Foothill Yellow-legged Frog (*Rana boylii*) and Umpqua National Forest / Klamath National Wildlife Refuge

Contents

Exercise 2.1: Assessing sensitivity

Length: 60 minutes
Lead-- All instructors needed to help groups
Format: small group
Output: Sensitivity checklist

We want you to gain experience identifying and articulating components of sensitivity for species, habitats, and ecosystems. You may find yourself distracted by the question of whether a particular characteristic is a component of sensitivity, exposure, or adaptive capacity; in the end it doesn't matter which bin you put characteristics into. What matters is that you understand how particular characteristics contribute to vulnerability or lack thereof.

Steps:

I. You will be working in groups of 6-8 people around a table. Each table will have a packet of information for Exercises 2.1, 2.2, and 2.3. This packet will include a variety of maps related to a particular species and administrative unit.
II. Examine the sensitivity checklists (species and administrative unit; based on Josh Lawler's Climate Sensitivity Database).
III. Work through the sensitivity checklist for one species and one place to provide an overall estimate of sensitivity as well as a list of factors that contribute to the relative sensitivity of the species and unit. Information on your species and administrative unit has been provided in the packet to help you develop a rank for sensitivity.
IV. We will take time at the end of the exercise to hear back from groups about their results.

Your assigned species will be clear from your packet's cover page. Below we have suggested species/administrative unit pairings (like fine wine and cheese), but you may opt to assess any administrative unit within your species' range if you have access to a computer and wish to look up information on your own.

1. **Species:** Foothill Yellow-legged Frog (*Rana boylii*): aquatic frog of California - BC; **Admin unit:** Umpqua-Klamath National Wildlife Refuge
2. **Species:** Greater Sage Grouse (*Centrocercus urophasianus*); **Admin unit:** Humboldt-Toiyabe National Forest
3. **Species:** Sandplain Gerardia (*Agalinis acuta*): annual plant occurring on disturbed sandy soils in Northeast USA, federally listed; **Admin unit:** Cape Cod National Seashore

Resources:

I. Species climate change sensitivity checklist
II. Place/habitat climate change sensitivity checklist
III. Species information (e.g., distribution, natural history, ecology)
IV. Place/habitat information (e.g., site description, dominant vegetation, management structure)

Species Climate Change Sensitivity Checklist

1. Physiological sensitivity
How sensitive is the physiology of the species to changes in moisture, temperature, CO_2 concentrations, pH?

Not very sensitive | Moderately sensitive | Very sensitive
1 2 3 4 5

2. Generalist or specialist
Is the species more of a generalist or a specialist?

Generalist | Specialist
1 2 3 4 5

3. Disturbance regimes
How sensitive is the species likely to be to a change in a disturbance regime (e.g., fire, flooding)?

Not very sensitive | Moderately sensitive | Very sensitive
1 2 3 4 5

4. Interspecific interactions
How sensitive are key interspecific interactions to climate change (e.g., competitive relationships, predator prey relationships, diseases, parasites)

Not very sensitive | Moderately sensitive | Very sensitive
1 2 3 4 5

5. Sensitive habitats
Does the species rely on habitats that will be particularly sensitive to climate change (e.g., vernal pools, shallow wetlands, alpine areas, coastal marshes, coral reefs)?

Not dependent | Highly dependent
1 2 3 4 5

6. Non-climatic stressors
To what degree is the species negatively impacted by other, non-climatic stressors (e.g., invasive species, overharvest, habitat loss)?

Slightly impacted | Severely impacted
1 2 3 4 5

Place/Habitat Climate Change Sensitivity Checklist

1. Physiological sensitivity
How sensitive is the physiology of the dominant vegetation type to changes in moisture, temperature, CO_2 concentrations, pH?

Not very sensitive		Moderately sensitive		Very sensitive
1	2	3	4	5

2. Place/ecosystem size
Is the administrative unit dominated by a single ecosystem/ habitat type, or does it encompass a range of climates and ecosystems?

Broad range				Single ecosystem
1	2	3	4	5

3. Disturbance regimes
How sensitive is the administrative unit likely to be to a change in a disturbance regime (e.g., fire, flooding)?

Not very sensitive		Moderately sensitive		Very sensitive
1	2	3	4	5

4. Individual species sensitivities
How sensitive are key species in the administrative unit to climate change (e.g., flagship species, ecosystem engineers, keystone species)

Not very sensitive		Moderately sensitive		Very sensitive
1	2	3	4	5

5. Sensitive habitats
Does the administrative unit contain (or is it characterized by) many habitats that will be particularly sensitive to climate change (e.g., vernal pools, shallow wetlands, alpine areas, coastal marshes, coral reefs)?

Not many				Many
1	2	3	4	5

6. Non-climatic stressors
To what degree are the habitats in the administrative unit negatively impacted by other, non-climatic stressors (e.g., invasive species, overharvest, habitat loss)?

Slightly impacted				Severely impacted
1	2	3	4	5

Foothill Yellow-legged Frog – Summary information

Natural History (NatureServe 2011)

- This species inhabits partially shaded, rocky streams at low to moderate elevations in areas of chaparral, open woodland, and forest. It seeks cover at the bottom of a pool when startled. Habitats, in order of decreasing favorability, include: (1) partially shaded, small perennial streams, at elevations of 30-1,000 meters, with at least some cobble-sized rocks; riffle areas and stream depth rarely greater than 1 meter, (2) intermittent, small, partly shaded, rocky streams displaying seasonal riffle habitat, (3) large (consistently greater than 1 meter in stream depth), partly shaded, perennial streams with rocky or bedrock habitat, (4) open perennial streams with little or no rocky habitat.
- Adults are mainly invertivorous; larvae eat algae, organic debris, plant tissue, and minute organisms in water.
- These frogs are inactive in cold temperatures and reduce activity during hot, dry weather. Usually they are most active during daylight hours.
- Breeding occurs between mid-March and early June, after stream flow subsides from winter storms and runoff.
- Eggs often are laid in clusters of about 1,000 eggs/mass. Larvae hatch in about 5 days at 20 ^{o}C, and metamorphose in summer.
- Species resident (it does not migrate) in areas where it is found.
- Barriers to movement include: busy major highway, especially at night, such that frogs rarely if ever cross successfully; urban development dominated by buildings and pavement; habitat in which site-specific data indicate the frogs virtually never occur.
- Available information indicates that individual ranids occasionally move distances of several kilometers (*R. luteiventris*, *R. blairi*) but most individuals stay within a few kilometers of their breeding sites (*R. aurora draytonii*, *R. capito*, *R. clamitans*, *R. luteiventris*). Similarly, maximum distance between capture points generally is a few kilometers or less (*R. aurora*, *R. catesbeiana*, *R. luteiventris*, *R. muscosa*). Dispersal data for juveniles are lacking for most species.

Disturbances (NatureServe 2011)

- Occurs in California and western Oregon; substantial ongoing decline, apparently due to habitat alteration, impacts of airborne agrochemicals, and/or effects of exotic species, UV-B radiation, and because recolonization abilities may be greatly restricted by local extirpation patterns.
- Stream scouring (may negatively impact frogs in streambed hibernation sites), stabilization of historically fluctuating stream flows as a result of dam construction, introduced incompatible aquatic animals, riverine and riparian impacts of non-selective logging practices, and other habitat degradation and disturbance caused by livestock grazing and in-stream mining all negatively impact the species.
- Adults, larvae, and/or eggs are vulnerable to an array of non-native predators such as predatory fishes (Paoletti et al. 2011), bullfrogs (*Rana catesbeiana*), and crayfish.
- Dam-controlled flows and lack of winter flooding may result in stable pool areas with established aquatic vegetation, and this may increase suitable habitat for exotic species such as bullfrogs. Decreased flows may force frogs into permanent pools where they are more susceptible to predation.

- River water velocity disturbance (for recreational flows for white water boating or peaking releases for hydroelectric power generation) have been shown to affect tadpole development and survivorship (Kupferberg et al. 2011)
- Interspecific matings between male *R. boylii* and female bullfrogs have been observed; these interactions with non-native bullfrogs might reduce the reproductive output of *R. boylii*.
- Logging and erosion from road cuts have resulted in periodically high levels of stream siltation in some areas of northern California. High levels of silt may inhibit the attachment of the egg mass to the substrate. Excessive accumulation of silt on the egg masses may have adverse effects on embryo development. Silt also reduces the interstitial spaces available for use by tadpoles, reduces algal growth on which the tadpoles feed, and can have a significant negative impact on adult frog food resources (e.g., aquatic macro-invertebrates).
- As for many other amphibians, its numbers have declined due to exposure to wind-borne pesticides (Davidson et al. 2002; Davidson 2004; Sparling & Fellers 2009).

Known climate change responses

- Periods of unusually warm summer water temperatures in northern California may be linked to outbreaks of the parasitic copepod (*Lernaea cyprinacea*) and malformations in tadpoles and young of the year (Kupferberg et al. 2009).
- Although it was not formally assessed by (Lawler et al. 2010), it is expected to shift its range as other Rana species.
- The species seemed to decline in a stronger fashion as sites got drier in CA (Davidson et al. 2002)

Comments on the species conservation status and threats

The species formerly was regarded as at least locally abundant in southwestern Oregon, but now it is rare or absent through the entire western half of the Oregon range. This frog has disappeared from more than 50% of historical locations in Oregon and is presumed extirpated from most of the northern and far eastern portions of the range in Oregon (NatureServe 2011).

