Bromus BREEnet

GBRMP

Understanding, Predicting and Managing Species Invasions in a Changing Environment – the case of annual brome grasses

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RMRS ROCKY MOUNTAIN RESEARCH STATION

USGS science for a changing world

UMASS AMHERST

ars

Colorado State University

NEW COLLABORATIVE EFFORTS

Exotic Bromus Grasses in the Western US: Current and future invasions, impacts, and management

USDA AFRI Project – M. Germino, J. Chambers, C. Brown

REEnet = Research, Extension, Education network

Integrating ecological forecasting methods to improve prioritization of invasive species management

USGS Powell Center – B. Bradley and J. Morisette

Enhancing scientific discovery and problem-solving through integrated research

THE RATIONALE

- Exotic *Bromus* grasses, particularly *B. tectorum,* continue to increase despite decades of research and management
- Interdisciplinary and cross-system approach is needed
- Wide range of individual and large team projects are working on *Bromus* - increased communication and coordination would benefit all
- Most efforts have focused on past or current invasions and impacts, but what does the future hold?
- ➢ Leveraging past and present work can advance science and management

  and lead to transformative research and extension

THE PROBLEM

- Annual grasses introduced in late 1800s (Cheatgrass, medusahead, red brome)
  - "Pre-adapted" to environment
  - Overgrazing at turn of century reduced perennial grasses & forbs
  - Rapid spread through depleted rangelands
  - Earlier growth & maturation than natives made the invaders highly competitive
  - Resulted in increase in flammable fine fuels with high rate of spread

- *Initiation of annual grass fire cycle with positive feedbacks to invasion*

THE CAUSES

- Elevated CO^2
  - CO^2 ↑ 280 to 386 ppm

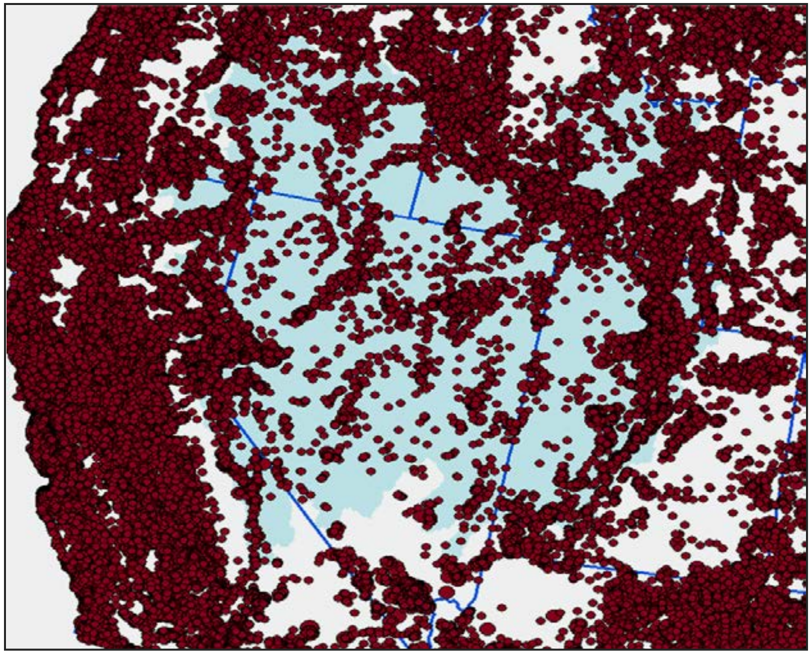
➢ *Positive effects on annual grass water relations & growth*

- Expanding human population
  - 2.9 to 4.9 million from 1990 to 2004
  - Increase in urban and renewable energy development, recreation use, roads, & utility corridors

➢ Nitrogen deposition

➢ Surface disturbance & invasion corridors

➢ Fire starts



Census 2000 Populated Blocks

THE CAUSES

- Inappropriate livestock use

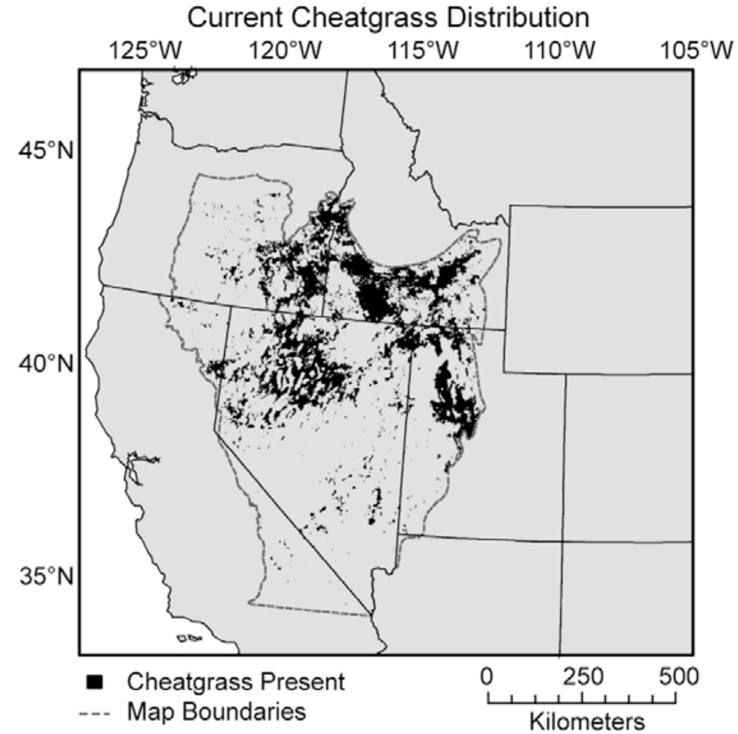
- Woodland expansion
  - 2 to 6 fold increase in area dominated by p-j since settlement; canopy closure of occupied areas within next 50 yrs
  - Increase in woody fuels -> increase in fire size and severity

