Climate change in the Crown of the Continent: Impacts and opportunities

Anne Carlson, Ph.D.
Climate Associate,
The Wilderness Society
Bozeman, Montana



Impacts of climate change in the COC

- Temperature and precipitation patterns
- Hydrology and water resources
- Forests and other plant communities
- Disturbance patterns
- Terrestrial and avian wildlife species
- Aquatic wildlife species

Temperature and precipitation patterns



The Crown of the Continent is getting warmer

- In the last century, average annual temperatures in Montana increased $1.5^0 – 3.4^0$ F (3.6^0-6.1^0 C)
- In the last century, average annual temperatures in West Glacier increased 2.0^0 F (3.6^0 C)

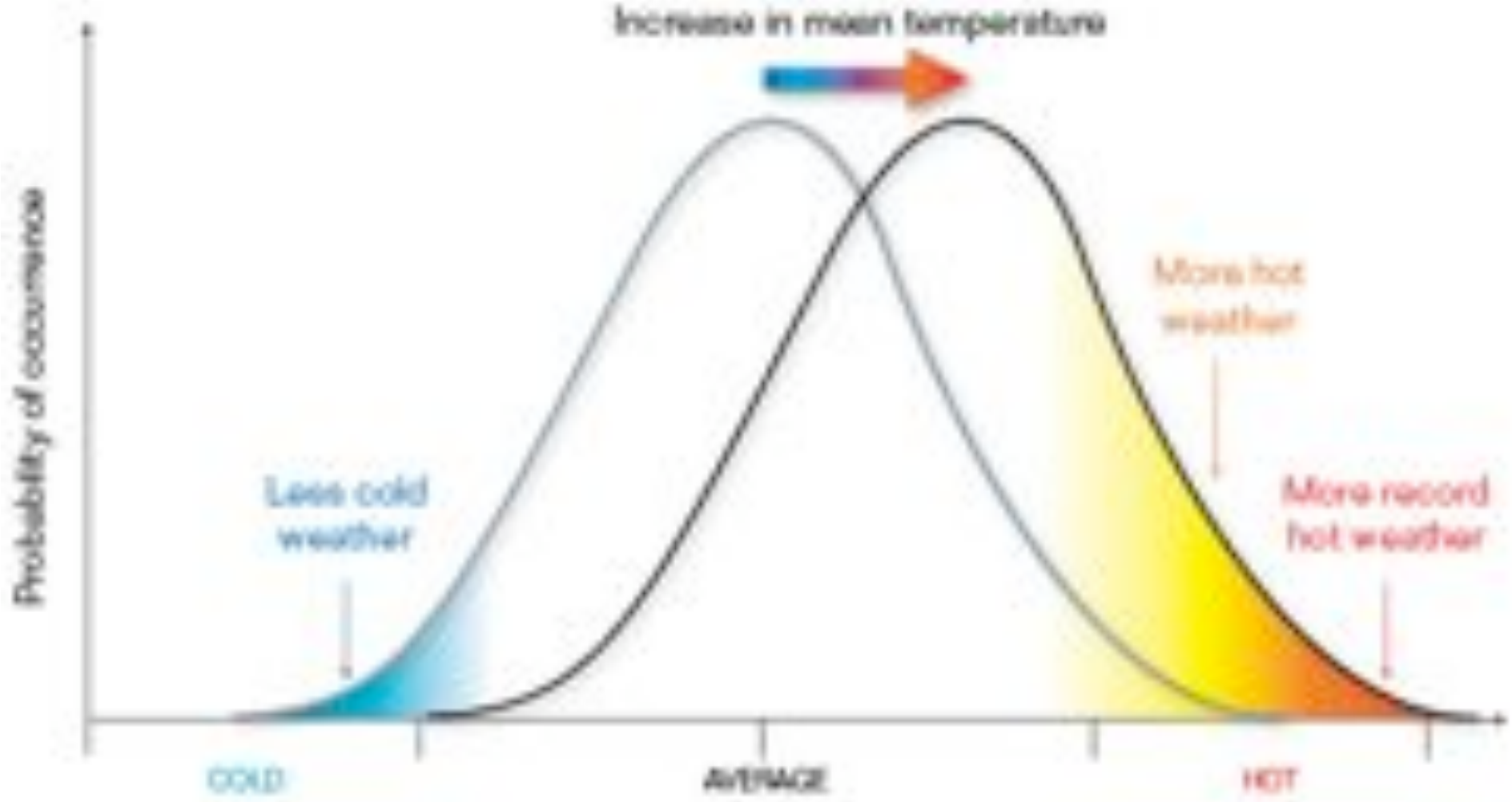
Saunders et al., 2010; Barnett et al. (2008); Bonfils et al., 2008; Saunders et al., 2008; Karl et al., 2009; Pederson et al., submitted; Climate Wizard Data Center; NOAA data)

Fewer cold days, more hot days

- Extremely cold days (<0^0 F; -18^0 C) are occurring less frequently in the Crown, while extremely hot days (>90^0 F; 35^0 C) are occurring more frequently
- 1895-1980: western Montana typically had 30-44 extremely cold days per year; 1981-2006: number of cold days per year declined to 14 per year
- 1895-1980: number of extremely hot days was, on average, 5 days per year; 1981-2006: number of extremely hot days per year tripled, to 15, on average, annually

(Barnett et al. (2008); Westerling et al., 2006; Karl et al., 2009; Pederson et al., submitted
NOAA data analyzed by Rocky Mountain Climate Organization, 2008)

