Salt marsh harvest mouse (*Reithrodontomys raviventris*) and California Tidal Marsh

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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; **Landscape:** Umpqua-Klamath National Wildlife Refuge
2. **Species:** Greater Sage Grouse (*Centrocercus urophasianus*); **Landscape:** Humboldt-Toiyabe National Forest
3. **Species:** Salt marsh harvest mouse (*Reithrodontomys raviventris*) **Landscape:** California Tidal Marsh

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, CO2 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, CO2 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

Salt Marsh Harvest Mouse – Summary information

Natural History (Shellhammer 1989 and 1998)

- The salt marsh harvest mouse (Reithrodontomys raviventris) is a small rodent species endemic to the San Francisco Bay area and Suisun Bay salt marshes in California.
- It is divided into two subspecies with the northern most species (*Reithrodontomys raviventris halicoete)s* and the southern subspecies *(Reithrodontomys raviventris raviventris)* lives in the East and South Bay marshes. Both are listed as federal and state endangered species
- An adult's length is twelve to eighteen centimeters (5 to 7 inches) and height is between 1.5 and 2.1 centimeters (0.6 to 0.8 inches). Weight of a mature mouse is approximately 10 to 20 grams (0.35 to 0.7 ounces).
- Its many predators feature raptors, egrets, herons, snakes, and owls, as well as opprotunitsti feeders such as shorebirds and mammals. Predation by domestic cats and non-native red foxes are a problem due to encroachment of the limited habitat by human development. The mice are dependent heavily on vegetation cover to avoid predation.
- The Salt Marsh Harvest Mouse has an average maximum age of 12 months, however most of the mice only live to about eight months.
- They do not have a high reproductive cycle as other species of mice would. They usually have around 4 offspring per litter and usually only once a year
- Little detail is known about the mouse's preferred microhabitat and its use of the tidal salt marsh macro habitat). Common pickleweed (*Sarcocornia pacific)* is the primary habitat, but non-submerged, salt-tolerant vegetation for escape during highest tides is essential (Shellhammer et al. 1982). It requires dense pickleweed as habitat for food, refugia, and nesting sites (Shellhammer H., 1982).
- The salt marsh harvest mouse is well adapted to living in hypersaline tidal environments. It has been shown to swim and tolerate high salinities in its food and water (Shellhammer 1989).
- Pickleweed seeds and vegetation is its main diet and it will drink saline water only slightly less salty than sea water (Fisler 1963).
- Pickleweed location and density has been shown to determine mouse locations (Padgett-flor *et al*. 2003). Movement of individuals between marshes does not seem to occur (Shellhammer 1977).

Disturbances

- The major threats to the salt marsh harvest mouse are habitat loss due to development, habitat fragmentation, sea level rise, habitat degradation by invasive plants or animals, and human disturbance (Takekawa et al. 2006).
- During extreme high tides the mice have been shown to move into marginal upland habitat using levees and other structures (Bias 1999). The importance of upper zones of non-tidal submerged plants for refugia is critical for the mouse along with higher elevation islands.
- If the mouse is also forced to move to higher elevation and outside of the salt marsh protective cover it becomes more vulnerable to predators. A lot of this remaining upland habitat is diked marshes or agricultural land.
- A recovery plan for the species was completed in 1984 by the U.S. Fish & Wildlife Service, with the aim of protecting, enhancing and restoring marsh habitat, and undertaking further research

into the species and its requirements, and a Tidal Marsh Ecosystem Recovery Plan developed by the US Fish & Wildlife Service, which will include this species, is currently under development

Known climate change responses

- No direct studies have been done to assess climate change impacts to salt marsh harvest mice. However, it is known that the salt marsh harvest mouse will use the upper plant parts of the vegetation during high water at which time it becomes vulnerable to predators and drowning.
- If sea level rise or storms were to inundate this habitat and submerge the salt marsh vegetation more frequently the mortality rate of the mouse will increase due to drowning, predations, and a decrease in reproduction success.
- The potential secondary impact from mean sea level rise and high tide frequency increase could be death of tidal salt marsh plant species especially pickleweed due to an increase in flooding events and an increase in anoxic conditions. This would indirectly affect the mouse population by losing its primary pickleweed habitat.

Abstract from Sea-level Rise modeling results (J. Takekawa et al. 2012)
U.S. Geological Survey, Western Ecological Reseach Center

Coastal ecosystems have been identified by the International Panel on Climate Change (2007) as areas that will be disproportionally affected by climate change. Sea-level rise projections for San Francisco Bay are 1.24 m by 2100 (Cayan *et al.* 2008). The expected accelerated rate of sea-level rise through the 21st century will put many coastal ecosystems at risk, especially those in topographically low-gradient areas.

Sea-level rise response modeling was conducted at 12 tidal salt marshes around San Francisco Bay estuary where marsh accretion and plant community state changes were assessed to 2100. Detailed ground elevation, vegetation, accretion, and water level data were collected at all sites between 2008 and 2011 and used as model inputs. A modification of the Callaway *et al.* (1996) model, the Wetland Accretion Rate Model for Ecosystem Resilience (WARMER), was developed to run sea-level rise response models for all sites. Our results showed that the vast majority, 95.8% (1,942 ha), of the marshes in our study were projected to lose marsh plant communities by 2100 and transition to mudflats. Three marshes were projected to maintain marsh vegetation to 2100, but they only comprised 4.2% (85 ha) of the total marsh area surveyed.

All other marsh sites had relatively low accretion rates relative to sea-level rise. WARMER projected all of these marshes to transition to mudflat by 2100. Corte Madera, China Camp, and San Pablo Bay NWR marshes lost all high marsh by 2030 (+ 0.24 m SLR), briefly transitioned to mid and low marsh plant communities, but ultimately transitioned to areas dominated by mudflat by 2080 (+ 0.85 m SLR). The three marshes located on the Petaluma River (Gambinini, Petaluma, and Black John) lost most high marsh habitat by 2030 (+ 0.24 m SLR) and transitioned to mostly mudflat by 2080 (+0.85 m SLR).

Projected loss of pickleweed (*Sarcocornia pacifica*) habitats by 2100 could affect many tidal marsh wildlife species such as the federally endangered salt marsh harvest mouse (*Reithrodontomys raviventris*) and state threatened California black rail (*Laterallus jamaicensis coturniculus*). Only 4% of the marsh area was projected to support cordgrass (*Spartina* spp.) habitats by 2100 that also would affect distribution of the federally endangered California clapper rail (*Rallus longirostris obsoletus*).

The modification of the San Francisco Bay estuary makes it especially susceptible to sea-level rise, since there are few areas available for upslope marsh transgression. Seven of the marsh sites we surveyed had adjacent open space, but five marshes were surrounded by urban infrastructure prohibiting upslope movement.

California Tidal Marsh - Summary Information

Basics

Salt marshes are dominated by halophytic plants with tolerance for high salinity levels and tidal inundation, resulting in strong zonation of vegetation from lower to higher tidal elevations (Mancera *et al.* 2005). The San Francisco Bay estuary supports one of the largest extents of salt marsh in western North America. In 1850, it covered an estimated 2,200 km^2 (Atwater *et al*. 1979), but fragmentation and modification through local- and watershed-scale land use changes resulted in loss of >80% of historic marshes (Goals Project 1999).

Species

The draft of the Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California identifies 11 species of concern. These include the salt *marsh* wandering shrew (*Sorex vagrans halicoetes*) and Suisun shrew (*Sorex ornatus sinuosus*), San Pablo vole (*Microtus californicus sanpabloensis*), California black rail (*Laterallus jamaicensis coturniculus*), three song sparrow subspecies of the San Francisco Bay Estuary (*Melospiza melodia* spp.), saltmarsh common yellowthroat (*Geothlypis trichas sinuosa*), old man tiger beetle (*Cicindela senilis senilis*), *Lathryrus jepsonii* ssp. *jepsonii* (delta tule pea), and *Spartina foliosa (*Pacific cordgrass).

Habitats

Healthy intact *tidal marsh* ecosystems include a variety of habitats, generally stratified in zones depending on their elevation in relation to the reach of the *tides* (Hinde 1954; Atwater and Hedel 1976, Peinado *et al*. 1994).

Low Marsh. Low marshes usually occur in narrow bands along *tidal* channel banks and *mudflat* edges, providing habitat for inundation-tolerant grasses or grasslike vegetation: *Spartina foliosa* (California cordgrass) in salt *marsh*, *Scirpus* species (bulrushes and tules), and *Typha* species (cattails) in *brackish* marshes.