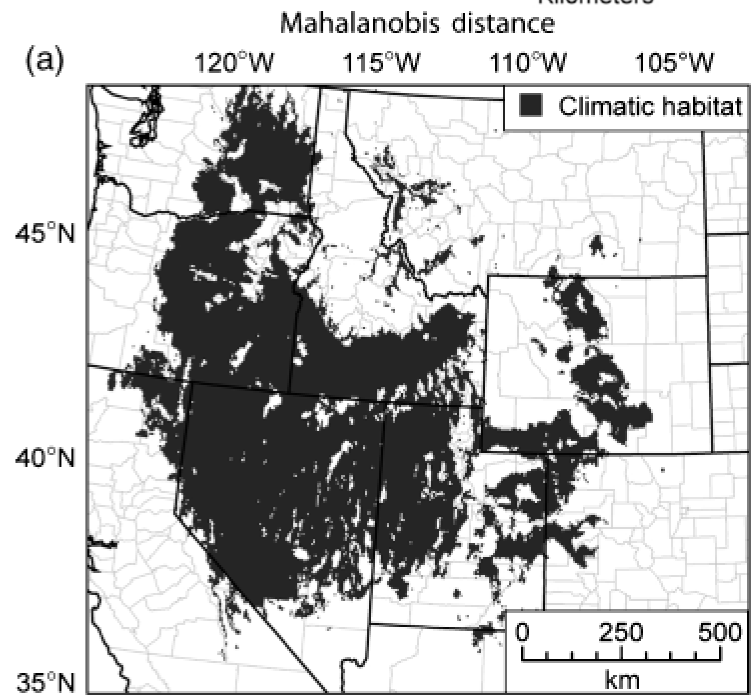
- Net effects of stressors
  - Decrease in native perennial grasses and forbs
  - Altered fire regimes

- Accelerated invasion & spread

THE POTENTIAL

- Predictive models and risk assessments
  - Remote sensing analysis - areas currently dominated by cheatgrass
    - *B. tectorum* dominated 40 000 km2 of NV and UT (1 km resolution – 1998; Bradley & Mustard 2005)
  - Species distribution/climate envelope models – areas with the climatic conditions to support cheatgrass
    - Most of Intermountain Region susceptible to invasion (Bradley et al. 2009)



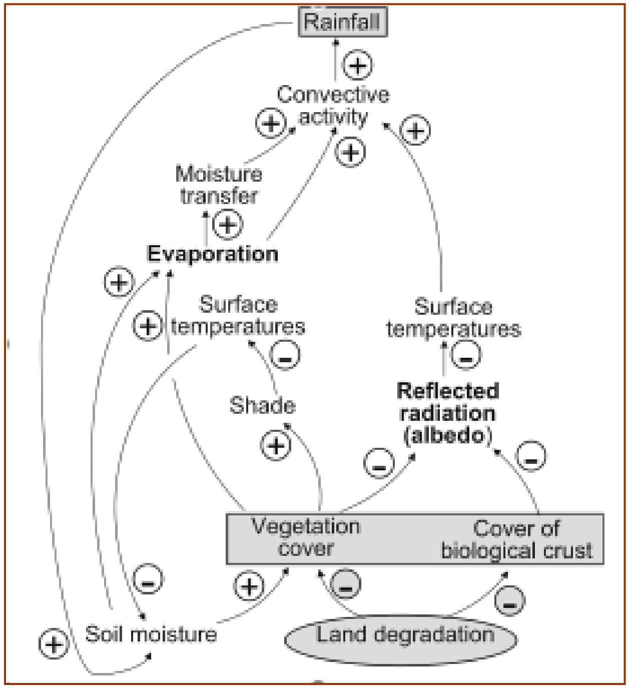


THE POTENTIAL

- Conversions to annual grass dominance

- Conversion of shrublands & woodlands from carbon sinks to carbon sources
(Bradley et al. 2006)
- Increase in the region's albedo potentially affecting circulation patterns, evaporation and precipitation

- Loss of biological diversity
- Loss of ecosystem services



Millenium Assessment

THE UNCERTAINTY – Climate Change

- Observed & predicted climate change
  - Temperature ↑ 0.6 º to 1.1º F in last 100 years
  - Predicted ↑ 3.6 to 9 ºF (2 to 5 ºC) by 2100
  - *Higher frost lines - upslope and northerly movement*
  - *Longer growing seasons – earlier spring green up & longer fire season*

