HERPETOLOGICAL CONSERVATION IN NORTHWESTERN NORTH AMERICA

DEANNA H OLSON (coordinating editor)

Pacific Northwest Research Station, USDA Forest Service, 3200 SW Jefferson Way, Corvallis, OR 97331

ABSTRACT—Conservation of the 105 species of amphibians, reptiles, and turtles in the northwestern United States and western Canada is represented by a diverse mix of projects and programs across ten states, provinces, and territories. In this paper, 29 contributing authors review the status of herpetofauna by state, province or territory, and summarize the key issues, programs, projects, partnerships, and regulations relative to the species and habitats in those areas. Key threats to species across this expansive area include habitat degradation or loss, invasive species, disease, and climate change. Many programs and projects currently address herpetological conservation issues, including numerous small-scale monitoring and research efforts. However, management progress is hindered in many areas by a lack of herpetological expertise and basic knowledge of species' distribution patterns, limited focus within management programs, insufficient funds, and limited communication across the region. Common issues among states and provinces suggest that increased region-wide communication and coordination may aid herpetological conservation. Regional conservation collaboration has begun by the formation of the Northwest working group of Partners in Amphibian and Reptile Conservation.

Key words: amphibians, reptiles, turtles, Canada, Pacific Northwest, declines, management, PARC

The conservation of amphibians, reptiles and turtles in North America is now of paramount concern because these taxonomic groups are the most threatened among vertebrates worldwide (Turtle Conservation Fund 2002; Stuart and others 2004; Lannoo 2005; IUCN Red List 2008), contributing to the apparent ongoing 6th massive extinction event on Earth (Wake and Vredenberg 2008). Understanding the threats to herpetofauna and their habitats is essential to advance effective conservation approaches. Common herpetological conservation issues among locations may lead to development of collaborative efforts across larger regions, increasing the collective conservation capacity for these animals. This process of identifying threats and integrating efforts across spatial scales for herpetological conservation is only beginning in northwestern North America.

Native herpetofauna in the northwestern United States and western Canada includes 105 species (Appendix 1). This fauna includes a host of both endemic species with restricted ranges, and broad-ranging taxa, where only the edge of their distributions may enter northwestern areas (for example, Nussbaum and others 1983; Stebbins 1985; Storm and Leonard 1995; St. John 2002; Maxell and others 2003; Werner and others 2004; Jones and others 2005; Matsuda and others 2006; Corkran and Thoms 2006; Slough and Mennell 2006). Salamanders are the most diverse (n = 31 species), followed by snakes (n = 25), frogs and toads (n = 22), lizards (n = 18), freshwater turtles (n = 5), and sea turtles (n = 4). In addition, several non-native species can be found in the wild across the northwest, and 1 turtle and 1 frog are native in the eastern portion of the region and introduced to the western portion (Appendix 1). Several taxonomic revisions have been recently identified (Spotlight 1, Appendix 1).

Native herpetological diversity in northwestern North America is in part a result of the complex geological processes that formed the massive mountain ranges and large plains of the region and subsequently split historical species ranges, fragmented habitats, and altered climates and habitats (Nussbaum and others 1983). Furthermore, glacial history has left a profound signature upon the ranges of herpetofauna throughout northwestern Canada and the United States, where both refugia and post-

Spotlight 1 — Dynamic Taxonomy

DEANNA H OLSON

Animal taxonomy has been undergoing refinement as new molecular techniques, such as those examining mitochondrial and nuclear DNA, help resolve relationships. Herpetological societies and organizations have had a role in endorsing new phylogenies by adopting name changes. However, at this time, there is considerable controversy regarding some of the changes that have been recently proposed for herpetofauna (Weins 2007; Pauly and others 2009). Criticisms range from there being insufficient science to warrant some name changes to some of the proposed name changes being arbitrary, leading to instability and confusion, or being impractical. It is important to note that we are in a timeframe of rapid change in this regard, and the scientific names of herpetofauna in northwestern North America are part of this ''taxonomic chaos'' (Pauly and others 2009). Because the dust has yet to settle on several names, it is important to recognize the alternative names that may be used for regional organisms (Appendix 1).

At the broadest scale of biological organization for herpetofauna, The Center for North American Herpetology now recognizes the former chordate class Reptilia as being 3 separate classes: Reptilia (lizards and snakes); Chelonia (turtles); and Eusuchia (crocodilians) (summary available at: http://www.cnah.org/taxonomy.asp). However, it should be noted that whereas in this case the science is not being refuted, there is ongoing discussion regarding the practicality of adopting this new taxonomy, and the term ''reptile'' is still in common usage to indicate any of these groups. Also, chordate phylogenetics continues to support the relatively distant relationship of amphibians to these 3 classes (for example, amphibians are more related to mammals than reptiles; http://www.cnah.org/taxonomy.asp), yet the traditional context of grouping amphibians, turtles, reptiles, and crocodilians together as herpetofauna persists.

Relationships at the family, genus and species levels also are being investigated and revisions are being proposed. In the northwest US and western Canada, there are both new species becoming recognized, in addition to new names being proposed for ''old species'' (Appendix 1). For example, new species proposals include the Scott Bar Salamander, *Plethodon asupak* (Mead and others 2005), Western Rattlesnake, *Crotalus oreganus* (Pook and others 2000; Ashton and de Queiroz 2001; Douglas and others 2002), Sierra Newt, *Taricha sierrae* (Kuchta 2007; formerly the California Newt, *Taricha torosa*, occurring in the northern Sierra Nevada of California), and Sierran Treefrog, *Pseudacris sierra* (Recuero and others 2006a,b; formerly the central clade of ''*regilla*'' occurring from Humboldt County, California, into the Sierra Nevada Mountains, eastern Oregon, Idaho and Montana). Molecular analyses also have resulted in re-naming proposals of known taxa including the American Bullfrog (*Lithobates catesbeianus*, formerly *Rana catesbeiana*), and Western Toad (*Anaxyrus boreas*, formerly *Bufo boreas*) (Frost and others 2006, Crother 2008). However, Pauly and others (2009) specifically refute the *Rana* and *Bufo* changes, and propose that new names be considered as Subgenus classifications. In their scheme, *Bufo boreas* would be *Bufo Anaxyrus boreas*, both *Rana catesbeiana* and *R. clamitans* would be in the *Rana Aquarana* group, and *Rana Amerana* would include *boylii*, *luteiventris*, *aurora* and *cascadae*. This is a dynamic situation, and more changes can be anticipated (e.g., Western Toad diversity has been described, Goebel and others 2009; Black Salamander [*Aneides flavipunctatus*] phylogeography is under study, Rissler and Apodaca 2007).

glacial colonization are evident in today's distribution patterns (Nussbaum and others 1983; for example, Western Toads[1], Goebel and others 2009). Whereas past events have shaped trajectories to extant taxa, northwestern herpetofaunal diversity is certainly reflective of current landscape diversity (for example, ''physiographic provinces'' of Nussbaum and others 1983; ''elements'' of Bury and Bury 2005), being representative of 29 ecoregions in the area (Pilliod and Wind 2008). Clear shifts in species

[1] Species binomials appear in Appendix 1.

TABLE 1. Native species richness of amphibians, turtles, and reptiles in 10 northwestern states and provinces, ordered by species richness. Sea turtles are included in parentheses and totals. Species with uncertain ranges are excluded.

	Amphibians			Reptiles		
State or Province	Frogs/Toads	Salamanders	Turtles	Snakes	Lizards	Total
No. California	12	21	1 (4)	17	11	66
Oregon	13	19	2 (4)	15	11	64
Washington	11	14	2 (4)	12	7	52
Wyoming	11	1	4	13	8	37
British Columbia	11	9	1 (4)	9	2	36
Idaho	8	4	1	12	10	35
Montana	9	4	3	10	4	30
Alberta	8	2	1	7	1	19
Alaska	3	3	0 (4)	0	0	10
Yukon Territory	4	0	0	0	0	4
Regional Total:	22	31	9	25	18	105

richness are evident with ecoregion, latitude and longitude (Appendix 1). Diversity peaks in northern California and Oregon (n = 66 and 64 species, respectively), with the Klamath-Siskiyou herpetofauna being particularly diverse (Bury and Pearl 1999), and is lowest in Yukon Territory (n = 4 species) (Table 1).

Within ecoregions, species-habitat associations further define distributions at finer spatial scales; due to microhabitat associations and limited dispersal abilities, distributions can be extremely patchy. A species may not occupy all suitable habitats within its apparent range due to a combination of factors including stochastic events affecting the dynamics of small populations and the lingering legacies of various past disturbances. Furthermore, cryptic tendencies of many species reduce detection probabilities and increase uncertainty regarding their status. Consequently, herpetological conservation concern can be heightened, and understanding the issues may be complex. The unique situation of these types of little-known species is gaining attention, and often requires combined species-specific and habitat-based conservation approaches (Raphael and Molina 2007).

In this paper, 29 contributing authors synthesize herpetological conservation needs and activities across this vast region, which extends over 1600 km west-to-east from the Pacific Ocean to Alberta, Montana and Wyoming, and 3800 km south-to-north from northern California to Alaska and Yukon Territory. We aim to: 1) review known and suspected threats to species, other conservation issues, and existing programs that occur at the scale of each U.S. state and Canadian province or territory; and 2) promote collaborative relationships that advance regional herpetological conservation efforts.

STATE, PROVINCE AND TERRITORY SUMMARIES

Northwestern herpetological conservation issues, programs, projects, partnerships, priorities, and regulations were summarized by representatives from 10 jurisdictions: British Columbia, Alberta, Yukon, Alaska, Montana, Wyoming, Idaho, Washington, Oregon, and northern California.

British Columbia (Purnima Govindarajulu)

Amphibians, reptiles, and turtles are the most threatened vertebrate groups in British Columbia. Of the 32 native species, excluding sea turtles (Appendix 1; Matsuda and others 2006), over half are listed in the provincial or federal conservation assessments, including 3 of 9 (30%) salamanders, 7 of 11 (64%) frogs, 1 of 1 (100%) turtles, 1 of 2 (50%) lizards and 6 of 9 (66%) snakes. Four sea turtles are occasionally sighted in near-shore areas, and are an additional concern (Appendix 1); Leatherbacks are ''red-listed'' (endangered).

The key threats facing these taxa can be divided into 3 groups depending on scale of the threat. At the largest scales are global impacts such as climate change and emerging infectious diseases. Next are regional threats affecting animals and habitats at landscape scales, such as forestry, mining, oil and gas exploration, and hydro-power projects; these threats typically

Spotlight 2 — Forest Management and Amphibians in the Pacific Northwest

ANDREW J KROLL AND JAMES G MACCRACKEN

Conservation of biological diversity is an increasingly visible component of intensive forest management in the Pacific Northwest. Potential impacts of timber harvest on forest-dwelling amphibians have been a continued concern due to widespread commercial forestry encompassing the ranges of several endemic taxa, including the genera *Ascaphus* (tailed frogs), *Dicamptodon* (giant salamanders), and *Rhyacotriton* (torrent salamanders), and selected *Plethodon* species (woodland salamanders). Several studies have reported significant differences in amphibian abundance between managed and unmanaged stands and that harvest operations significantly reduce amphibian abundance (for example, Corn and Bury 1989; Dupuis and Steventon 1999). Reduction of late-successional forest and associated intensification of forest management practices has raised concerns about the long-term viability of amphibians on managed landscapes. However, relationships between species and forest management practices are complex for 2 reasons. First, spatial and temporal variation in research results implies that site-specific (for example, stream, forest stand, local climate) characteristics and species differences may interact with management actions to influence amphibian responses (for example, coastal versus inland climate influence—Diller and Wallace 1994; Raphael 1988; Welsh 1990; Welsh and Lind 1988, 1995; landform influence -Dupuis and others 2000; Russell and others 2004; microhabitat cover availability – [down wood] Rundio and Olson 2007; [coarse substrates] Kluber and others 2008). Second, several previous research efforts have not evaluated the assumption that amphibian detection probability does not vary spatially or temporally, or is equal to 1 (for general and specific evaluations of this assumption, see Bailey and others 2004a, 2004b; MacKenzie 2005; MacKenzie and others 2005; McKenny and others 2006), a consideration that should be taken into account when interpreting results. While effectiveness of regulatory forest management practices (for example, Washington state Forest and Fish Rules, federal Northwest Forest Plan riparian reserves) is currently under assessment, several amphibian taxa appear to occur at relatively high densities in some stands that have sustained repeated harvests and only recently received regulatory protection, suggesting either population resilience or recolonization of suitable habitat (for example, Stoddard and Hayes 2005; Olson and Rugger 2007; Kluber and others 2008; Kroll and others 2008). Novel research approaches to experimentally examine regulatory prescriptions while incorporating detectability probabilities for target species (Kroll and others 2008) are needed regionally to improve the strength of inference about relationships between management practices and amphibian responses to untangle the apparently complex relationships.

occur at a scale > 25 km^2. At smaller scales are the diverse threats arising from human encroachment, including agricultural expansion, grazing, residential and recreational development, roads, wetland loss and modification, fish stocking, introduced species, feral pets, and chemical pollution. The lack of baseline population trend monitoring also can be considered a threat, as it hampers early detection of declines and effective conservation planning. The greatest threat is human encroachment, with 14 species affected compared to 4 or 5 species in the other threat categories.

