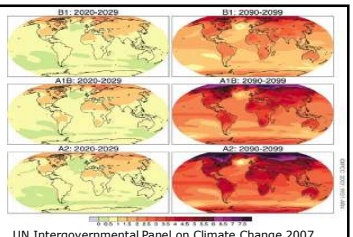
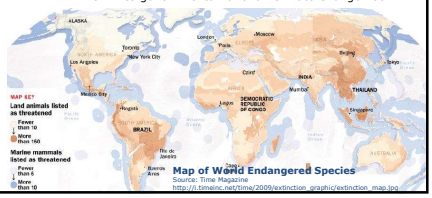
Species Conservation under Changing Climate Regimes



UN Intergovernmental Panel on Climate Change 2007

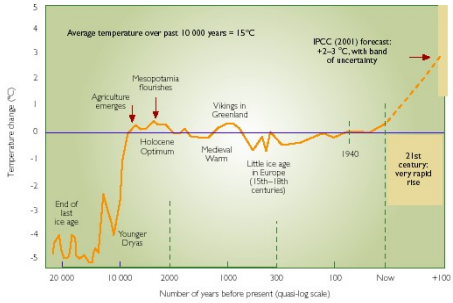


Variation in climate

Differences in climate may include two types of variation:

- **Climatic variation**- changes in climate from one year to the next
- **Climatic change**- changes in climate over time, changes in the mean values (temperature, precipitation, precipitation seasonality, etc.

Climate change through time



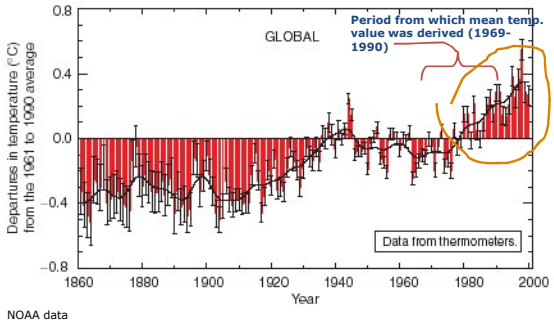
Variations in Earth's average surface temperature over the past 20,000 years

World Health Organization (www.who.int/globalchange/climate/summary/en/)

Human-induced global changes

- Climate change
- Increased human population density and resource demand
- Increasing intensive and extensive land use
- Nitrogen fixation and agricultural application
- Fragmentation (smaller and more isolated habitats)
- Increased wildland-urban interface issues
- Fire exclusion & fuel accumulation
- Exotic species introductions
- Altered communities, processes and structures
- Species extinction

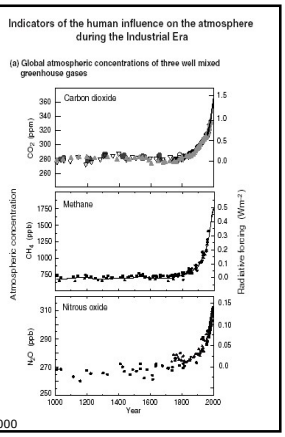
Earth's surface temperature, 140 yr



NOAA data

Greenhouse gasses

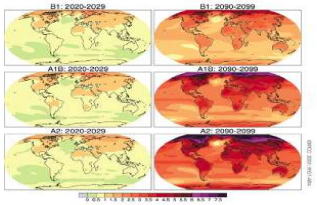
- CO_2 content has increased by 31% since 1750
- Higher concentration now than at any time in last 650,000 yr, and probably more than at any time in last 20 million yr
- Rate of increase in concentration is unprecedented in the last 20,000 yr



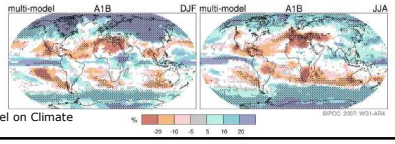
UN Intergovernmental Panel on Climate Change 2000