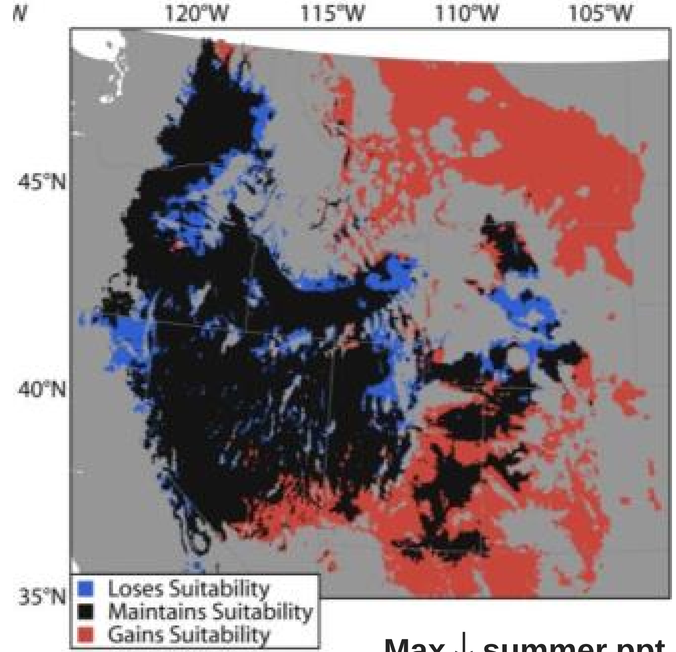
  - Precipitation and stream flow increased in last 50 years – but RH ↓
  - Projected changes in ppt highly variable, but the average is near zero, slight ↑ fall/winter & ↓ spring/summer
  - Increase in extreme events - droughts, very wet periods, floods
  - *Increased ET , aridity and variability – dieoff and local extinction*
  - *Decrease in spring/summer ppt -* ↑ susceptibility to cheatgrass

THE MODEL PREDICTIONS

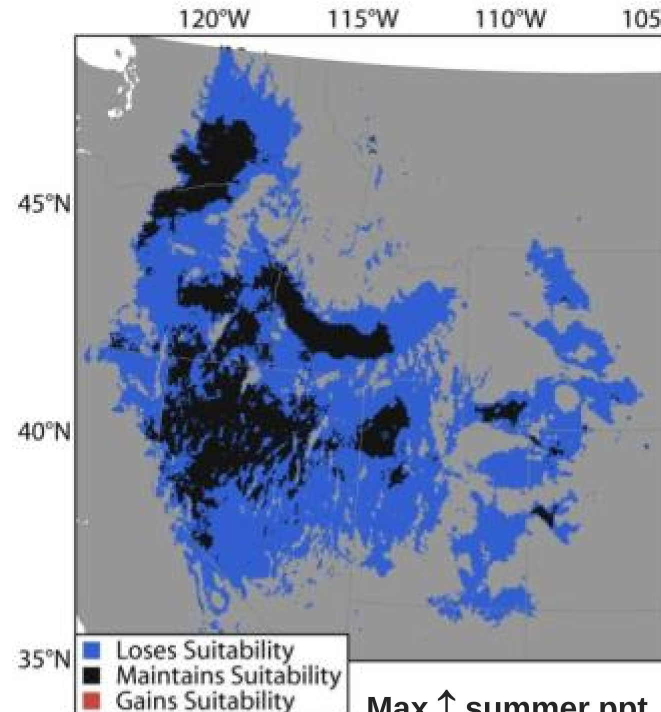
- Species distribution models coupled with ensemble climate change models can predict most likely scenario
- Ensemble models show little change in climate habitat
- Can explore uncertainty using different climate change scenarios
  - Predictive models suggest that cheatgrass distribution may be highly responsive to ppt seasonality (Bradley et al. 2009)

