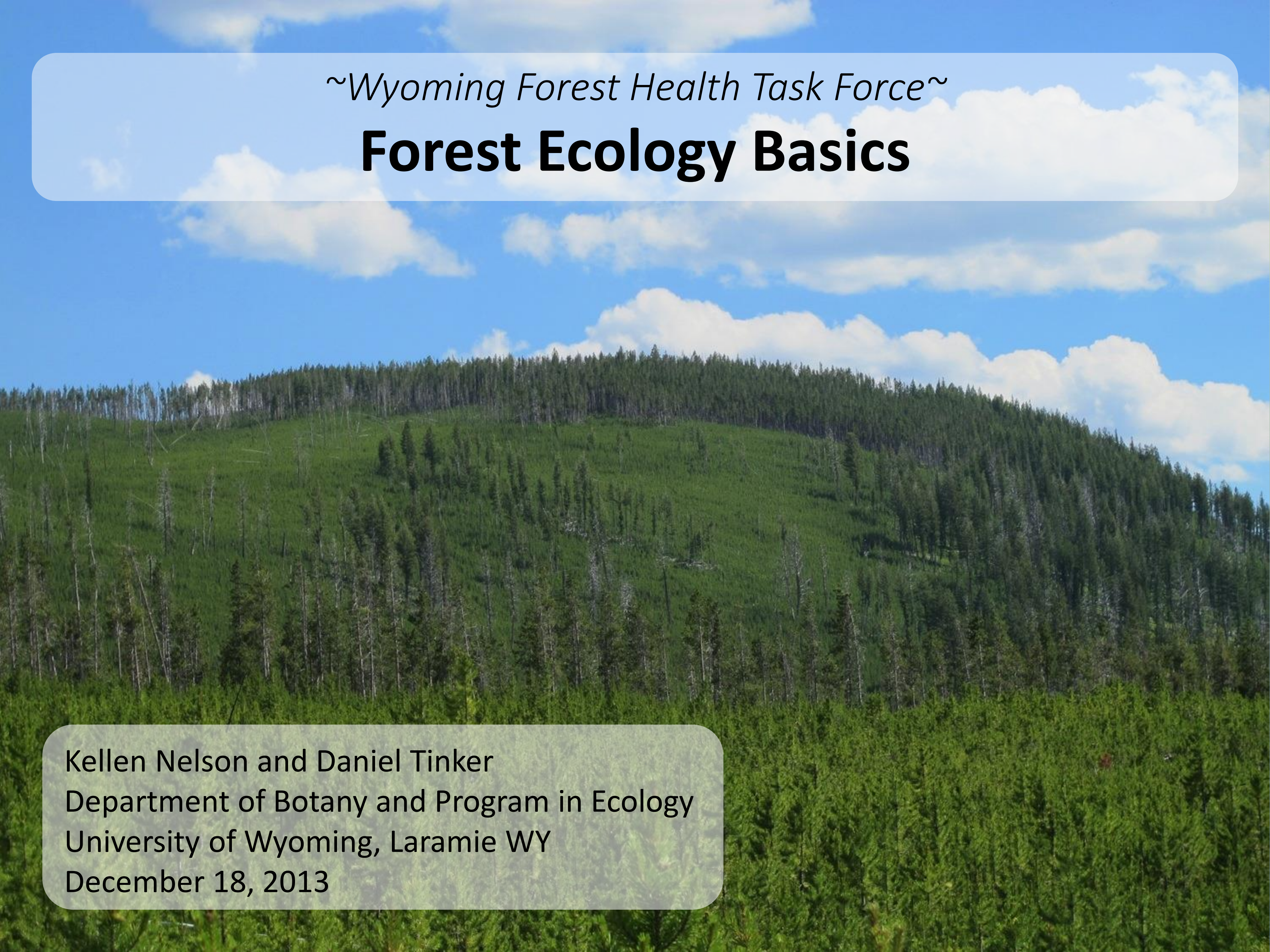

~Wyoming Forest Health Task Force~

Forest Ecology Basics

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December 18, 2013

Outline

1. Wyoming’s Forests
2. Criteria for Evaluating Forest Health
3. Natural Forest Disturbance Regimes
4. Climate Change Projections and Future Forests

Abiotic factors influence the biogeography of forests

- Forest cover and productivity are generally determined by the biophysical template.
  - Soils, precipitation, temperature, light availability.
- Elevation: Temperature decreases with elevation, but precipitation increases.
- Aspect: Temperature and light intensity decrease from south-west to north-east, but moisture availability is generally highest on north slopes.

Forest types in Wyoming

Juniper Woodland (~1 million acres)

- Occurs at the lowest elevations and on south facing slopes. Drought resistant and slow growing. Generally sparse and low growing (<25’ tall).

Ponderosa Pine (~1.1 million acres)

- Mid-elevations, drier exposed slopes. Generally denser than other areas in its distribution. Generally relies on summer precipitation. Concentrated in north-east and central Wyoming.