Middle marsh. Broad, nearly flat *tidal marsh* plains typically represent the middle *marsh* zone, dominated mostly by low herbaceous and weakly woody species, often with creeping growth habits. This zone is typically dominated by *Sarcocornia pacifica* (pickleweed) and sometimes also *Cuscuta* spp. (dodder; Howell 1949) in young/developing marshes, but consists of variable mosaics of *Sarcocornia pacifica, Cuscuta salina* (salt marsh dodder), *Jaumea carnosa, Distichlis spicata* (saltgrass) and *Frankenia salina* (alkali-heath) in established salt marshes.

High marsh. In the San Francisco BayEstuary high *marsh* now is often confined to natural *levees* along *tidal* creek banks and edges of artificial *dikes*. High *marsh* typically occurs along elevated or better-drained *sediment* deposits associated with major creek banks, *alluvial fans*, stream mouths, and

gradients to terrestrial soils. This zone may be dominated by a variety of plant species with higher plant species richness and intraspecies variability than the lower zones.

High *tidal marsh* often is dominated by a variable association of *Grindelia stricta var. angustifolia* (*marsh* gumplant), *Distichlis spicata*, *Sarcocornia pacifica*, *Frankenia salina*, but includes many other species that have declined or are regionally rare in *tidal* marshes. In the eastern part of the *estuary*, *Cressa truxillensis* (alkali-weed) is common in the high *marsh* zone.
High *tidal marsh* with lower soil *salinity* also includes *Baccharis douglasii* (marsh baccharis) and *B. pilularis* (coyote brush), *Scrophularia californica* (California figwort), *Leymus triticoides* (creeping wildrye), *Rosa californica* (California rose), and *annual* salt-tolerant herbs.

Brackish tidal marsh. Regionally, *brackish marsh* refers to vegetation that develops under fluctuating mixed salt and *freshwater* influence. *Brackish marsh* vegetation prevails in the vicinity of river and creek discharges, for example, in the Petaluma Marsh, Napa-Sonoma Marshes, and Suisun Marsh and Bay (Baye *et al*. 2000).

Tidal brackish marsh vegetation in the San Francisco Bay Estuary is distinguished from salt *marsh* by several factors, particularly the structure and composition of low *marsh* and middle *marsh* vegetation. Low *brackish marsh* is dominated by *Scirpus maritimus* (alkali-bulrush), *Scirpus acutus* (hardstem tule), *Scirpus californicus* (California tule), and *Typha* spp. (cattails). *Spartina* is a significant component of low *brackish tidal marsh* only west of Grizzly Bay. Middle *marsh* plains in *brackish* marshes vary in composition more than in salt marshes, and in years of high runoff include significant abundance of bulrushes (*Scirpus americanus* in Suisun area, *S. maritimus* in south San Francisco Bay and north San Pablo Bay), rushes (*Juncus balticus*, *J. lesueurii* and intermediates), *Triglochin maritima* (sea-arrow grass), and many herbaceous *tidal marsh* plants with relatively low salt tolerance.

The highest plant species diversity is usually found in the high *marsh* zone in both salt and *brackish tidal* marshes (the upper *marsh* edge and higher creek *berms* or natural *levees*). The distinction between *brackish* and salt *marsh* is weakest in the high *marsh* zone because salt influence can be locally elevated by evaporation or depressed by surface drainage or groundwater discharge. As a result, there is considerable variability and overlap in plant species of high *brackish* and high salt *marsh*.

Key Issues

Habitat loss, fragmentation, and edge effects: The greatest historical and present threat to *tidal marsh* ecosystems and the species they support is the destruction and alteration of habitat. Loss of coastal wetland habitat to urban and industrial development has been extensive in California, with 90 percent of these wetlands being lost since settlement of the region (Goals Project 1999). Habitat fragmentation occurs when *tidal marsh* habitat, once extensive and contiguous, is divided into relatively small discontiguous fragments. In addition to the difficulty of supporting a *viable population* on a habitat fragment of limited area, *marsh* fragments may lack the full range of habitat features needed by a species throughout its life cycle. For example, a fragment might contain feeding and nesting habitat for the salt *marsh* harvest mouse, but completely lack refuge from high *tides* or *storm surges*. As remaining *marsh* areas are reduced in size, *edge effects* become increasingly severe. Local extinction rates in habitat fragments generally increase as habitat area decreases and distance from neighboring *populations* increases (Hansk 1999). Correspondingly, breeding *populations* of species with limited *population* densities and dispersal, such as the California clapper rail, have generally been lost from

smaller and more isolated *tidal marsh* fragments, and are at risk in many fragments where they still persist.

***Diking**:* Many hundreds of miles of *dikes* or *levees* dissect former *tidal* areas of the San Francisco Bay Estuary and Humboldt Bay. Most were first constructed years ago to create salt ponds, allow agriculture, or for purposes related to flood control. Maintenance of *dike* systems continues to isolate *tidal* marshes into areas too small to develop complex *tidal* drainage networks. Drying of *marsh sediments* has resulted in increased decomposition of organic matter in the soil or peat, causing *subsidence* of the ground surface. Groundwater pumping may also contribute to *subsidence*. Many *diked* areas are today substantially below sea level as a result, in some areas by more than 6 meters (20 feet).

Loss of ecotones: Prior to settlement of the bay area by Europeans, *tidal* baylands graded landward into transitional zones (or *ecotones*) of low-lying moist grassland or willow thickets, including some *vernal pool* grasslands, and then into upland areas (Goals Project 1999). Appropriately sized and structured *ecotones* are a critical component of California clapper rail and salt marsh harvest mouse habitats, especially in urbanized settings. These areas provide two primary benefits to adjoining wetlands by (1) absorbing and deflecting disturbances originating in upland areas, and (2) providing upland *refugia* during high *tide* and flood events, both of which ultimately influence habitat quality and carrying capacity of *tidal* marshes for clapper rails.

***Salinity changes*:** Both fresher and more saline conditions alter *tidal marsh* habitats, often with adverse consequences to the species that live there. Diking can alter *salinity* conditions, both in water and soils. Gradual changes in *salinity* in California estuaries are projected to result from sea level rise pushing saline ocean water further inland (Knowles 2002, Knowles and Cayan 2002, Wilkinson 2002).

Invasive species: One of the most pressing threats to the *tidal* marshes of California is invasion and modification of the ecosystem by *non-native* species—in the San Francisco Bay Estuary in particular, by the eastern cordgrass *Spartina alterniflora*. *Non-native* plant species capable of living in *tidal* marshes have invaded and profoundly altered vegetation, or threaten to do so, over extensive areas. *Invasive* species cause major impacts to the structure of vegetation, species competition, and composition within communities, and even to the soil-building properties of the *tidal marsh* ecosystem. Plant invasions harm *tidal marsh* animal *populations* by altering food availability or habitat structure. Invasions by *non-native* animals also affect *tidal marsh* species. To date, most animal impacts of concern have been those of *non-native* predators, such as red fox and Norway rats, on native prey species.

Disease: Ecosystem-wide disease issues are not currently known to exist.

Climate Change: Coastal areas are high-risk zones from the impacts of global climate change, with significant increases in the frequencies of extreme weather and storm events, and sea-level rise forecast by 2100. These physical processes are expected to alter estuaries resulting in loss of intertidal wetlands and their component wildlife species. Coastal ecosystems are particularly sensitive to the impacts of climate change, because they represent a narrow, transitional ecotone between the marine and terrestrial environments. They have been designated as high-risk zones to climate change impacts that are especially sensitive to: (1) projected sea-level rise, (2) ocean temperatures, and (3) global atmospheric and oceanic circulation patterns resulting in an increase in storm frequency and intensity (IPCC 2007; Cayan *et al.* 2008; Hoegh-Guldberg and Bruno 2010). Sea-level rise and an increase in extreme climate events will be the most significant factors threatening these ecosystems and their

dependent biodiversity (Thorne et al. 2012). In addition, an increase in ambient temperature has been shown to cause vegetation dieback in salt marshes (McKee *et al.* 2004); however impacts from ocean acidification and ocean temperature changes on estuaries are highly uncertain (Hoegh-Guldberg and Bruno 2010). Regardless of which climate change projection and resultant sea-level rise and storm model is used through 2100, thousands of hectares of coastal salt marshes will be permanently inundated if marsh accretion processes are not able to keep up. If natural or anthropogenic barriers inhibit marsh transgression to higher elevations, even greater loss will occur in the phenomenon known as 'coastal squeeze'. The local current rate of sea-level rise in the estuary is 2.2 mm/year (Cayan *et al.* 2008) which will primarily affect the salt marsh over the long-term (>25 years), but may change vegetation inundation frequency over the short-term for most of the area. Over 30 years there was an observed change of vegetation composition in the San Francisco Bay estuary to more salt-tolerant species (eg. *Sarcocornia pacifica*) (Watson and Byrne 2012).