Umpqua National Forest / Klamath Basin Wildlife Refuge - Summary Information

Basics

The Umpqua National Forest (UNF) is nestled on the west side of the Cascade Mountains. Explosive geologic events have shaped the distinctive landscape on the 984,602-acre forest, and provide spectacular scenery as well as an abundance of natural and cultural resources. Visitors discover a diverse place of thundering waters, high mountain lakes, heart-stopping rapids, and peaceful ponds. The Forest is characterized by its many waterfalls, including the 272-foot Watson Falls on the North Umpqua Highway. The Boulder Creek Wilderness, 19,100 acres, is entirely within the Forest boundaries. Two other wilderness areas are shared with other Forests: Rogue-Umpqua Divide Wilderness, 26,350 acres, and Mt. Thielsen Wilderness, 26,593 acres.

As other National Forests, the Umpqua National Forest mission includes promoting ecosystem health (including protection of species and natural systems), providing multiple benefits to people (including diverse commercial and non-commercial human uses), developing the best scientific information available to deliver technical and community assistance and delivering effective public service. Activities in line with this mission include timber management, conservation and restoration, watershed management, fire management, recreation and archaeology among others.

The Klamath Basin National Wildlife Refuge Complex is operated by the United States Fish and Wildlife Service located in the Klamath Basin of southern Oregon and northern California near Klamath Falls, Oregon. It consists of Bear Valley, Klamath Marsh and Upper Klamath National Wildlife Refuge (NWR) in southern Oregon and Lower Klamath, Tule Lake, and Clear Lake NWR in northern California.

The Lower Klamath NWR was the first waterfowl refuge in the United States. Consisting of 46,900 acres, it includes shallow freshwater marshes, open water, grassy uplands, and croplands that are intensively managed to provide feeding, resting, nesting, and brood rearing habitat for waterfowl and other water birds. Clear Lake NWR has an area of 46,460 acres. About 20,000 acres is open water. The balance is the surrounding upland habitat of bunchgrass, low sagebrush, and juniper. Upper Klamath NWR is composed of 15,000 acres of mostly freshwater marsh and open water. Tule Lake NWR encompasses 39,116 acres of mostly open water and croplands. Klamath Marsh NWR consists of 40,646 acres of freshwater marsh and adjacent meadows. Bear Valley NWR protects a vital night roost site for wintering bald eagles. It consists of 4,200 acres of largely old growth Ponderosa Pine, Incense-cedar, White Fir and Douglas-fir forest.

Klamath Basin Refuges consist of a variety of habitats including freshwater marshes, open water, grassy meadows, coniferous forests, sagebrush and juniper grasslands, agricultural lands, and rocky cliffs and slopes. These habitats support diverse and abundant populations of resident and migratory wildlife with 433 species having been observed on or near the Refuges. In addition, each year the Refuges serve as a migratory stopover for about three-quarters of the Pacific Flyway waterfowl, with peak fall concentrations of over 1 million birds. Approximately 17,000 acres in Tule Lake NWR are leased by potato, onion, horse radish, alfalfa, and cereal grains within the Public Lease Lands program administered by the U.S Bureau of Reclamation. Other activities conducted in the NWR complex include hunting, recreation, wildlife observation, water production, wildlife conservation, among many others.

Species

The Umpqua National Forest is at the juncture of several distinct geologic provinces, providing a wide spectrum of habitat for a diversity of plants and wildlife. The Forest is home to 18 fish species, including winter steelhead (*Oncorhynchus mykiss*), Chinook (*Oncorhynchus tschawytscha*) and coho (*Oncorhynchus tschawytscha*) salmon, and sea-run cutthroat trout (*Oncorhynchus tschawytscha*). The Forest abounds with 66 mammal species, including bobcat, American marten (, Pacific fisher (*Martes pennati*), Pacific fringed myotis (*Myotis thysanodes vespertinus*); 236 bird species, including Northern Spotted Owl (*Strix occidentalis caurina*), Yellow Rail (*Coturnicops noveboracensis*); and 27 reptile and amphibian species, including Northwestern pond turtle (*Clemmys marmorata marmorata*) and Southern torrent salamander (*Rhyacotriton variegatus*). Anadromous, or sea-going fish enjoy 359 miles of streams with thousands more miles of streams covering the forest landscape.

Among the species found on the Klamath Basin NWR complex are: White-faced Ibis (*Plegadis chihi*); Great Blue Heron (*Ardea herodias*); Black-crowned Night Heron (*Nycticorax nycticorax*), Great (*Ardea alba*) and Snowy (*Egretta thula*) egrets; Double-crested Cormorant (*Phalacrocorax auritus*); Bald Eagle (*Haliaeetus leucocephalus*); Greater Sage Grouse (*Centrocercus urophasianus*); Western (*Aechmophorus occidentalis*), Clark's (*Aechmophorus clarkii*) and Eared (*Podiceps nigricollis*) grebes; American white pelican (*Pelecanus erythrorhynchos*); Greater White-fronted (*Anser albifrons*), Snow (*Chen caerulescens*), Ross's (*Chen rossii*), Cackling (*Branta hutchinsii*) and Canada geese (*Branta canadensis*), all of which nest in the Arctic tundra; and several species of terns (*Sterna spp.*) and gulls (*Larus spp.*). Other species that can be found on this complex include: Lost River (*Deltistes luxatus*) and shortnose (*Chasmistes brevirostris*) suckers, both listed as Endangered; pronghorn antelope (*Antilocapra americana)*, mule deer (*Odocoileus hemionus)*, and Wolverine (*Gulo gulo*).

Key issues

Disturbances: Fire suppression practices have significantly increased the amount of fire fuel in the UNF forests. Currently, the Forest Service is evaluating a thinning and clean-up project to reduce the probability of large wildfires.

Invasive species: Feral swine (*Sus sp.*) are invasive in OR. They are free-roaming pigs found on public or private land. They vary in size and coloration. They damage habitat (restricting timber growth, reducing and/or removing understory and compacting soils) and forage on a number of items (such as acorns, forbs, grasses, fungus, leaves, berries, fruits, roots, tubers, corn and other agricultural crops, insects, crayfish, frogs, salamanders, snakes, mice, eggs of groundnesting birds, small mammals, fawns, lambs, calves, kid goats and carrion) and they can transmit disease to wildlife, livestock and humans.

Nutria (*Myocastor coypus*) causes stream bank erosion and subsequent sedimentation of streams with their burrowing and feeding. They are such voracious feeders that they can denude areas of vegetation, which are referred to as "eat outs." The burrowing activity of nutria is known to cause damage to road beds, levees, dikes, and other structures

Invasive aquatic species are a serious problem in Oregon. They wreak havoc on lakes, rivers, streams and wetlands. There are currently over 134 nonindigenous aquatic species reported in Oregon. They include bullfrogs (*Rana catesbeiana*), crayfish, invasive fish and more. For example, most algae blooms are harmless, but some blue-green algal blooms can produce toxins that may sicken people and animals. Blue-green algae are found in many nutrient-rich Oregon lakes.

Disease and pests: UNF has been affected by Mounatin Pine Beetle (*Dendroctonus ponderosae*) outbrakes killing large numbers of Lodgepole pines (*Pinus contorta*) and other tree species, especially near Diamond Lake.

Water supply conflicts: Like most places in the West, the Klamath Basin is naturally arid and rainfall is very limited. There is conflict over the allocation of water supply to make natural and human uses compatible.

Climate change: Climate change has contributed to an increase in the extent and severity of Mountain Pine beetle outbreaks. Insect outbreaks such as this represent an important mechanism by which climate change may undermine the ability of northern forests to take up and store atmospheric carbon and to recover from disturbances (Kurz et al. 2008).

References

Davidson, C. 2004. Declining downwind: amphibian population declines in California and historical pesticide use. Ecological Applications **14**:1892-1902.

Davidson, C., H. B. Shaffer, and M. R. Jennings. 2002. Spatial Tests of the Pesticide Drift, Habitat Destruction, UV-B, and Climate-Change Hypotheses for California Amphibian Declines. Conservation Biology **16**:1588-1601.

Kupferberg, S. J., A. Catenazzi, K. Lunde, A. J. Lind, and W. J. Palen. 2009. Parasitic Copepod (*Lernaea cyprinacea*) Outbreaks in Foothill Yellow-legged Frogs (*Rana boylii*) Linked to Unusually Warm Summers and Amphibian Malformations in Northern California. Copeia **2009**:529-537.

Kupferberg, S. J., A. J. Lind, V. Thill, and S. M. Yarnell. 2011. Water Velocity Tolerance in Tadpoles of the Foothill Yellow-legged Frog (*Rana boylii*): Swimming Performance, Growth, and Survival. Copeia **2011**:141-152.

Kurz, W. A., C. C. Dymond, G. Stinson, G. J. Rampley, E. T. Neilson, A. L. Carroll, T. Ebata, and L. Safranyik. 2008. Mountain pine beetle and forest carbon feedback to climate change. Nature **452**:987-990.