Forest types in Wyoming

Lodgepole Pine (~2.6 million acres)

- Higher elevation dominated by winter precipitation. Largest forest type in Wyoming. Generally composed of dense even-aged and multi-aged forest stands.

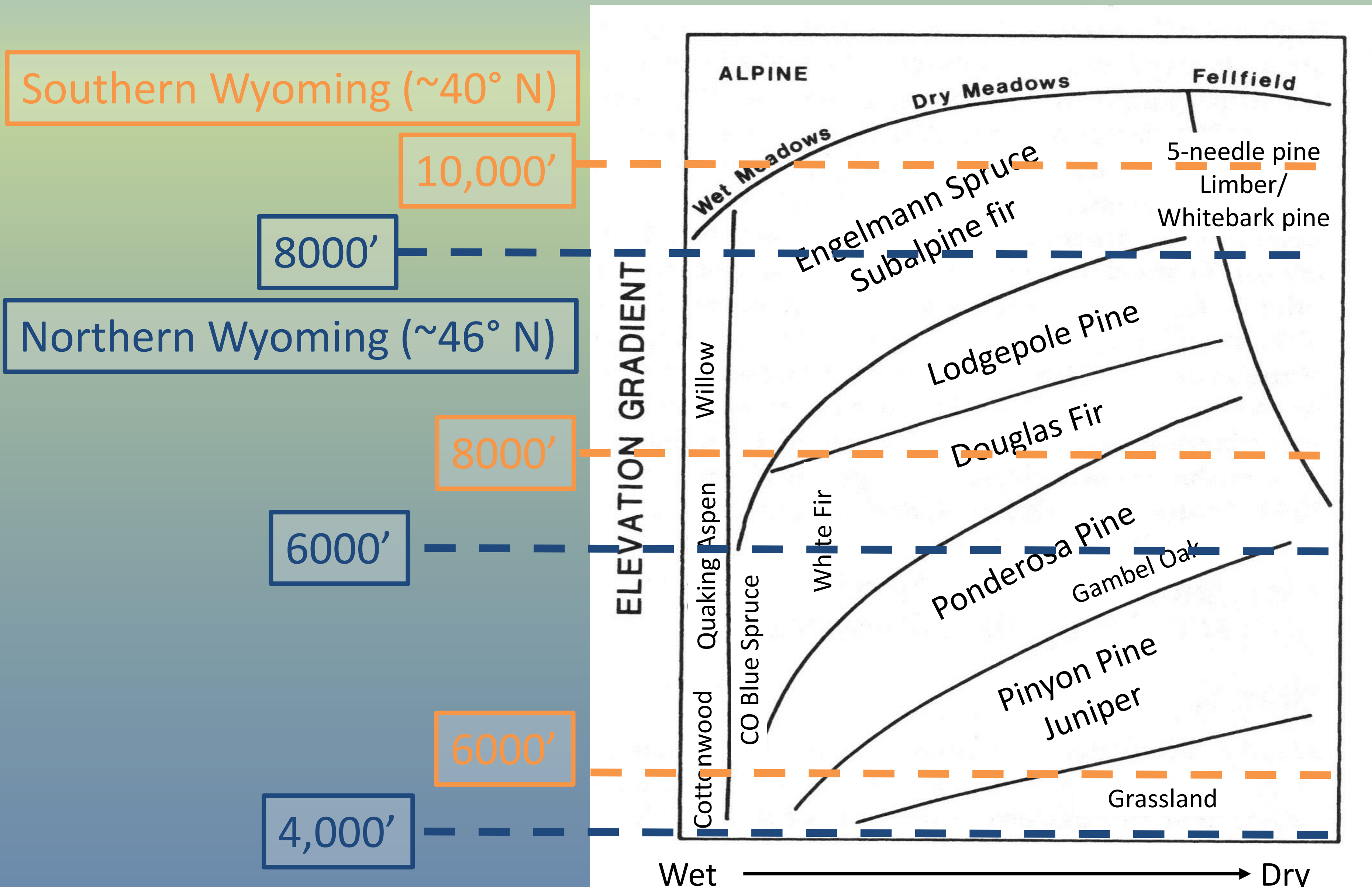
Engelmann spruce/Subalpine fir (~1.8 million acres)

- Highest elevations and north facing slopes. Adapted to harsh winter conditions and winter precipitation. Generally composed of dense, multi-age forest stands.

Aspen (~0.75 million acres)

- Shares mesic locations in the ponderosa pine, lodgepole pine, and Engelmann spruce/subalpine fir zones.