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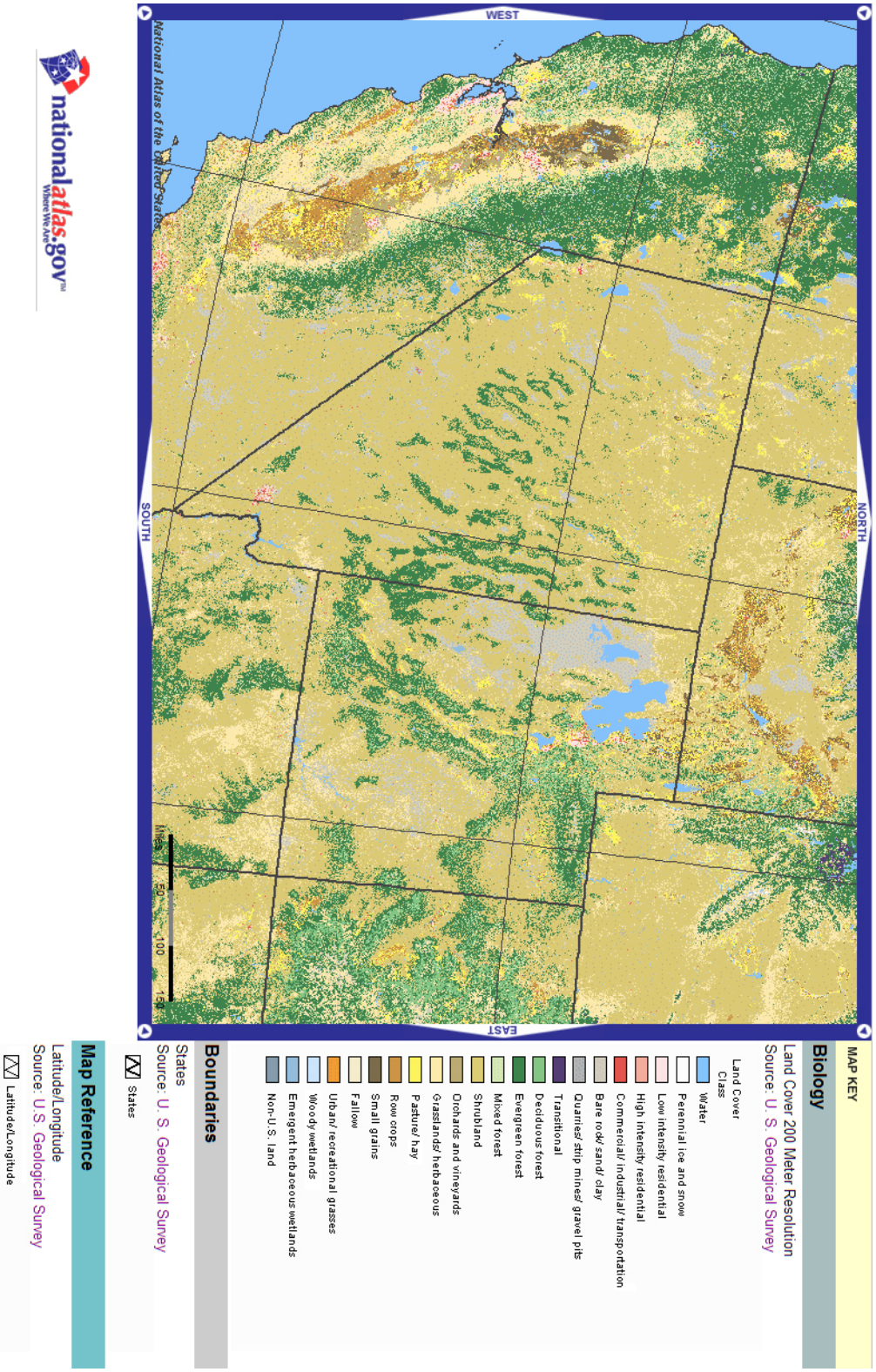
California Land Cover



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.

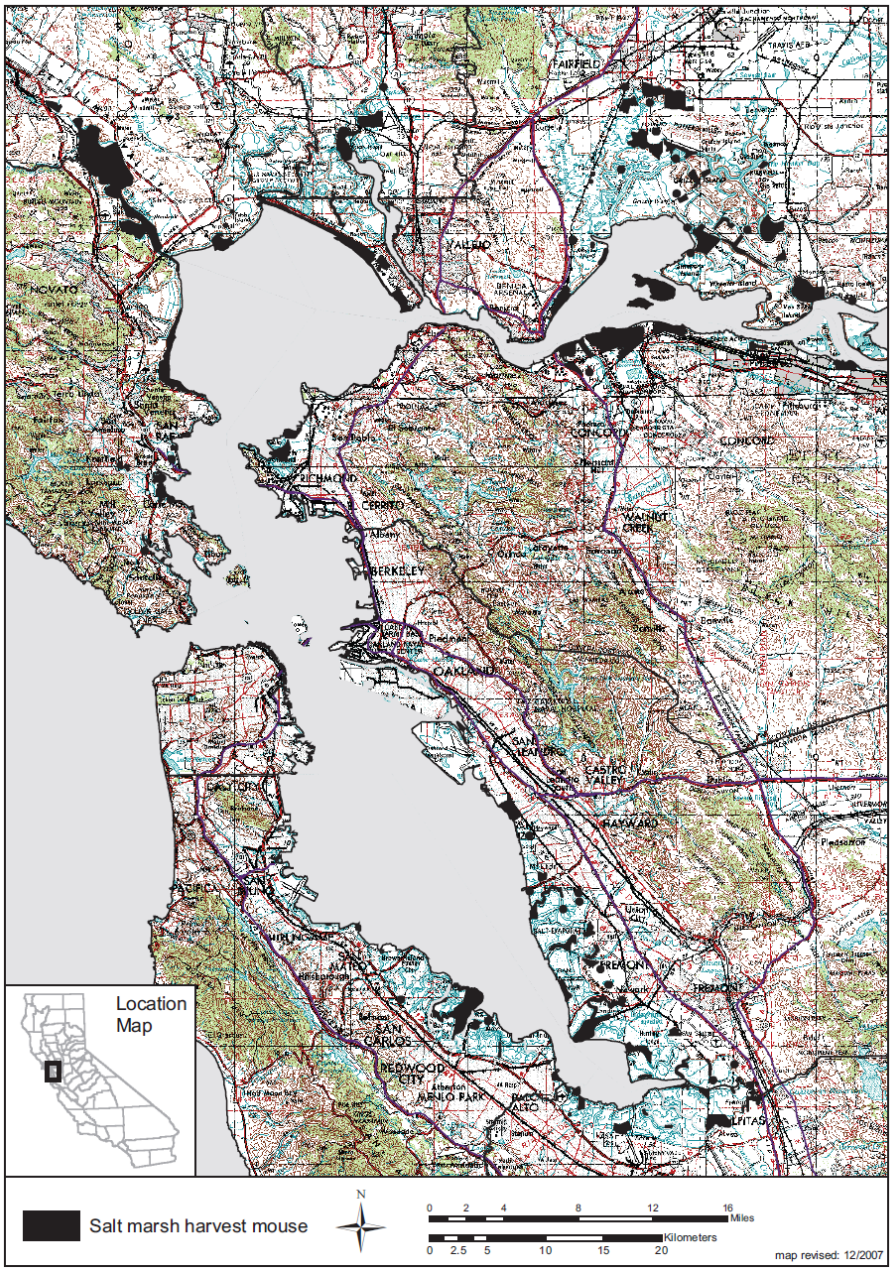
Resources:

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.