At the level of global threats, a collaborative project among Ministry of Environment, academia and non-government organization (NGO) researchers initiated in 2008 will map the prevalence of the amphibian chytrid fungus, *Batrachochytrium dendrobatidis* (*Bd*), across the province, increase surveillance for amphibian mass mortalities and assess the ecological drivers of *Bd* emergence. *Bd* presence has been documented in many amphibians in BC (Garner and others 2006; Adams and others 2007) and has caused mortalities in Northern Leopard Frogs.

At the regional scale, forestry activities can have adverse effects on native herpetofauna (Spotlight 2) (for example, Dupuis and Steventon 1999; Wahbe and others 2004). The Forest and Range Practices Act can provide protection for identified herpetofauna of conservation

concern through the establishment of Wildlife Habitat Areas and Wildlife Habitat Features that protect breeding and hibernation sites. Monitoring effectiveness of these measures in achieving conservation goals for tailed frogs, Gopher Snakes, and Western Rattlesnakes is ongoing. There is no information on the extent of effects of other industrial threats such as oil and gas exploration and independent power projects, and there are no specific industry regulations concerning herpetofauna.

Although human encroachment is identified as the foremost threat, management of these threats is difficult because the impacts are small scale, localized, and regulated by various levels of government. There are few regulations that provide habitat protection. For example, important amphibian breeding habitats such as small ephemeral wetlands are offered little protection because most regulations are centered on fish habitat or water sources for humans.

Currently, conservation projects to mitigate human encroachment are primarily carried out by NGOs such as stewardship groups, naturalist clubs, private zoos/aquaria, conservancy councils, volunteers, and by some hydro-dam compensation programs. These projects include head-starting of tadpoles of endangered Spotted and Northern Leopard Frogs, creation of ephemeral wetlands, surveys for rare and sensitive species, invasive species control, and public education efforts. Although these efforts have achieved significant gains, they are often plagued by lack of long-term funding.

Efforts similar to the baseline, mid-level and apex monitoring schemes of the Amphibian Research and Monitoring Initiative (ARMI, Spotlight 3) are underway to establish long-term monitoring sites in collaboration with volunteers, NGOs, academia and private consultants to address the lack of knowledge regarding long-term population trends. Major priorities for herpetological conservation in BC include: 1) increasing awareness of human encroachment threats to herpetofauna; 2) increasing coordination to better manage threats; and 3) addressing knowledge gaps in distribution, threats, population trends, and effectiveness of recovery efforts. These efforts are strongly dependent on long-term funding and effective data management.

Alberta (Kris Kendell)

Eight species of reptile, 1 turtle, and 10 species of amphibian are known to occur in Alberta. In this province, many reptiles and amphibians are at the most northern part of their North American distribution and must cope with harsh climatic conditions. The greatest diversity of reptiles and amphibians is found in the grasslands natural region of southern Alberta. However, some reptile and amphibian species also are found farther north into Alberta's parkland, boreal forest, foothills, and Canadian Shield natural regions.

Habitat loss and alteration is the most pervasive threat to reptile, turtle, and amphibian populations in Alberta. Chemical contaminants, such as pesticides, herbicides, and fertilizers, introduction of exotic predators, and road kill also contribute to population declines in Alberta. Less visible factors, such as increased ultraviolet radiation, disease, and climate change further threaten Alberta's herpetofauna. Furthermore, poor knowledge of the historical and current distribution, and the lack of long-term habitat occupancy and trend data for many species have hindered the ability of Alberta biologists to understand changes in herpetofauna populations.

Alberta Sustainable Resource Development has initiated a general status exercise as an initial evaluation of the well-being of wild species populations in Alberta. The General Status of Alberta Wild Species 2005 lists Alberta's herpetofauna as ''At Risk'' ($n = 2$ species), ''May be at Risk'' ($n = 5$ species), ''Sensitive'' ($n = 8$ species), and ''Secure'' ($n = 3$ species). Further research is required to determine the status of 1 snake species in Alberta. Species designated as ''May be at Risk'' receive a detailed status assessment, which is used to determine whether there is reason to recommend that a species be considered ''At Risk'' and protected as Endangered or Threatened under Alberta's Wildlife Act (www.srd.gov.ab.ca/fishwildlife/status/).

Species protected under Alberta's Wildlife Act qualify for a recovery plan under the supervision of the Alberta Fish and Wildlife Division. Currently, the Northern Leopard Frog is the only herpetological species in Alberta with an established recovery team and a recovery plan (Alberta Northern Leopard Frog

Spotlight 3 — The USGS Amphibian Research and Monitoring Initiative in the Pacific Northwest

PAUL STEPHEN CORN

The Amphibian Research and Monitoring Initiative (ARMI) was established in 2000 by the U. S. Geological Survey (USGS), with broad goals to determine the status and trends of amphibians in the United States and to conduct research on the causes of declines (Corn and others 2005b; Muths and others 2005). ARMI is a partnership within USGS, with participation by biologists, hydrologists, and geographers, and each of ARMI's 7 regions has one or more lead scientists from USGS's Biology and Water Disciplines. Three ARMI regions include portions of the Pacific Northwest, and lead scientists include: Michael Adams, Forest and Rangeland Ecosystem Science Center, Corvallis, Oregon; Chauncey Anderson, Oregon Water Science Center, Portland; Stephen Corn, Northern Rocky Mountain Science Center, Missoula, Montana; Gary Fellers, Western Ecological Research Center, Point Reyes, California; and Erin Muths, Fort Collins Science Center, Colorado.

Monitoring under ARMI adheres to a hierarchical 3-tiered framework or pyramid, from atlas and inventory studies at the base, to intensive population studies at a few select sites at the top (for example, Muths and others 2006). Emphasis, however, is at the middle level—on monitoring amphibian species within well-defined areas (for example, national parks), where sample locations are selected using a probabilistic scheme and status of amphibians is determined by changes in occupancy (MacKenzie and others 2006). Examples of mid-level monitoring by ARMI include the national parks of the Continental Divide (Corn and others 2005a), Department of Interior lands in the Willamette Valley (Adams 2006), and public lands surrounding Lassen Peak in California (Fellers and others 2008).

Research by ARMI into causes of amphibian declines covers a broad range of topics, including development of new techniques, and is often specific to a regional issue. Recent work by ARMI scientists in the Northwest has contributed to understanding the phylogeography of the Western Toad species complex (Goebel and others 2009) and interactions between dispersal, landscape, and genetic variation in Columbia Spotted Frogs (Funk and others 2005a,b), developed new techniques for detecting the amphibian chytrid fungus *Bd* (Kirshstein and others 2007), evaluated effectiveness of reintroduction efforts (Muths and others 2001; Dreitz 2006; Fellers and others 2007; Muths and Dreitz 2008), and examined the effects of a variety of influences on amphibian populations. These include fire (Bury 2004; Hossack and others 2006a; Hossack and Corn 2007, 2008; Guscio and others 2008), livestock grazing (Adams and others 2009), contaminants (Sparling and Fellers 2007), invasive species (Knapp and others 2001; Adams and others 2003), ultraviolet radiation (Adams and others 2001, 2005; Corn and Muths 2002; Palen and others 2002; Hossack and others 2006b), climate and weather (Corn 2003, 2005; Scherer and others 2005, 2008), and disease (Adams and others 2007; Pearl and others 2007; Murphy and others 2008; Muths and others 2008; Petrisko and others 2008; Hossack and others 2009). For more information, visit the ARMI web site at http://armi.usgs.gov.

Recovery Team 2005). The recovery plan focuses on: the protection of exiting populations from anthropogenic disturbances; population inventories and monitoring; habitat assessments; the reintroduction (translocation) of frogs to some sites within their historical range; the implementation of stewardship projects with cooperative landowners; and the collection of additional data to aid in reintroduction efforts, including population genetics and disease surveillance work.

Several other conservation-oriented research, management, and outreach projects, programs, and initiatives are underway in the province. In 2008, the Valley Zoo, John Janzen Nature Centre in Edmonton, and the Calgary Zoo participated in the international ''Year of the Frog'' campaign that focused on public education about local amphibian species, and the global crisis affecting amphibians. Grassroots organizations play an important role in herpetological conservation in Alberta. For example, the Friends of Fish Creek Provincial Park Society is partnering with Fish Creek Provincial Park (Fish Creek District) within the City of Calgary to conduct

volunteer-based monitoring studies on local amphibian and gartersnake populations. The Alberta Volunteer Amphibian Monitoring Program and Alberta Snake Hibernaculum Inventory are delivered by the Alberta Conservation Association (ACA); these programs aim to increase awareness of the conservation issues facing amphibians, reptiles, and turtles and provide a better understanding of their distribution in Alberta. Volunteers submit their observations of species locations, including snake den locations, to the ACA, which are reviewed and then forwarded to Alberta Sustainable Resource Development (2005) for uploading into the Fisheries and Wildlife Management Information System. Other innovative projects in the province include examining the feasibility of using culverts as a means of reducing road mortality of a dwindling population of Long-toed Salamanders in southwestern Alberta, investigating macro- and micro-habitat use of Western Toads in north-central Alberta using radio telemetry, and a multi-species program called MULTISAR that promotes conservation on a landscape level. Lastly, an annual Alberta Amphibian and Reptile Specialist Group workshop has convened each year since its inception in 1996.

Yukon Territory (Brian G Slough)

The Yukon Territory and northern British Columbia (BC) (north of 59°N) are home to 5 amphibian species and no reptiles or turtles. The Wood Frog is the most wide-ranging species, and is found below treeline to 68°N. Three other species cross the Yukon border at 60°N, including the Columbia Spotted Frog, Western Toad, and Boreal Chorus Frog (Slough and Mennell 2006). The Long-toed Salamander ranges to the Taku River in northwestern BC. The Western Toad is listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2002) as a species of ''Special Concern'' since they are relatively intolerant of urban expansion, conversion of habitat for agricultural use, non-native predators and competitors, and disease. The other species are considered secure in BC, however the Western Toad is ''Sensitive'' and both the Columbia Spotted Frog and the Boreal Chorus Frog ''May be at Risk'' in the Yukon (Canadian Endangered Species Conservation Council 2006) where they have few occurrences and small areas of occupancy.

The major issues facing amphibians in northern Canada are climate change and emerging diseases. Parks Canada has initiated a Wood Frog Calling Survey in Kluane National Park (C Wong, pers. comm.), and Nature Serve Yukon maintains a biodiversity database of amphibian records. The governments of BC and the Yukon, Nature Serve Yukon, Parks Canada, Environment Canada, and the Northern Research Institute at Yukon College have supported amphibian surveys.

Recent projects (BG Slough, principal investigator) in northern BC and the Yukon include long-term monitoring of a winter breeding Western Toad population in northwestern BC and surveys for the amphibian chytrid fungus *Bd* (detected in Western Toads and Wood Frogs as far north as Coal River, Yukon; Slough 2009).

Alaska (Kim Hastings and Sanjay Pyare)

Six amphibians reach the northern limits of their natural ranges in Alaska, along with 4 sea turtles occasionally found in near-shore ocean areas (MacDonald and Cook 2007) (Appendix 1). Most of the amphibians are restricted to the southeastern portion of the state, with the notable exception of the Wood Frog. Although endemism is relatively common in the island archipelago of southeastern Alaska (Cook and others 2001), it has not been investigated in amphibians. State conservation status ranks for the 6 amphibian species range from imperiled (Columbia Spotted Frog, JR Lindell and EM Grossman, unpubl. data) to widespread, abundant and secure (for example, Wood Frogs). Two introduced frogs also are found in the state, the Northern Red-legged Frog and the Pacific Treefrog.