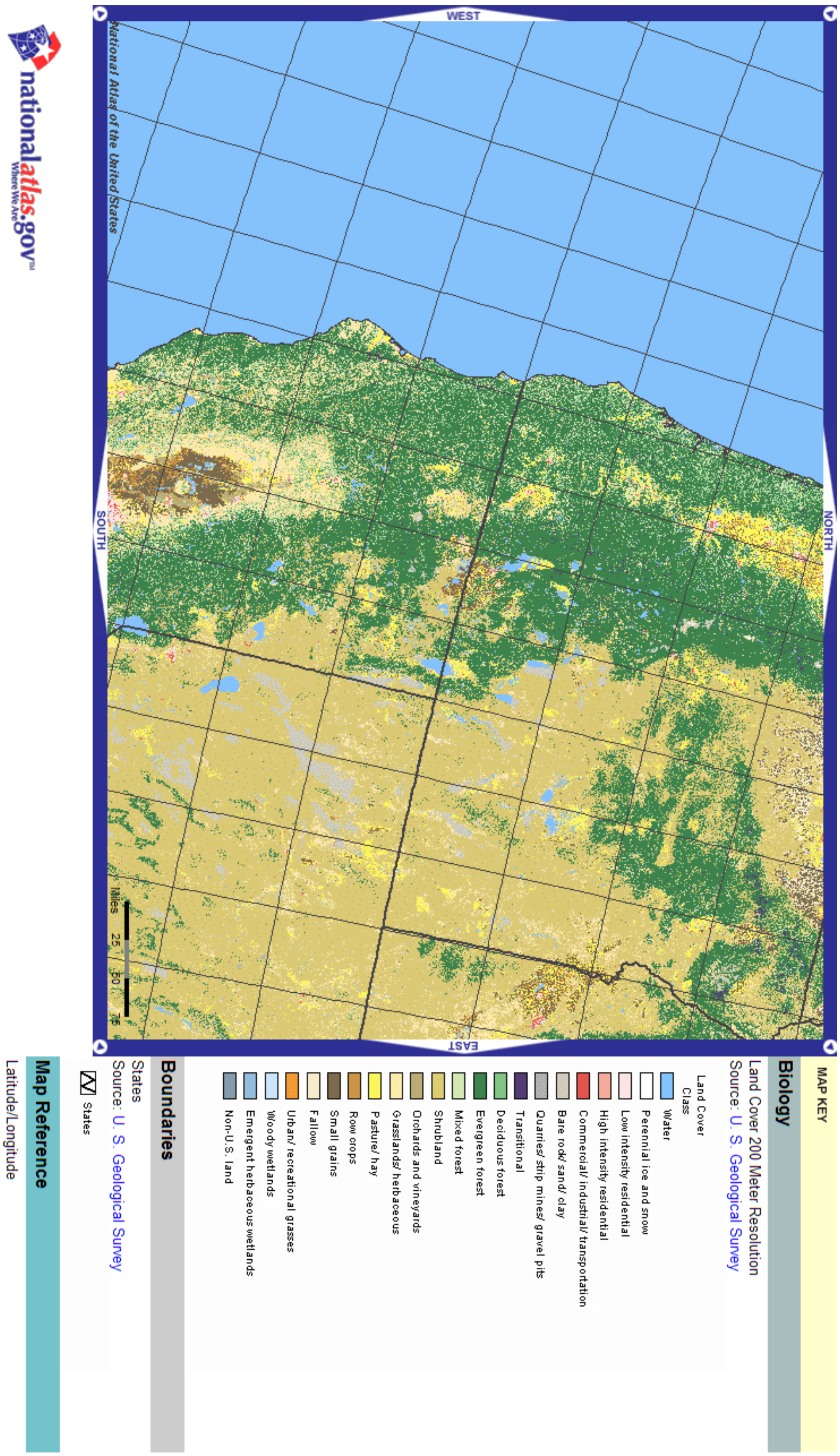
Lawler, J. J., S. L. Shafer, B. A. Bancroft, and A. R. Blaustein. 2010. Projected Climate Impacts for the Amphibians of the Western Hemisphere. Conservation Biology **24**:38-50.

NatureServe. 2011. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Retrieved December 27, 2011, from http://www.natureserve.org/explorer.

Paoletti, D. J., D. H. Olson, and A. R. Blaustein. 2011. Responses of Foothill Yellow-legged Frog (*Rana boylii*) Larvae to an Introduced Predator. Copeia **2011**:161-168.

Sparling, D. W., and G. M. Fellers. 2009. Toxicity of two insecticides to California, USA, anurans and its relevance to declining amphibian populations. Environmental Toxicology and Chemistry **28**:1696-1703.

Umpqua National Forest / Klamath Basin Wildlife Refuge land cover



Exercise 2.2: Assessing exposure

Length: 60 minutes
Lead-- All instructors needed to help groups
Format: small group

Output: A discussion of exposure for your species and your administrative unit The goal of the questions below is to get you thinking about what elements of exposure are most important for assessing the vulnerability of the particular species, habitats, or places with which you are concerned. The metrics of change most commonly presented in the media—e.g. changes in average global or regional temperature and changes in average global or regional rainfall—aren't always the most appropriate metrics for a particular VA.

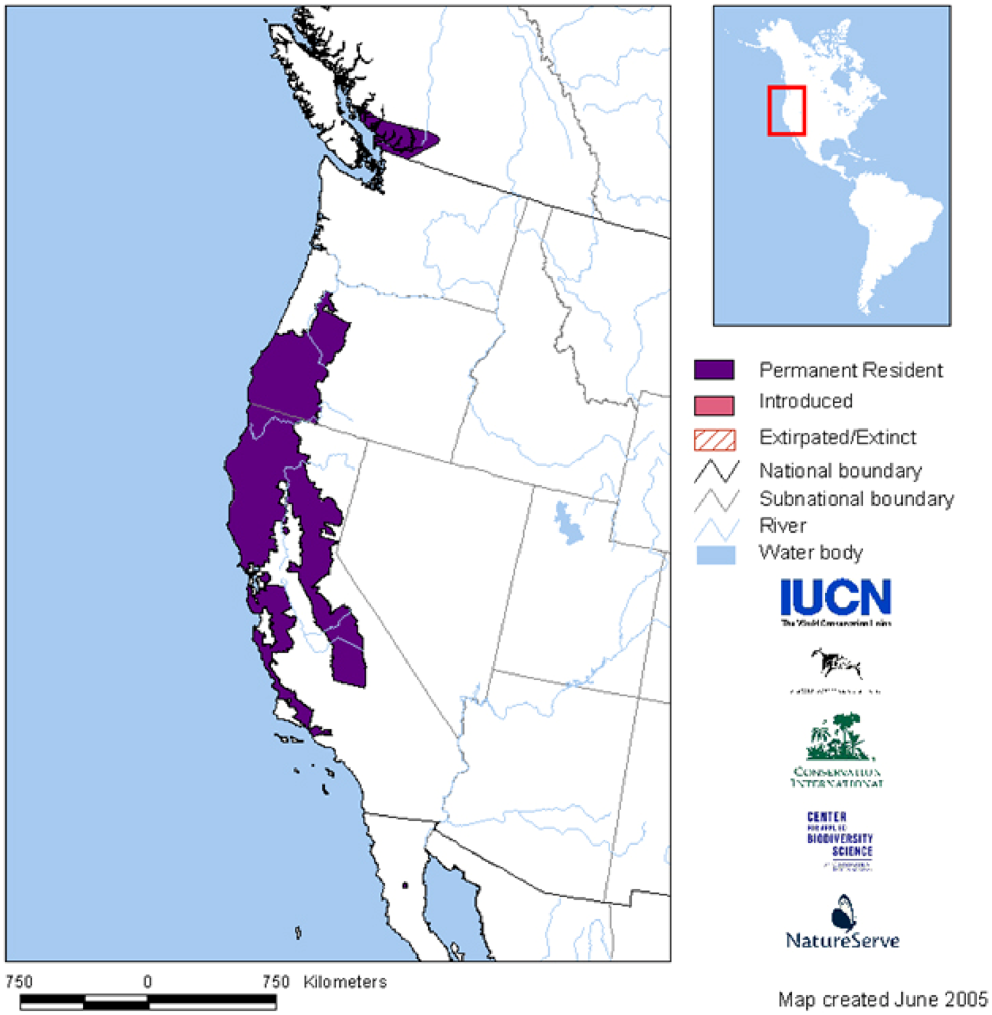
Resources:

I. Range (for species) or boundaries (for habitat/administrative unit)
II. Shaded relief map for relevant area (created using the National Atlas; can go to nationalatlas.gov and look in the geology layer if you want to zoom in)
III. Maps of projected changes in various climate variables for the relevant area.