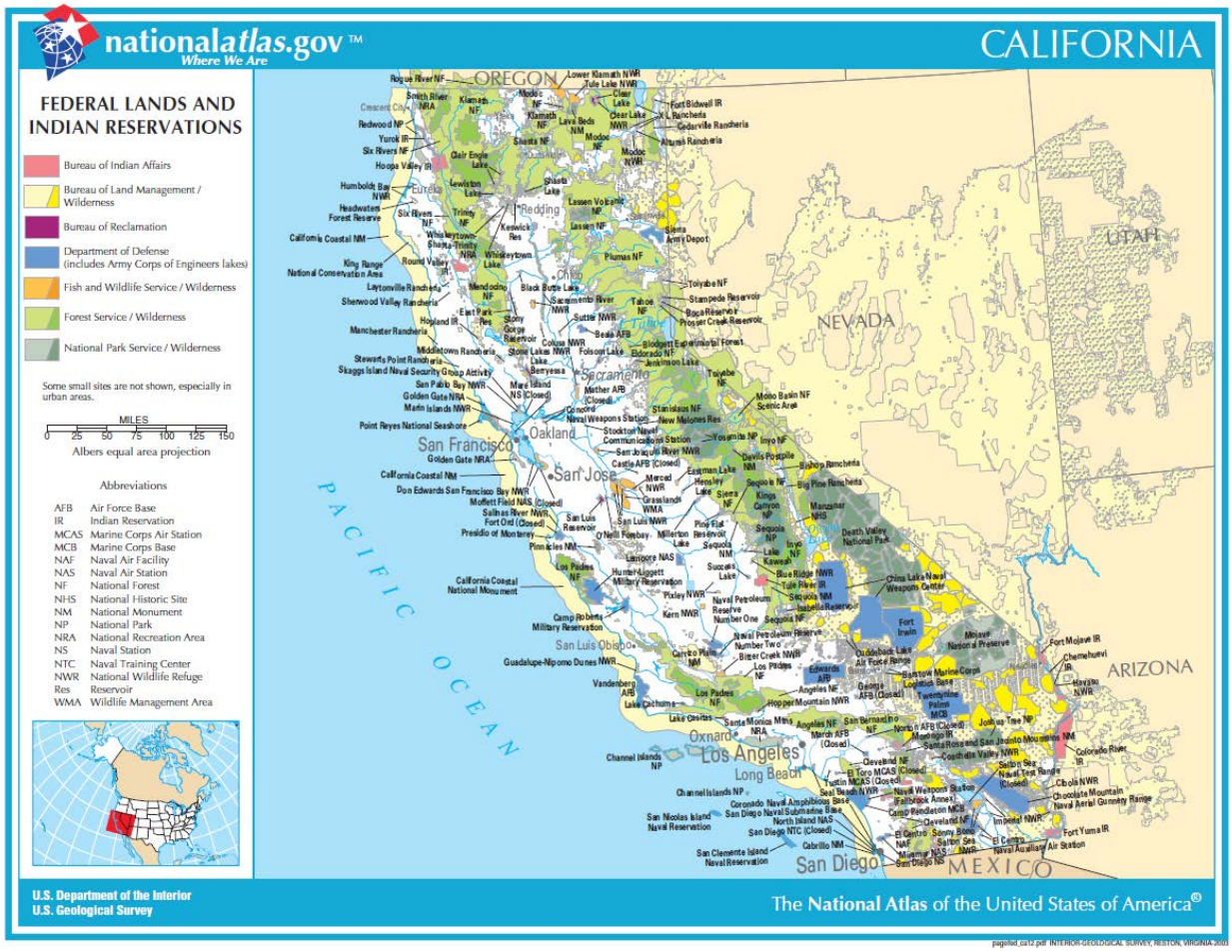
Questions to consider:

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.

Salt Marsh Harvest Mouse Distribution Map

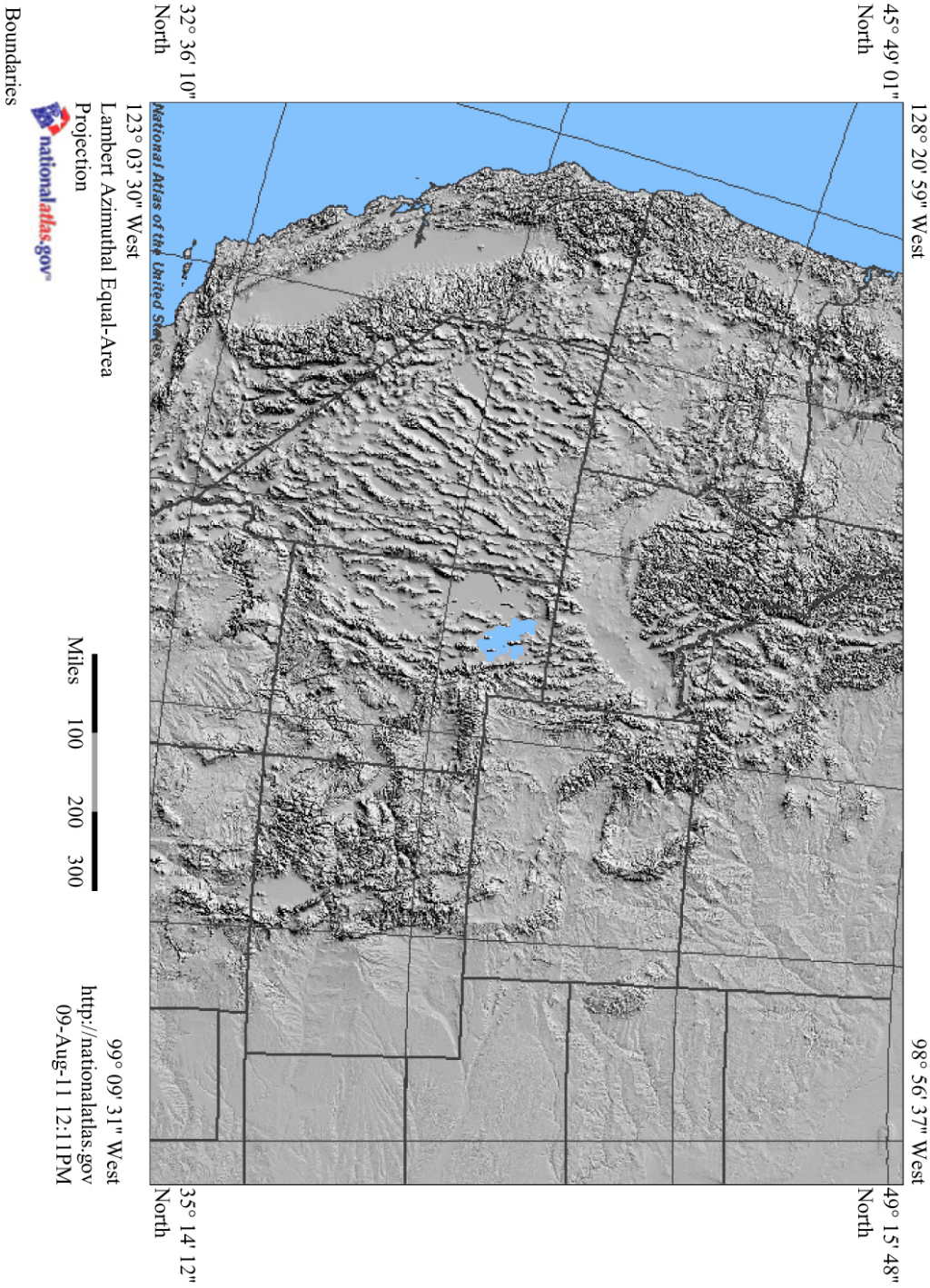


California Managed Lands Boundaries



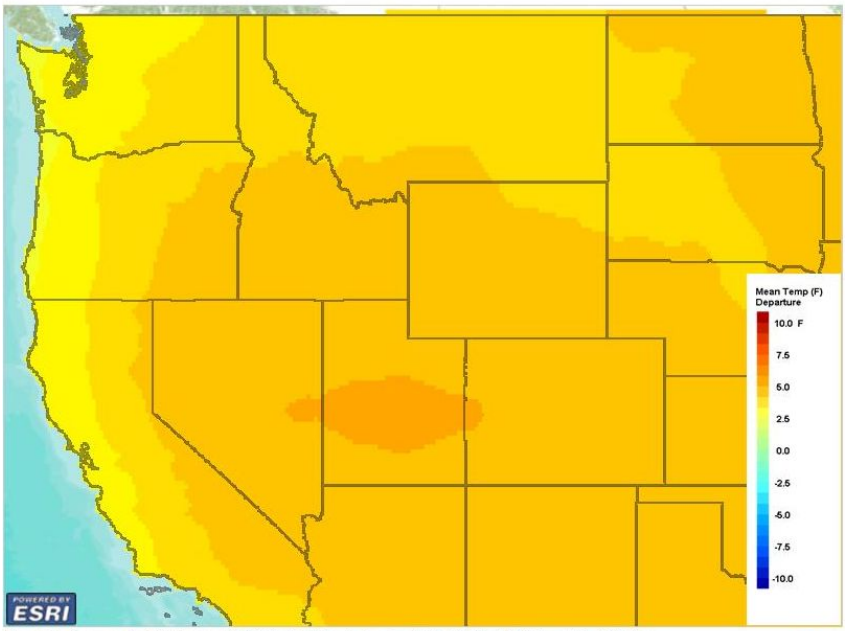
Exposure Assessment Tools

Topography



Annual temperatures

Change in Annual Temperature by the 2050s
Model: Ensemble Average, SRES emission scenario: A2



Map data Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, AND, USGS, NRCAN, and the GIS User Community
Data Source: Base climate projections downscaled by Maurer, et al. (2007) Santa Clara University. For more information see About Us.