Habitat alteration is a key issue in Alaska. Habitat fragmentation is a concern particularly in southeastern Alaska, because the Tongass Land Management Plan does not consider the critical roles forested habitats play in non-breeding life stages, especially for overwintering and migration to and from breeding sites. Western Toads in southeastern Alaska spend $> 95\%$ of their life in areas located up to several kilometers from aquatic breeding sites (S Pyare, unpubl. data); much of this in forested habitats. Areas that experienced greater historical logging have lower occupancy among Western Toad populations in the region (S Pyare,

unpubl. data). In addition, Western Toads, and possibly other species, appear to occasionally use streams during post-breeding dispersal phases. While road culverts create fish passage restrictions, especially on smaller streams, the effects of poorly designed culverts on amphibian movements are unknown. Climate change is a cause of concern, but there is little information about phenology and breeding habits of amphibians in Alaska, and impacts from changes in habitat microclimates are difficult to evaluate.

Disease, and to a lesser degree species introductions, are significant concerns. Preliminary sampling found the chytrid fungus, *Bd*, in frog and toad populations, in the southeast and south-central regions of the state (Reeves and Green 2006; Adams and others 2007; Reeves 2008). These results are accompanied by anecdotal reports of declines in Western Toad populations, although no causal link has been investigated. Amphibian deformities have been detected in Wood Frogs in south-central Alaska (KA Trust and H Tangerman, unpubl. data) and surveys noting deformities are continuing in this area. An introduced population of Northern Red-legged Frog is being monitored as it spreads (L Lerum, R Piehl, unpubl. data).

Individuals from government agencies and non-governmental organizations have begun coordinating amphibian conservation efforts in Alaska. An internet mailing list was established in 2003 and the first 2 statewide Alaska Amphibian Conferences were held in 2004 and 2006. In 2005, Alaska's Comprehensive Wildlife Conservation Strategy (CWCS; http://www.sf.adfg.state.ak.us/statewide/ngplan/) identified statewide information and conservation needs for amphibians. In 2007, the Alaska Amphibian Working Group was established to: 1) facilitate networking among members; 2) coordinate knowledge-gathering about amphibians and their habitats in Alaska, and further the dissemination of that knowledge; and 3) promote conservation of amphibians as integral parts of Alaskan ecosystems. A website (www.alaskaherps.org) is currently being developed. Research priorities include amphibian distributions, status and trends, continued surveys for the presence of *Bd* (especially in south-central and interior portions of Alaska), and assessments of threats posed by climate change. In addition, Alaska amphibian populations could play important research roles by serving as outgroups for regional and national genetic and phylogeographic analyses, understanding basic life history and ecology in relatively pristine settings, and population trends at a climate change frontier.

Montana (Paul Hendricks and Bryce Maxell)

Despite encompassing nearly 380,730 km^2, Montana is home to only 13 native amphibians, 14 native reptiles, and 3 native turtles, with breeding populations of 2 additional exotic species: American Bullfrog and Western Fence Lizard. Because of its interior continental location astride the Rocky Mountains, Montana includes Great Plains, Rocky Mountain, Pacific Northwest, and Great Basin faunal elements. Range boundaries for most of the native species intersect Montana, and all confirmed Montana records for Coeur d'Alene Salamander, Idaho Giant Salamander, and Western Skink in the northwest, and Smooth Greensnake in the northeast, are within 60 km of the state border.

Of the native herpetofauna, 15 species (50%) are currently Montana Animal Species of Concern (SOC; Montana Natural Heritage Program and Montana Department of Fish, Wildlife, and Parks 2009), and 9 of these are considered of greatest conservation need in Montana's Comprehensive Fish and Wildlife Conservation Strategy (Montana Department of Fish, Wildlife, and Parks 2005). The SOC species include the 4 previously noted with very limited distributions, as well as others more widely distributed but with evidence for declines (Northern Leopard Frog, Western Toad, Greater Short-horned Lizard; Maxell and others 2003; Werner 2003), or for which there are insufficient records to determine range and status with confidence (Great Plains Toad, Plains Spadefoot, Spiny Softshell, Snapping Turtle, Northern Alligator Lizard, Common Sagebrush Lizard, Milksnake, Plains Hog-nosed Snake). Although none are listed under the federal Endangered Species Act, 11 of 15 SOC are recognized by the U.S. Forest Service and/or Bureau of Land Management as species of conservation concern in Montana.

The base-level, mid-level and apex monitoring schemes established by the Amphibian Research and Monitoring Initiative (ARMI, Spotlight 3) are being implemented in Montana to address data deficiencies for amphibians. Base-level statewide occupancy surveys of more

than 8,650 water bodies in 571 watersheds have been completed in the last 8 y (Maxell 2009), adding over 10,400 observation records and nearly doubling the number of records that were available for recent state herpetological publications (Maxell and others 2003; Werner and others 2004). Mid-level monitoring and apex-level population studies and research efforts are mostly being conducted in Glacier and Yellowstone National Parks and on US Fish and Wildlife Service Refuge lands (e.g., Corn and others 2005a; Muths and others 2005; Hossack and others 2006b; Hossack and Corn 2007). Data deficiencies for reptiles are much more extensive. Base-level statewide occupancy surveys for reptiles in rock outcrops only began in 2008 as part of a collaborative effort between the Montana Natural Heritage Program and the Montana Department of Fish, Wildlife, and Parks and are expected to be completed in 2011. Research on the population biology, ecology, and conservation of reptiles has been limited to an ongoing radio-telemetry study of the Spiny Softshell in the Yellowstone and Missouri Rivers, and a demographic study of the Greater Short-horned Lizard in the south central portion of the state. Consequently, little is known about the population biology, ecology, and conservation concerns for Montana's reptiles.

Documented or suspected threats to Montana's herpetofauna are numerous (Maxell 2000; Maxell and others 2009), and include a variety of natural and human-caused disturbances and habitat alterations, as well as state-wide occurrence of pathogens such as amphibian chytrid fungus (*Bd*) and possibly a virus affecting Tiger Salamanders (Muths and others 2008; Maxell and others 2009). Stand-replacing fires, cattle grazing, fish stocking, and energy development are perhaps the most immediate threats affecting the native herpetofauna at the landscape scale. American Bullfrog populations are widespread in the valley bottoms of western Montana and are expanding from centers of introduction across the state. Significant reptile mortalities are commonly observed on primary and secondary roads across the state.

Programs enacted to mitigate detrimental impacts have been few, but include the reintroduction of Northern Leopard Frogs and the creation of highway crossings for Painted Turtles through a wetland complex in the Mission Valley on the Flathead Indian Reservation. Significantly, there is increased awareness among federal land managers, in southwestern and eastern portions of the state, of the need to protect springs from the impacts of livestock by creating partial or complete livestock exclosures that prevent the destruction of surface water flow and wetland vegetation, and reduce trampling mortality of amphibians.

Wyoming (Alan Redder)

Wyoming' herpetofauna reflect its high altitude and dry climate. There are 37 native species, including 1 salamander, 5 frogs, 6 toads, 4 turtles, 13 snakes, and 8 lizards, with many of these taxa found mostly at the edges of the state and at the limits of their geographic distributions. The Ornate Box Turtle may have been extirpated in Wyoming, but surveys are needed for confirmation. Elevation is the main determinant of amphibian, reptile, and turtle distributions in Wyoming; high altitude grassland and shrubland basins (>1433 m [>4700 ft]) are bisected by various mountain ranges, resulting in a transitional herpetofauna composed of a mix of Great Plains, Great Basin and northern and southern Rocky Mountain elements. Some populations (Wyoming Toad, Smooth Greensnake, Wood Frog) appear to be relicts from previous more widely distributed ranges. Relatively few data are available from the eastern third of the state due to the prevalence of private land, and from the Wind River Indian Reservation where access is limited.

Major impacts on this fauna arise from mineral development. The extraction of groundwater as part of coalbed methane development in the Powder River Basin region threatens to change the chemical, thermal and flow characteristics of streams in northeastern Wyoming. Groundwater is pumped from coal seams to release methane; the resulting water is cold and clear compared to the generally shallow warm silty streams. Groundwater discharge also changes the water level and timing of peak and minimum stream flows. Effects of hydrologic changes and increased human activity on herpetological populations are under investigation by the Bureau of Land Management (BLM), Wyoming Game and Fish Department and the Wyoming Natural Diversity Database

(WYNDD). The BLM is funding herpetological surveys in 2008 by WYNDD personnel on the mainstem of the Powder River and some of its larger tributaries.

Watersheds in the rest of the state face greatly increased disturbance from conventional oil and gas exploration and production. Road construction for well pads and infrastructure has resulted in large areas with very dense road networks, which are likely to increase direct mortality for many species as well as increased habitat fragmentation. Watersheds in the center of the state could see similar increased disturbance due to the resumption of uranium mining. For example, the area around Flaming Gorge, which contains the only populations of Midget Faded Rattlesnakes (*Crotalus oreganus concolor*), is likely to be severely affected by mining activity.

Western Toad populations in both the Greater Yellowstone area and the Snowy Range and Sierra Madre in the southeast have been severely reduced. The fungus *Bd* has been found in most anuran species at many locations throughout the state including Yellowstone National Park. No Western Toads have been seen in southeastern sites since 2003. WYNDD, in cooperation with the Shoshone NF, conducted further surveys for Western Toads in the Greater Yellowstone Ecosystem during the 2008 and 2009 field seasons.

A cooperative multi-agency reintroduction program is in progress for the Wyoming Toad. Besides 1 site in the Laramie Basin where it persists, 2 other locations have been stocked with tadpoles. Successful over-winter survival has occurred at the Porter Lake site, but none have yet been observed at the Rock River site. Other local wildlife refuges are being considered for additional reintroductions.

Idaho (William Bosworth and Charles R Peterson)

Idaho's native herpetofauna comprises 12 amphibians, 22 reptiles, and 1 turtle (Appendix 1, Table 1). Additonally, the American Bullfrog and the Rough-skinned Newt are naturalized. Only a single nonnative turtle, the Pond Slider, is known to occur in the state, but information is not yet sufficient to determine whether breeding populations are established. Approximately 1 in 4 species are thought to be rare or declining in Idaho. None are currently listed under the federal Endangered Species Act, but a population segment of the Columbia Spotted Frog, comprising part of the range occurring south of the Snake River in southwestern and south-central parts of the state, is a Candidate for listing. One species, the Wood Frog, may be extirpated from Idaho. Conservation priorities for at-risk species are identified in the Idaho Comprehensive Wildlife Conservation Strategy (IDFG 2005), which is a document intended to facilitate communication, coordination, and collaboration among resource management agencies and other entities active in conservation efforts within the state. The Strategy lists 11 herpetological species among the Species of Greatest Conservation Need within Idaho. By intention, this list includes all special-status species recognized by resource management agencies.

Current known and suspected threats to amphibian populations in Idaho include disease, habitat changes resulting from resource use, invasive species, and climate change. Among pathogens, the amphibian chytrid fungus, *Bd*, is of particular interest, but its current distribution and impacts on amphibian population viability are poorly known. Loss of riparian wetlands and isolated water bodies arising from climate change and resource use is also of primary importance to amphibian conservation.

Reptile populations in Idaho are affected by habitat change in xeric systems throughout the state. Invasive plants, such as Cheatgrass (*Bromus tectorum*), have had tremendous, widespread effects on vegetation structure, invertebrate and mammal prey availability, and successional processes, such as fire frequency and severity. In addition, road-kill is a significant concern for snakes.

Management, conservation, and research activities in Idaho are often collaborative projects among state and federal agencies and universities. The highest-profile management activities are currently focused on Columbia Spotted Frog habitat in the southwestern part of the state. Collaboration between state agencies (Idaho Department of Lands and Department of Fish and Game [IDFG]) and the US Fish and Wildlife Service has resulted in changes to livestock grazing management and other habitat management activities on an important wetland. Research and conservation activities include inventory and monitoring projects. Examples include surveys of lentic-breeding

amphibians in northern Idaho (a collaboration between IDFG and the US Forest Service); surveys of amphibians and reptiles in south-central Idaho (IDFG and the US Bureau of Land Management), studies of Idaho Giant Salamander distribution, habitat associations, and landscape genetics (IDFG and University of Idaho); surveys and monitoring of amphibian populations on the Caribou-Targhee National Forest (US Forest Service, IDFG, and the Idaho State University Herpetology Laboratory); surveys, habitat modeling, and population monitoring of reptiles on the Idaho National Laboratory (US Department of Energy, Environmental Science and Research Foundation, Inc., Stoller Corporation, and the Idaho State University Herpetology Laboratory). The National Park Service has inventoried amphibians and reptiles on all their lands. Idaho Power has funded extensive surveys of amphibians and reptiles in areas affected by their dams. The US Bureau of Land Management has funded scores of amphibian and reptile challenge cost-share projects. Information from these projects is intended to inform land-use decisions implemented by land and resource management agencies.