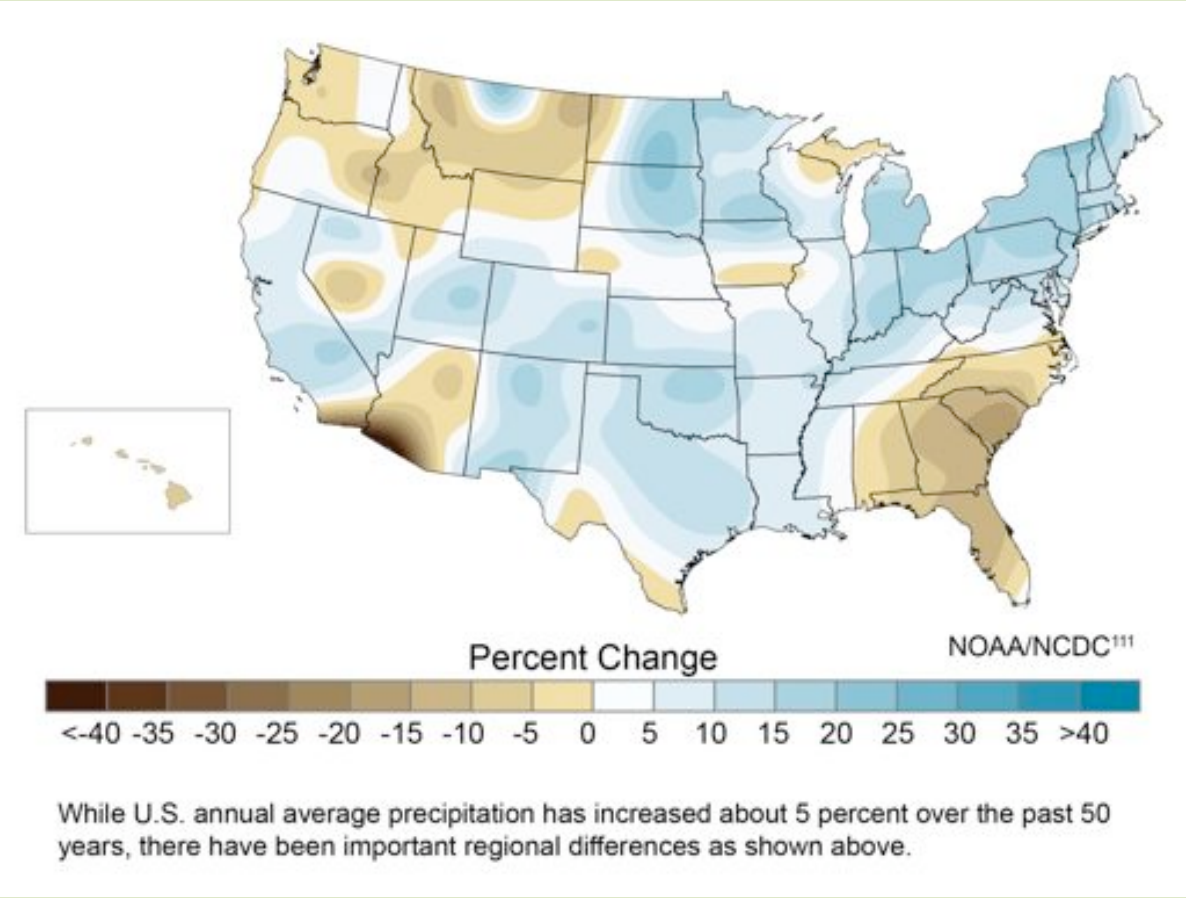
Increases in the average annual temperature,
even by just a few degrees, can shift temperatures at the extremes dramatically



The Crown of the Continent is getting drier

- Precipitation patterns vary at long time scales, and are often “noisy” at shorter time scales as a result
- Pacific Decadal Oscillation
- Earlier snowmelts each spring lead to longer annual summer droughts

(Karl et al., 2009; Pederson et al., submittedNOAA National Climatic Data Center, 2009;)