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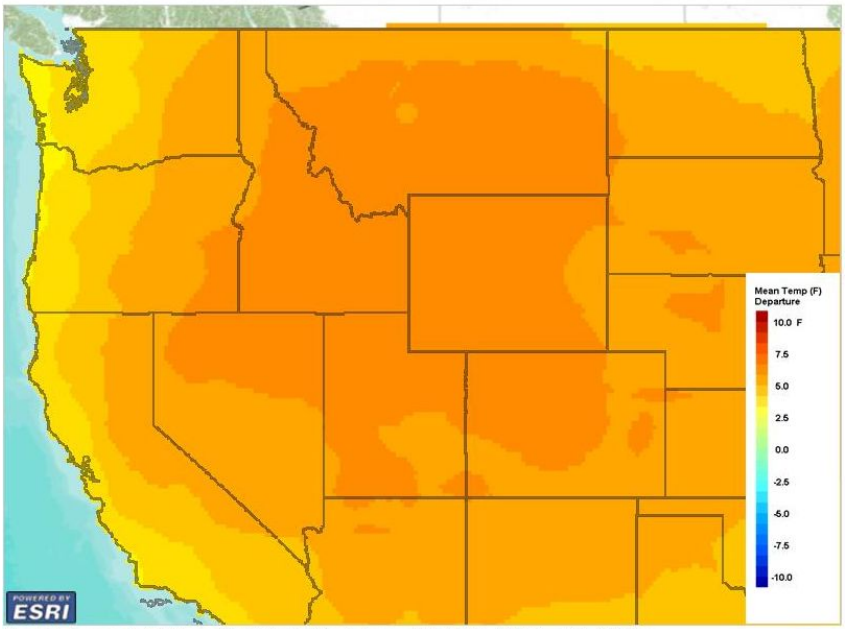
Summer temperatures

Change in Jun-Aug Temperature by the 2050s
Model: Ensemble Average, SRES emission scenario: A2



Map data Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, AND, USGS, NRCAN, and the GIS User Community
Data Source: Base climate projections downscaled by Maurer, et al. (2007) Santa Clara University. For more information see About Us.

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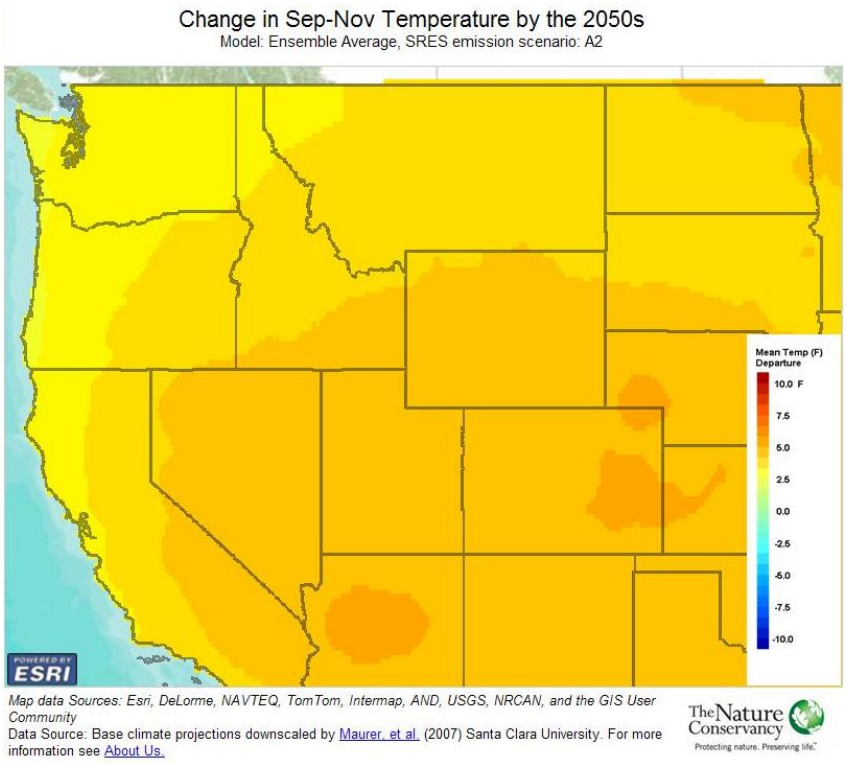
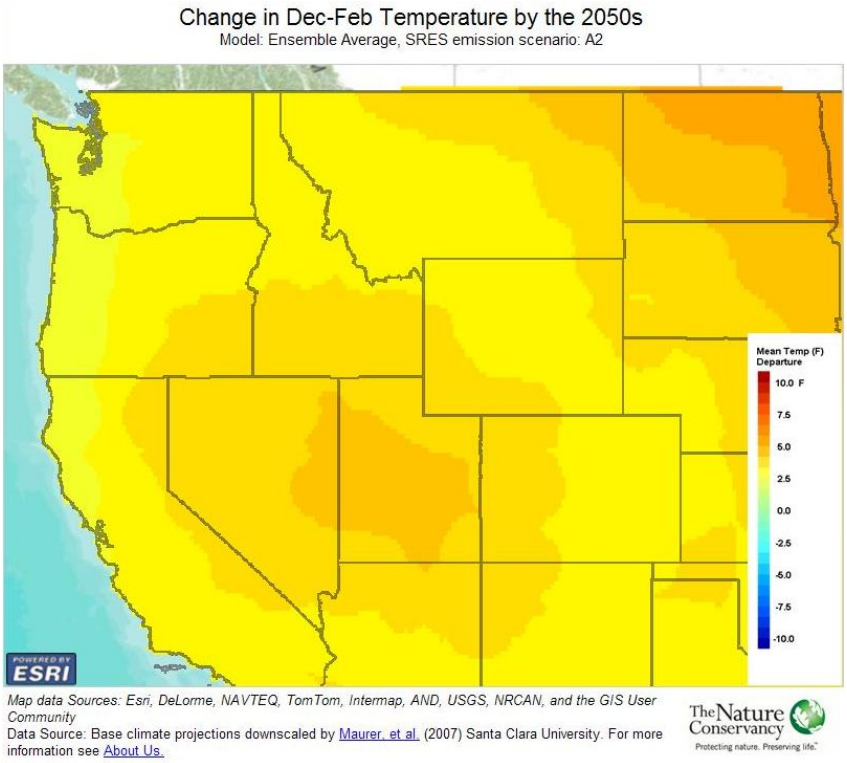
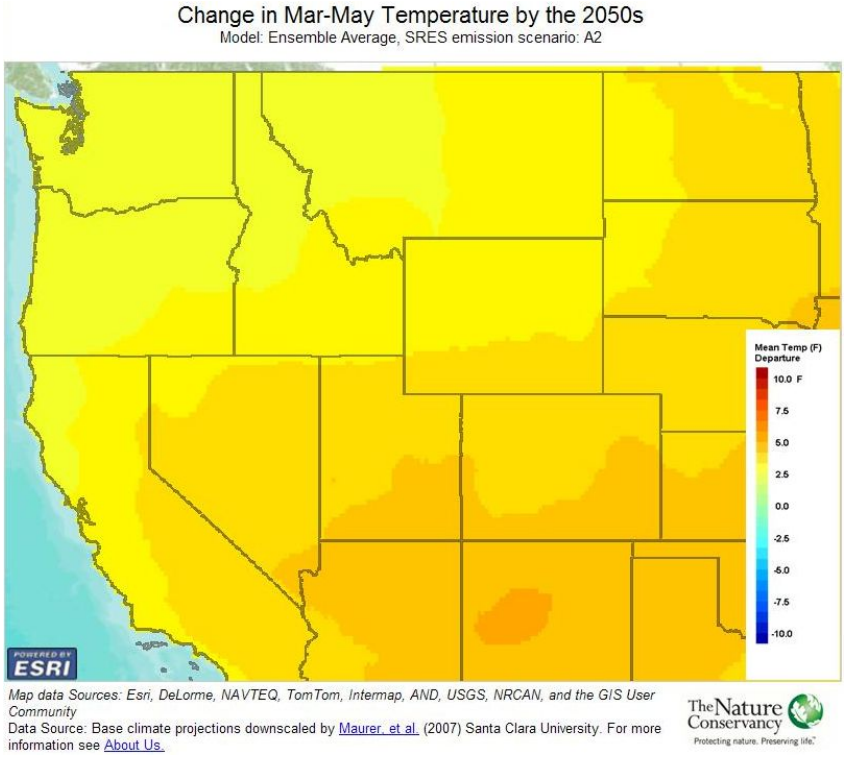
Fall temperatures



