public's attention, estimates of how climate change will affect key industries in Washington (like sportfishing, tourism, and the shellfish industry) will help encourage Washingtonians to protect these resources.
- **Link terrestrial, coastal, and marine conservation efforts.** While marine ecosystems do require specific management actions, they are not independent of terrestrial ecosystems. Conservation efforts should be linked so there is a system level approach and that conservation programs are not created in isolation.

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, the cost of delay, and the length of time required for restoration are not known 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. This will allow cities and counties to find out what impacts are relevant to where they live.

ADAPTATION IN ACTION: PROVIDING NATURE A RIGHT-OF-WAY.

The North Pacific Flyway Office of Ducks Unlimited has initiated a project to help coastal communities in the Pacific Northwest adapt to rising sea levels with no net loss of coastal wetlands.²⁴ The project entails working with scientists to better understand how potential changes to coastal habitats under sea-level rise will affect waterfowl, seabirds, and other key species, building on recent modeling efforts by the National Wildlife Federation and others.²⁵ Ducks Unlimited is also building local partnerships with land owners and other stakeholders and promoting public policy to update wetland programs to address sea-level rise. Finally, they are involved in direct, on-the-ground restoration efforts such as purchasing development rights in upland areas to enable coastal habitats to migrate inland as sea levels rise.



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Freshwater Habitats

Freshwater and Riparian Habitats		
<p>Key Impacts</p> <ul style="list-style-type: none"> Increased water temperatures Reduced snowpack and shrinking glaciers Reduced base flows and increased peak flows Increased erosion and sedimentation Decreased forest cover/buffer zones/riparian areas 	<p>Potential Management Actions</p> <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 	<p>Information Gaps</p> <ul style="list-style-type: none"> Better monitoring of soil temperatures, species, etc. Inventory for cold water refugia Species responses to temperature increase

Key Impacts

- Increased water temperatures.** Future temperature projections show extended periods where the weekly average water temperature in many of the region's rivers and streams will exceed 69.8°F (21°C).²⁶ Water temperatures at and above this level are extremely stressful for salmon and steelhead, causing changes in migration timing, reduced growth rates, reduced oxygen, and increases in susceptibility to toxins, parasites, predators, and disease.²⁷
- Reduced snowpack and shrinking glaciers.** Average snowpack across the state is projected to decrease by an average of 30% by the 2020s, with even greater declines in the following decades. In addition, glaciers across the region are rapidly retreating. These changes will contribute to a significant loss of summer water availability in sensitive areas.
- Reduced base flows and increased peak flows.** Climate change will result in significant changes in streamflow patterns across the state. Many of today's snowmelt-dominated rivers will become transient basins; current transient basins will become rainfall



dominated rivers.²⁸ Summer streamflows are projected to decrease on the western slope of the Cascades.²⁹ More winter flooding with increased peak flows will occur in sensitive transient streamflow basins common in the Cascades.³⁰

- Increased erosion and sedimentation.** 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.³¹

- Decreased forest cover/buffer zones/riparian areas.** Shifts in seasonal water patterns due to climate change 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 riparian areas, leading to spatial and temporal changes in habitat availability for wildlife as reduced water availability impacts certain habitats differently than others. Existing stressors caused by poor land use practices such as reduced vegetative cover are exacerbated by climate change impacts. Decreased forest cover due to population expansion and development decreases buffer zones along riparian areas, which are necessary for mitigating the severity of extreme weather events such as flooding.

Potential Management Actions

- Water conservation.** Reservoir and hydropower system infrastructures 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 water resources. 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.** Because the past is no longer an effective indicator of future scenarios, 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. 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.
- **Provide species access to the most resilient areas.** Vulnerability assessments will determine which habitats will be in the most resilient watersheds under various scenarios of climate change. Because habitats most resilient to climate change impacts are those 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 stocks.
- **Understanding human dimensions of climate change – human responses by integrating social and natural resource management.** 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. For example, 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.

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 are currently residing in these cold water areas.
- **Species responses to temperature increase.** How water temperature affects species is not entirely understood, but temperature and species interactions need to be better studied as these interactions are not linear and there may be an unknown threshold.

ADAPTATION IN ACTION: NAVIGATING WATER ISSUES IN THE YAKIMA RIVER.

The National Wildlife Federation is working with a diverse group of stakeholders to help shape water management in the Yakima River watershed to better meet the needs of water users and also fish and wildlife, while at the same time look ahead to the challenges of climate change. The primary goal of the project is to help communities in the region recognize pending climate change impacts and develop proactive strategies to enhance both community resilience and ecosystem function.