Hydrology and water resources



The Crown's glaciers are disappearing

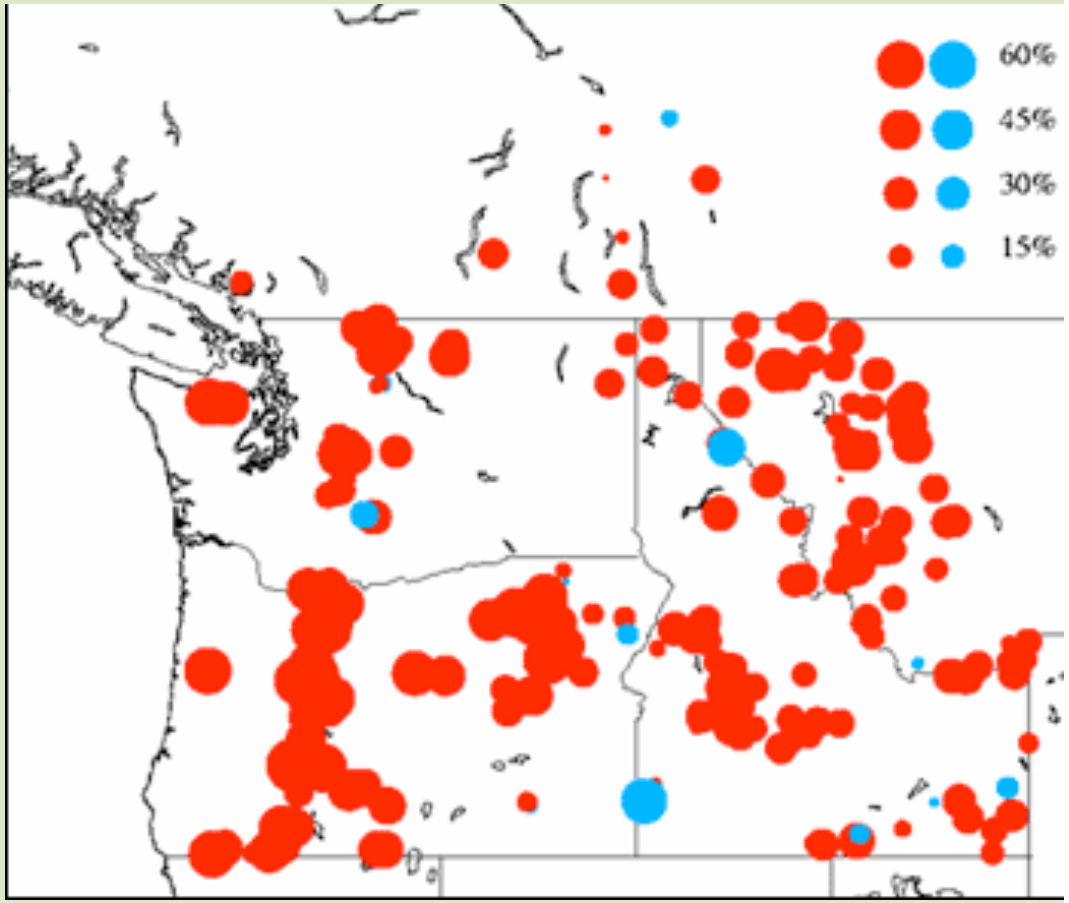
- Warming temperatures are accelerating the melting of glaciers and permanent snowfields
- In 1850, Glacier National Park had ~150 glaciers covering 99 kms^2
- Currently estimate that 37 glaciers remain covering <16 kms^2 (only 25 glaciers >25 acres)
- Last week ,Sheperd and Miche Wabun glaciers were declared functionally extinct
- Glacier NP's glaciers expected to disappear entirely by 2030

(Hall and Fagre, 2003,; Great Falls Tribune, 2010; US Geological Survey website)


Chaney Glacier: 1850 to Present

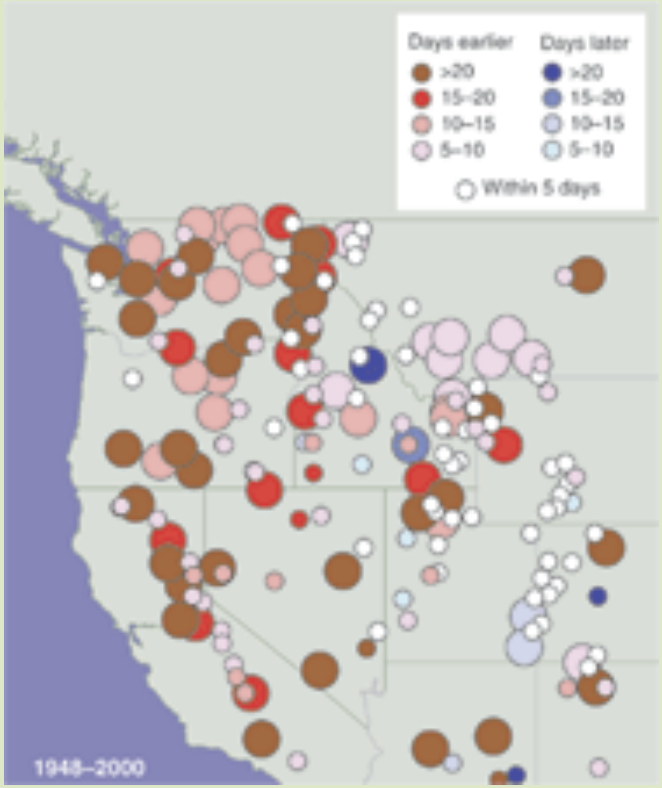
Average snowpack is declining

- Between 1950 and 1997, annual snowpack levels in the western United States declined 15-30%; this trend is expected to continue (P. Mote et al. (2005))
- Snowpack in Montana holds 60-75% of the state's water supply (Serreze et al. 2001;



Snowpack is melting earlier in the spring

- **Warmer temperatures earlier in the year have resulted in snowpack melting 1-4 weeks earlier than historic average**
  (Moore et al., 2007; McCabe and Clarjke, 2005; Luce and Holden, 2009)
- **Precipitation is increasingly arriving as rain instead of snow during the winter** **(Mote, 2003; Service, 2004; Barnett et al., 2008; Mote et al., 2005; Knowles et al., 2006; Saunders et al., 2008)**



Streamflows have been declining over the last 60 years

- Reduced snowpack, coupled with earlier peak snow melt in the spring, lead to reduced stream flows throughout summer
- Significant reductions (~20%) observed in streamflow in the Crown over the last century (Rood, 2010)
- Between 1950 and 2008 in NW Montana, streamflows decreased at 83% of U.S. Geological Survey stream gauge sites examined by 31% (range: 21-48%), on average, in just 58 years (Leppi, 2010)