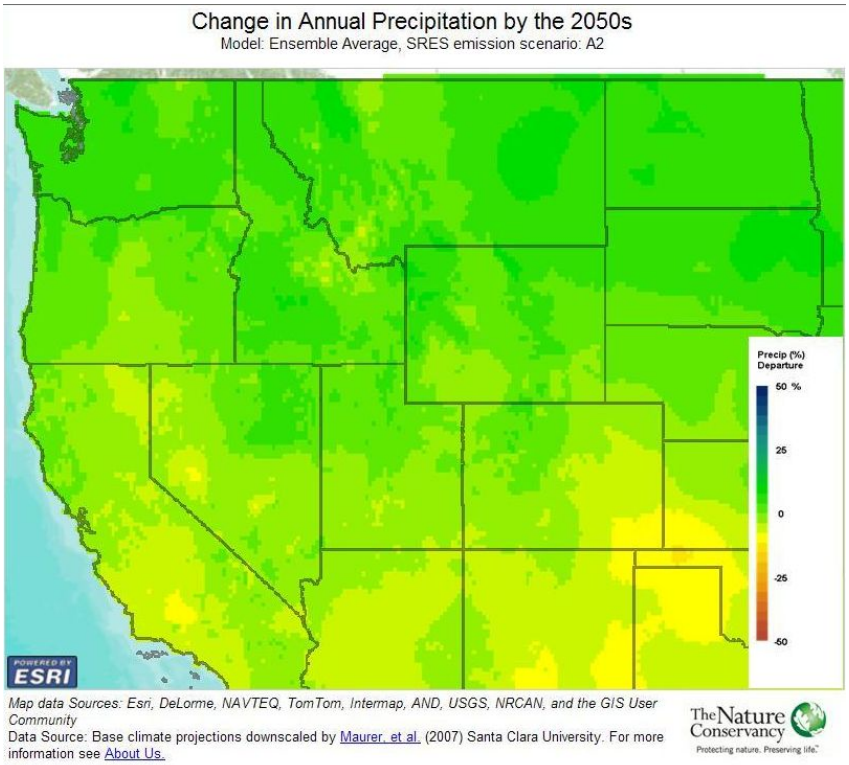
Winter temperatures



Spring temperatures

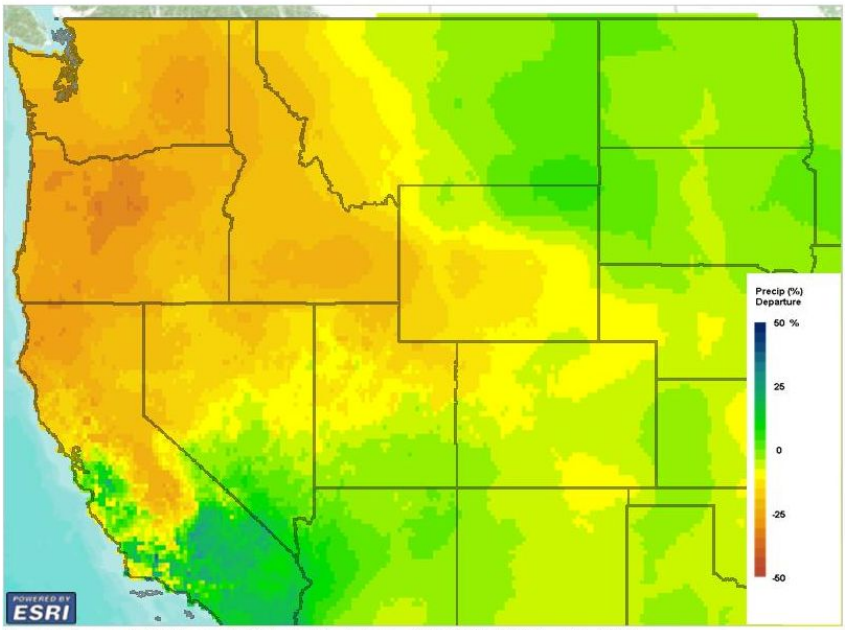


Annual precipitation



Summer precipitation

Change in Jun-Aug Precipitation by the 2050s
Model: Ensemble Average, SRES emission scenario: A2



Map data Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, AND, USGS, NRCAN, and the GIS User Community
Data Source: Base climate projections downscaled by Maurer, et al. (2007) Santa Clara University. For more information see About Us.

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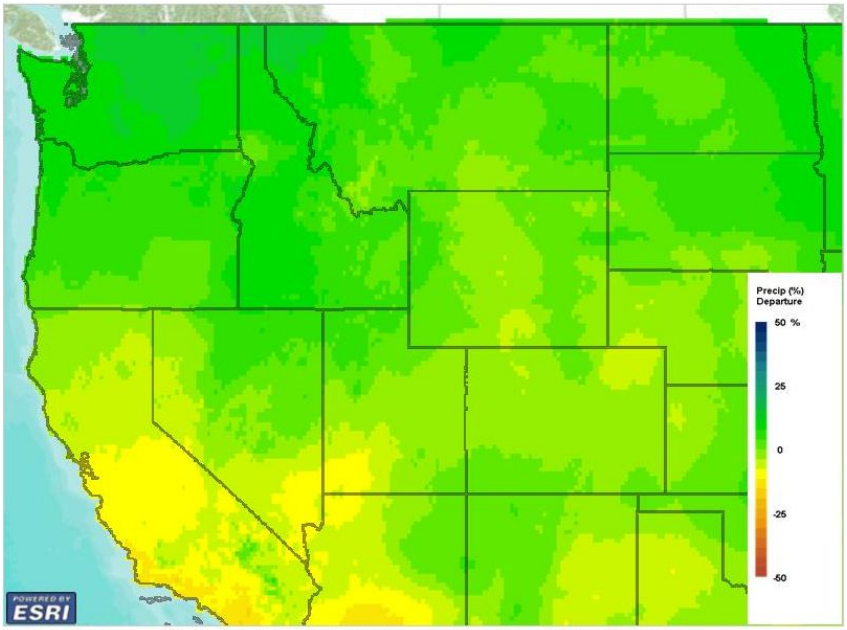
Fall precipitation

Change in Sep-Nov Precipitation by the 2050s
Model: Ensemble Average, SRES emission scenario: A2



Map data Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, AND, USGS, NRCAN, and the GIS User Community
Data Source: Base climate projections downscaled by Maurer, et al. (2007) Santa Clara University. For more information see About Us.

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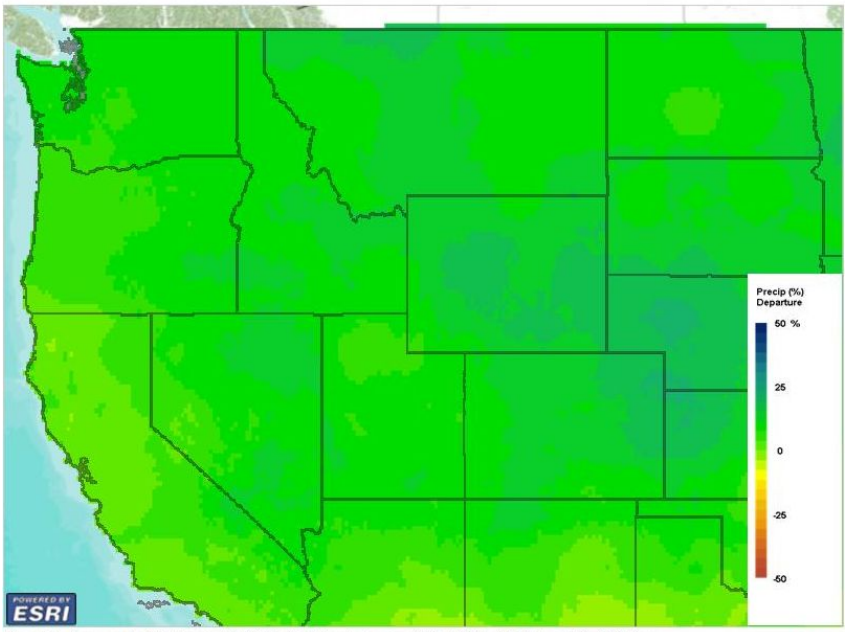
Winter precipitation

Change in Dec-Feb Precipitation by the 2050s
Model: Ensemble Average, SRES emission scenario: A2



Map data Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, AND, USGS, NRCAN, and the GIS User Community
Data Source: Base climate projections downscaled by Maurer, et al. (2007) Santa Clara University. For more information see About Us.