    + 40 % with a max ↓ summer ppt

    - 70% with a max ↑ summer ppt



Max ↓ summer ppt



Max ↑ summer ppt

THE CONSTRAINTS - Resistance to Invasion

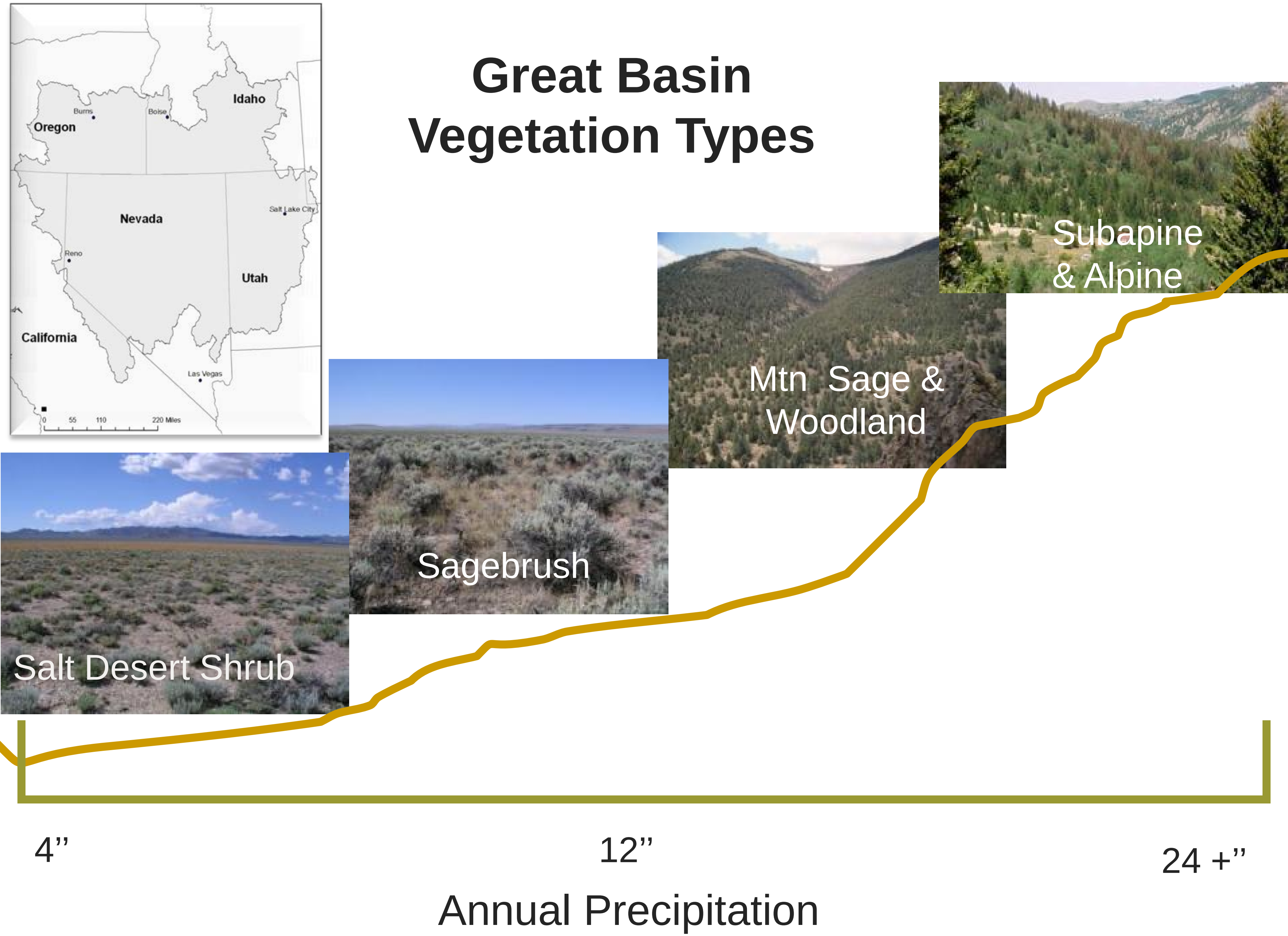
The abiotic and biotic factors and ecological processes in an ecosystem that limit the population growth of an invading species

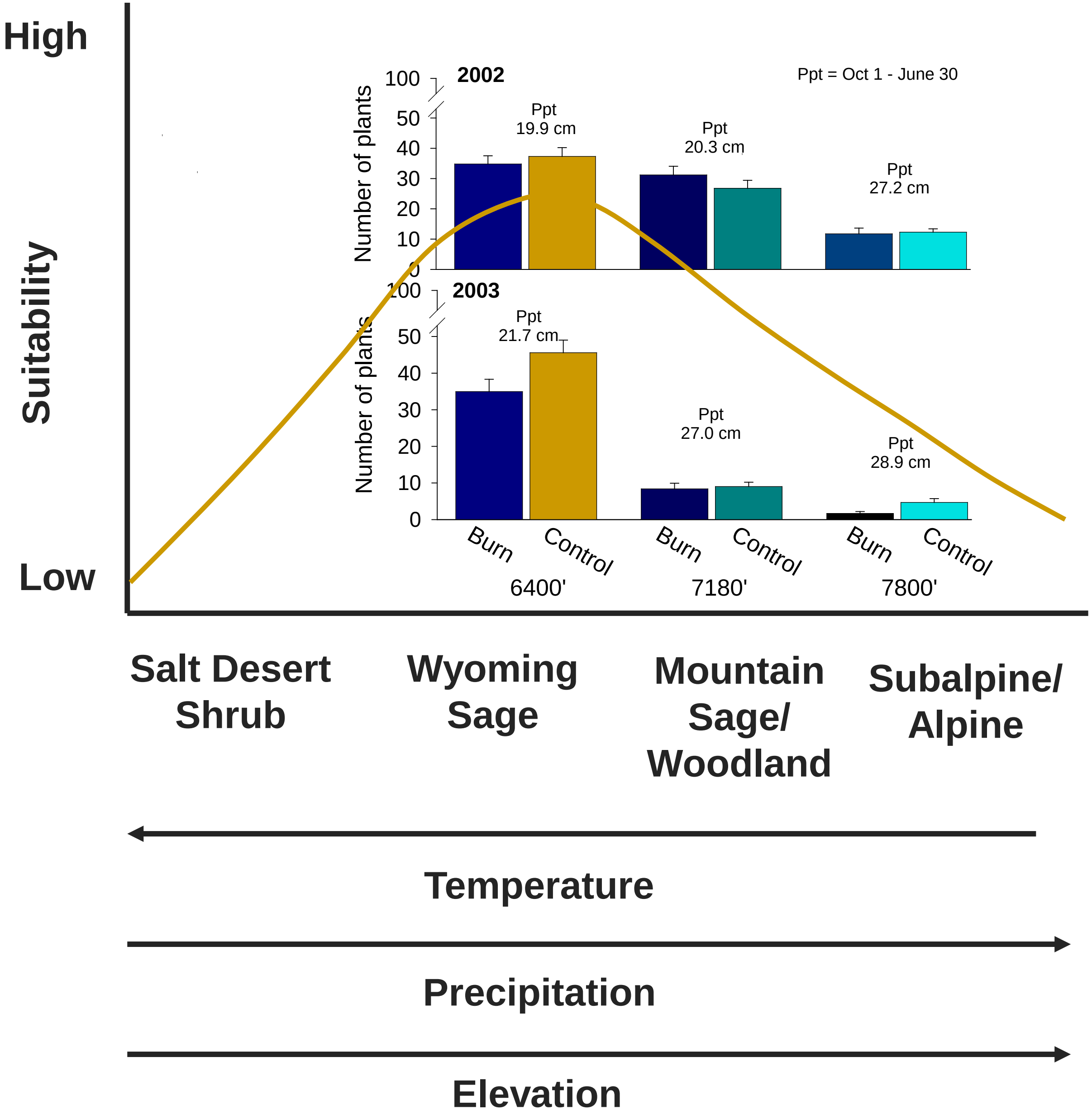
- Where is an invader capable of growing?