Impacts on Human Communities

Forests and other plant communities



Declining forest health in the West

- Mortality rates in healthy coniferous stands have tripled (0.2% to 0.6%)over the past several decades
- Reduced snowpack increases length of summer drought; warmer temperatures lead to higher rates of evaporative loss
- New growth is often failing to replace dying trees
- Smaller trees could become more dominant, dramatically changing structure of forest, carbon storage capacity, and ability to support wildlife
- Loss of native plant species (sudden aspen tree decline) (van Mantgem et al.,2009)

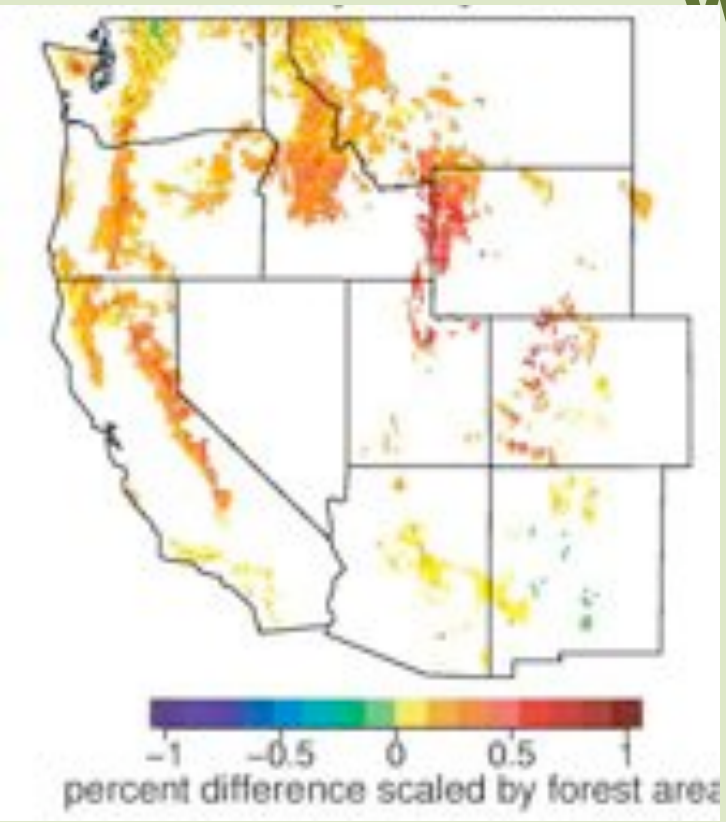
Disturbance:
wildfire, insect outbreaks, pathogens, and invasive plants

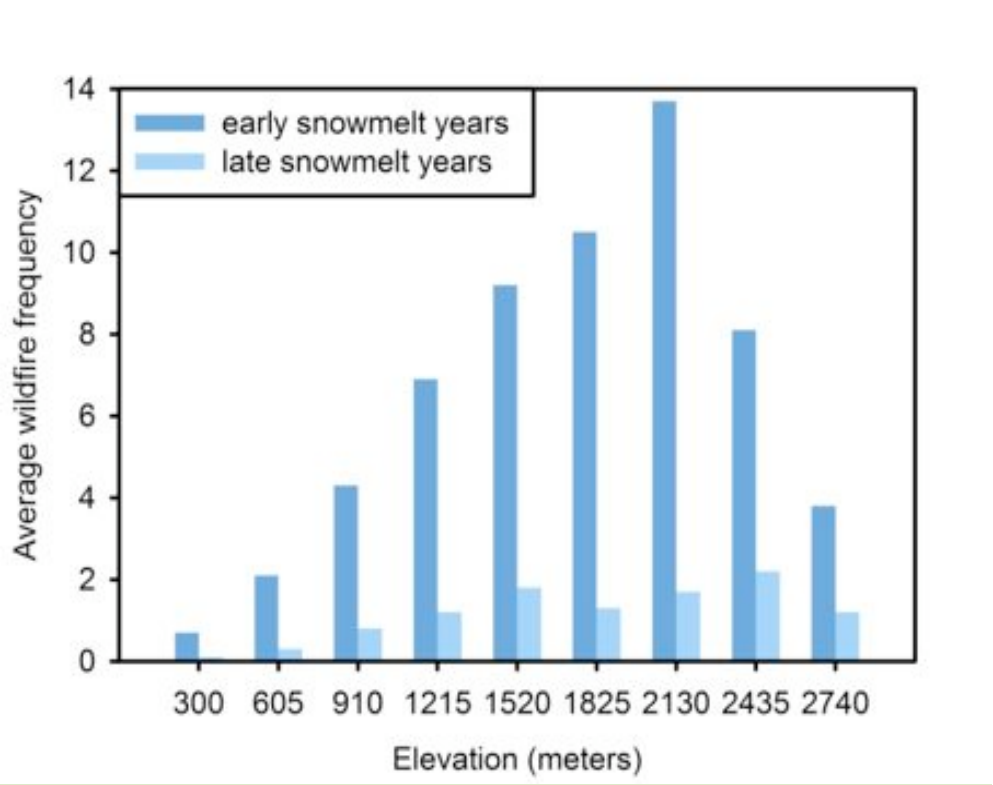


Wildfire patterns have changed

- Earlier snowmelt dates correspond to increased wildfire frequency (Westerling et al. (2006)
- Large wildfire activity increased suddenly in 1980's: larger fires, longer fire durations and longer fire seasons
- Annual area burned by large forest fires (<400 ha) in the West from 1987-2003 was 6 times the area burned from 1970-1986