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Grassland and Shrubland Habitats

Grassland and Shrubland Habitats		
Key Impacts <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 	Potential Management Actions <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 	Information Gaps <ul style="list-style-type: none"> Migration patterns Species interactions Post-fire ecosystem restoration

Key Impacts

- Altered hydrology.** Permanent and seasonal changes in water abundance will have impacts on grassland and shrubland habitats. Floods and droughts are already ecosystem stressors and they will become more frequent with climate change, with projections showing an increase in frequency and severity of both winter flooding summer droughts.³² Ephemeral pools and year round reservoirs in some areas may no longer adequately supply freshwater to ecosystems.³³ Drought will interact with other stressors, such as fire and insects, to further increase grassland vulnerability.³⁴



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- Increasingly frequent and severe fires.** Increased frequency of droughts will cause more frequent and severe wildfires.³⁵ Changes in the natural balance of fires could result in the loss of species – including fire dependant species if fires become too hot, severe, and frequent.

- Expansion of invasive species.** Invasive species are already a significant problem for grassland systems and are projected to become worse. As temperatures increase, species will tend to migrate northward where possible in an effort to adapt to changing climate conditions.³⁶ Many invasive plant species will be able to take advantage of systems that have been weakened by extreme events such as wildfires.³⁷
- Changes in land use.** Existing habitat is becoming more fragmented as eastern Washington communities expand. Possible human migration north due to changes in climate will cause further development

and habitat fragmentation, decreasing wildlife corridors and posing a problem for species that need to migrate in adaptive response to climate change. Current grazing practices and mono-crop agriculture are causing changes in the biological elements of the soil. Because soil is the underlying basis of everything else, problems and changes in the soil can impact the whole ecosystem.

- Loss of endemics and species diversity.** As diverse species respond to climate change in different ways, important connections between pollinators, breeding birds, insects, and other wildlife and the plants on which they depend will become disrupted.³⁸ These shifts can result in changes in the food web, broken or altered predator-prey relationships, and species extinction through the inability of some species to adapt.

Potential 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.** Site-specific research is needed to 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 converted to less water intensive crops through incentives and other programs with 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 invasive species while simultaneously promoting fire dependant natives. Pre-planned flooding events would decrease erosion damage and allow certain areas to become temporarily inundated, encouraging 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.** The public must be educated about the benefits of changes in land use management like prescribed burns and pre-planned flooding events in order to gain the public support required for success. In addition to education, incentives are necessary to encourage farmers and cattle ranchers to participate in conservation measures on agricultural and grazing land.

Information Gaps

- **Migration patterns.** Due to the complexity of ecosystems, it is not understood how climate change will affect species migrations. 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.

ADAPTATION IN ACTION: RECONNECTING WASHINGTON'S SHRUB-STEPPE HABITATS.

Scientists with the Nature Conservancy have been working with a modeling tool called ClimateWizard to measure habitat connectivity of the remaining shrub-steppe in central and eastern Washington as the basis for establishing common priority areas for conservation in the face of climate change. ClimateWizard is a tool developed by researchers at the Nature Conservancy, the University of Washington, and the University of Southern Mississippi to help “downscale” scenarios of projected changes in temperature and precipitation due to global warming.



Jim Cummins, WDFW

Forest Habitats

Forest Habitats		
Key Impacts <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 	Potential Management Actions <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 	Information Gaps <ul style="list-style-type: none"> • Vegetation community responses • Phenology and species inter-relationships

Key Impacts

- **More frequent storm events.** An increase in the frequency of storm events (such as rain-on-snow events) will contribute to hillside erosion and landslides, damage to riparian zones, and downstream flooding.
- **Increased forest fires.** Higher temperatures and more frequent droughts will lead to longer, more-severe wildfire seasons.³⁹ Forest fires were traditionally considered an eastern Washington problem, but climate change will cause more frequent wildfires in western Washington as well.



- **Expansion of invasive species.** Changes in temperature and increased disturbances such as wildfires are likely to exacerbate expansion of invasive vegetation.⁴⁰ 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.⁴¹

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 pests.** If forest habitats become smaller and more fragmented due to climate change, they are likely to lose carrying capacity (i.e., the ability of the ecosystem to support existing biomass).⁴² In addition, higher average temperatures and increased drought stress will contribute to an expansion of forest diseases and pests such as mountain pine beetle and western spruce budworm.