Oregon (Deanna H Olson and R Bruce Bury)

Oregon is home to 60 native amphibians, reptiles, and freshwater turtles, plus 4 sea turtles, 2 invasive frogs, 2 invasive freshwater turtles, and 1 introduced lizard (Appendix 1, Table 1). Of the native species, excluding sea turtles, 33 (55%) are State Sensitive. Both species of freshwater turtles, Painted Turtles and Western Pond Turtles, are of very high concern. Two frogs (Oregon Spotted Frog and Columbia Spotted Frog) are Candidates for listing under the US Endangered Species Act (ESA). Three sea turtles are ESA-listed as Endangered (Leatherback, Green, Olive Ridley); and 1 is ESA-listed as Threatened (Loggerhead).

Primary threats to Oregon herpetofauna are habitat loss, invasive species, diseases, chemical pollutants, and climate change. The habitat issue is complex, with private land management in urban, rural and forested areas of key concern statewide (for example, Bury 2008a, 2008b). Habitat fragmentation is an issue for many species, with specific concern for connectivity of habitats used throughout a species' life cycle (breeding, foraging, overwintering). Alteration of stream habitats that affect this fauna include the loss of aquatic connectivity due to culverts (Sagar and others 2006), loss of terrestrial connectivity due to upland management (Olson and others 2007; Olson and Burnett 2009), water temperature increases, sedimentation, pollutants, and water impoundments (Olson and Davis 2007; Bury 2008c). Development of riparian forest management alternatives along streams is a key conservation tactic to address numerous species (Bury 2005; Olson and others 2007). Other aquatic threats are nonnative bullfrogs and fishes (Pearl and others 2004, 2005). Chemical contaminants are of particular concern in agricultural areas, and are suggested as contributing factors to losses of species such as Western Pond Turtles (Henny and others 2003) and Oregon Spotted Frogs (Cushman and Pearl 2007; Marco and others 1999). Diseases are a concern for amphibians, including the water mold *Saprolegnia* which has caused mass mortality of eggs, and the aquatic fungus *Bd* (Pearl and others 2007) which is linked to mortality in frogs both regionally (for example, Johnson and others 2006) and globally (for example, Berger and others 1998; Daszak and others 2003). Climate change may have a host of effects, but endemic species with restricted ranges and species with narrow ranges along elevational gradients (for example, in the Oregon Cascade Range) appear to be most vulnerable to altered temperature, precipitation, and snow pack or melt patterns (Spotlight 4) (Blaustein and others 2001; Corn 2003). Related to both projected climate change and past fire suppression activities in forestlands that have resulted in increased fuel loading is an expected increase in the frequency and severity of fires in Oregon as well as the larger northwest region; the effects of this altered disturbance regime on herpetofauna is of greatest concern for rare forest-dependent amphibian species (Bury and others 2002; Pilliod and others 2003; Bury 2004).

Oregon herpetological conservation is best described as a patch-work of measures, programs and projects being undertaken by different groups and individuals. The Oregon Department of Fish and Wildlife has a new ''Conservation Strategy'' for 21 priority species (Spotlight 5). Research on topics related to herpetological

Spotlight 4 — Climate Change and Amphibian Conservation in the Pacific Northwest

NOBUYA SUZUKI

Climate change has increasingly become a concern for conservation of amphibians regionally and worldwide in recent years (Kiesecker and others 2001; Corn 2005; Blaustein and Dobson 2006). However, few studies have assessed effects of climate change on amphibians in the Pacific Northwest (for example, Blaustein and others 2001; Kiesecker and others 2001; Corn 2003). The pattern of climate change in the Pacific Northwest region is highly variable and complex due to El Niño/Southern Oscillation (ENSO) cycles, which return every 2 to 7 y and last <1 to 2 y, and to the Pacific Decadal Oscillation (PDO) cycles, which have alternating cool and warm phases lasting 20 to 30 y (Mantua and Hare 2002; Corn 2005).

Recent studies (Mote 2003; Nolin and Daly 2006; Mote and others 2008) and our results (Suzuki and Olson, unpubl. data) indicate that snow pack levels in the Cascade Range in Oregon and Washington have decreased over time since the beginning of the PDO warm phase in the late 1970s. Most recently, PDO Index values signaled the beginning of a cool phase in 1998, but the patterns have switched back and forth between cool and warm phases for the last decade without snow pack levels fully recovering to the levels of the previous cool-and-wet period which occurred from 1947 to 1976.

To anticipate potential effects of low snowmelt water availability for amphibians, gartersnakes, and other aquatic organisms that are adapted to lentic habitats in the Cascade Range, we are currently developing Geographic Information Systems (GIS) models to determine locations across the landscape where low and unstable snow pack levels may adversely affect ecological and biological processes of lentic habitats. Our model shows that lentic habitats in the Oregon Cascade Range may be more vulnerable to climate change than those in the Washington Cascades due to lower snow pack levels, higher annual fluctuations in snow pack levels, and higher summer temperatures. Identification of geographic locations vulnerable to climate change may be used to focus conservation efforts, for example to manage habitats for connectivity among lentic habitats and to minimize additional human-induced threats to species in these areas.

conservation is being conducted by many individuals, with particularly active programs being conducted at Oregon State University (Spotlight 6), US Geological Survey (Spotlight 2) and the US Forest Service (for example, Olson and others 2007). Inventories on some federal lands have been accruing baseline knowledge of species (for example, Spotlight 7). The Oregon Zoo has programs for captive rearing (headstarting) and reintroduction of Oregon Spotted Frogs and Western Pond Turtles. In Oregon, dominant herpetofauna management needs include increasing our basic understanding of species distribution and abundance patterns, general ecology, and disturbance effects, and implementation of conservation strategies to retain species current distributions.

Washington (Lisa Hallock)

Washington's native herpetofauna includes 25 amphibian, 19 reptile and 2 freshwater turtle species, and 4 sea turtles are occasional visitors to the near-shore coast (Appendix 1). The American Bullfrog is a widespread exotic and the Green Frog and Pond Slider are exotics with limited distributions. Van Dyke's Salamander and Olympic Torrent Salamander are endemic to the state. Two amphibian, 1 turtle, and 2 snake species are listed as critically imperiled by NatureServe state rankings (Northern Leopard Frog, Oregon Spotted Frog, Western Pond Turtle, California Mountain Kingsnake, Striped Whipsnake). The Oregon Spotted Frog is a federal Candidate for listing under the Endangered Species Act.

Primary threats to Washington's herpetofauna are habitat loss, degradation and fragmentation, invasive plant and animal species, diseases, and chemical pollutants. Other threats include lack of information needed to protect and conserve populations, small population sizes, and lack of political will and public interest in the conservation of certain species. Some species are declining even in protected

Spotlight 5 — The Oregon Conservation Strategy: A Blueprint for Statewide Conservation

AUDREY HATCH

All US states and 6 US territories have created State Wildlife Action Plans (SWAPs) as a big-picture framework for wildlife conservation. The Oregon Conservation Strategy is Oregon's SWAP, developed by the Oregon Department of Fish and Wildlife (ODFW). The Strategy uses the best available science to create a vision and conceptual framework for long-term conservation of Oregon's native fish and wildlife. The Strategy identifies priority species, habitats, and areas on-the-ground for conservation action. The Strategy takes an adaptive management approach to incorporate new information; therefore, monitoring is an important component of the Strategy. Several amphibians, reptiles, and turtles are monitoring priorities, and frogs are featured in several outreach tools to promote the Conservation Strategy.

In 2007, ODFW (with partners including Oregon Department of Transportation, Federal Highways, US Forest Service, and US Fish and Wildlife Service) initiated the 1st step of a long-term project to address barriers to wildlife movement, a key statewide conservation issue. ''Wildlife linkages areas,'' important movement areas for wildlife, were identified and mapped as they co-occurred with paved roads. In many cases, establishing these areas will help to identify priorities for management, surveys or other additional work. Oregon wildlife linkage areas, which include areas specific to herpetofauna, are expected to be of interest to partners such as transportation planners and land use planners.

areas for unknown reasons. The impact that climate change may have on Washington's herpetofauna is not well understood.

Effects of disease on Washington's amphibian populations are just starting to be addressed, and both Central Washington and Washington State universities have ongoing research programs (for example, Forson and Storfer 2006; Parris and others 2006). Individual Northern Leopard Frogs (S Wagner, Central Washington University, pers. comm.) and Oregon Spotted Frogs (Hayes and others 2009) have tested positive for the aquatic fungus *Bd*, but effects on populations are largely unknown.

The Washington Department of Fish and Wildlife (WDFW) is responsible for determining wildlife population status, management, and recovery. They are also responsible for enforcement and review of all scientific research that involves capturing amphibians, turtles, and reptiles. These efforts involve partnerships with other government agencies and private organizations, such as the Oregon, Pt. Defiance, Woodland Park zoos and NW Trek, with whom they participate in captive rearing and reintroduction projects for Western Pond Turtle and Oregon Spotted Frog. In consultation with government agencies and nongovernmental organizations, the WDFW developed a Comprehensive Wildlife Conservation Strategy in 2005 that includes wildlife action plans for 19 amphibian, reptile, and turtle species. Other herpetological conservation efforts in the state are undertaken by government agencies (Spotlight 7), private organizations, university researchers and individuals. The Cooperative Monitoring, Evaluation and Research Committee oversees landscape-level studies investigating the impact of forestry practices on stream associated species in western Washington (for example, Hayes and others 2006; Quinn and others 2007). Participants include WDFW, the private timber industry, tribes, Washington Department of Natural Resources (DNR), Washington Department of Energy, US Fish and Wildlife Service and environmental groups. The Washington Natural Heritage Program (DNR) and the US Bureau of Land Management have cooperated on inventories to determine the distribution and status of shrub-steppe herpetofauna. Other examples of recent herpetological inventories include North Cascades and Olympic National Parks (Bury and Adams 2000; Adams and Bury 2002), Hanford Nuclear Reservation (Soll and Soper 1996; LA Hallock, unpubl. data), Ft. Lewis (Adams and others 1998; LA Hallock, WP Leonard, unpubl. data; RB Bury, unpubl. data), and Yakima Training Center (ENSR Consulting). Examples of species-specific inventories include surveys for the Van Dyke's Salamander (Wilson and others 1995; US Survey and Manage Program of the Northwest

Spotlight 6 — Research on Amphibian Decline Topics

ANDREW R BLAUSTEIN AND BETSY A BANCROFT

Conservation of amphibians has been a major focus of several research programs in northwestern North America. Studies of the mechanisms involved in population declines have included long-term field observations, conceptual modeling, laboratory experiments and field experiments, and approaches from the molecular to the community level. We provide examples from our research in Oregon below.

Amphibians are faced with both biotic and abiotic stressors in natural and managed systems (for example, Blaustein and Kiesecker 2002). In Oregon, these include 3 pathogens — an oomycete, *Saprolegnia*; a chytrid fungus, *Bd*; and the trematode, *Ribeiroia* (for example, Blaustein and others 1994, 2005; Blaustein and Johnson 2003), and abiotic stressors such as ultraviolet–B (UVB) radiation, nitrate fertilizers and other contaminants (for example, Bancroft and others 2008). There are interspecific and often intraspecific differences in susceptibility to stressors, making it difficult to generalize how specific stressors affect ''amphibians.'' For example, anuran species vary in their response to *Saprolegnia* infection; high embryonic mortality due to infection occurs in Cascades Frogs and Western Toads but not Northern Pacific Treefrogs. Northwest anuran larvae also show interspecific variation in susceptibility to *Bd* (Blaustein and others 2005). Variation in susceptibility to disease may contribute to pathogen-induced changes in species interactions and community structure. For example, the differential effects of *Saprolegnia* on larval recruitment of Northern Pacific Treefrogs and Cascades Frogs reversed the outcome of competitive interactions between the 2 species (Kiesecker and Blaustein 1999). Amphibians also respond to stressors at the molecular and physiological levels (Blaustein and Belden 2003). We have measured the ability of Oregon amphibians to repair UV-induced DNA damage by measuring activity of the repair enzyme photolyase and quantified a more general stress response by measuring stress hormones and stress-induced protein levels.