The Crown's forests are becoming more vulnerable to wildfire

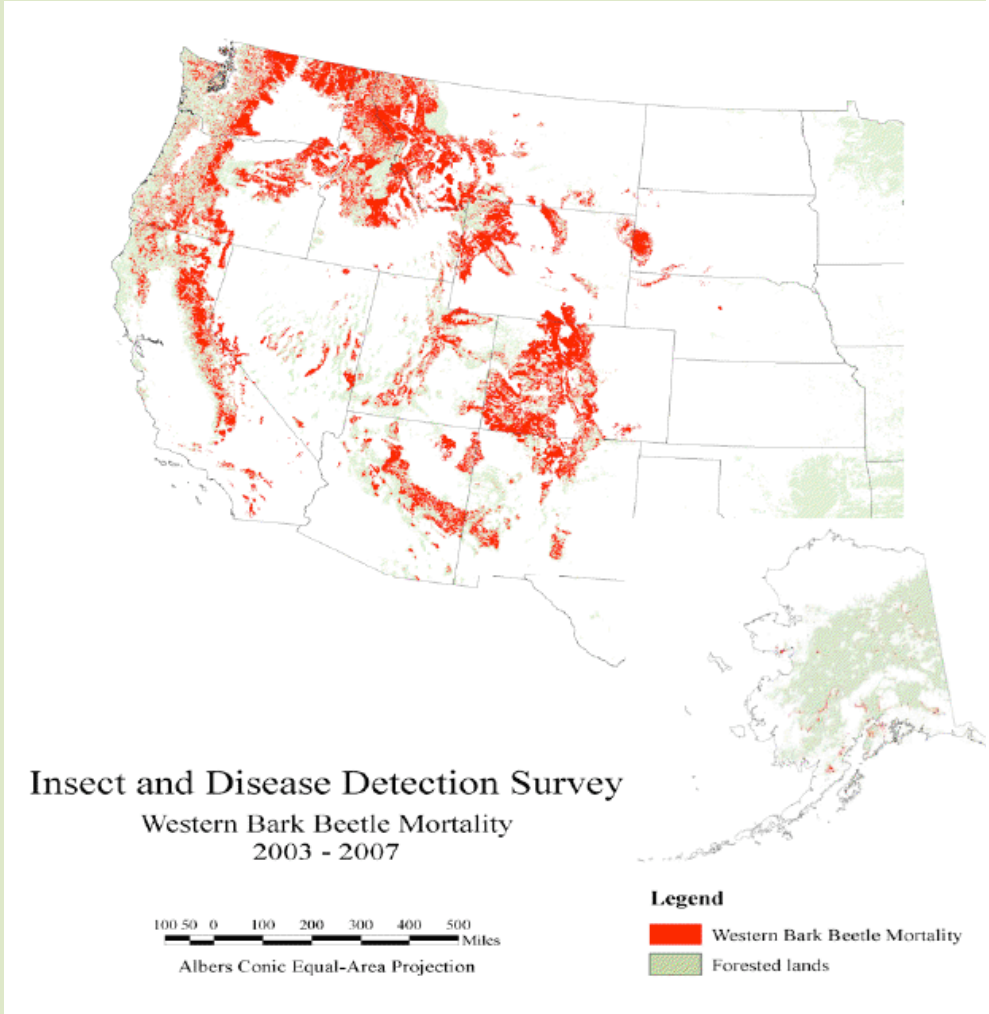




Percent difference in total moisture deficit from October to August in early versus late snowmelt years for 1970 to 1999 (Westerling et al., 2006)

More frequent and severe pine bark beetle outbreaks

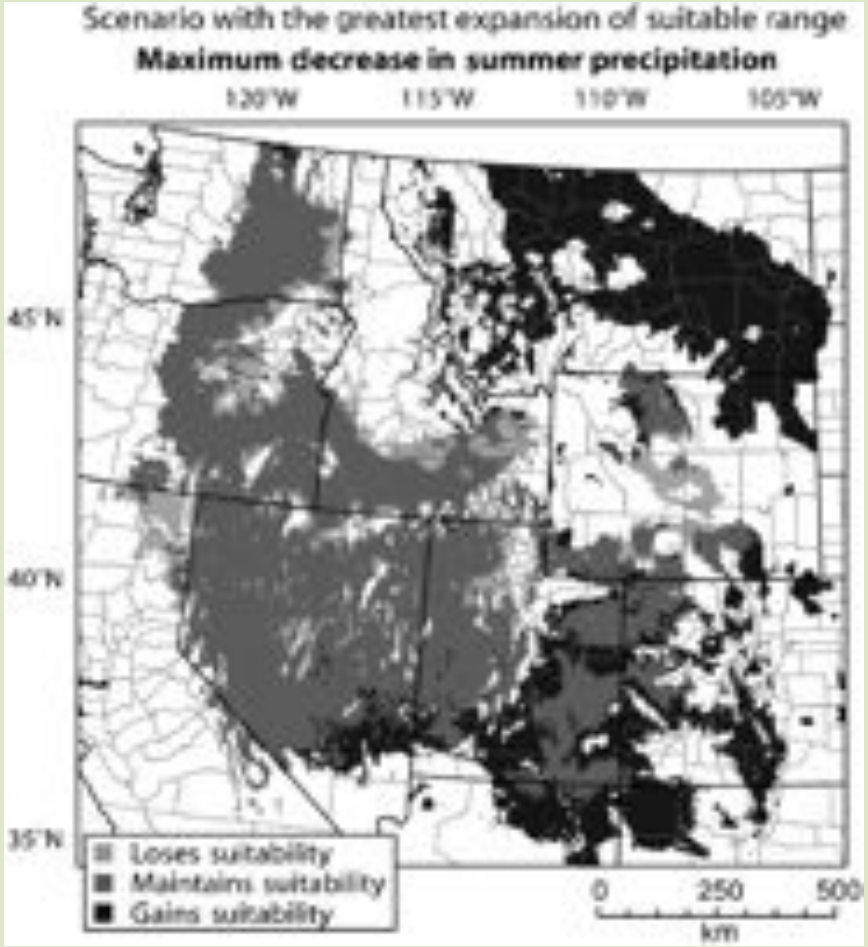
- Severe outbreak of pine bark beetles currently underway
- 30 million acres in British Columbia; ~5 million acres in Montana in 2009 (Forest Service Northern Region's Health Protection Team; Western Forestry Leadership Coalition, 2009)
- Pin e beetles now invading new habitats and host species, as well as completing their breeding cycles twice as quickly (Logan et al., 2003)
- Past 30 years, an invasive insect species, the willow stem borer, has attacked up to 75% of willows in some areas of B.C. as average temperatures have warmed (Pojar, 2010)