Projected global changes in temperature and precipitation

Predicted temperature patterns

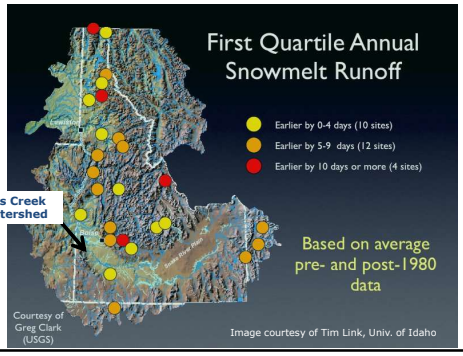


Predicted precipitation patterns

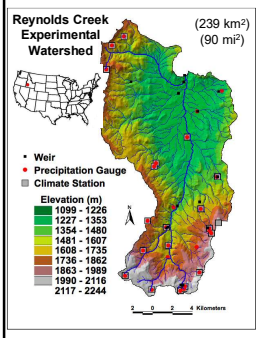


UN Intergovernmental Panel on Climate Change 2007

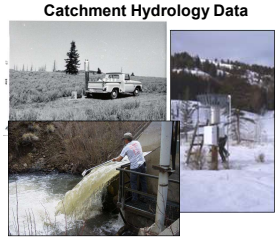
Other climate influences



Reynolds Creek Experimental Watershed



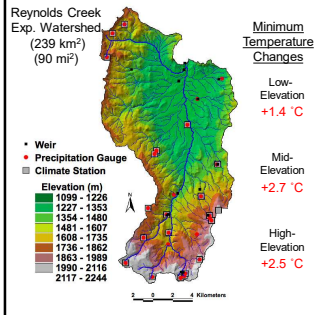
50 Years of Climate, Streamflow, and Catchment Hydrology Data



- 32 climate stations
- 28 precipitation stations
- 5 EC systems
- 14 weirs
- 6 microclimate stations
- 4 hillslope hydrology sites
- 3 highly instrumented headwater basins sites

Images and data courtesy of Fred Pierson and Jason Williams, NW Watershed Research Center

Measured Elevational Trends in Air Temperature



Minimum Temperature Changes

Low-Elevation +1.4 °C

Mid-Elevation +2.7 °C

High-Elevation +2.5 °C

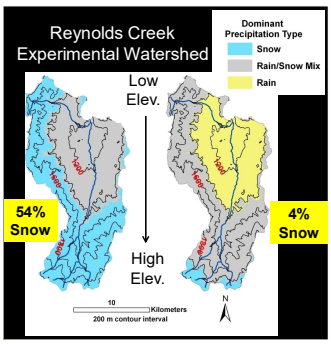
Minimum air temperatures warming over the period of record (1965-present).

Similar trends occurring for maximum air temperatures.

What will be the future environmental consequences of these changes?

Image and data courtesy of Fred Pierson and Jason Williams, NW Watershed Research Center

Elevational Change in Precipitation Regime, 1984 to 2010



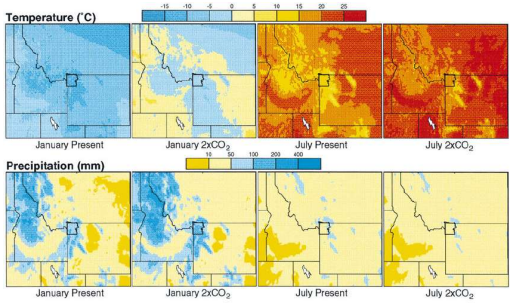
Proportion of snow to rain has decreased across all elevations.

Annual precipitation and total streamflow is unchanged, but seasonal water availability has been greatly altered.

Streamflow is greater in winter/early spring, and reduced in late spring/summer.