Our research reveals complex interactions among stressors and how they affect amphibians. This can be illustrated, for example, by the complex interactions among pathogens, UVB radiation and climate change. The effects of *Saprolegnia* infections on larval recruitment in amphibians are moderated by the spatial distribution of egg masses and their exposure to UVB. Exposure of eggs to UVB is in part determined by water depth at amphibian oviposition sites, which depends on winter precipitation. Winter precipitation in the Oregon Cascade Range is modified by El Niño/Southern Oscillation events, resulting in a link between large-scale climatic patterns and disease in Pacific Northwest amphibians. Furthermore, *Saprolegnia* is often carried by introduced salmonid fishes, and hatchery-reared fishes can transmit the pathogen to amphibians. Other complex interactions among stressors affect amphibians in Oregon. These include the combined effects of UVB and nitrate fertilizers and UVB and pesticides (Blaustein and others 2003). Recent research has focused on the effects of stressors at the community level. For example, the harmful effects of UVB radiation can affect producer trophic levels that may influence the growth and development of amphibian consumers. Our studies strongly suggest that numerous factors, acting alone or in concert with one another, contribute to amphibian population declines. These include habitat destruction, global environmental change (including increasing ultraviolet radiation), pollution, disease and invasive species.

Forest Plan), Larch Mountain Salamander (Herrington and Larsen 1985; US Survey and Manage Program, unpubl. data), Oregon Spotted Frog (McAllister and others 1993), Northern Leopard Frog (Leonard and others 1999), Western Pond Turtle (R Milner, unpubl. data; RB Bury, unpubl. data; JC Nordby, unpubl. data), Night Snake (Weaver 2006), and Striped Whipsnake (LA Hallock, unpubl. data).

Two conservation resources available in Washington are the WDFW reptile, turtle, and amphibian (herp) database and the Washington Herp Atlas (Spotlight 8). The WDFW herp database contains over 21,000 museum and

Spotlight 7 — The Forest Service and Bureau of Land Management Interagency Special Status and Sensitive Species Program in Oregon and Washington

ROB HUFF AND KELLI VAN NORMAN

The main objective for management of rare species on Forest Service (FS) and Bureau of Land Management (BLM) lands in Oregon and Washington is to avoid actions that lead to loss of species viability or Threatened and Endangered listing under the US Endangered Species Act. To help meet this objective, the FS and BLM in Oregon and Washington identified approximately 900 rare botanical and wildlife species as Sensitive species, requiring the agencies to assess the potential impact from any agency project on these species, and to promote species conservation. Of the 900 species, 16 are amphibians, and 8 are reptiles or turtles. To assist biologists and managers in evaluating potential project impacts and management for the conservation of these species, the Forest Service and BLM Interagency Special Status and Sensitive Species Program (ISSSSP) employs surveys, research, and monitoring and develops conservation planning documents and tools.

A primary tool developed by the ISSSSP is the Conservation Assessment, which provides species-specific information and management guidance for resource managers. Assessments summarize research, compile known site information for Oregon and Washington, assess habitat and threats, provide species and habitat management guidelines, identify information gaps, and suggest research, inventories, or monitoring to address those gaps. Conservation Assessments have been completed for 9 amphibian species and are in draft stage for 6 other amphibians and 2 turtles.

ISSSSP has funded numerous projects to fill knowledge gaps. These have included inventories to determine species distributions, development of habitat and risk models using landscape-scale parameters available in Geographic Information Systems (for example, Suzuki and others 2008), field validation of habitat models, and population-specific monitoring. Development of standardized survey protocols has been done for several species in order to standardize methods and to facilitate data compilation and analyses among projects.

The tools developed and information gathered by the ISSSSP indicate that FS and BLM lands in Oregon and Washington play varying roles in providing for the conservation of the 16 amphibian species on the ISSSSP list. For example, for 4 amphibians, species conservation is almost entirely dependent upon BLM and Forest Service lands, due to the high overlap of their ranges with these federal land ownerships. For 1 species reliant almost exclusively on FS/BLM lands, the Siskiyou Mountains Salamander (*Plethodon stormi*), a Conservation Strategy has been approved between the BLM, Forest Service and the US Fish and Wildlife Service (Olson and others 2009a). The Strategy provides prescriptive management requirements to ensure the species' protection on federal lands in Oregon. More information is available at: http://www.fs.fed.us/r6/sfpnw/issssp/

observation records contributed by biologists. The on-line Washington Herp Atlas (a cooperative project of the DNR, WDFW, US Bureau of Land Management, and US Forest Service) provides current information about Washington's herps including distribution maps generated from the WDFW herp database. The website is also designed to obtain information from field personnel and dedicated amateurs by providing information on inventory and research needs for each species.

Northern California (Hartwell H Welsh Jr)

Northern California marks the southwestern corner of the Pacific Northwest ecological region. There are 28 reptile, 33 amphibian, and 1 freshwater turtle species in northern California (north of San Francisco Bay). Four sea turtles may be occasionally sighted off-shore. Six amphibians are endemic to this region: the Scott Bar Salamander; the Shasta Salamander; the Black Salamander; the California Slender Salamander; the California Giant Salamander; and

Spotlight 8 — The Washington Herp Atlas Project
LISA HALLOCK

The Washington Herp Atlas Project is a cooperative program among the Washington Department of Natural Resources (DNR), Bureau of Land Management (BLM), Washington Department of Fish and Wildlife (WDFW), and US Forest Service (USFS) with the aims to obtain and provide information on Washington's herpetofauna. To facilitate this, the atlas has species accounts that feature descriptions, identification tips, habitat information, photographs, and inventory and research needs. Information obtained through this project is entered into the WDFW Herp database and is used to track the current status of each species, document rare species occurrences, analyze population trends, identify critical habitat and establish conservation priorities. More information is available at: http://www1.dnr.wa.gov/nhp/refdesk/herp/index.html

Red-bellied Newt. Other amphibian species have distributions largely restricted to northern California, although they range into other areas (for example, Wandering Salamander).

Chief concerns of herpetological conservation in northern California include habitat loss and degradation, disease, and invasive species. Amphibians associated with older forest conditions have been a research emphasis (for example, Welsh 1990), to gain a better understanding of both their habitat requirements and the potential impacts of timber harvest (for example, Diller and Wallace 1994; Welsh and Lind 1988, 1991, 1995). Plethodontid salamanders do not require aquatic habitats for breeding but instead rely on cool, moist terrestrial refugia on the forest floor that are commonly adversely affected by timber management activities (Welsh and Droege 2001; Welsh and others 2008). However, effects of timber harvest on forest herpetofauna appear to be less along the cool marine influenced coast, where forest microclimates remain cool after trees are removed (for example, Diller and Wallace 1994). Nonetheless, there is evidence of negative impacts of forestry on stream amphibian populations even in these coastal areas (for example, Welsh and others 2000); with these impacts having potentially long-term effects (for example, Ashton and others 2006). In stream systems, integrity of substrate conditions, water temperatures and flow levels are key parameters that can be severely altered by timber harvest, road crossings, and water impoundments (Welsh and Ollivier 1998; Welsh and Hodgson 2008). For example, the change in stream flow conditions due to water releases from dams has been linked to losses of stream frogs such as the Foothill Yellow-legged Frog (Lind and others 1996). Among reptiles and turtles in northern California, the Western Pond Turtle may be one of the most vulnerable to losses from habitat change is (Spotlight 9).

Amphibian diseases are an increasing concern in northern California. In particular, surveillance efforts are documenting the scope and implications of 2 pathogens, *Bd* and an iridovirus. For example, as part of their *Bd* surveillance in coastal northern California, Nieto and others (2007) found that Northern Red-legged Frog larvae infected with *Bd* had a lower diversity of oral parasites than larvae free of *Bd* infection. Mao and others (1999) found Northern Red-legged Frog larvae and native Threespine Sticklebacks (*Gasterosteus aculeatus*) infected with a new iridovirus (*Ranavirus* spp.); this is unusual in that the pathogen infects animals belonging to 2 different taxonomic classes.

Introduced fishes are a prime concern relative to native amphibians in northern California (Welsh and others 2006), with new evidence emerging that such introductions can have unanticipated indirect negative effects beyond fish predation (Pope and others 2008).

Inventory and monitoring efforts for herpetofauna in northern California have been ongoing for many years, and provide baseline data for status assessment for several areas and species. Inventories have been conducted of high elevation lakes in the Trinity Alps, Marble Mountains, and Russian wilderness areas of the Klamath Mountains (Welsh and others 2006), the Whiskeytown National Recreation Area (RB Bury and others, US Geological Survey), and for several plethodontid salamanders on federal lands (for example Nauman and Olson 2005).

Spotlight 9 — Western Pond Turtle Conservation Strategy for California
DON ASHTON AND HARTWELL H WELSH JR

A conservation strategy for the Western Pond Turtle is under development by the California Department of Fish and Game (CDF&G) and the US Forest Service's Redwood Sciences Laboratory. The conservation strategy will: 1) provide resource managers and researchers with current information on the distribution, status, ecology, conservation, and management of the Western Pond Turtle, including public educational needs; 2) identify conservation issues and propose actions to assist state and federal agencies with decision making and priority setting for the conservation and management of Western Pond Turtles; 3) recommend standards and protocols for monitoring and mitigation; and 4) outline future research needs. The strategy will approach Western Pond Turtle conservation from several perspectives, emphasizing habitat protection through restoration and maintenance of ecosystem function. It will address and rank conservation issues by Ecoregions as defined in California's Wildlife Action Plan (http://www.dfg.ca.gov/wildlife/wap/report.html), defining the threats, specifying management goals, and detailing potential region-specific conservation actions. It will discuss inclusion of turtles in large-scale conservation planning, including habitat conservation plans, multi-species conservation strategies, and voluntary conservation agreements.

Updated range maps for the Western Pond Turtle in California will be assembled from museum records, CDF&G's Amphibian and Reptile Species of Special Concern in California (ARSSC) database, and CDF&G's California Natural Diversity Database (CNDDB). Unreported locality data on this species should be submitted to CNDDD through their website (http://www.dfg.ca.gov/biogeodata/cnddb/, email:). The conservation strategy will rely heavily on input from researchers and other interested parties with expertise on Western Pond Turtles, and particularly expertise relative to the species' conservation issues in specific bioregions of the state. To assist with or contribute to the Western Pond Turtle Conservation Strategy contact Don Ashton (dashton@fs.fed.us) and ask to be added to the ''WPT ConStrat'' email list.

Development of survey methods (for example, Fellers and Freel 1995; Welsh and others 1997; Clayton and others 2009) have aided standardized assessments in the region. Knowledge of potential change in species status will rely on the development and broad implementation of such protocols.

Lastly, genetic studies have been highly productive in northern California, demonstrating how barriers like mountain ranges and rivers can influence speciation in low-vagility species. The Black Salamander species complex is likely to be one of the next groups for which new species are formally recognized using a combination of genetic and phyleogeographic analyses, with the inland group in Shasta County (the iëcanus Cope 1883 lineage) and the southern group near Santa Cruz (the niger Myers and Maslin 1948 lineage) being raised to species status (Rissler and Apodaca 2007). These new tools have allowed conservation efforts to be focused on populations of key concern (for example, Mead and others 2005).

COMMON THEMES AMONG STATES AND PROVINCES

Deanna H Olson

The main issues across the region are a combination of known and suspected threats that affect the survival of individuals and populations, and hurdles that biologists face which consequently affect species management. Dominant threats to native species include many types of habitat degradation or loss. Forest management is a key habitat issue in several western states and provinces (Spotlight 2; for example, Welsh and others 2008), with many amphibians, in particular, being associated with older forest conditions (Blaustein and others 1995), and stream amphibians and forested headwaters being particular concerns (for example, Corn and Bury 1989; Corn and others 2003; Wahbe and others 2004; Olson and others 2007; Welsh and Hodgson 2008). Additionally, much of the northwestern region is covered by other habitat types, and hence diverse habitat issues are encountered. Regard-

less of habitat type, habitat fragmentation from both natural and anthropogenic disturbances is a growing issue region-wide for all herpetofauna; retaining existing habitats, restoring affected habitats, and specifically managing larger contiguous blocks of habitat and connectivity among habitat blocks are consistent themes across the northwest.

Climate change and its effect on habitat is being recognized as a known or suspected threat in most areas, and includes direct changes to habitat that can take conditions to the limits of tolerance of some species, and indirect effects on habitats which may degrade conditions or alter life history parameters (Appendix 2; Corn 2005; Lind 2008). Evidence and concern for altered habitats in response to climatic factors are being reported region-wide, but particularly at higher latitudes (Yukon, Alaska) and higher altitudes (Cascade Range, Rocky Mountains, Klamath Mountains). Climate change research in the Cascade Range is predicting more drastic changes to aquatic habitats in Oregon, compared to Washington (Spotlight 4). Climate change may affect amphibians, reptiles and turtles differently, with potentially more adverse effects on cool, moisture-sensitive amphibians (Appendix 2). In some circumstances, reptiles may expand their ranges if climates are altered, such as increasing their distribution latitudinally or altitudinally if cold temperature limitations are altered. In many respects, climate change is a potential or suspected threat, and more information is needed to document its scope and impact.