Western Forestry Leadership Coalition, 2009

Increase in invasive weed species

- Changing climate increases amount of suitable habitat available for invasive weeds
- Fire is one of the primary mechanisms of invasion for some noxious weed species
- Decreased precipitation in the summer, especially, expected to cause cheatgrass invasion to expand by 45% by 2100 under the worst case scenario



- Bradley, B.A. (2009) Global Change Biology 15: 196.

Outbreaks of pathogens: West Nile disease

- During years of drought, insect species that compete with, and prey on, mosquitoes suffer reductions in population size
- Mosquito population sizes increase 1-2 years after a drought
- Increases in mosquito population lead to more severe outbreaks of West Nile virus

(Wang et al., 2010)

Montana Department of Agriculture, 2010

Avian and terrestrial wildlife species



Avian species

- Annual bird counts from mid-1960's – 2006 reveal that 170 (56%) of bird species living in U.S. shifted their distributions, on average, 40 miles (64 kms) North in the last 40 years
- 55% of grassland bird species are in steep decline
- Short-eared owls, Eastern and Western meadowlarks, white-tailed ptarmigan, waterfowl

Endangered/ threatened species

- Lynx: dependent on cold, snowy winters (require four months/yr)
- 90% probability of Crown remaining snow suitable this century
- Decline in prey species (snowshoe hares)
- Wolverines: 35 breeding individuals (28-52 range) believed to inhabit Montana, Idaho and Wyoming
- Strongly associated with persistent snow cover; only den in snow

Other wildlife species: game species

- Elk: reduced winter kill on elk, new areas opened up by beetle kill; elk populations expected to increase as hunter population decreases (Creel, 2009)
- Pronghorn: ??
- Mountain goat: sub-alpine fir trees colonizing alpine meadows; loss of 4% of meadows in GNP to date (Fagre, 2010)
- Migrating waterfowl: Montana has many part-time resident species that are likely to be seriously impacted by rising sea levels (e.g. flooding predicted in 50% of arctic bird breeding grounds) (Pojar, 2010; Ken McDonald, Wildlife Division Administrator, Montana Fish, Wildlife & Parks)

Aquatic species



Trout fisheries

- Decreased streamflows
- Increased water temperatures
- Decreased dissolved oxygen levels
- Increased toxicity of pollutants
- Complications from human response to climate change (i.e. increased water diversion)
- Increased winter flooding
- Increased wildfires

(Ficke et al. (2007) Rev Fish Biol Fisheries 17: 581; Williams et al. (2007) Wild Trout IX Symposium)

Meltwater lednian stonefly

- Mist forest fly that is only found in Glacier National Park status in the U.S.
- Currently being considered for Endangered Species status in United States
- Depends on melt-water from glaciers to sustain its coldwater habitat