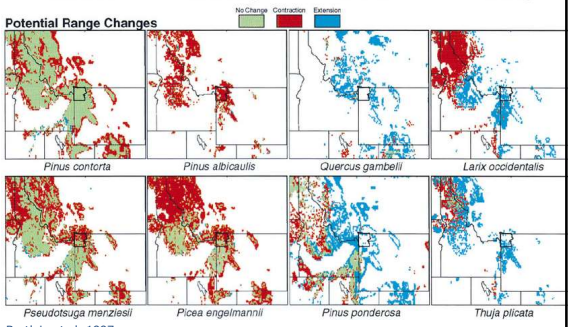
Images and data courtesy of Fred Pierson and Jason Williams, NW Watershed Research Center

Present and projected temperature and precipitation in 2 X CO_2



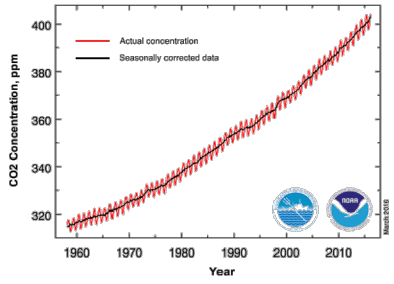
Bartlein et al. 1997

Present and projected temperature and precipitation in 2 X CO_2



Bartlein et al. 1997

Have we reached 2xCO_2 since 1997?



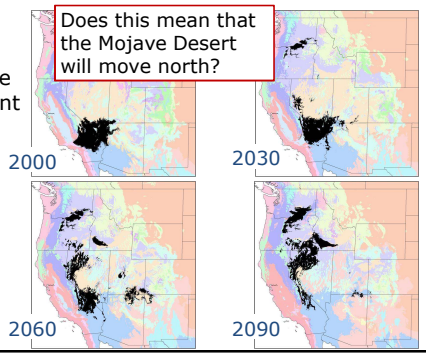
Climate Envelope Models

1. Describe the "climate envelope" which is the climate where a species currently lives (precipitation, temperature, etc. etc.)
2. Then map the geographic shift of that "envelope" under a climate change scenario. Different time periods can be mapped.
3. Several scenarios are often mapped because of uncertainty in climate predictions.

Changes in the locations of environments capable of supporting vegetation types

Mojave Desert-like environment

Does this mean that the Mojave Desert will move north?

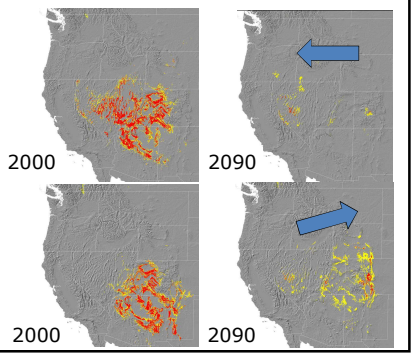


Courtesy of G. Rehfeldt, US Forest Service

Species will respond individually to climate change

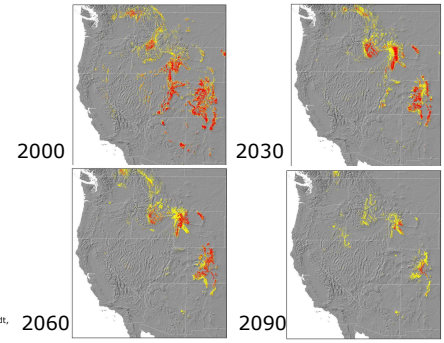
Utah juniper

Pinyon pine



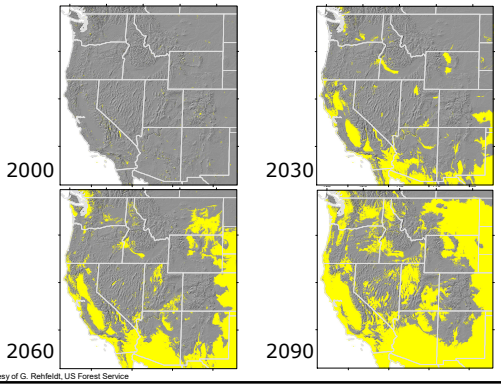
Courtesy of G. Rehfeldt, US Forest Service

Future aspen suitable habitat locations



Courtesy of G. Rehfeldt, US Forest Service

Novel climates are predicted (Areas in yellow)