Across the northwest, there is a long list of additional known or potential threats to herpetofauna. In particular, invasive species and diseases are multi-faceted concerns for amphibians, with the introduction of American Bullfrogs, stocked fishes, and the amphibian chytrid fungus (*Bd*) being consistent threads in the reports across several areas. These 3 specific threats also are related because bullfrogs are carriers of *Bd* (for example, Garner and others 2006), and bullfrogs with *Bd* may occur in fish hatcheries (Green and Dodd 2007). The Global *Bd* Mapping Project (Olson and Ronnenberg 2008) has now unveiled a web-based mapping tool (www.spatialepidemiology.net/bd-maps) to track *Bd* occurrences worldwide. *Bd* site-location data from the American northwest is extremely well represented in the database on this web portal, which should aid both the science and management of *Bd* in the region. Addressing the issues of disease and invasive species with a larger geographic focus, with collaborative efforts across state and province boundaries, may more effectively meet these increasingly complex conservation challenges.

Threats specific to reptiles are somewhat under-represented in the state and province summaries. This faunal group is less studied, their ecology is less well understood, and their conservation issues are not as well identified across the region.

Many management hurdles across the region are primarily related to insufficient information and funds. Whereas an incomplete understanding of species' distributions is an issue everywhere, there appears to be a particular deficit of information on amphibian, turtle, and reptile occurrences in several regions (for example, Wyoming, Alberta, Yukon, Alaska, eastern Oregon). Databases to house locality information are often similarly lacking or incomplete, however, databases of protected or at-risk species' sites and sometimes sites of more common species are fairly comprehensive in some areas (for example, Washington Herp Atlas, Washington Department of Fish and Wildlife reptile and amphibian database, Montana Natural Heritage Program, NatureServe Yukon, Alberta Fisheries and Wildlife Management Information System [FWMIS]). Further, a lack of access to the literature or species information is an issue affecting some resource managers trying to make science-based management decisions. Across the region, lack of funding is a common theme, with amphibians and reptiles often appearing to be lower priority taxa or under-represented in many agency programs. Only 1 northwestern state (Wyoming) has a full-time State Herpetologist, for example, but state experts for other taxonomic groups are common and often duplicated among multiple positions (for example, fisheries biologists). Similarly, Yukon, Alberta and British Columbia do not have designated provincial or territorial herpetologists. In contrast, 19 other US states have dedicated State Herpetologists with several of these having multiple positions focusing on amphibian, turtle, and reptile concerns (P. Nanjappa, Amphibian

and Reptile Coordinator, Association of Fish and Wildlife Agencies, pers. comm.). Consequently, no one in northwest regional states, provinces or territories has defined stewardship over just this fauna, and conservation concerns can both lag and increase. It should be noted that all northwestern jurisdictions do have biologists with herpetofaunal responsibilities in addition to other often non-game taxa such as bats and butterflies; and some areas have a network of such individuals. In particular, there is a network of US federal scientists in the northwest conducting herpetological research. However, there is a distinction between having herpetological expertise or conducting studies on herpetofauna and having herpetological stewards officially responsible for species management issues. There often is a separation between species research and management within government agencies and other institutions, and bridging these functions is key for herpetological conservation in the northwest. Also, gaps in conservation programs will arise without defined stewardship; 1 example may be that very little attention was given to sea turtles in the above state and province reports.

Perhaps an indirect consequence of the lack of direct oversight for this fauna, across the region, is that regulations on herpetofauna vary considerably with jurisdiction. State, provincial and federal regulations in the northwest address topics such as: 1) native and introduced species and some habitats such as snake dens (Alberta); 2) removing animals from the wild; 3) releasing captive animals into the wild; and 4) propagation of species. Each area has different rules. Furthermore, counties, parks, cities or academic institutions may have additional or different regulations from states or provinces. When seeking legal policies regarding these animals, it may be imperative to query different departments and programs, under fish, wildlife, or non-game wildlife designations. Both Canada and the US are members of the Convention on International Trade in Endangered Species of Fauna and Flora (CITES), which prohibits endangered species from entering commercial markets, an additional protective measure to existing state, provincial, federal and other regulations. There is a huge commercial trade in herpetofauna, and trade policies for native or non-native amphibians, turtles, and reptiles are not well established for many areas. For example, disease transmission is emerging as an issue for management in amphibians, turtles, and reptiles within the pet, food, zoological, bait, and scientific markets (for example, Reaser and others 2008; Rowley and others 2007). In 2008, *Bd* was listed as a notifiable disease by the World Organization for Animal Health (OIE: Office International des Epizooties) resulting in international trade biosecurity recommendations (OIE 2008). Interestingly, trade issues did not surface as key conservation concerns in the state and province summaries above. It is uncertain if the issue is truly of secondary importance in this region, or if the effects have not yet been fully considered and this reflects another ''gap'' in conservation stewardship. Pet trade issues specific to reptiles and turtles are a concern globally and warrant investigation in the northwest.

A variety of small-to-large scale programs and projects are addressing herpetological conservation across the region, many of which are accruing information that will aid future management. Inventory and monitoring programs appear to be ongoing in all states and provinces except Yukon, but they are often location- or species-specific. Partnerships are pivotal to such programs, and liaisons exist between biologists at government agencies, tribes, industrial landowners, universities, and nonprofit and environmental institutions. For example, the US Farm Bill provides federal financial and technical assistance for private farm and ranch landowners to contribute substantially to herpetological conservation (Spotlight 10). Several forest certification programs are available for small to large woodlot owners to advance species protections on their lands (Suzuki and Olson 2007). Research is largely within the domain of universities and federal government agencies, with some exceptions. Across the continent, the US Geological Survey is implementing the Amphibian Research and Monitoring Initiative (Spotlight 3), for which partnerships have been forged among university and agency cooperators. A disjunction is often apparent, however, between critical information needs for managing many areas and the objectives of ongoing research projects; in particular, the efficacy of approaches to manage populations is rarely being investigated.

Spotlight 10 —USDA Farm Bill Contributes to Amphibian, Reptile, and Turtle Conservation on Private Lands

WENDELL C GILGERT

Numerous conservation provisions and programs target fish and wildlife on private farm and ranch lands through the US Department of Agriculture Farm Bill, administered by the Natural Resources Conservation Service (NRCS). Beginning with the inclusion of the Swampbuster Provisions in the 1985 Farm Bill and continuing through the current 2008 Farm Bill, species conservation efforts have expanded dramatically. Today, most Farm Bill programs offer financial and technical assistance for conservation of fish and wildlife resource concerns coequal with the more traditional agency focus on soil erosion, water and air quality, and livestock waste management concerns. The Wetland Reserve Program, Environmental Quality Incentive Program, Conservation Reserve Program, and the Wildlife Habitat Incentive Program are 4 Farm Bill programs specifically targeting amphibian, reptile, and turtle habitat conservation that have yielded positive and exciting results. Projects that benefit herpetofauna range from conservation easements and general habitat conservation practices, (for example, hedgerows, riparian buffers, field border and contour buffer strips) to habitat creation, enhancement and management for specific herpetological species including several federal or state listed, threatened, or endangered species. Examples of benefited herpetofauna include: the Santa Cruz Long-toed Salamander (*Ambystoma macrodactylum croceum*) in California; the Columbia Spotted Frog in Utah; and the Wyoming Toad in Wyoming. Technical assistance and guidance for planning and implementation of Farm Bill programs is provided by NRCS Field Office Conservationists. NRCS has developed an array of technical publications, training sessions, innovative habitat restoration techniques, and guidance documents that provide NRCS field personnel with knowledge and skills to specifically assist with the restoration and management of reptile, turtle, and amphibian habitat on America's farms and ranches.

Species-specific working groups have been convened in several northwestern states and provinces to address conservation issues within those specific jurisdictions. For example, in Alberta there is a recovery team for the Northern Leopard Frog, and in Oregon, Washington and California there are working groups assigned to develop conservation assessments or strategies for endemic species such as the Oregon Spotted Frog and the Western Pond Turtle (Spotlight 9). Such teams are often composed of species experts and land managers, working collaboratively to advance practical conservation measures with multiple cooperative agencies. These activities heighten the priority of conservation actions for these targeted species.

A common theme presented in the state, province and territory summaries is that there are many people and groups interested in attending to herpetological conservation concerns in northwestern North America, often using a variety of small-scale approaches. Advocacy is strong for this fauna in the region, and the role of single individuals, the cumulative effects of small projects, and the variety of partnerships among landowners and agencies are building blocks of capacity for effective conservation. To further invigorate herpetological conservation, Partners in Amphibian and Reptile Conservation, a non-profit continent-wide organization, is now fully established in the northwest.

NORTHWEST PARTNERS IN APHIBIAN AND REPTILE CONSERVATION

David S Pilliod and Elke Wind

Partners in Amphibian and Reptile Conservation is an organization that has been addressing concerns for herpetofauna over the last 10 y (Olson and others 2009b). The Northwest regional working group of Partners in Amphibian and Reptile Conservation (NW PARC) recently formed to advance herpetological efforts across states and provinces in this region. NW PARC activities include contributing to products aimed to guide species management or inventories, organizing task teams to address specific topics, and providing information and a forum for networking regarding herpetological concerns in the region. The newly released book *Habitat Management Guidelines for Amphibians*

and Reptiles of the Northwestern United States and Western Canada (Pilliod and Wind 2008) provides a source of information for private, state, and federal landowners and resource managers who are interested in managing and restoring habitats for amphibians, turtles, and reptiles. The PARC Inventory and Monitoring handbook (Graeter and others 2009) has guidance for species across North America, and appendices specific to northwestern species.

Eight NW PARC task teams currently exist: 1) Communications; 2) Training; 3) Inventory and Monitoring; 4) Linkage Areas / Important Herp Areas; 5) Impacts of Disturbance; 6) Restoration; 7) Disease; and 8) Species-based Best Management Practices. Task teams and their priorities will be revisited at least annually, to focus regional efforts on selected topics. Three of these task teams were identified in 2008 and are discussed further below.

TRAINING TASK TEAM

Charles R Peterson

Herpetological conservation requires a workforce educated in the biology and ecology of regional amphibians, turtles, and reptiles. In particular, knowledge of species-habitat associations is paramount if habitat management is to mitigate for a variety of anthropogenic or natural disturbances (for example, Pilliod and Wind 2008: habitat management guidelines). Training sessions are needed to inform landowners and land managers on these topics, yet the topics to be addressed in training sessions will vary with area and audience. The Northwest PARC Training Task Team was initiated to explore the need for training, to determine who the various audiences for training may be, and to compile already-existing training opportunities.

COMMUNICATIONS TASK TEAM

Alan Redder and Richard S Nauman

Communication on regionwide topics of amphibian, turtle and reptile conservation is being advanced by the development of a Northwest PARC website, a ''Facebook'' group, an email list for occasional notices, and a newsletter. The need for multiple means of effective communication was recognized by the diversity of individuals interested in herpetological conservation in the northwest. Web-posted lists are planned of ''go-to'' people, regulations, meeting minutes, task team updates, and species lists by habitat, state, and status. For example, there are many projects ongoing in the region addressing various species, habitats, and threats. Integration among projects or species-efforts may be possible to capitalize on progress seen in other geographic areas, which will increase project effectiveness and streamline efforts.

INVENTORY AND MONITORING

Lisa Hallock and Aimee P McIntyre

Inventory is an overwhelming regional need that crosses political boundaries. Many northwest areas do not have accurate distribution maps of their local fauna, which is reflected in the uncertain status of many species and neglected management attention. To understand species' population trends, basic information such as occurrence is needed. In particular, knowledge of species distributions appears to be a hurdle to species management in Wyoming, Alberta, Alaska, Yukon, and eastern Oregon.

Conjoined with the need for inventory is the need for a repository for such information. Natural Heritage Programs have assumed the role of species data managers in many areas, although their capacity and their attention to amphibian, turtle and reptile data are quite variable. Sometimes they compile data only on species of concern, and do this only as data are provided to them. Migration of knowledge from museums, governments, biologists and natural historians may not be part of their program.