Questions to consider:

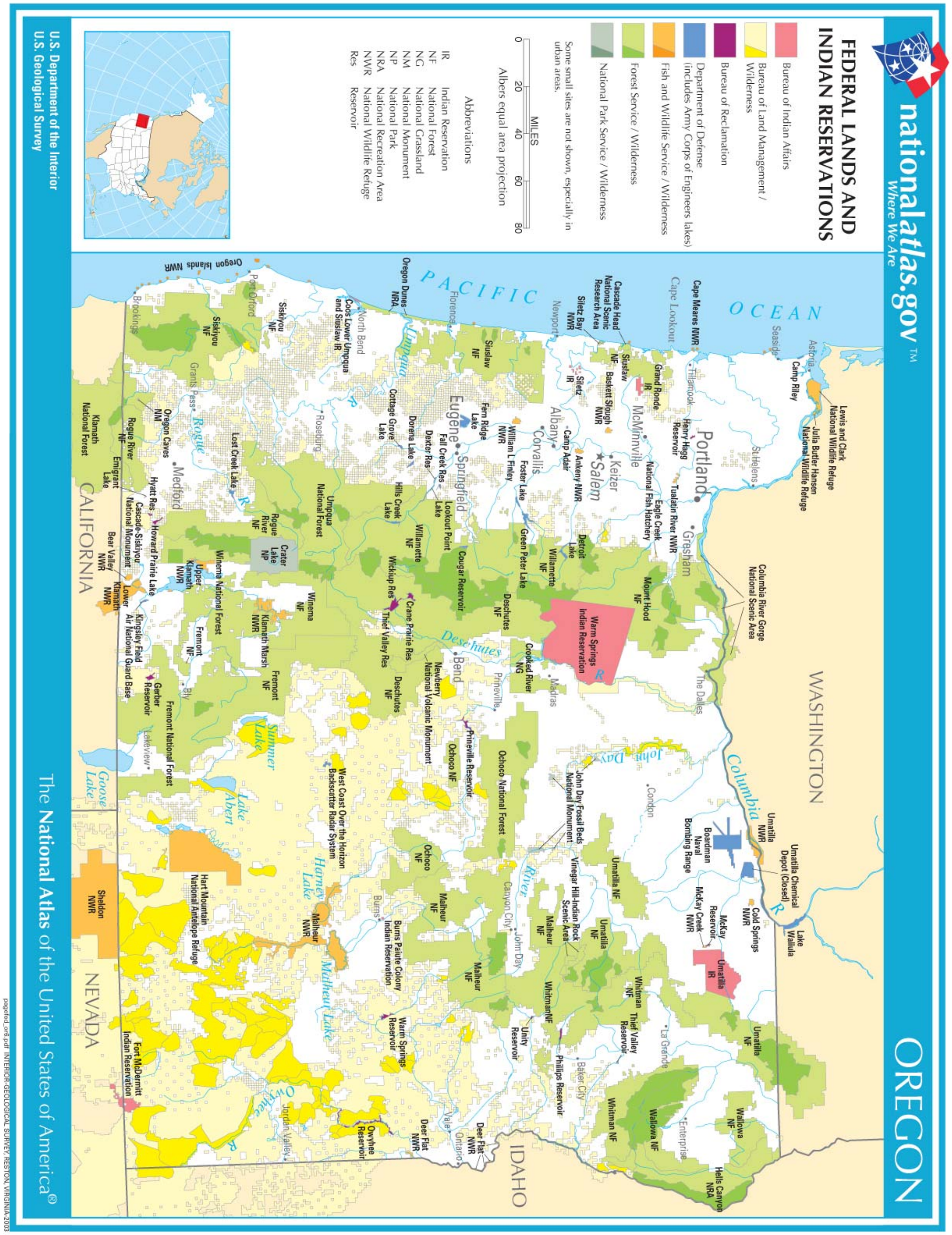
1. What elements of exposure are likely to be most relevant or important for the species in question? For the habitat or administrative unit? (NOTE: there may be elements that are in the "most relevant" category that have not been provided to you in the packet. List any layers missing that you think would help you better evaluate exposure).
2. For species: What factors are most important in determining the species' range? Think not just about climate variables, but about other factors as well (e.g. presence of particular plants, absence of particular competitors, etc.). How might this influence the variables on which you chose to focus?
3. For administrative units: What are the goals, vision, or mandate for this administrative unit? What factors are most important in determining the ability of the unit to meet these goals, vision, and mandates?
4. What factors might influence exposure? That is, what factors influence the actual amount of climatic change experienced by the species or place in question? For example, some types of air pollution reflect heat and thereby slow warming; type and density of plant cover can influence heating, cooling, moisture, and fire regime.
5. How would you express exposure for the species in question—maps of each variable separately? Of only the most important variables? A combined map showing average change in all variables? A single ranking or score for exposure across the entire range/unit? Exposure maps or scores for a few key species or habitat types within the administrative unit? Think about various ways you might want to use the VA results and how different ways of expressing exposure (and ultimately overall vulnerability) might be better or worse for each type of use.

Foothill Yellow-legged Frog Range Map



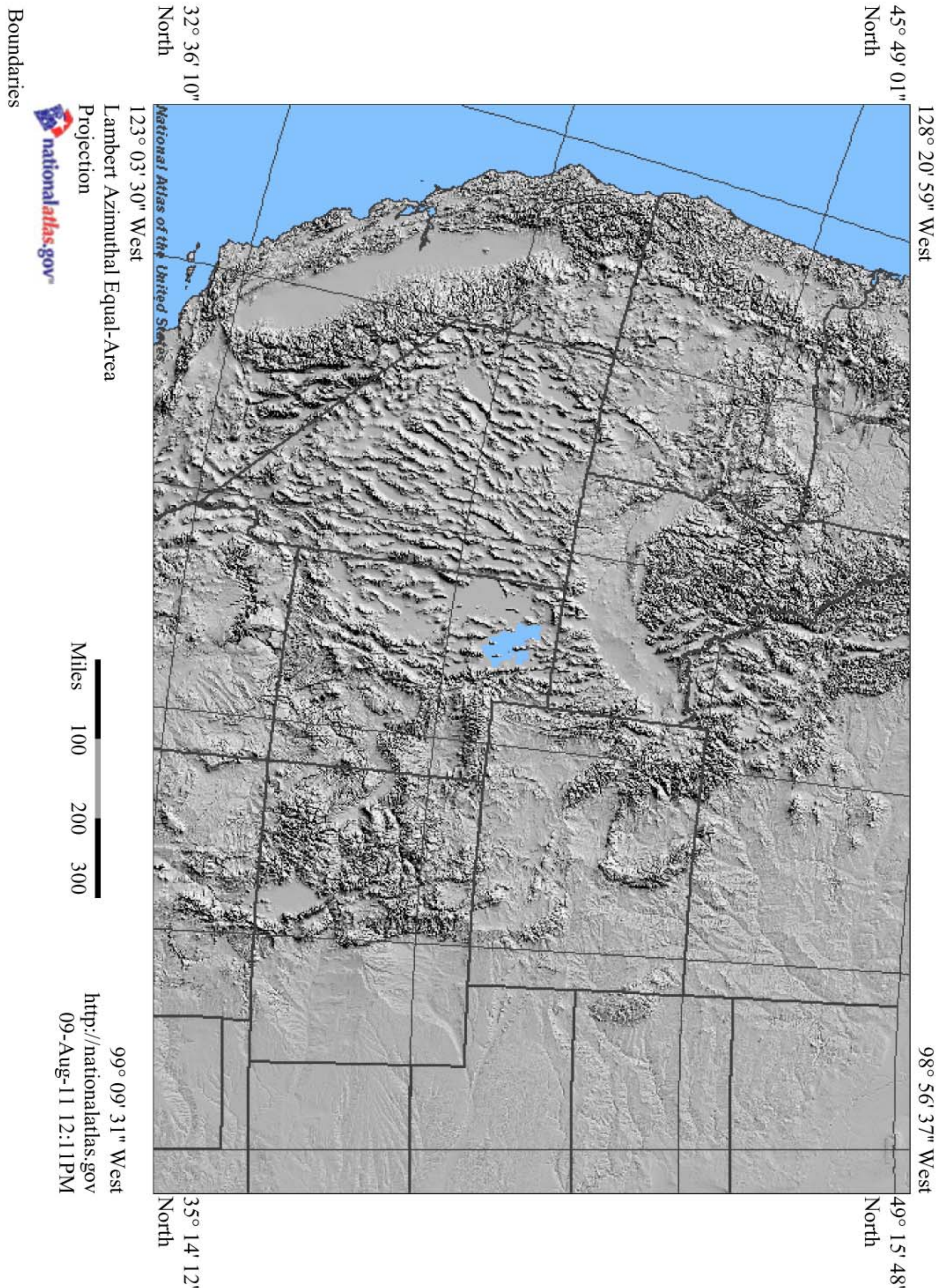
Range includes Pacific drainages from the upper reaches of the Willamette River system, Oregon (west of the Cascades crest), south to the upper San Gabriel River, Los Angeles County, California, including the coast ranges and Sierra Nevada foothills in the United States (Stebbins 2003). The species occurred at least formerly in a disjunct location in northern Baja California. Two specimens were collected in 1965 at an elevation of 2,040 meters at the lower end of La Grulla Meadow, Sierra San Pedro Martir, Baja California, Mexico; subsequent searches have not detected the species in that area. The species apparently has disappeared from portions of its historical range, especially in southern California. Extant *R. boylii* populations are not evenly distributed in California; in the Pacific northwest, 40 percent of the streams support populations, whereas that number drops to 30 percent in the Cascade Mountains (north of the Sierra Nevada), 30 percent in the south coast range (south of San Francisco), and 12 percent in the Sierra Nevada foothills. Elevational range extends from sea level to around 2,130 meters (NatureServe 2011).