Potential 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. Creating conservation incentives for private landowners is necessary for establishing habitat connectivity and engaging the private sector would increase the amount of land managed with conservation in mind.
- **Increase interagency collaboration.** Forest conservation requires increased interagency collaboration. Both resource and non-resource agencies must be involved in conservation discussions to integrate their work and to prevent duplication of work. It is also important to think about forest management as a regional issue as conservation strategies that are not confined to state borders are necessary for success.

- **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 Species of Greatest Conservation Need (SGCN) should be revised to include 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 a sufficient land area to which species can adaptively migrate. 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. It is necessary for public agencies, such as the U.S. Forest Service and the Washington Department of Natural Resources, to work with each other and with private landowners to make land management more feasible. Conservation areas should be designed to improve resilience, habitat connectivity, and provide land for adaptive migrations.

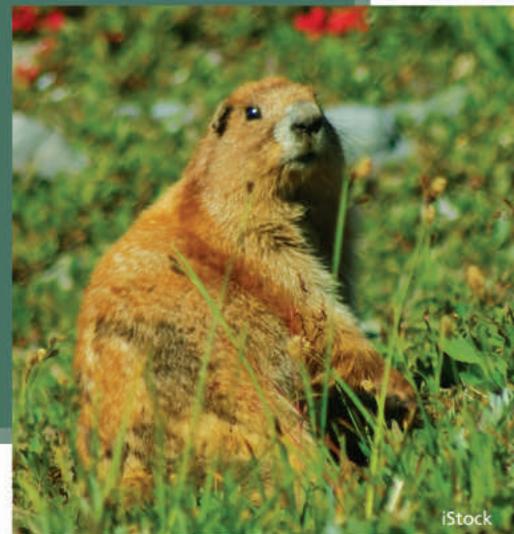
Information Gaps

- **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.
- **Phenology and species interrelationships.** 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.

ADAPTATION IN ACTION: MANAGEMENT OPTIONS FOR OLYMPIC NATIONAL FOREST.

The ongoing development of a climate change adaptation strategy for the Olympic National Forest (ONF) is an example of how collaboration among diverse stakeholders and building on existing conservation objectives and tools can provide a useful starting point.⁴³ ONF is a “restoration forest,” which means that management objectives are focused on promoting biodiversity and landscape diversity, restoring aquatic systems, and protecting threatened and endangered species.⁴⁴ This puts management of the forest under a number of different policy mandates, such as the Northwest Forest Plan (for planning), the National Environmental Policy Act (for management actions) and the Endangered Species Act (for species protection). In addition, the forest is a mosaic of lands managed by government agencies, tribes, and private property owners. Given this broad umbrella, an important aspect of management in ONF is the necessity of working across different federal and state agencies, nongovernmental organizations, tribes, and public citizens, all of whom have been engaged in the adaptation planning process.

In addition, the current focus on biodiversity already helps build resilience to climate change while new strategies are being developed.



Synthesis and Next Steps

Washington's fish and wildlife and numerous ecological and economic services they provide are treasured by the millions of people who call the state home or visit each year. Unfortunately, many of the state's ecological systems face serious problems due to human activities, including habitat fragmentation, pollution, and invasive species. While numerous efforts are currently underway to restore the health of the region's natural systems, the task before us is even more daunting because we also face the challenges brought on by climate change. With Washington's human population expected to grow considerably in the coming decades, proactively confronting these challenges today is of paramount importance.

Over the next two years, Washington will be developing an "integrated climate change response strategy," as directed by the 2009 legislation, "State Agencies – Emissions Reduction" (E2SSB 5560).⁴⁵ As this process moves forward, we must ensure that ecosystem health and protection of biological diversity are considered as high priorities. Local, state, and federal agencies,

scientific institutions, tribes, nongovernmental organizations, and other key stakeholders will need to work together to build on the existing CWCS, the WBCS, and other relevant conservation plans as a critical platform for developing a comprehensive climate change and wildlife action plan for the state and, ultimately, the region.



Moving forward, there are several key management actions that participants during the February 2009 workshop identified as priorities. These include:

- **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 and the National Wildlife Federation's Project Budburst. One way for citizens to get involved is to join Teaming
- **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 dependent 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. In addition, it will be important to broaden efforts across state lines and national borders.
- **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 coastal habitats, where estuaries will become inundated and uplands should be protected today to provide for future coastal 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.