Progress has been made over the last 2 decades relative to development of inventory guidelines for northwestern herpetofauna. Sampling protocols are available for stream amphibians (for example, Bury and Corn 1991; Fellers and Freel 1995; Welsh and Hodgson 1997; Welsh and Ollivier 1998; Olson and Weaver 2007), terrestrial amphibians (Corn and Bury 1990; Olson 1999), lentic breeding amphibians (Olson and others 1997), and western pond turtles (Bury and Germano 2008; RB Bury and others, unpubl. data). General survey methods for amphibians are discussed in Heyer and others (1994). Development of survey protocols specific to northwest snakes

and lizards are largely lacking, however numerous field guides are available with additional guidance for survey efforts (for example, Nussbaum and others 1983; Stebbins 1985; Jones and others 2005; St. John 2002; Storm and Leonard 1995; Matsuda and others 2006; Maxell and others 2003).

The Northwest PARC Inventory and Monitoring Task Team is assessing inventory status regionally. The Team's objectives are to: find out what states and provinces are already doing relative to species inventories and data management; conduct outreach to determine where data should be sent for inclusion in existing programs, and connect groups that encounter species with these inventory databases; develop a standard data format and list of protocols for inventories by taxon and habitat type; develop guidance for photographic and specimen vouchers; and provide specific knowledge to assist inventory programs, including identification of animals, lists of species by state or province, and a list of experts available to assist. This Task Team intersects the Training Task Team in that it involves training as field crews are assembled. It intersects the Communication Task Team in that it has a need for establishing a website for efficient communication of basic knowledge, and a need to conduct outreach and connect groups with inventory databases and standard protocols.

Summary and Future Considerations

Several patterns are evident among the herpetofauna of chief concern in northwestern North America. Species at greatest risk of losses are often: 1) at the margin of their range, being at the northernmost or westernmost extreme of their distribution within one or more of the states or provinces covered here; or 2) endemic species, having restricted distributions within the region. These 2 categories are fairly inclusive of most native northwest herpetofauna, because even the few species with continental distributions, such as Northern Leopard Frogs, Wood Frogs, or Gophersnakes, reach the edges of their ranges in Alaska, Yukon, and British Columbia. More specifically, conservation emphasis on ranids and bufonids is a repeated theme among states and provinces. These anurans appear to be particularly vulnerable to losses, perhaps due to their reliance on both aquatic and terrestrial systems for different parts of their life cycles, the concomitant alterations their habitats have undergone as a result of anthropogenic activities, and the role of pathogens in their population dynamics. Headstarting and translocation programs are underway (Oregon, Alberta) or being considered in several areas for these animals, in hopes to forestall local extinctions. However, the efficacy of this conservation tool is yet to be demonstrated in the region, and lessons learned from both successes and failures will be important to document. More effective conservation actions would be to retain, rather than to regain, species distributions.

Reptile species conservation is emerging as a concern in many areas across the northwest. While basic knowledge of general herpetological distributions is lacking across the region, much less information is available for most reptiles. This has been a somewhat neglected taxon, and basic ecological information is needed in many cases in order to begin to understand conservation issues. People's attitudes towards reptiles, and especially snakes, are also an issue throughout the Pacific Northwest. The deliberate destruction and degradation of over-wintering dens of snakes and intentional killing of snakes in the Pacific Northwest is undoubtedly a real threat to some local populations. Standardized inventory techniques need development for northwestern reptiles, and formal programs for population monitoring are long overdue for reptiles, turtles, and amphibians.

Climate change is becoming an often-repeated mantra of doom among environmentally minded scientists and publics, and is reiterated here, yet with more specific consequences for the northwestern herpetofauna. Habitat conditions appear to be changing most quickly for pond-breeding amphibians occurring at high elevations and high latitudes. One study is adding an interesting twist to this, in that amphibian breeding ponds at high elevations at lower latitudes (Oregon) may be seeing more radical changes than those at high elevations at higher latitudes (Washington) (Spotlight 4). More research is warranted to develop predictive modeling of these effects across the region and incorporation of those findings into species and land management plans. For example, modeled habitat effects due to climate change

can be included in landscape planning, to manage areas to provide contiguous habitats for species connectivity, and to reduce likelihood of interacting stressors that have anthropogenic origins. In particular, management of fire-prone ecosystems may be warranted with the prediction that climate change factors may increase the frequency or severity of wild fires.

Several proposals relative to herpetological conservation are relevant to be considered by the region's state and provincial wildlife management agencies. First, compilation and standardization of regulations for native and nonnative herpetofauna is needed, and this needs to be effectively communicated to the science and management communities, and the public. Second, effective data management programs are needed to ensure that species information is compiled, which will then allow for science-based management decisions. Third, herpetological conservation programs are needed at the state or provincial level, not just for those target species that are classified ''endangered,'' but for the 2 classes of vertebrates altogether because in many areas, the majority of them are of concern. Formalizing a steward to attend to these animals will go a long way to having their needs assessed and addressed. This steward can be an effective liaison between fisheries, wildlife, and forestry departments that may manage herpetological habitats, and can be the liaison between states and provinces as conservation issues cross political boundaries. A state or provincial herpetologist could oversee data compilation and regulations, and serve as the liaison with myriad local projects and programs that are ongoing within their area. Lastly, this liaison could assist with the efforts of conservation task teams, such as those conceived and managed by the volunteer efforts of Partners in Amphibian and Reptile Conservation or other groups. Without such oversight, much effort could go for naught; it could be wasted as duplicate programs are initiated in different areas, and key lessons learned from efforts are not known and built upon for subsequent projects. Whereas full-time state and provincial herpetological conservation coordinators would be most effective, rewording existing position descriptions to allow part-time dedication to these tasks would be a boon at this time. Alternatively or perhaps in addition, a single person as a larger ''regional herpetologist'' for the northwest or west, serving as a liaison across the various political jurisdictions and focusing on these topics would enable the region in its capacity to conduct more effective herpetological conservation. Collectively, Northwest PARC may be able to begin to serve in this role to some extent, but time and energy of volunteers are limiting commodities subject to the vagaries of personal priorities. More dedicated action is past due for these animals, many of which are already well along a path to becoming relicts, if not memories.

LIST OF CONTRIBUTING AUTHORS

DON T ASHTON, USDA Forest Service, Pacific Southwest Research Station, Redwood Sciences Laboratory, 1700 Bayview Drive, Arcata, CA 95521

BETSY A BANCROFT, College of Forest Resources, University of Washington, Box 352100, Seattle, WA 98195

ANDREW R BLAUSTEIN, Department of Zoology, Oregon State University, Cordley Hall 3029, Corvallis, OR 97331

WILLIAM BOSWORTH, Idaho Department of Fish and Game, 600 S Walnut St., Boise, ID 83707

R BRUCE BURY, US Geological Survey, USGS Forest and Rangeland Ecosystem Science Center, 3200 SW Jefferson Way, Corvallis, OR 97331

PAUL STEPHEN CORN, USGS Northern Rocky Mountain Science Center, Aldo Leopold Wilderness Research Institute, 790 E Beckwith Ave, Missoula, MT 59801

WENDELL C GILGERT, USDA Natural Resources Conservation Service, West National Technical Support Center, 1201 NE Lloyd Blvd, Suite 1000, Portland, OR 97232

PURNIMA GOVINDARAJULU, Ecosystems Branch, Wildlife Science Section, BC Ministry of the Environment, PO Box 9338 Stn Prov Govt, Victoria, BC V8W 9M1

LISA HALLOCK, Washington Department of Natural Resources, Natural Heritage Program, Olympia, WA 98504

KIM HASTINGS, US Fish and Wildlife Service, 3000 Vintage Park Blvd., Suite 201, Juneau, AK 99801

AUDREY HATCH, Conservation Strategy Monitoring Coordinator, Oregon Department of Fish and Wildlife, 3406 Cherry Ave NE, Salem, OR 97303

PAUL HENDRICKS, Montana Natural Heritage Program, Natural Science Room 205, University of Montana, 32 Campus Drive, Missoula, MT 59812

ROB HUFF, 333 SW 1st Ave, US Department of Interior, Bureau of Land Management, Portland, OR 97208

KRIS KENDELL, Alberta Conservation Association, 101, 9 Chippewa Road, Sherwood Park, AB T8A 6J7

ANDREW J KROLL, Weyerhaeuser Company, WTC 1A5, PO Box 9777, Federal Way, WA 98063

JAMES G MACCRACKEN, Longview Timberlands, LLC, Box 667, 10 International Way, Longview, WA 98632

BRYCE MAXELL, Montana Natural Heritage Program, 1515 East Sixth Avenue, Helena, MT 59620

AIMEE P MCINTYRE, Washington Department of Fish and Wildlife, 600 Capitol Way North Olympia, WA 98501

RICHARD S NAUMAN, National Center for Conservation Science & Policy, 84 4th Street, Ashland, OR 97520

DEANNA H OLSON, USDA Forest Service, Pacific Northwest Research Station, 3200 SW Jefferson Way, Corvallis, OR 97331

CHARLES R PETERSON, Department of Biological Sciences, Idaho State University, Pocatello, ID 83209

DAVID S PILLIOD, US Geological Survey, Forest and Rangeland Ecosystem Science Center, Snake River Field Station, 970 Lusk St, Boise, ID 83706

SANJAY PYARE, Department of Natural Science, University of Alaska Southeast, 11120 Glacier Hwy, Juneau, AK 99801

ALAN REDDER, Wyoming Natural Diversity Database, Wyoming Natural Diversity Database, Dept. 3381, Room 223 Wyo Hall, University of Wyoming, 1000 E University Ave, Laramie, WY 82071

BRIAN G SLOUGH, Consultant Biologist, 35 Cronkhite Road, Whitehorse, YT Y1A 5S9

NOBUYA SUZUKI, Department of Zoology, Oregon State University, Corvallis, OR; current address: Quest University, 3200 University Boulevard, Squamish, BC V8B 0N8

KELLI VAN NORMAN, 333 SW 1st Ave, US Department of Interior, Bureau of Land Management, Portland, OR 97208

HARTWELL H WELSH JR., USDA Forest Service, Pacific Southwest Research Station, Redwood Sciences Laboratory, 1700 Bayview Drive, Arcata, CA 95521

ELKE WIND, E. Wind Consulting, Suite A, 114 Fifth St., Nanaimo, BC V9R 1N2

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APPENDIX 1

Checklist of amphibians (a), and turtles and reptiles (b), occurring in the North American northwest, with names following Crother (2008). Species are grouped alphabetically by native and non-native, order (Caudata, Anura), family, genus and species names. Locations follow Lannoo (2005), Jones and others (2005), Matsuda and others (2006), Stebbins (1985), Maxell and others (2003), Werner and others (2004) and contributing authors' recommendations. Location acronyms: California (CA); Oregon (OR); Washington (WA); British Columbia (BC); Yukon (YT); Alaska (AK); Alberta (AB); Idaho (ID); Montana (MT); and Wyoming (WY). ''?'' indicates uncertain location. Sea turtles are not included. Former names are indicated in parentheses.

a) Class Amphibia

Group	Species	Northwest Locations
Native		
Caudata [Salamanders]		
Ambystomatidae	Northwestern Salamander *Ambystoma gracile*	AK, BC, CA, OR, WA
	Long-toed Salamander *Ambystoma macrodactylum*	AB, AK, BC, CA, ID, MT, OR, WA
	Barred Tiger Salamander *Ambystoma mavortium* (*tigrinum*)	AB, BC, CA, ID, MT, OR, WA, WY
(Dicamptodontidae)	Idaho Giant Salamander *Dicamptodon aterrimus* (*ensatus*)	ID, MT
	Cope's Giant Salamander *Dicamptodon copei* (*ensatus*)	OR, WA
	California Giant Salamander *Dicamptodon ensatus*	CA
	Coastal Giant Salamander *Dicamptodon tenebrosus* (*ensatus*)	BC, CA, OR, WA
Plethodontidae	Clouded Salamander *Aneides ferreus*	CA, OR
	Black Salamander *Aneides flavipunctatus*	CA, OR
	Arboreal Salamander *Aneides lugubris*	CA
	Wandering Salamander *Aneides vagrans* (*ferreus*)	BC, CA
	California Slender Salamander *Batrachoseps attenuatus*	CA, OR
	Oregon Slender Salamander *Batrachoseps wrightorum* (*wrighti*)	OR
	Ensatina *Ensatina eschscholtzii*	BC, CA, OR, WA
	Shasta Salamander *Hydromantes shastae*	CA
	Scott Bar Salamander *Plethodon asupak*	CA
	Dunn's Salamander *Plethodon dunni*	CA, OR, WA
	Del Norte Salamander *Plethodon elongatus*	CA, OR
	Coeur d'Alene Salamander *Plethodon idahoensis* (*vandykei*)	BC, ID, MT
	Larch Mountain Salamander *Plethodon larselli*	OR, WA
	Siskiyou Mountains Salamander *Plethodon stormi*	CA, OR
	Van Dyke's Salamander *Plethodon vandykei*	WA
	Western Red-backed Salamander *Plethodon vehiculum*	BC, OR, WA
Rhyacotritonidae	Cascade Torrent Salamander *Rhyacotriton cascadae* (*olympicus*)	OR, WA
	Columbia Torrent Salamander *Rhyacotriton kezeri* (*olympicus*)	OR, WA
	Olympic Torrent Salamander *Rhyacotrition olympicus*	WA
	Southern Torrent Salamander *Rhyacotriton variegatus* (*olympicus*)	CA, OR
Salamandridae	Rough-skinned Newt *Taricha granulosa*	AK, BC, CA, OR, WA
	Red-bellied Newt *Taricha rivularis*	CA
	Sierra Newt *Taricha sierrae* (*torosa*)	CA
	California Newt *Taricha torosa*	CA
Anura [Frogs and Toads]		
Ascaphidae	Rocky Mountain Tailed Frog *Ascaphus montanus* (*truei*)	BC, ID, MT, OR, WA, AB?
	Coastal Tailed Frog *Ascaphus truei*	BC, CA, OR, WA,
Bufonidae	Wyoming Toad *Anaxyrus baxteri* (*Bufo*)	WY
	Western Toad *Anaxyrus boreas* (*Bufo*)	AB, AK, BC, CA, ID, MT, OR, WA, WY, YT
	Great Plains Toad *Anaxyrus cognatus* (*Bufo*)	AB, MT, WY
	Canadian Toad *Anaxyrus hemiophrys* (*Bufo*)	AB, MT?
	Woodhouse's Toad *Anaxyrus woodhousii* (*Bufo*)	WA, ID, MT, OR, WY