Umpqua National Forest / Klamath Basin Wildlife Refuge boundary

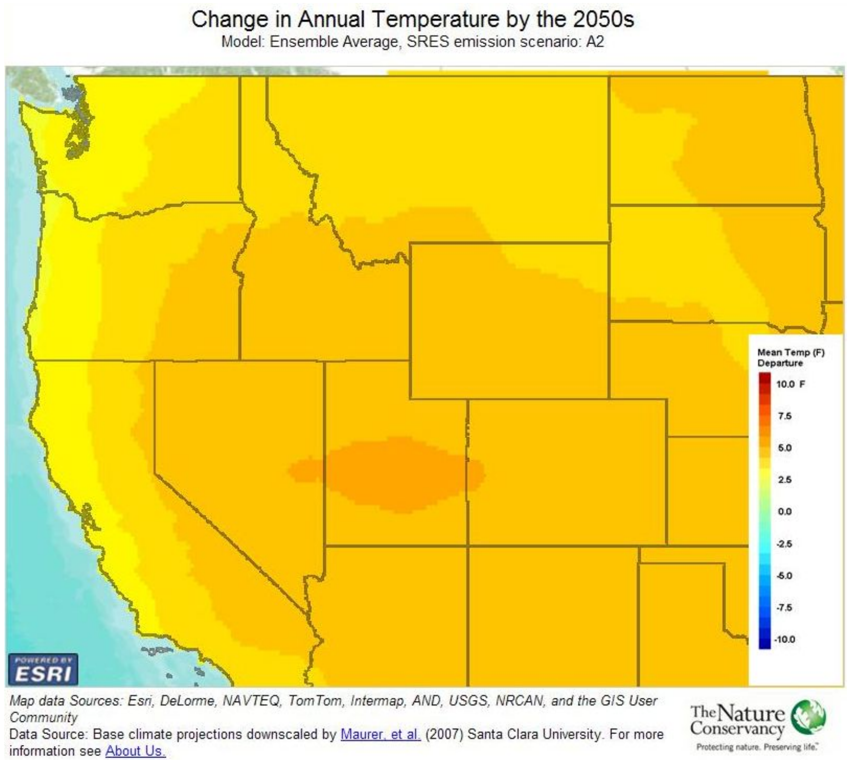


Foothill Yellow-legged Frog exposure assessment tools

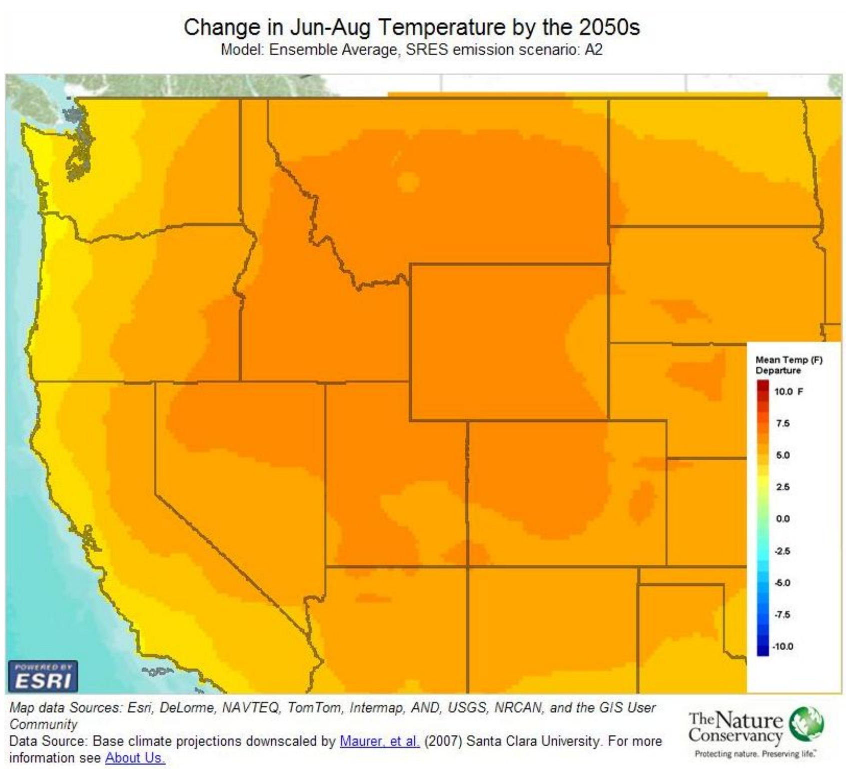
Topography



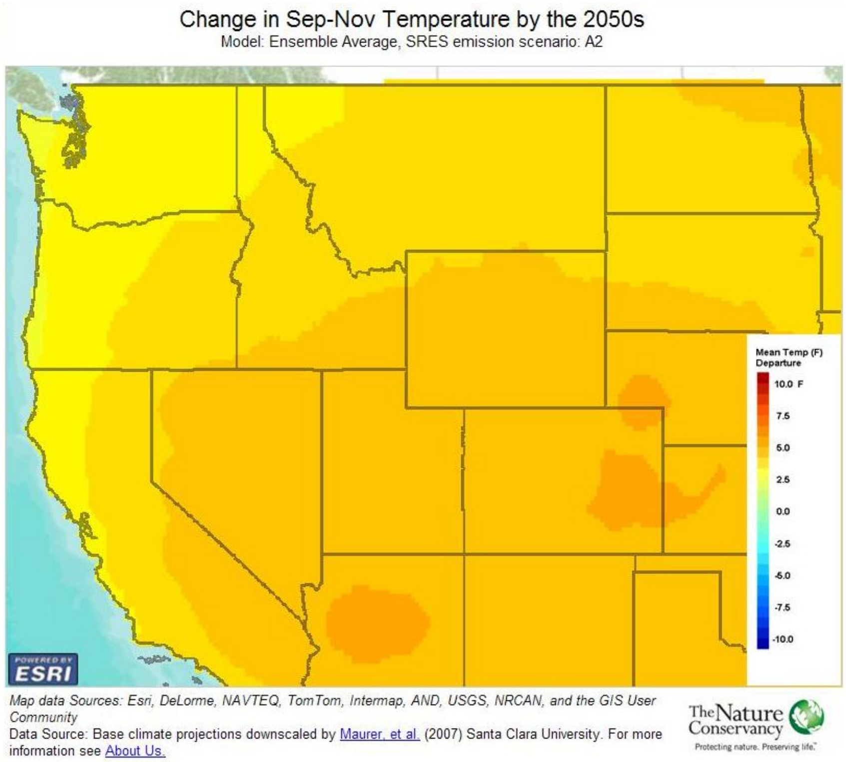
Annual temperatures



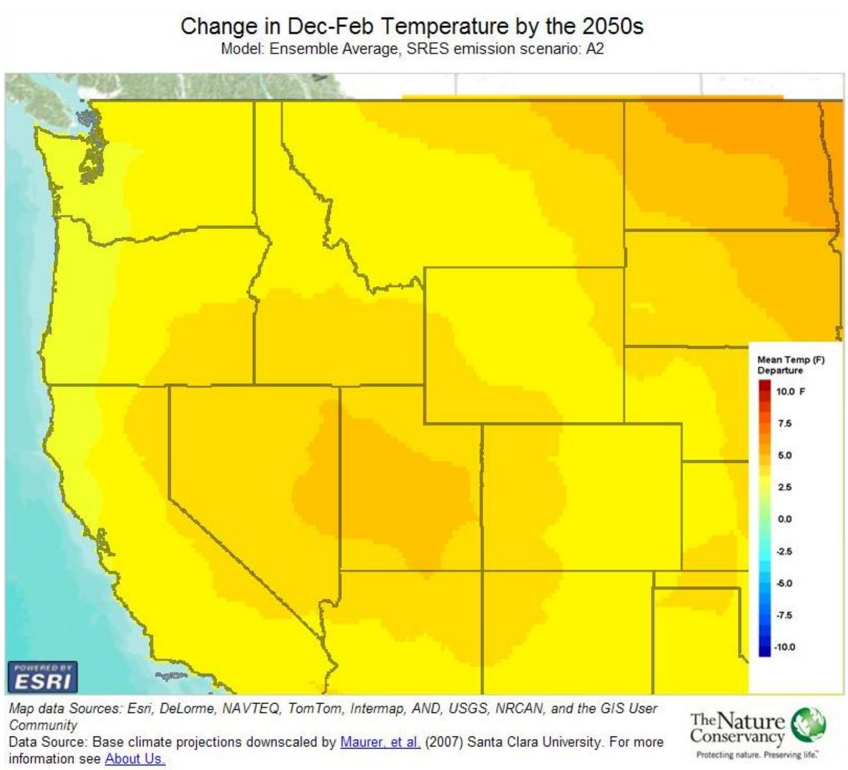
Summer temperatures



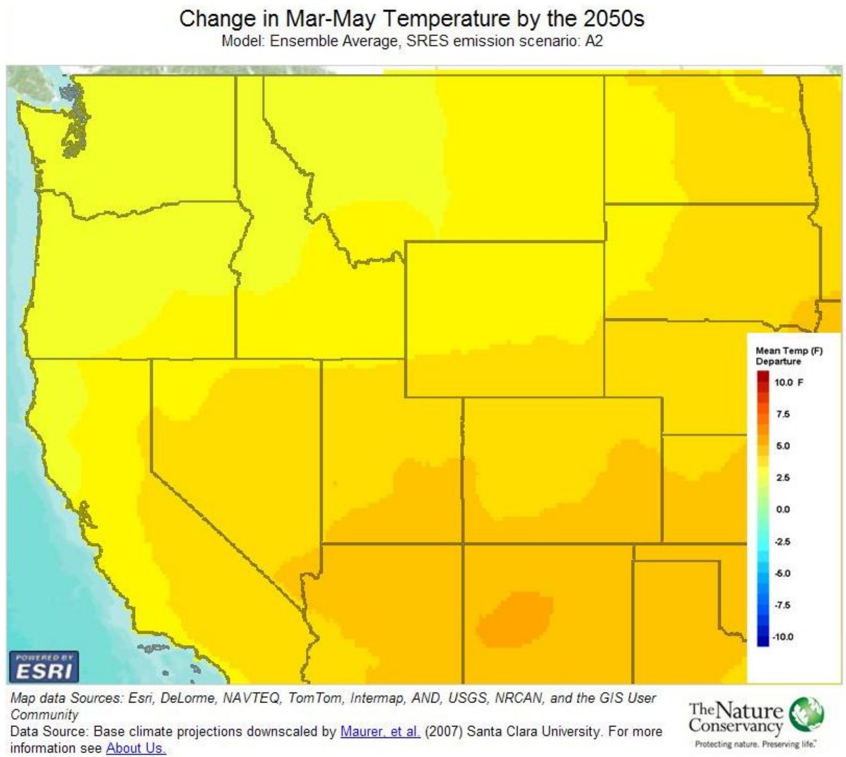
Fall temperatures



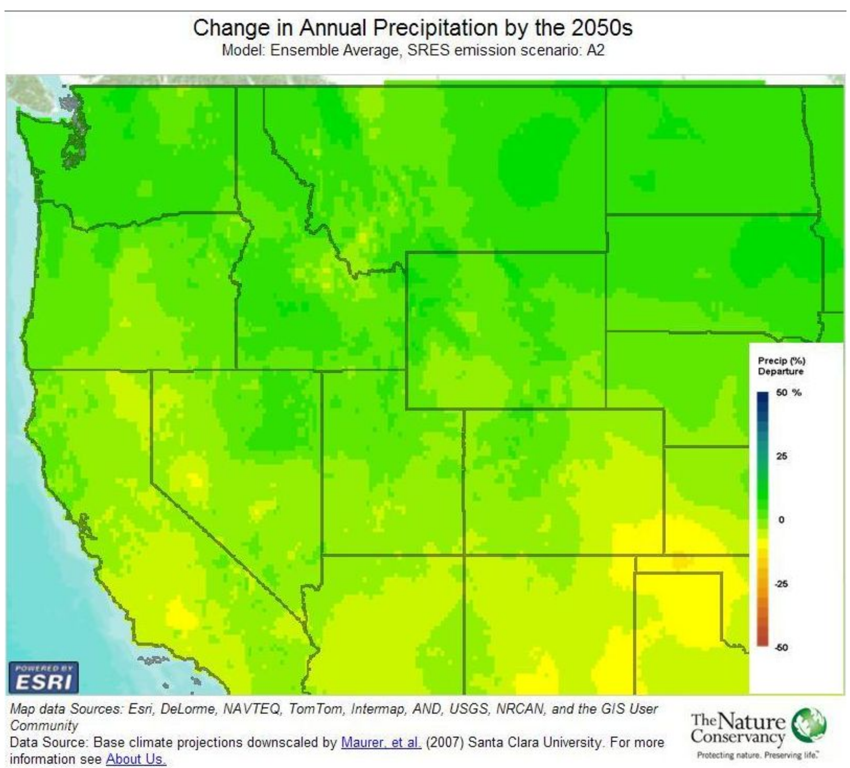
Winter temperatures



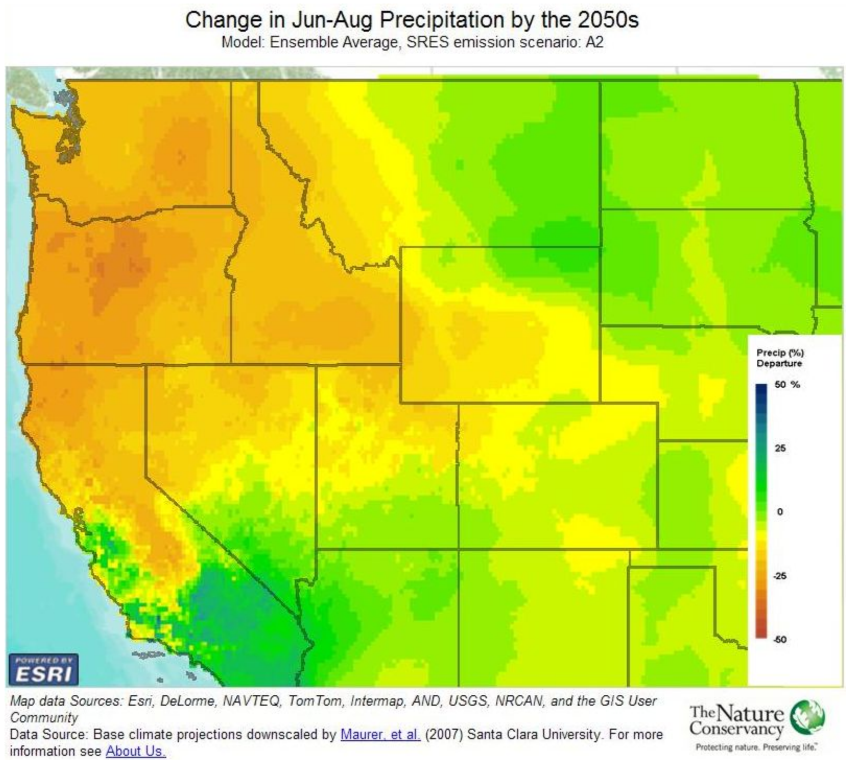
Spring temperatures



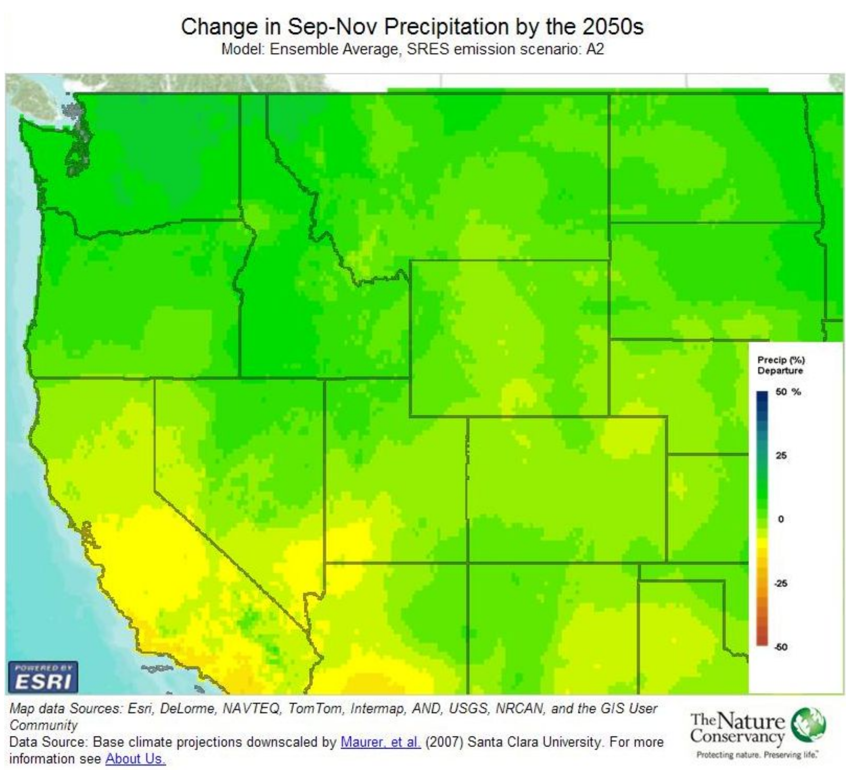
Annual precipitation



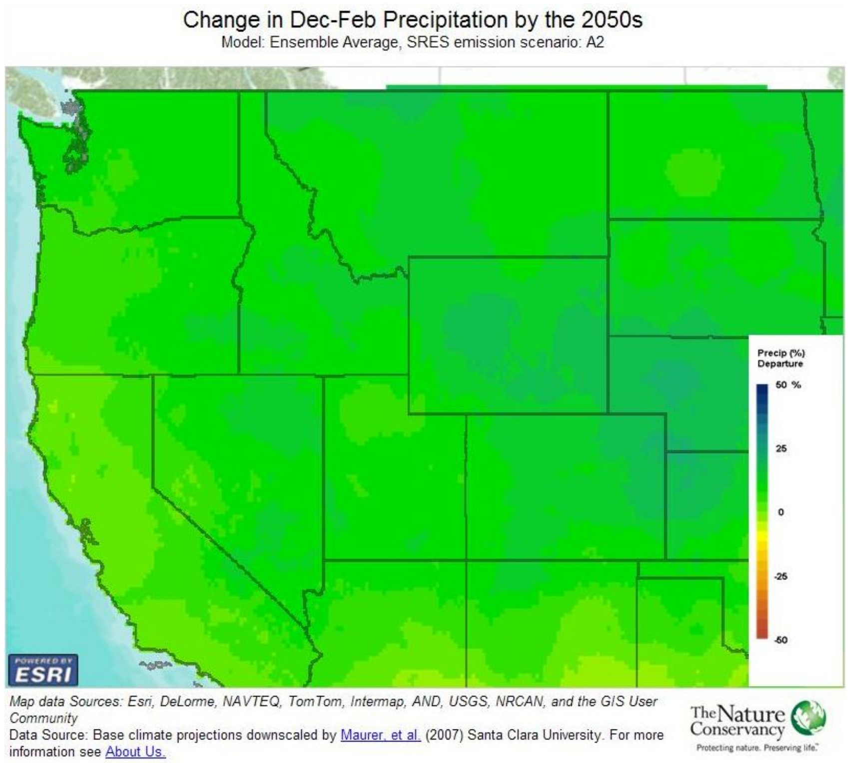
Summer precipitation



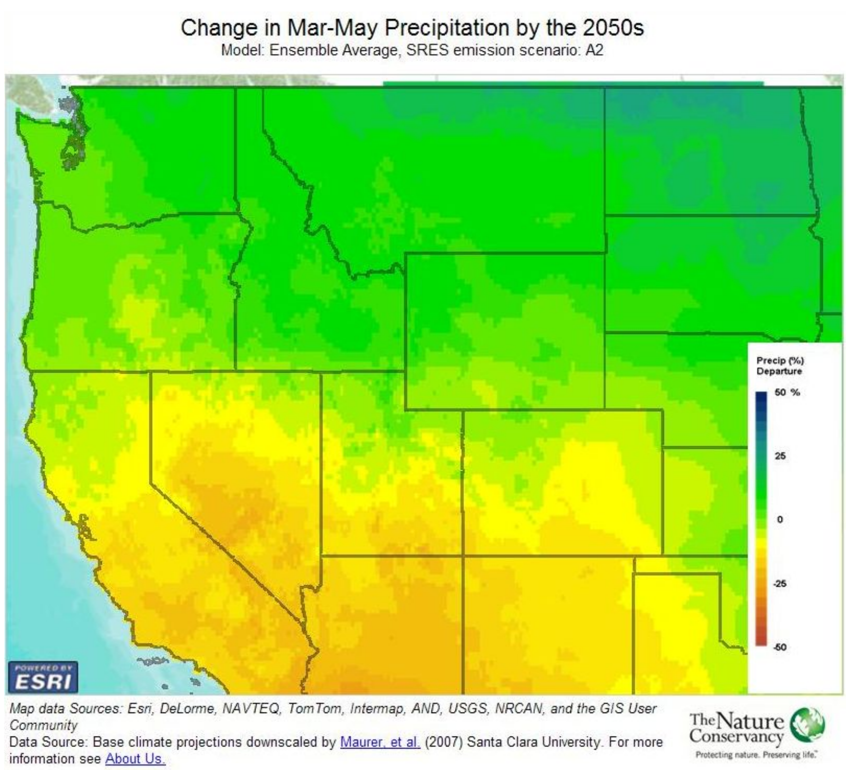