Courtesy of G. Rehfeldt, US Forest Service

Prioritizing aspen management

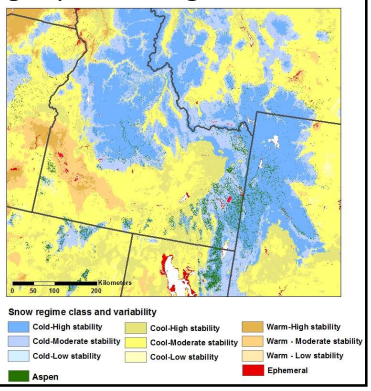
Snow/rain over the past 14 years

Ephemeral (0) – rain dominated, aspen likely to be related to highly localized microhabitats

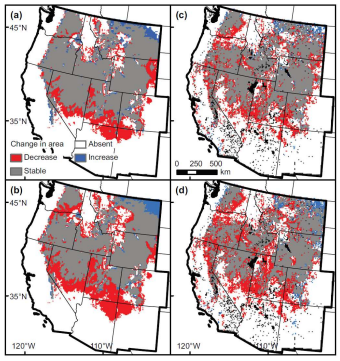
Warm (1) – snow drift dependent stands unlikely to be viable in near term

Cool (2) – aspen potentially sensitive to changing rain/snow regime

Cold (3) – snow dominated, aspen least sensitive to changing rain/snow regime



Species distribution model Ecohydrologic model

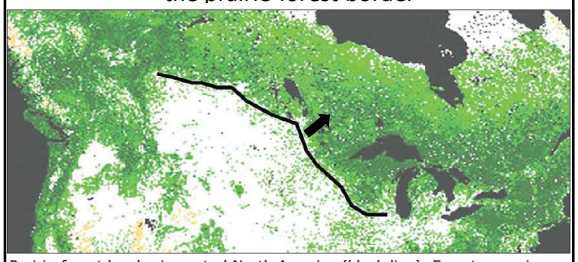


Current (a) vs 2070-2099 (c) (B1 climate scenario)

Current (b) vs 2070-2099 (d) (A2 climate scenario)

Schlaepfer et al. 2012

Predicted impact of environmental changes on the prairie-forest border

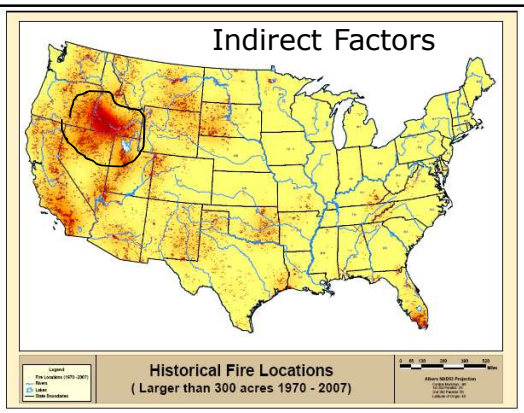


Prairie-forest border in central North America (black line). Forest cover is shown in green, non-forest in white and water in black.

Global warming is predicted to cause the existing prairie-forest border to shift to the northeast. Forest will change to savannas or grasslands.

Source: Frelich & Reich 2010, Frontiers in Ecology

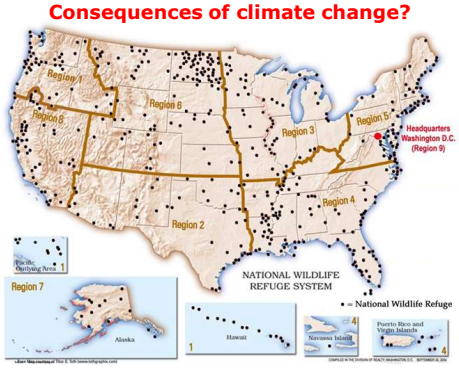
Indirect Factors



Source: BLM Boise District RAC

US Fish and Wildlife Service National Wildlife Refuge System

Consequences of climate change?



Source: US Fish and Wildlife Service

Conservation Approaches

Relationship between three conservation approaches that land managers may undertake and possible responses of individual species to environmental disruptions.

Component redundancy- suggests that in natural systems greater ecosystem resilience, despite changing climates, may be achieved by increasing species and community redundancy,

Functional redundancy- is the idea that different components of a system can fulfill the same functions, thereby producing the same result.

Increased connectivity- suggests that success is achieved by ensuring that suitable habitats are always within easy reach of one another.