- **Tap new sources of revenues to fund climate change adaptation.** Washington is already making considerable investments to restore and protect fish and wildlife from ongoing threats, and these efforts need to continue. At the same time, new efforts are required to specifically address impacts of climate change, and these new activities will require additional sources of funding. Thanks to the efforts of Teaming With Wildlife, the federal State Wildlife Grants Program was established in 2000 and has become a growing source of funding to implement the CWCS. Teaming With Wildlife continues to urge Congress to allocate additional resources to that program to support the significant conservation actions that are now necessary in an era of global warming. In addition, Teaming With Wildlife coalition leaders have been working to set aside dedicated funding in federal climate change legislation to enable agencies to build climate change into the CWCS and other relevant fish and wildlife conservation strategies.

The outcomes and recommendations highlighted in this report are intended to help set the stage in Washington and across the Pacific Northwest for an ongoing, collaborative, stakeholder-driven effort to develop a meaningful climate change adaptation strategy. The National Wildlife Federation, the Washington Department of Fish and Wildlife, the Washington Biodiversity Council, the Washington Wildlife Federation, and Teaming With Wildlife are committed to working with other partners across the region on this important endeavor. Ultimately, with the right investments, we can change the forecast for Washington's fish and wildlife and ensure that the many benefits they provide for us all will endure for generations to come.

Appendix

Presenters

Senator Phil Rockefeller
Washington State Legislature

Hon. Peter Goldmark
Washington State Department of
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Phil Anderson
Washington State Department of
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Rocky Beach
Washington State Department of
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People for Puget Sound
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Puget Sound Regional Council
Yorik Stevens-Wajda
Robin McClelland

Puget Sound Partnership
David St. John

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
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Dave Beauchamp
Karen Raegan

U.S. Fish and Wildlife Service
Kate Benkert
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James Michaels
Joanne Stellini