Fall precipitation

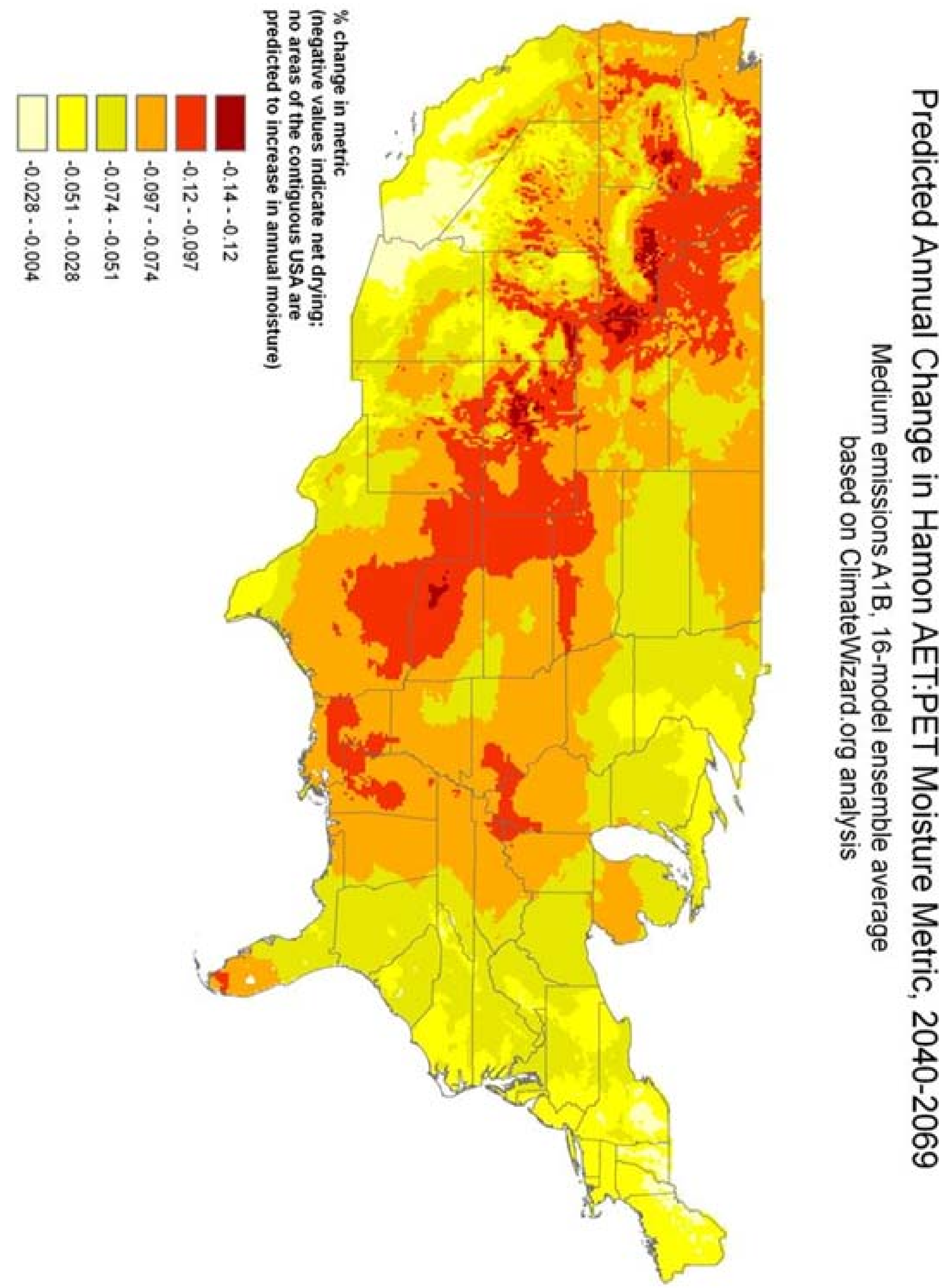


Winter precipitation



Spring precipitation




Predicted Annual Change in Hamon AET:PET Moisture Metric, 2040-2069
Medium emissions A1B, 16-model ensemble average
based on ClimateWizard.org analysis
% change in metric
(negative values indicate net drying;
no areas of the contiguous USA are
predicted to increase in annual moisture)
-0.14 - -0.12
-0.12 - -0.097
-0.097 - -0.074
-0.074 - -0.051
-0.051 - -0.028
-0.028 - -0.004

Exercise 2.3: Adaptive Capacity and Assessing Vulnerability

Length: 60 minutes
Lead-- All instructors needed to help groups
Format: small group

In this exercise, we're asking you to think about the ability of species and habitat/administrative units to respond to climate change in ways that minimize its negative effects. Remember, don't get too caught up in whether you'd categorize a particular characteristic as adaptive capacity vs. exposure or sensitivity; the key is to think about vulnerability from a number of angles.

Output:

1. A measure of adaptive capacity for your species and your administrative unit
2. An overall vulnerability score/ranking for your species and administrative unit. Do this by pooling the results of your sensitivity, exposure, and adaptive capacity analyses in a way that makes sense to you. This could be qualitative or quantitative, spatial or numeric, it's up to you. Just be ready to defend your choices!