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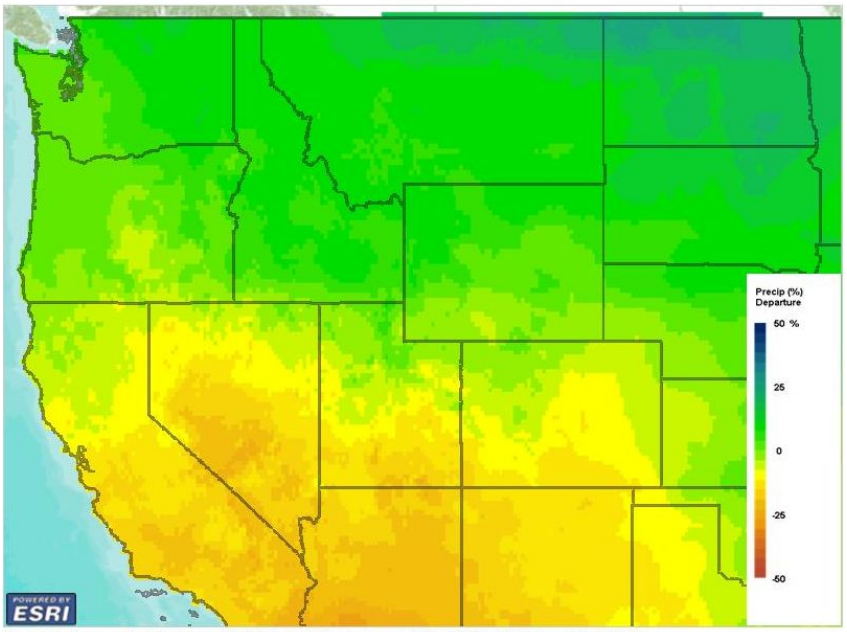
Spring precipitation

Change in Mar-May Precipitation by the 2050s
Model: Ensemble Average, SRES emission scenario: A2



Map data Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, AND, USGS, NRCAN, and the GIS User Community
Data Source: Base climate projections downscaled by Maurer, et al. (2007) Santa Clara University. For more information see About Us.

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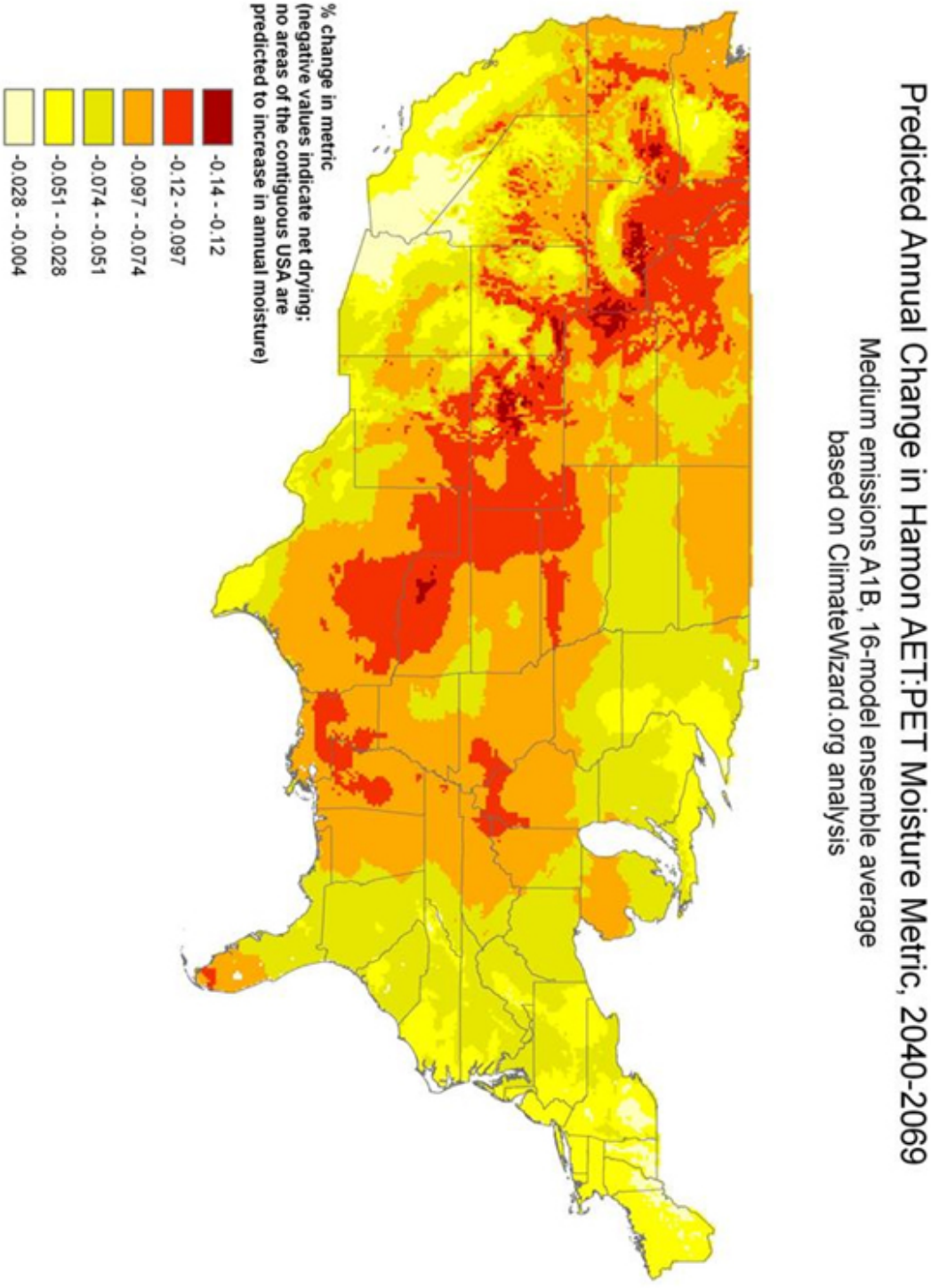

Predicted Annual Change in Hamon AET:PET Moisture Metric, 2040-2069
Medium emissions A1B, 16-model ensemble average
based on ClimateWizard.org analysis
% change in metric
(negative values indicate net drying;
no areas of the contiguous USA are
predicted to increase in annual moisture)
-0.14 - -0.12
-0.12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

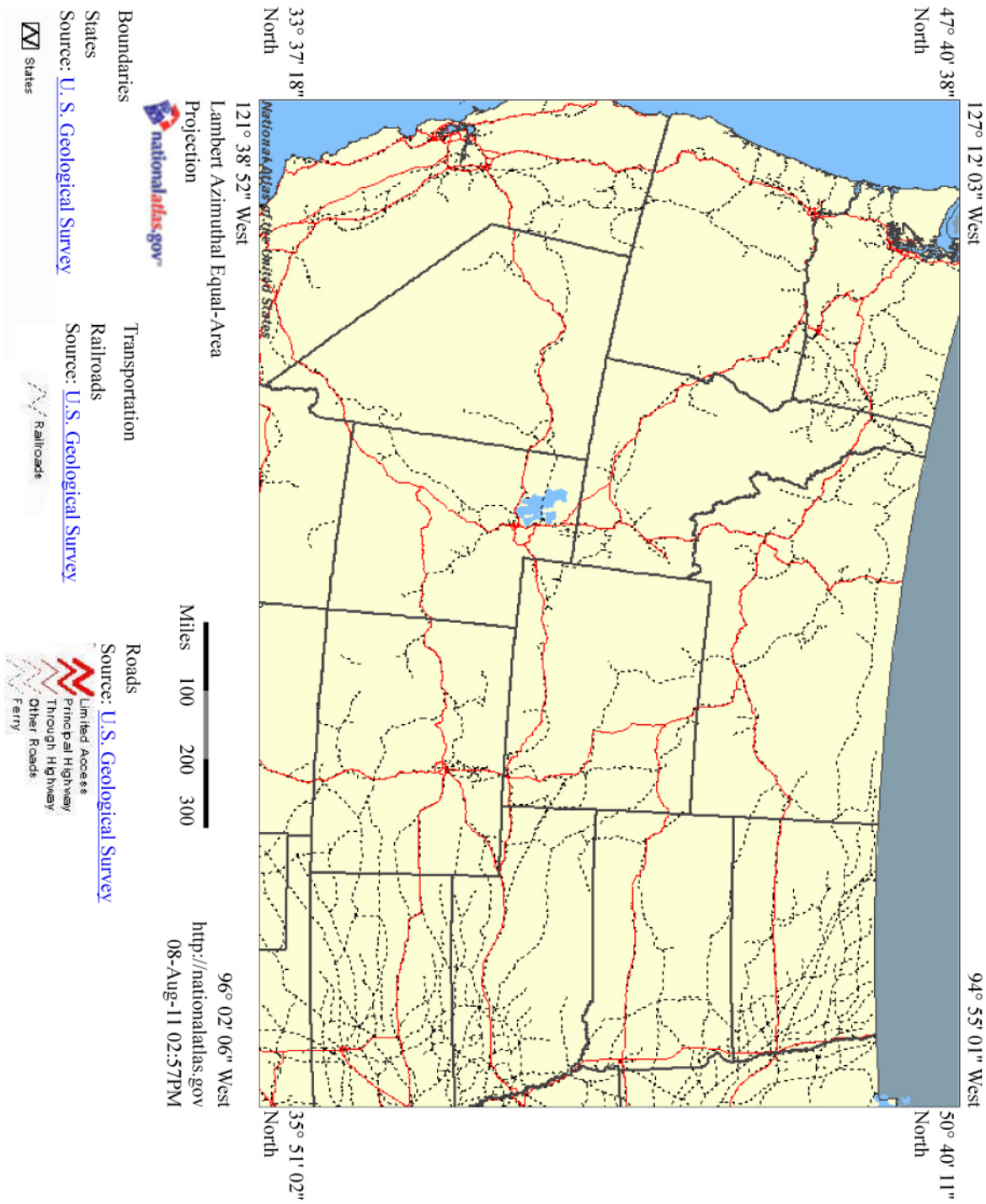
- Is its evolutionary rate fast? Slow? Somewhere in between?
- Roughly speaking, is there sufficient genetic diversity or availability of favorable alleles within the species to support evolutionary adaptation?
- Are individuals in this species capable of phenotypic adjustment in response to changes 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:

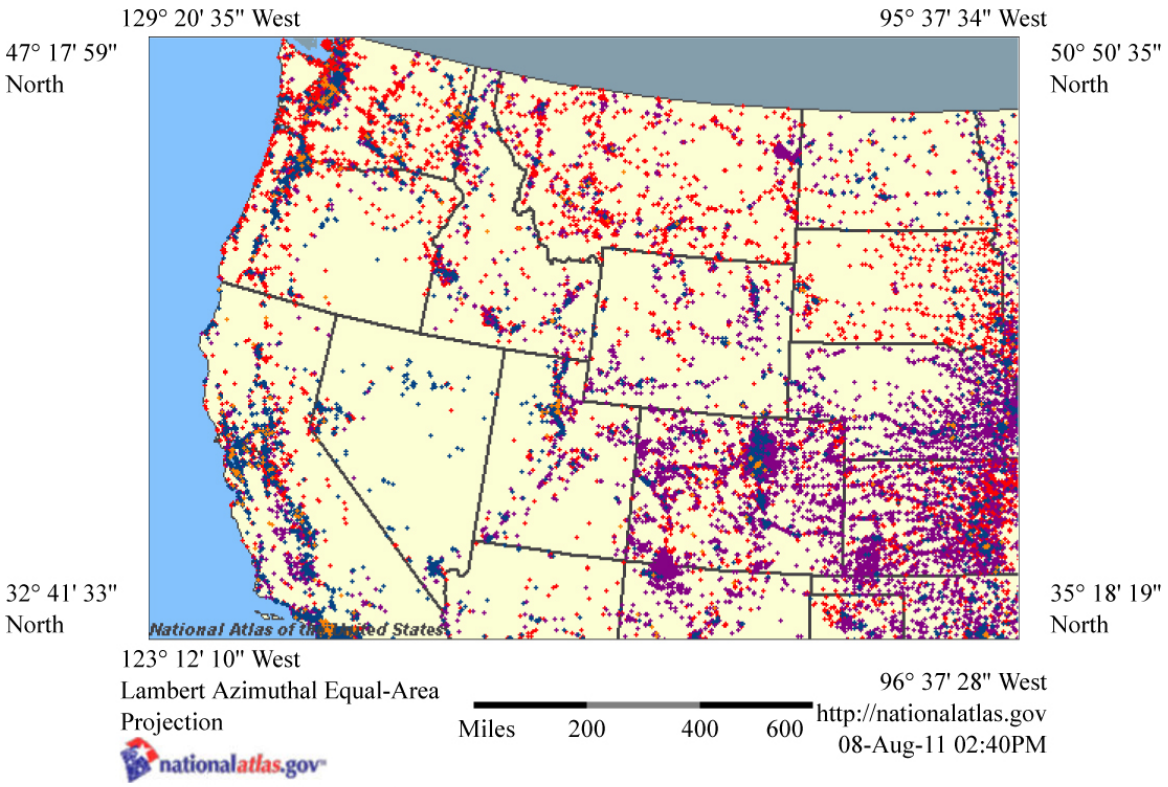
- What are the defining characteristics of the habitat community, and how vulnerable are they to climate change? E.g. presence of particular minerals in the soil may not be affected by climate change, whereas presence of vernal pools may be heavily affected.
- Is there a diversity of species in each 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?

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

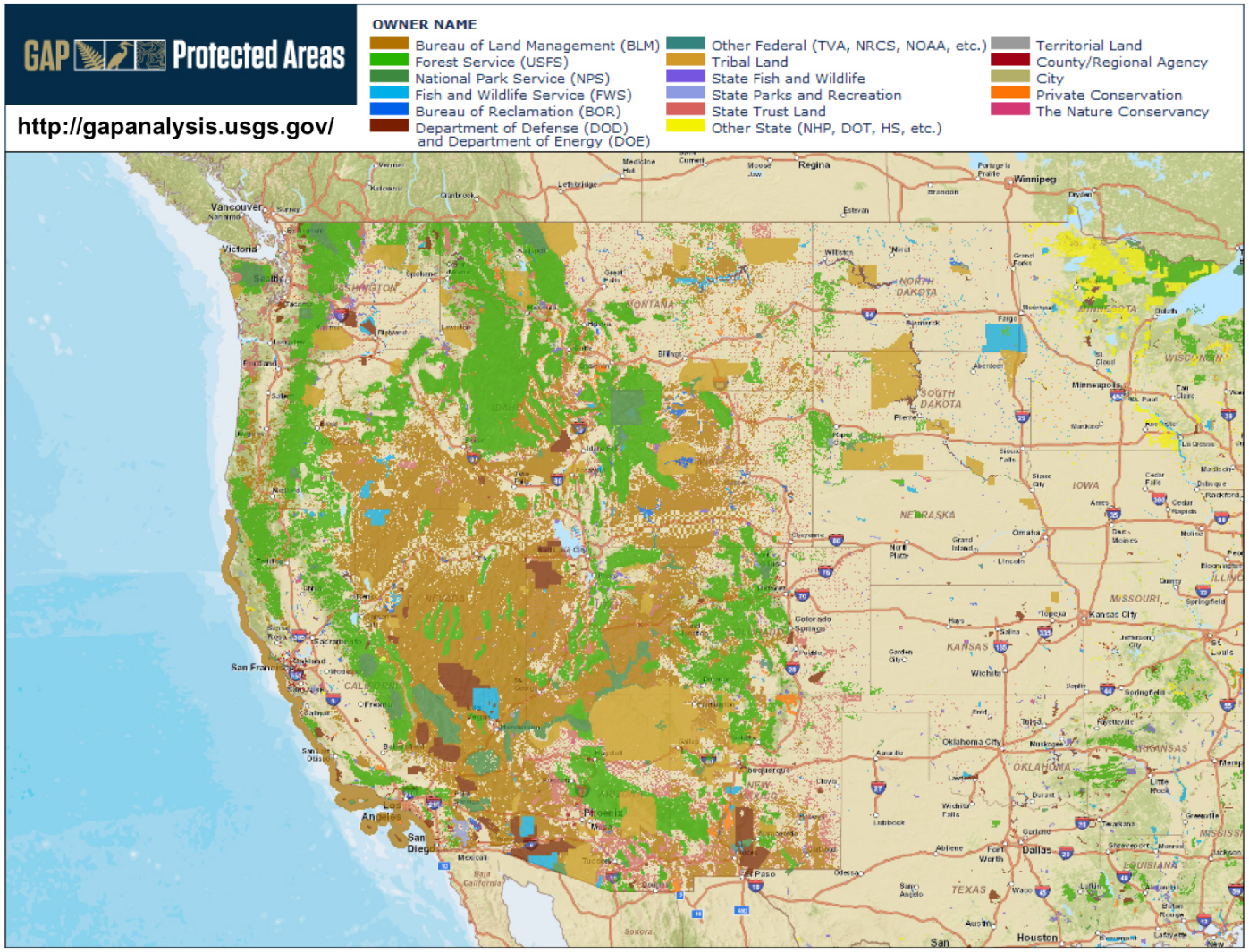
Air Releases
Source: U.S. Environmental Protection Agency

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 Salt Marsh Harvest Mouse range