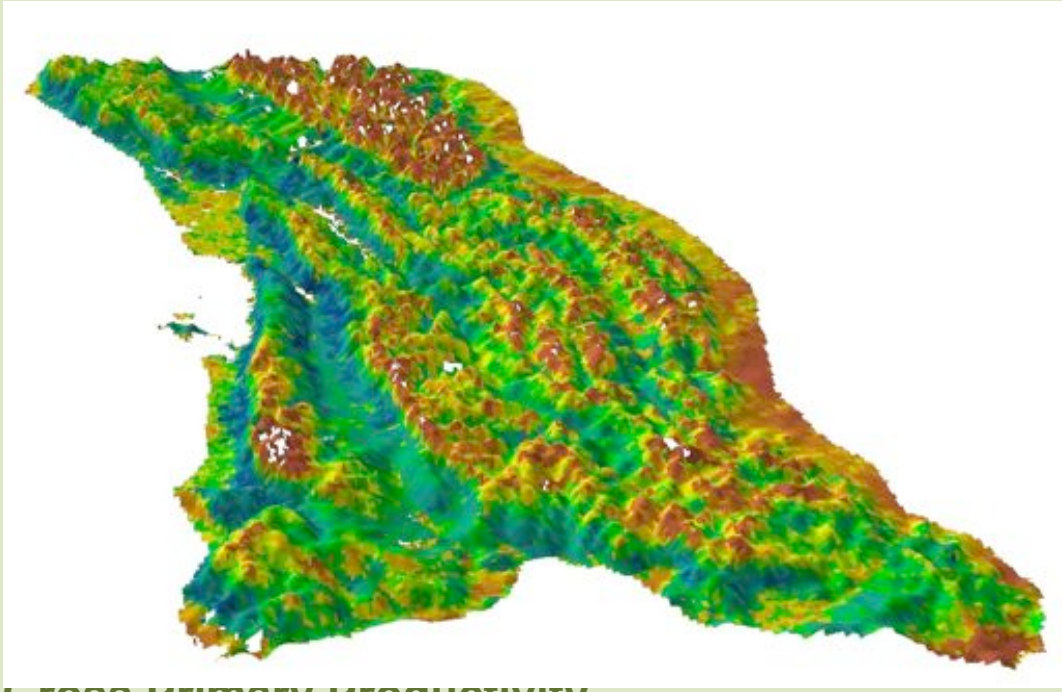
Lednia tumana

Where do we go from here?



What don't we know?

- Details about the vast majority of species' biology
- Best methods for ecosystem management
- Ability to detect approaching regime shifts
- Ability to predict knock-on effects
- Regional models of climate change effects largely unavailable



Gross Primary Productivity
Professor Steve Running,
University of Montana, Missoula

Increasing landscape resilience

- Protect large areas
- Increase connectivity
- Create and manage buffer zones around reserves
- Protect key ecosystem features
- Mitigate other threats
- Representation
- Replication
- Protect refugia (current and predicted)
- Restoration
- Maintain natural disturbance dynamics

Heller and Zavaleta, 2009; Blate et al., 2009

Adding a climate layer to restoration work

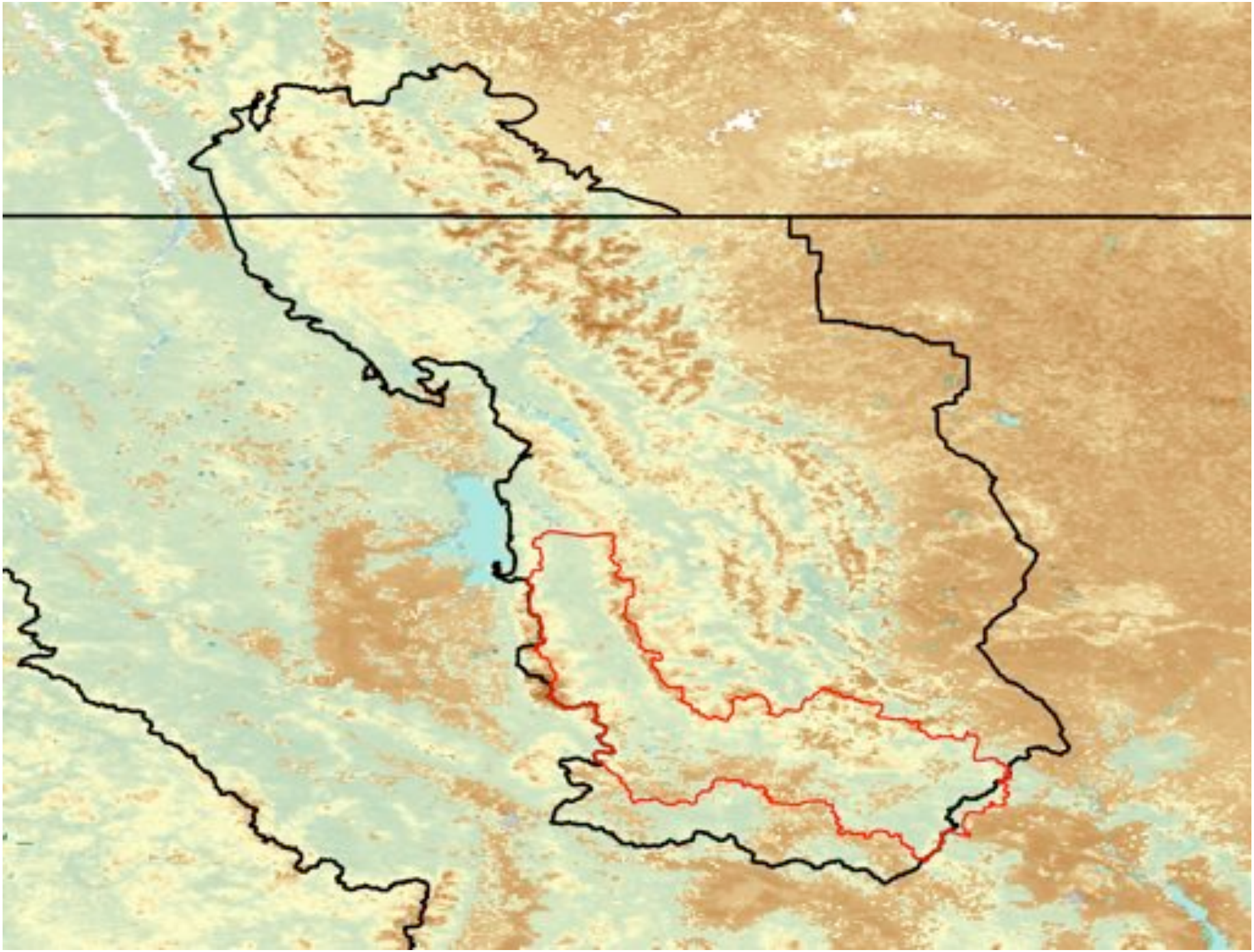
- Forest Landscape Restoration Act (March, 2009)
- Restoration at the landscape level at 10 sites across the U.S.
- Each project should have a ten-year restoration plan
- Cooperative Forest Land Restoration Project (CFLRP): 10 month collaborative on 1.5 million acres in the southwestern Crown of