  Fundamental Niche

- Where does the invader actually occur?

  Realized Niche


Great Basin
Vegetation Types
Idaho
Burns
Boise
Oregon
Nevada
Salt Lake City
Reno
Utah
California
Las Vegas
0
55
110
220 Miles
Subapine
& Alpine
Mtn Sage &
Woodland
Sagebrush
Salt Desert Shrub
4”
12”
24 +”
Annual Precipitation

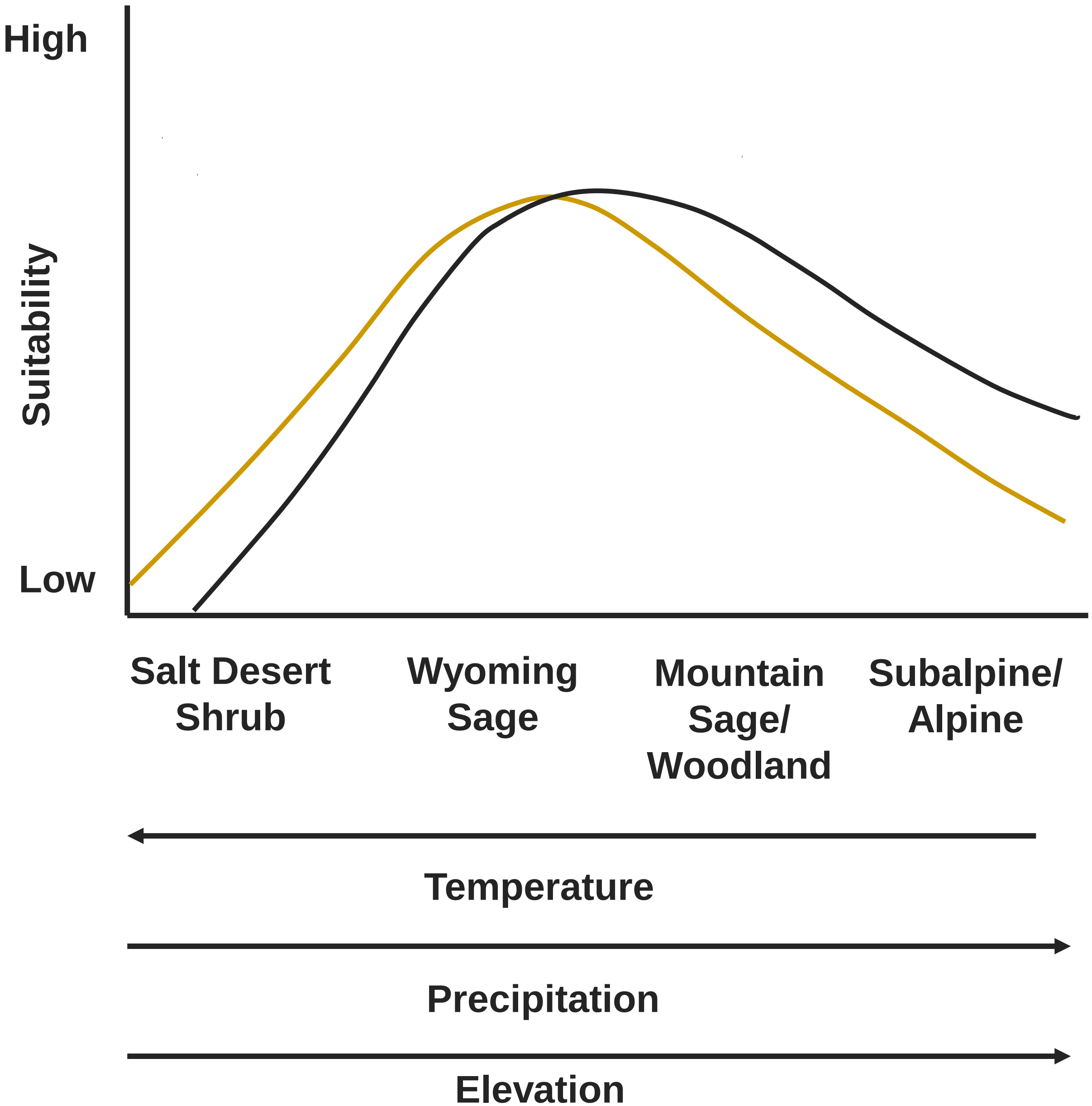


Data from Chambers et al. 2007

Resistance reflects a species fundamental niche

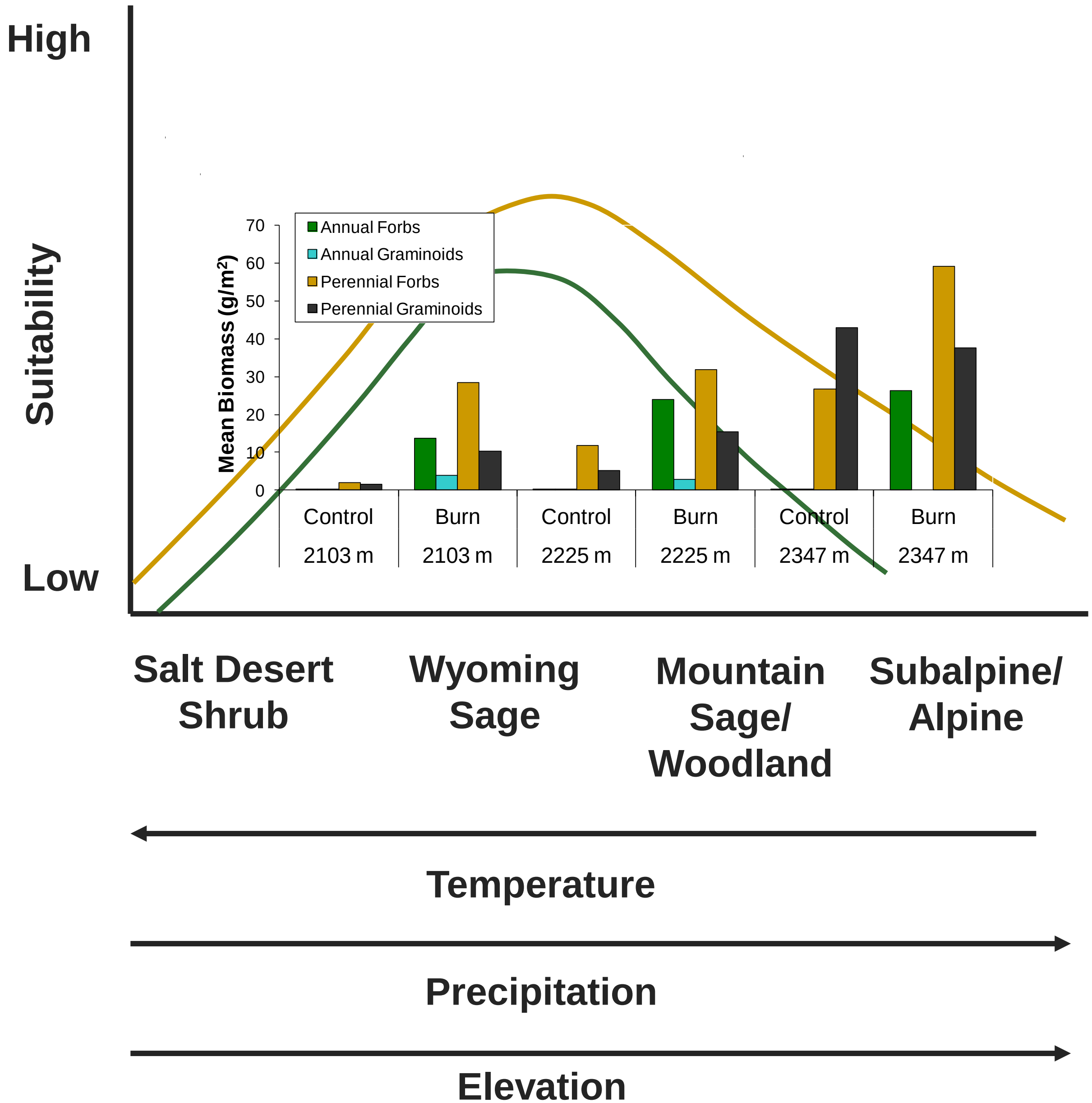
- Studies over climate gradients show resistance higher in stressful environs
  - Low and variable ppt
  - Cold temperatures