Dunwiddie et al. 2009

Assisted migration

What are the advantages?

What are the disadvantages?

What are the risks?

Seeding and planting sagebrush

- Seeding sagebrush generally unsuccessful
- Seed sources often do not contain information about source or climate of where the seed was obtained.
- Match the climate of origin of the seed source to the place where it is planted (more important than subspecies, especially if seeds come from far away)

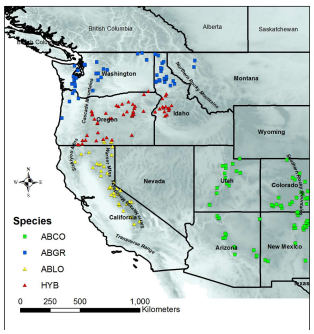
Germino 2017

Lessons from the 2015 Soda Fire

- Seed from warmer sites had higher success
- Weather after seeding is important, more success if cooler wetter year after seeding
- Better records of the source of seeds and where they are planted is needed

Germino 2017

Abies grandis – Abies concolor complex



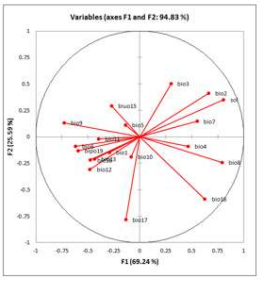
Ott et al. 2015

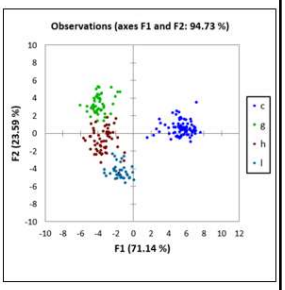
Table 2. List of correlations between the environmental variables and factors F1, F2 and F3 from the discriminant analysis.

Variable	F1	F2	F3
Bio-1 Annual Mean Temperature	-0.293	-0.147	0.524
Bio-2 Mean Diurnal Range Temp.	0.661	0.410	-0.482
Bio-3 Isothermality (Bio2/Bio7) (*100)	0.300	0.503	-0.005
Bio-4 Temperature Seasonality	0.464	-0.089	-0.399
Bio-5 Max. Temp, of Warmest Month	-0.137	0.112	0.005
Bio-6 Min. Temp. of Coldest Month	-0.620	-0.091	0.547
Bio-7 Temperature Annual Range	0.551	0.146	-0.543
Bio-8 Mean Temp. of Wettest Quarter	0.791	-0.243	0.082
Bio-9 Mean Temp. of Driest Quarter	-0.729	0.131	0.222
Bio-10 Mean Temp. of Warmest Quarter	-0.084	-0.191	0.402
Bio-11 Mean Temp of Coldest Quarter	-0.399	-0.020	0.576
Bio-12 Annual Precipitation	-0.481	-0.307	0.487
Bio-13 Precipitation of Wettest Month	-0.437	-0.209	0.516
Bio-15 Precipitation Seasonality	-0.272	0.220	0.539
Bio-16 Precipitation of Wettest Quarter	-0.476	-0.220	0.509
Bio-17 Precipitation of Driest Quarter	-0.134	-0.784	-0.060
Bio-18 Precipitation of warmest Quarter	0.624	-0.589	-0.162
Bio-19 Precipitation of Coldest Quarter	-0.385	-0.130	0.516
Solar Insolation	0.806	0.350	-0.173

Ott et al. 2015

Adaptation to new environments





Ott et al. 2015

Conclusions

- Hybrids occupy distinct habitats that are variably intermediate between *A. grandis* and *A. concolor* (parental taxa)
- Hybrid habitats have lower precipitation in the summertime than associated with either progenitor.
- We hypothesize that moisture stress and high levels of solar insolation in the summertime associated with hybrid populations have played an important role in the observed patterns of introgression of key traits: leaf angle, specific leaf area and abundance of adaxial stomates.
- Phenotypic plasticity may allow hybrids to adapt to an environment with a higher degree of variability in moisture stress.
- Hybrids may have an adaptive advantage over *A. grandis*.

Ott et al. 2015

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