Resources:

I. Species/place information from the Sensitivity Exercise
II. Highways map
III. Pollution sources map (Air Releases, Superfund National Priorities List Sites, Toxics Release Inventory, Water Discharge Permits; (created using the National Atlas; can go to nationalatlas.gov and look at the "environment" layer if you want to zoom in)
IV. GAP protected areas map

Questions to consider:

Species:

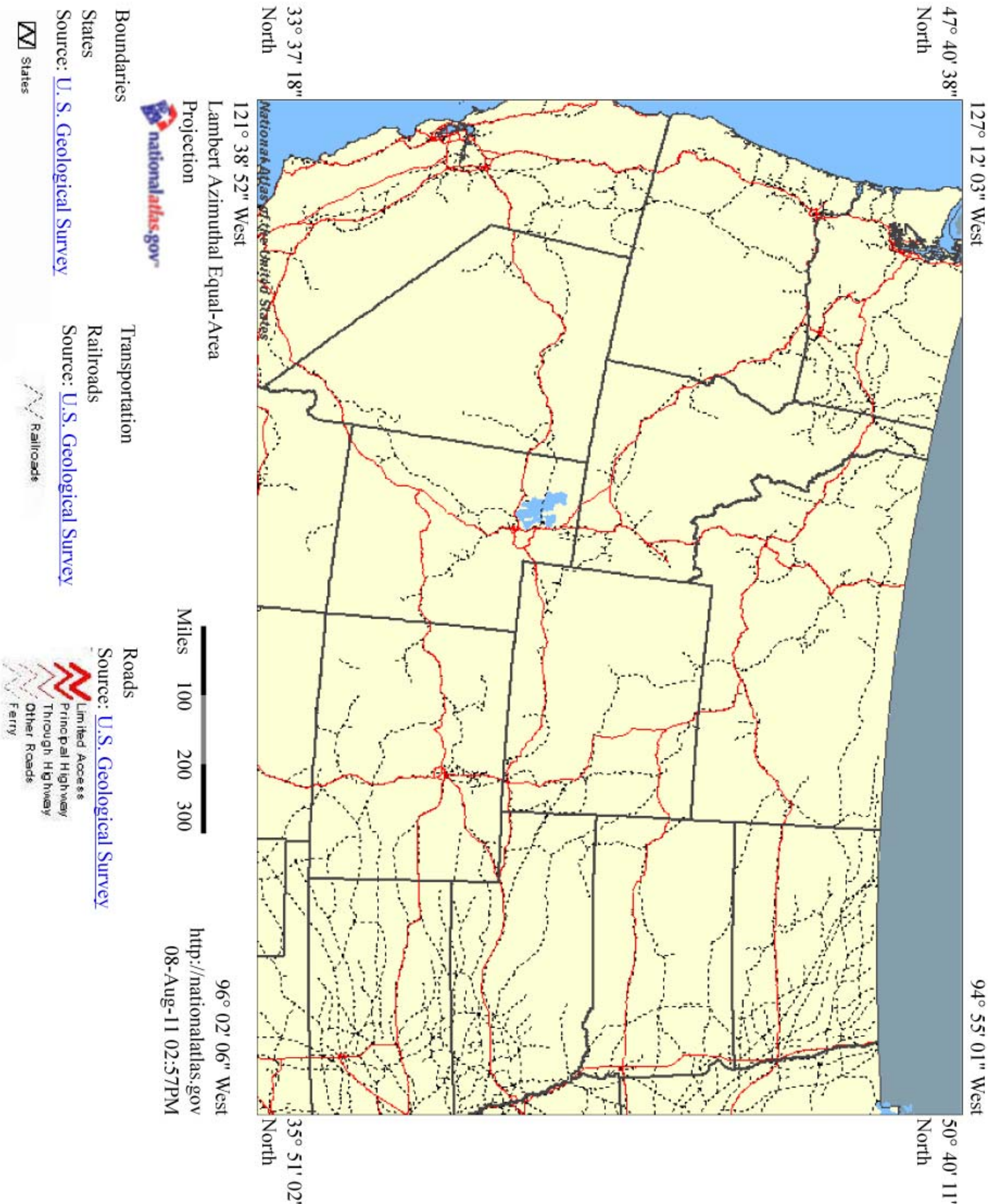
- Is its evolutionary rate fast? Slow? Somewhere in between?
- Roughly speaking, is there sufficient genetic diversity or availability of favorable alleles within the species to support evolutionary adaptation?
- Are individuals in this species capable of phenotypic adjustment in response to changes in their environment?
- Is there evidence that this species is already adjusting/adapting to change (e.g. shifting behavior, range, host plants, etc.)?
- Is the geography, land use, etc. such that it would be possible for individuals to seek out refugia during times of particular climate stress (e.g. prolonged heat wave)?
- Is the geography, land use, etc. such that it would be possible for species range shift to occur? Remember that species' range shifts typically happen by differential survival and reproduction, not by the purposeful movement of individuals to new locations.
- Are there multiple populations with enough connectivity among them to allow for rescue effects and gene flow?

Administrative unit/habitat:

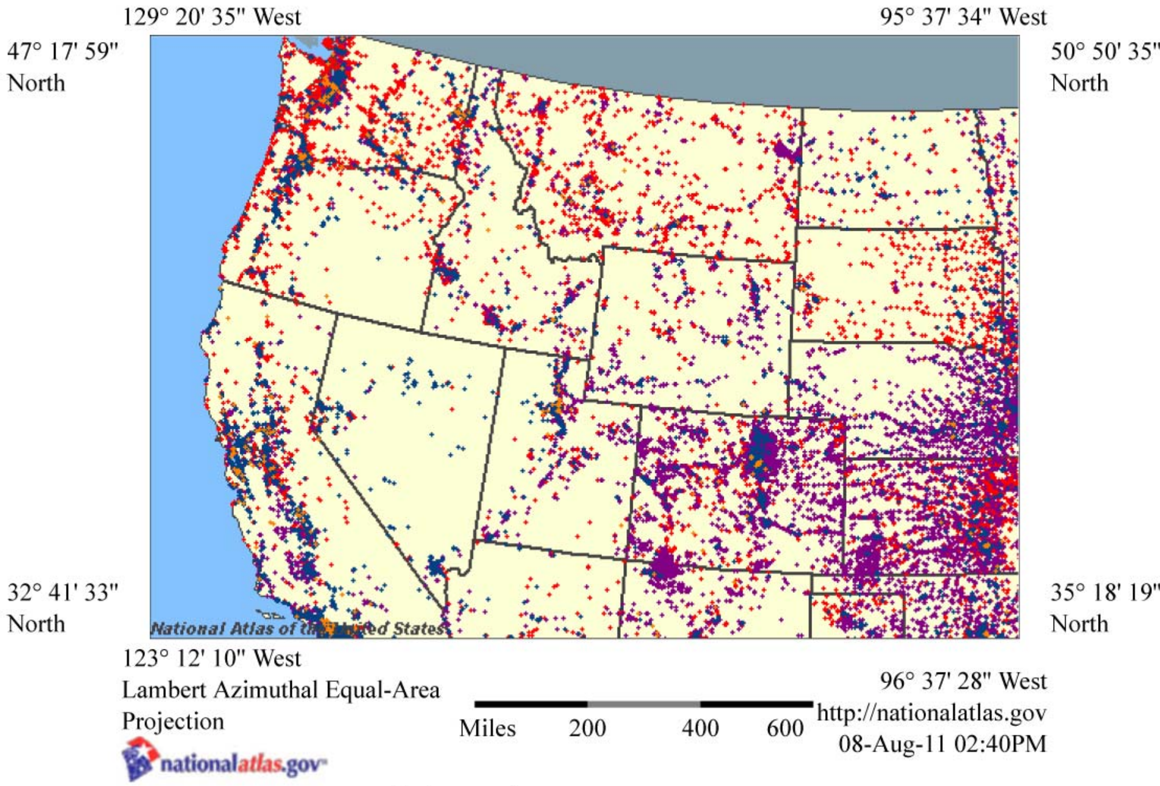
- What are the defining characteristics of the habitat community, and how vulnerable are they to climate change? E.g. presence of particular minerals in the soil may not be affected by climate change, whereas presence of vernal pools may be heavily affected.
- Is there a diversity of species in each functional group within the community/habitat?
- Is the geography, land use, etc. such that it would be possible for the community/habitat to shift location over time?
- Are there microclimates within the area that could support refugial communities?
- What is the nature of people's relationship to this habitat/community? Does it occur in areas where there is strong development pressure? Do people value this habitat because of services it provides (e.g. clean water, hunting or fishing opportunities, etc.)?
- Consider adaptive capacity of species and habitats within the unit.
- How rigid/specific are the rules governing management of the unit (e.g. for National Parks, what is in the enabling legislation)?
- Is there a General Management Plan or something similar? If so, how does this affect the adaptive capacity of the unit?

Foothill Yellow-legged Frog Adaptive Capacity Assessment Tools

Roads



Environmental Risk Sites



Boundaries

States
Source: U. S. Geological Survey

States

Environment

Water Discharge Permits
Source: U.S. Environmental Protection Agency

Water Discharge Permits

Air Releases
Source: U.S. Environmental Protection Agency

Air Releases

Toxics Release Inventory
Source: U.S. Environmental Protection Agency

Toxics Release Inventory

Superfund National Priorities List Sites
Source: U.S. Environmental Protection Agency

Superfund National Priorities List Sites

Protected Areas in Foothill Yellow-legged Frog range