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Endnotes

- 1 Washington Department of Fish and Wildlife. 2005. *Washington's Comprehensive Wildlife Conservation Strategy*.
- 2 Washington Biodiversity Council, 2007. *Washington Biodiversity Conservation Strategy: Sustaining Our Natural Heritage for Future Generations*.
- 3 Climate Change Wildlife Action Plan Work Group. 2009. *Voluntary Guidance for States to Incorporate Climate Change into State Wildlife Action Plans & Other Management Plans* (Association of Fish and Wildlife Agencies).
- 4 Lawler, J. and M. Mathias. 2007. *Climate Change and the Future of Biodiversity in Washington: A Preliminary Assessment* (Washington Biodiversity Council).
- 5 Ibañez, I., et al. 2006. "Predicting Biodiversity Change: Outside the Climate Envelope, Beyond the Species-Area Curve." *Ecology* 87: 1896-1906.
- 6 McKenzie, D., et al. 2004. "Climate Change, Wildfire, and Conservation." *Conservation Biology* 18: 890-902.
- 7 Glick, P. 2006. *Fish Out of Water: A Guide to Global Warming and Pacific Northwest Rivers* (National Wildlife Federation).
- 8 Glick, P., J. Clough, and B. Nunley. 2007. *Sea-level rise and Coastal Habitats in the Pacific Northwest* (National Wildlife Federation).
- 9 Orr, J.C., et al. 2005. "Anthropogenic Ocean Acidification Over the Twenty-First Century and its Impact on Calcifying Organisms." *Nature* 437: 681-686.
- 10 U.S. Geological Survey. 2000. "Is Seawater Intrusion Affecting Ground Water on Lopez Island, Washington?" *USGS Fact Sheet* 057-00.
- 11 Washington Economic Steering Committee and the Climate Leadership Initiative. 2006. *Impacts of Climate Change on Washington's Economy: A Preliminary Assessment of Risks and Opportunities* (Washington Department of Ecology and Washington Department of Community, Trade and Economic Development).
- 12 Climate Impacts Group (CIG). 2009. *The Washington Climate Change Impacts Assessment: Evaluating Washington's Future in a Changing Climate* (CIG, University of Washington).
- 13 Lawler, J., et al. 2009. Resource Management in a Changing and Uncertain Climate." *Frontiers in Ecology and the Environment* e-View.
- 14 Glick, P., A. Staudt, and B. Stein. 2009. *A New Era for Conservation: Review of Climate Change Adaptation Literature* (National Wildlife Federation).
- 15 Western Governors' Association (WGA). 2008. *Wildlife Corridors Initiative*. <http://www.westgov.org/wga/publicat/wildlife08.pdf>, accessed August 31, 2009.
- 16 Washington's Climate Change Challenge Adaptation Working Groups. 2008. *Leading the Way: Preparing for the Impacts of Climate Change in Washington: Recommendations of the Preparation and Adaptation Working Groups* (Washington Department of Ecology).
- 17 Lawler, J., et al., 2009.
- 18 Peterson, G.D., G.S. Cumming, and S.R. Carpenter. 2003. "Scenario Planning: a Tool for Conservation in an Uncertain World." *Conservation Biology* 17: 358-366.
- 19 Glick, Clough, and Nunley, 2007.
- 20 CIG, 2009.
- 21 Kennedy, V.S., et al. 2002. *Coastal and Marine Ecosystems & Global Climate Change: Potential Effects on U.S. Resources* (Pew Center on Global Climate Change).
- 22 Orr, 2005.
- 23 CIG. 2005. *Uncertain Future: Climate Change and its Effects on Puget Sound* (CIG, University of Washington).
- 24 Ducks Unlimited. 2009. *Sea-Level Rise in the Pacific Northwest: Providing Nature a Right-of-Way* (Ducks Unlimited, Inc. North Pacific Flyway Office).
- 25 Glick, Clough, and Nunley, 2007.
- 26 CIG, 2009.
- 27 Poole, G., et al. 2001. *Technical Synthesis: Scientific Issues Relating to Temperature Criteria for Salmon, Trout, and Char Native to the Pacific Northwest* (U.S. EPA Region 10).
- 28 Elsner, M. M., et al. 2009. "Implications of 21st Century Climate Change for the Hydrology of Washington State." *The Washington Climate Change Impacts Assessment: Evaluating Washington's Future in a Changing Climate* (CIG, University of Washington).
- 29 U.S. Global Change Research Program. 2009. *Global Climate Change Impacts in the United States*. T.R. Karl, et al., eds. (Cambridge University Press).
- 30 Mantua, N., et al. 2009. "Impacts of Climate Change on Key Aspects of Freshwater Salmon Habitat in Washington State." *The Washington Climate Change Impacts Assessment: Evaluating Washington's Future in a Changing Climate* (CIG, University of Washington).
- 31 Independent Scientific Advisory Board (ISAB). 2007. Climate change impacts on Columbia River Basin fish and wildlife (Northwest Power and Conservation Council. ISAB). <http://www.nwcouncil.org/library/isab/ISAB%202007-2%20Climate%20Change.pdf>, accessed August 31, 2009.
- 32 Climate Change Science Program (CCSP). 2008. *Weather and Climate Extremes in a Changing Climate. Regions of Focus: North America, Hawaii, Caribbean, and U.S. Pacific Islands*. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research [T.R. Karl, et al. (eds.)] (U.S. Department of Commerce, NOAA's National Climatic Data Center).
- 33 Vano, J.A., et al. 2009. *Climate Change Impacts on Water Management in the Puget Sound Region, Washington, U.S.A. The Washington Climate Change Impacts Assessment: Evaluating Washington's Future in a Changing Climate* (University of Washington Climate Impacts Group).
- 34 Lawler and Mathias, 2007.
- 35 McKenzie, et al., 2004.
- 36 Breshears, D., et al. 2005. "Regional Vegetation Die-Off in Response to Global-Change-Type Drought." *Proceedings of the National Academy of Sciences* 102: 15144-15148.
- 37 Lawler and Mathias, 2007.
- 38 Janetos, A., et al. 2008. "Biodiversity." *The Effects of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity in the United States* (CCSP and Subcommittee on Global Change Research): 151-181.
- 39 CIG, 2009.
- 40 Bautista, S.L. 2008. *Climate Change and Invasive Plants: Information for PNW Invasive Plant NEPA* (U.S. Forest Service, Region 6).
- 41 Lawler and Mathias, 2007.
- 42 Oneil, E., B. Lippke, and L. Mason. 2007. *Discussion Paper (DP8): Eastside Climate Change, Forest Health, Fire and Carbon Accounting. Future of Washington's Forest and Forest Industry Study* (College of Forest Resources, University of Washington).
- 43 Joyce, L.A., et al. 2008. "National Forests." Chapter 3 in S.H. Julius and J.M. West (eds.) *Preliminary Review of Adaptation Options for Climate-Sensitive Ecosystems and Resources. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research*: 3-1 to 3-127.
- 44 Littell, J., D. Peterson, and K. O'Halloran. 2007. "Adaptation to Climate Change in Olympic National Forest: A Case Study." Presentation to *Climate Change: Implications for Olympic Peninsula Forest Ecosystems Forum, Forks, WA, 23 February 2007*.
- 45 State of Washington Engrossed Second Substitute Senate Bill (E2SSB) 5560, Chapter 519, Laws of 2009. State Agencies – Emissions Reduction. Effective Date: 07/26/09.

Setting the Stage:

Ideas for Safeguarding Washington's Fish and Wildlife in an Era of Climate Change

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