Partners in the Collaborative Forest Landscape Restoration Project

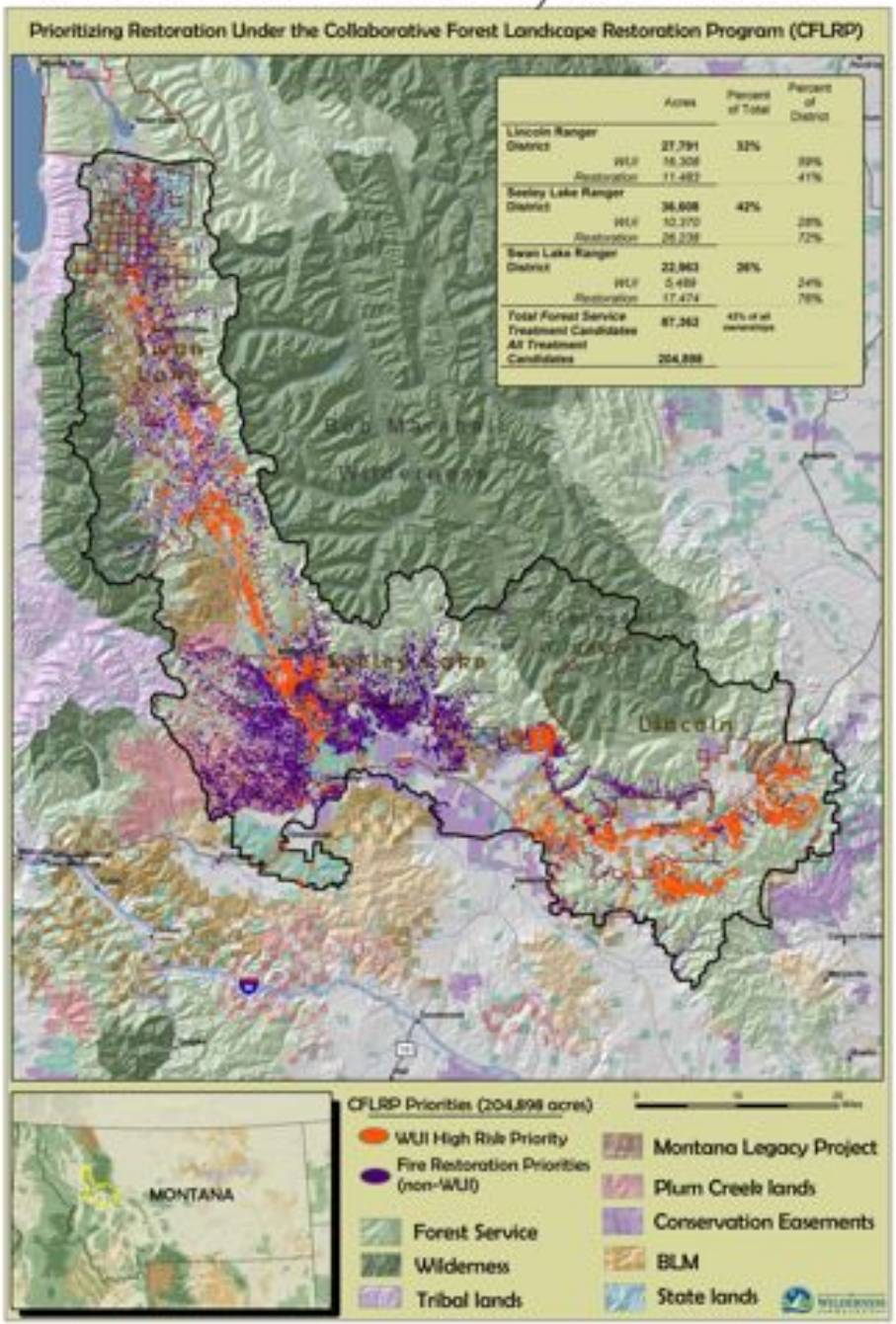
- Forest Service (Lolo, Helena, Flathead)
- MT Department of Natural Resource Conservation University of Montana
- Blackfoot Challenge
- The Nature Conservancy
- Rocky Mountain Elk Foundation
- Wildlife Conservation Society
- American Wildlands
- Clearwater Resource Council
- The Wilderness Society

Groups that have been briefed and have had an opportunity to comment

- Pyramid Mountain Lumber
- Plum Creek Timber Company
- Salish Kootenai Tribe
- Montana Trout Unlimited
- Montana Governor’s Office



The Southwestern Crown of the Continent



Proposed Work

- Fuel retention treatments in the wildland-urban interface(WUI) treatments: 27,000 acres
- Vegetation restoration: 50,000 acres
- Weed treatment/ wildlife habitat improvements: 81,600 acres
- Removal of non-native fish species: 3,000 acres
- Stream restoration work: 937 miles
- Road decommissioning: 400 miles
- Maximizing retention of large trees

Adding a climate layer to restoration work

- Experimental framework coupled with extensive, long-term monitoring program
- Collecting information on the effect of different treatments across landscape (different forest types, different elevations, etc.)
- Iterative decision-making cycles (every 3-5 years)
- Regular analyses of monitoring data allow managers to incorporate current ecological information into management strategies