APPENDIX 1. Continued.

a) Class Amphibia

Group	Species	Northwest Locations
Hylidae	Boreal Chorus Frog *Pseudacris maculata* (*triseriata*)	AB, BC, ID, MT, WY, YT
	Northern Pacific Treefrog *Pseudacris regilla* (*Hyla*)	BC, CA, MT, OR, WA, ID?
	Sierran Treefrog *Pseudacris sierra* (*Hyla regilla*)	CA, ID, MT, OR, WA? BC?
Ranidae	American Bullfrog *Lithobates catesbeianus* (*Rana catesbeiana*)	Eastern WY
	Northern Leopard Frog *Lithobates pipiens* (*Rana*)	AB, BC, CA ID, MT, OR, WA, WY
	Wood Frog *Lithobates sylvaticus* (*Rana sylvatica*)	AB, AK, BC, WY, YT, ID? MT?
	Northern Red-legged Frog *Rana aurora*	BC, CA, OR, WA
	Foothill Yellow-legged Frog *Rana boylii*	CA, OR
	Cascades Frog *Rana cascadae*	CA, OR, WA, BC?
	California Red-legged Frog *Rana draytonii* (*aurora*)	CA
	Columbia Spotted Frog *Rana luteiventris* (*pretiosa*)	AB, AK, BC, ID, MT, OR, WA, WY, YT
	Oregon Spotted Frog *Rana pretiosa*	BC, WA, OR, CA
Scaphiopodidae (Pelobatidae)	Plains Spadefoot *Spea bombifrons*	AB, MT, WY
	Western Spadefoot *Spea hammondii*	CA
	Great Basin Spadefoot *Spea intermontana*	BC, CA, ID, OR, WA, WY
Non-native		
Caudata		
Salamandridae	Rough-skinned Newt *Taricha granulosa*	ID
Anura		
Hylidae	Northern Pacific Treefrog *Pseudacris regilla* (*Hyla*)	AK
Ranidae	American Bullfrog *Lithobates catesbeianus* (*Rana catesbeiana*)	BC, CA, OR, ID, MT, WA, western WY
	Green Frog *Lithobates clamitans* (*Rana*)	BC, WA
	Northern Red-legged Frog *Rana aurora*	AK

b) Classes Chelonia [turtles] and Reptilia [lizards and snakes]

Group	Species	Northwest Locations
Native		
Testudines [Turtles]		
[Freshwater Turtles]		
Chelydridae	Snapping Turtle *Chelydra serpentina*	MT, WY, AB?
Emydidae	Western Pond Turtle *Actinemys marmorata* (*Clemmys*)	CA, OR, WA
	Painted Turtle *Chrysemys picta*	AB, BC, ID, MT, OR, WA, WY
	Ornate Box Turtle *Terrapene ornata*	WY
Trionychidae	Spiny Softshell *Apalone spinifera* (*Trionyx*)	MT, WY
[Sea Turtles]		
Cheloniidae	Loggerhead Sea Turtle *Caretta caretta*	AK, BC, CA, OR, WA
	Green Sea Turtle *Chelonia mydas*	AK, BC, CA, OR, WA
	Olive Ridley Sea Turtle *Lepidochelys olivacea*	AK, BC, CA, OR, WA
Dermochelyidae	Leatherback Sea Turtle *Dermochelys coriacea*	AK, BC, CA, OR, WA,
Squamata [Lizards and Snakes]		
[Lizards]		
Teiidae	Six-lined Racerunner *Aspidoscelis sexlineata* (*Cnemidophorus*)	WY
	Western Whiptail *Aspidoscelis tigris* (*Cnemidophorus*)	CA, ID, OR
	Great Basin Collared Lizard *Crotaphytus bicinctores*	CA, ID, OR
	Northern Alligator Lizard *Elgaria coerulea* (*Gerrhonotus*)	BC, CA, ID, MT, OR, WA
	Southern Alligator Lizard *Elgaria multicarinata* (*Gerrhonotus*)	CA, OR, WA
	Long-nosed Leopard Lizard *Gambelia wislizenii*	ID, CA, OR
	Common Lesser Earless Lizard *Holbrookia maculata*	WY
	Pygmy Short-horned Lizard *Phrynosoma douglasii*	CA, ID, OR, WA, MT?

APPENDIX 1. Continued.

b) Classes Chelonia [turtles] and Reptilia [lizards and snakes]

Group	Species	Northwest Locations
	Greater Short-horned Lizard *Phrynosoma hernandesi* (Mountain Short-horned Lizard)	AB, MT, WY, ID?
	Desert Horned Lizard *Phrynosoma platyrhinos*	CA, ID, OR
	Many-lined Skink *Plestiodon multivirgatus* (*Eumeces*)	WY
	Western Skink *Plestiodon skiltonianus* (*Eumeces*)	BC, CA, ID, OR, MT, WA
	Prairie Lizard *Sceloporus consobrinus* (*undulatus*)	WY
	Common Sagebrush Lizard *Sceloporus graciosus*	CA, ID, MT, OR, WA, WY
	Western Fence Lizard *Sceloporus occidentalis*	CA, ID, OR, WA
	Plateau Fence Lizard *Sceloporus tristichus* (*undulatus*)	WY
	Ornate Tree Lizard *Urosaurus ornatus*	WY
	Common Side-blotched Lizard *Uta stansburiana*	ID, CA, OR, WA
[Snakes]		
Boidae	Northern Rubber Boa *Charina bottae*	BC, CA, ID, MT, OR, WA, WY, AB?
Colubridae	North American Racer *Coluber constrictor*	AB, BC, CA, ID, MT, OR, WA, WY
	Striped Racer *Coluber lateralis* (California Whipsnake, *Masticophis*)	CA
	Striped Whipsnake *Coluber taeniatus* (*Masticophis*)	CA, ID, OR, WA
	Sharp-tailed Snake *Contia tenuis*	CA, OR, WA
	Ring-necked Snake *Diadophis punctatus*	CA, ID, OR, WA
	Plains Hog-nosed Snake *Heterodon nasicus*	AB, MT, WY
	Desert Nightsnake *Hypsiglena chlorophaea* (*torquata*)	CA ID, OR, WA
	Common Kingsnake *Lampropeltis getula* (*getulus*)	CA, OR
	Milksnake *Lampropeltis triangulum*	MT, WY
	California Mountain Kingsnake *Lampropeltis zonata*	CA, OR, WA
	Smooth Greensnake *Opheodrys vernalis*	MT, WY
	Gophersnake (Bullsnake, Great Basin Gophersnake and Pacific Gophersnake) *Pituophis catenifer* (*melanoleucus*)	AB, BC, CA, ID, MT, OR, WA, WY
	Long-nosed Snake *Rhinocheilus lecontei*	CA, ID
	Western Groundsnake *Sonora semiannulata*	ID, OR
	Red-bellied Snake *Storeria occipitomaculata*	WY
	Plains Black-headed Snake *Tantilla negriceps*	WY
	Aquatic Gartersnake *Thamnophis atratus* (*couchii, ordinoides, elegans*)	CA, OR
	Sierra Gartersnake *Thamnophis couchii*	CA
	Terrestrial Gartersnake *Thamnophis elegans*	AB, BC, CA, ID, MT, OR, WA, WY
	Northwestern Gartersnake *Thamnophis ordinoides*	BC, CA, OR, WA
	Plains Gartersnake *Thamnophis radix*	AB, MT, WY
	Common Gartersnake *Thamnophis sirtalis*	AB, BC, CA, ID, MT, OR, WA, WY, AK?
Viperidae	Western Rattlesnake *Crotalus oreganus*	BC, CA, ID, OR, WA, WY
	Prairie Rattlesnake *Crotalus viridis*	AB, ID, MT, WY
Non-native Testudines		
Chelydridae	Snapping Turtle *Chelydra serpentina*	BC, OR, western Montana, WA? AB?
Emydidae	Pond Slider *Trachemys scripta*	BC, ID, OR, WA,
Geoemydidae	Asiatic (Chinese) Turtle *Chinemys reevesi*	BC
Squamata		
	Plateau Striped Whiptail *Aspidoscelis velox* (*Cnemidophorus*)	OR
	Common Wall Lizard *Podarcis muralis*	BC
	Western Fence Lizard *Sceloporus occidentalis*	MT

APPENDIX 2

Summary of potential climate change concerns for herpetofauna of northwestern North America (see also Corn 2005; Lind 2008; Spotlight 4). Issues are grouped into categories, but may overlap, and have different emphasis areas.

Northwest Herpetofauna or Locations of Key Concern	Management Considerations
Altered Microclimates	
1. Amphibian species associated with cool, moist north-facing slopes, or moderated west- and east-facing slopes may be affected. 2. Amphibian species associated with cool, moist conditions in forests that are harvested may be subject to microclimates beyond their tolerance (stream and terrestrial species). 3. Altered precipitation patterns may affect habitat limitations of amphibians, turtles, and reptiles.	1–3. Retain habitats resilient to temperature/moisture changes, such as tree retention in forests, and reduce anthropogenic disturbances to habitats that are particularly critical for species, such as areas with hill-shading.
4. Altered spring/summer temperatures, precipitation, snow pack and melt may change the breeding phenology of amphibians, turtles, and reptiles, such as earlier breeding or shortened growing seasons. 5. Variable weather can affect survival, for example if ponds ice-over during amphibian breeding or dry early with drought, or reptile and turtle basking opportunities may be affected. 6. Altered microclimates may affect prey species, and hence foraging opportunities. 7. Invasive species ranges may expand with warming trends in the Northwest, including species having apparently adverse effects on native fauna, such as bullfrogs and warm-water fishes. 8. Disease organisms may have altered distributions, or species may have increased susceptibility to disease because they are stressed from altered habitats.	4–8. Reduce additional impacts to the environmental conditions potentially affected by microclimate change.
Increased Fire Frequency or Intensity	
1. Fire may alter habitats and cause direct mortality to herpetofauna. 2. Although some species may be resilient to natural fire regimes, increased frequencies or intensities of fires may have adverse effects.	1–2. Manage fire ecosystems to reduce potential for stand-replacement fires (for example, where appropriate, reduce fuel loads, apply forest thinning prescriptions to dense secondary forests).
Altered Hydrology	
1. Headwater stream hydrology may be altered with reduced precipitation, or precipitation patterns that vary in space or time, affecting ~1/4 native amphibians. 2. Ephemeral ponds may be especially vulnerable to drying with reduced or variable precipitation patterns.	1–2. Reduce additional stressors to habitats and animals occurring in association with headwater streams and ephemeral ponds.
Range Reductions	
1. Endemic species with already restricted ranges. 2. Species occurring only at mid- or high-elevation areas. 3. Species with fragmented distributions. 4. Species at the margins of their ranges.	1–4. Design landscape management approaches to retain connected habitats across a species range, and to allow ranges to migrate with predicted gradients in climate conditions.