➢ Wyoming sage most susceptible



Climate warming may shift where fundamental niche occurs on the landscape

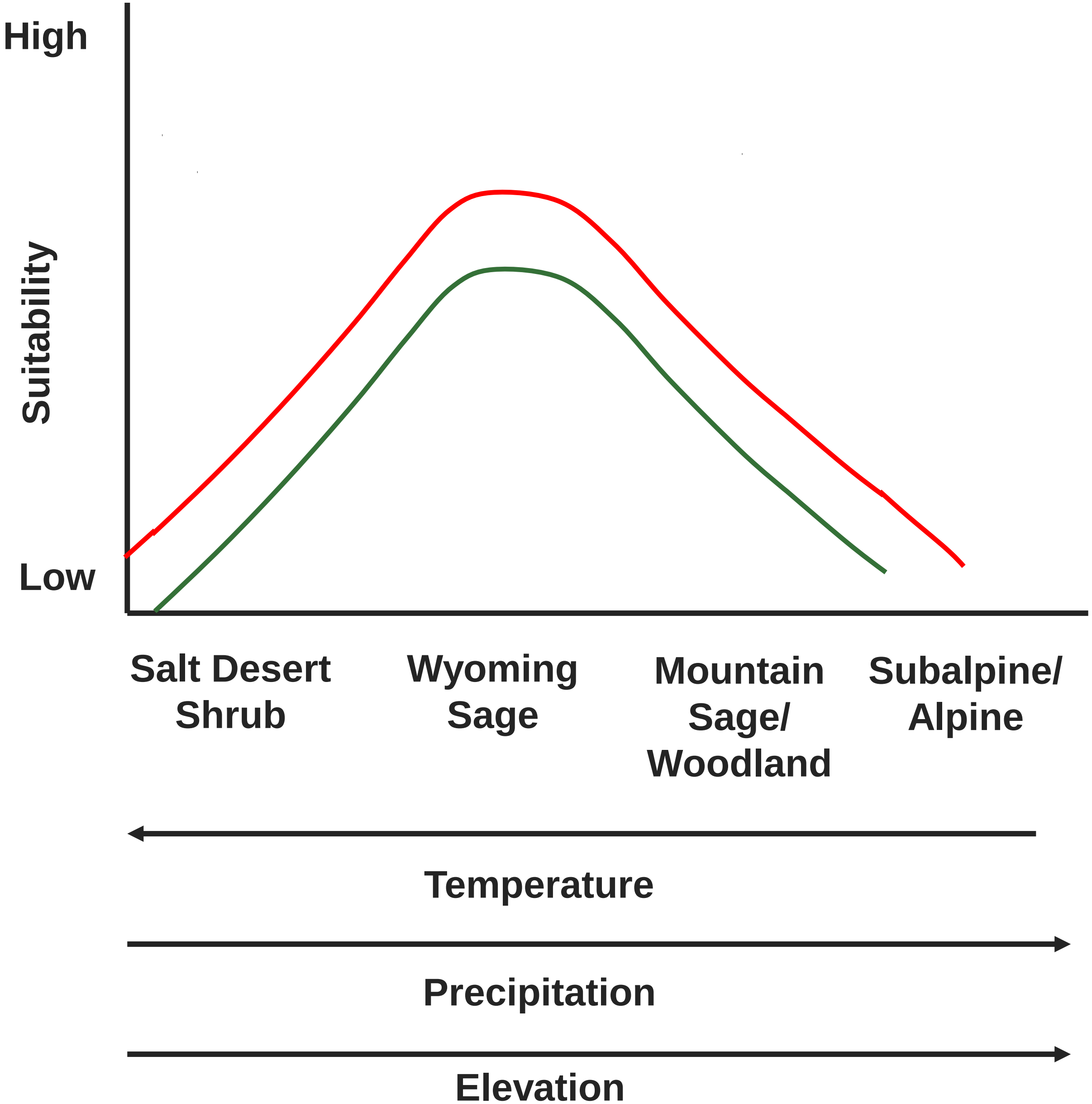
- Lower elevations may no longer support cheatgrass
- Higher elevation communities may become less resistant



Data from Chambers 2005

Realized niche of a species is less than its fundamental niche

- Native community increases resistance
- Studies over climate gradients show resistance is higher in more productive environs
  - Increased competition from native species
  - More rapid recovery after disturbance



Realized niche of invader may increase due to stressors

- Factors that give cheatgrass competitive advantage
  - Decreased competition from native grasses and forbs
  - Altered fire regimes

THE INFORMATION SOURCES

- Experimental and Observational Studies
  - Climate manipulation experiments, observations across climate gradients, and observations over time

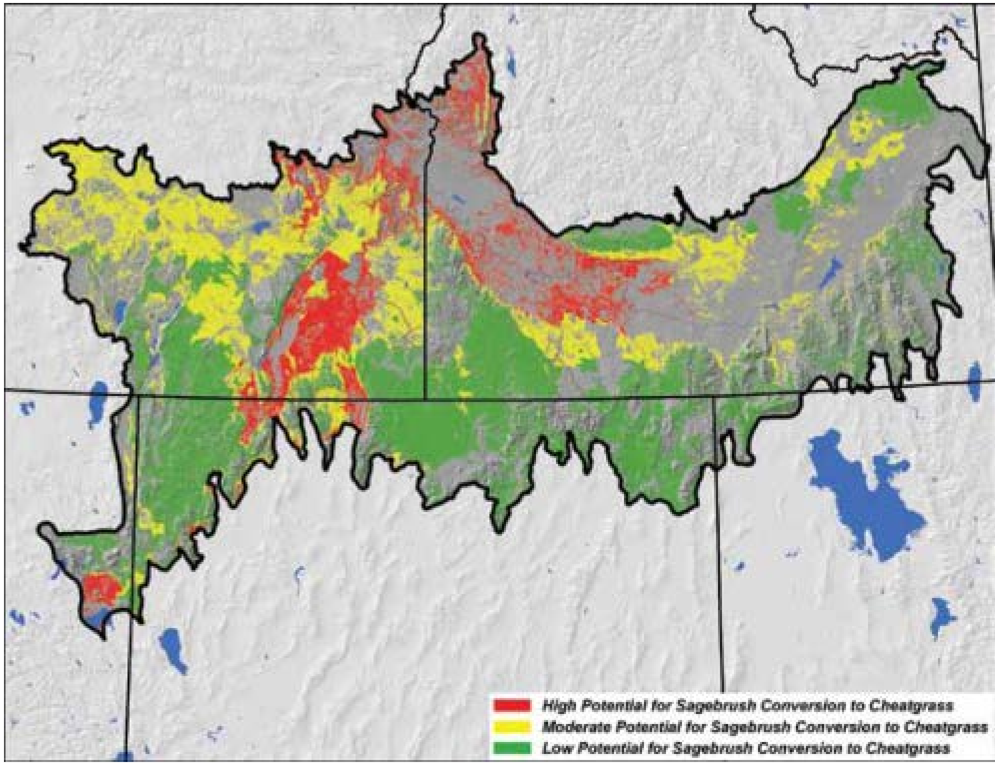
- Provide information on interactions among climate, vegetation and species
- Existing work specific to a study system(s) & relevant primarily at local to regional scales
- Need to synthesize existing information & develop large-scale interdisciplinary studies to address information gaps

- Have yet to clearly define the fundamental or realized niches of a an invader or native species in Intermountain Region

THE INFORMATION SOURCES

- Species Distribution Models & Risk Assessments
  - Predict species invasion under different land use or climate scenarios at landscape scales

- Lack of detailed data on species distributions and environmental variables that determine those distributions limit accuracy
- Difficult to
  ~include finer scale variables like soil type
  ~ include variables that influence realized niche
  ~scale-down to management/ project level



Rapid Ecoregional Assessment Northern Basin and Range And Snake River Plain

THE NEED – An integrated approach

- Ecologists and species distribution models use many of the same terms when describing global change impacts
  - Often have different interpretations of same concepts even within disciplines
  - Usually work at different scales

- Lack of integration among and within experimental and modeling frameworks has the potential to yield different results and management recommendations

THE OBJECTIVES OF THE NEW COLLABORATIVES

Develop a basic understanding of the factors that determine invasive species distributions and their relative abundance on the landscape and effectively integrate that information into predictive modeling and management

- Promote idea exchange and development through syntheses, symposia and proceedings, proposals and a common website and database
- Provide an all inclusive network of researches and managers working on bromes

TOPICS ADDRESSED AND WORKING GROUPS

- Changing species distributions under current and future climates
- Resistance, resilience, and transitions
- Adaptive management
- Appropriate restoration tools
- Communication and technology transfer

Each group includes some blend of ~

- Synthesis, modeling, prediction,
- Interdisciplinary and large-scale experiments combining research, management, and extension
- Concepts and tools
- Communication and tech transfer

SYNTHESES, MODELING AND PREDICTION

- ***Database*** - the existing distributional, biological and ecological information on invasive bromes that can be used to support existing research and explore new questions
- ***Research paper*** - defining the fundamental niche of invasive species using cheatgrass in the Great Basin as an example (linked to JFSP, RMRS, BYU, ARS research on hydrothermal regimes and cheatgrass establishment)
- ***Synthesis papers*** -
  - Resistance to invasion and resilience to disturbance in Great Basin (linked to RMRS, ARS and JFSP – Sage STEP research)
  - Integrating niche concepts and use in experimental ecology and modeling
  - Integrating the different types of modeling used to predict species distributions

INTERDISCIPLINARY AND LARGE-SCALE EXPERIMENTS COMBINING RESEARCH, MANAGEMENT AND EXTENSION

- USDA NIFA proposal to examine effects of climate on Cheatgrass and two native restoration species

- Sites located across latitudinal gradients to examine effects of the seasonal distribution of precipitation and elevation gradients to examine changes in precipitation/temperature regimes
- Studies designed to examine effects of ~
  - Abiotic factors (soil temperature, water and nutrient availability)
  - Biotic factors (genetics, plant community competition)
  - Climate manipulations of temperature (night time warming) and precipitation (change in seasonal distribution) on ~
    - demography, growth and reproduction of cheatgrass and two native analogs commonly used in restoration (Sandberg's bluegrass and squirreltail)
- Models of the effects of climate and other environmental variables on cheatgrass distribution

DECISION TOOLS FOR PRIORITIZING MANAGEMENT ACTIVITIES & DETERMINING BEST APPROACHES

- Syntheses, field guides and web tools for understanding the probability of invasion/conversion to bromes based on topographic position, soil characteristics and vegetation community characteristics under different climate and land management scenarios
- Mechanisms for communication and technology transfer
  - Refereed syntheses publications
  - Symposium & proceedings – ESA , 2013
  - Interface with existing science delivery networks, e.g., GB Science Delivery Project
  - Website for communication and information exchange

Http://greatbasin.wr.usgs.gov/GBRMP/BromusREENET.html

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