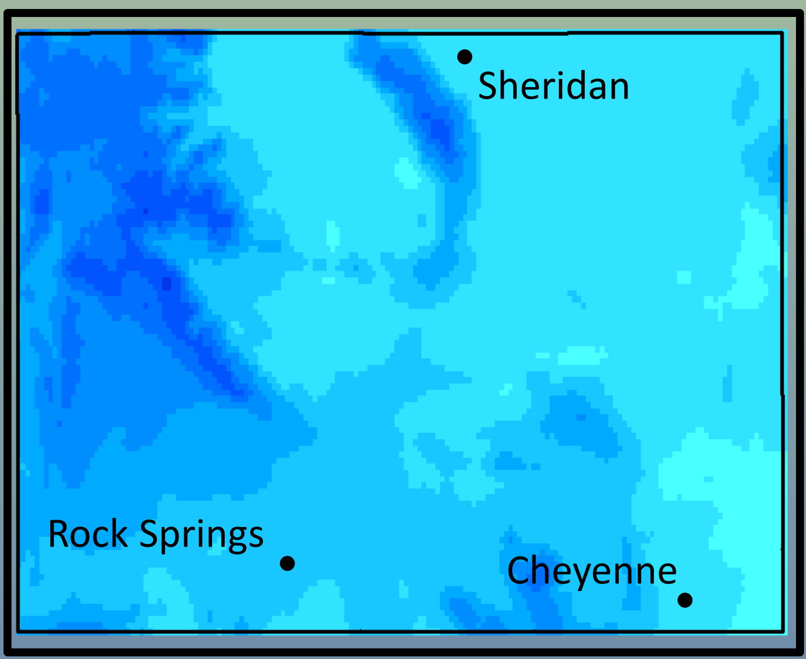
Wyoming's Forests

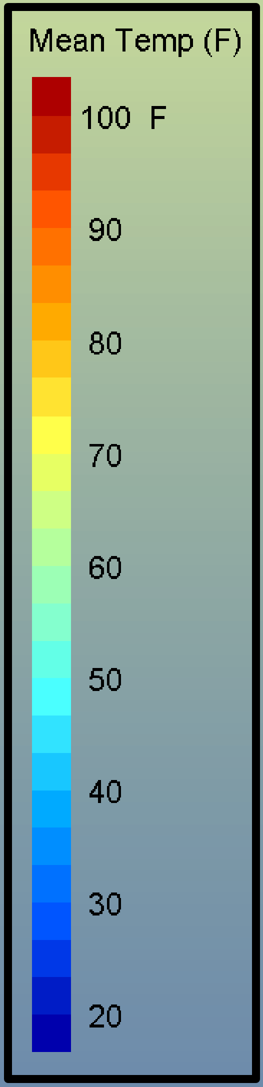


Adapted from Peet (2000)

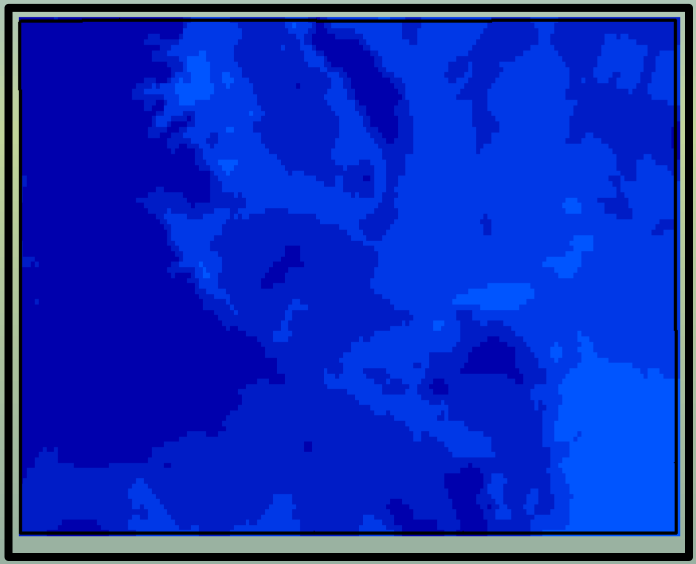
Mean Annual Temperature

Mean annual temperature (1951-2006)

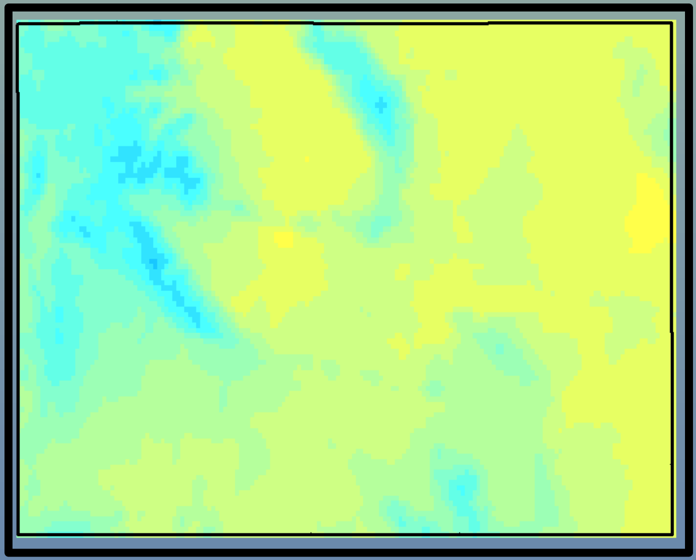




Mean winter temperature (1951-2006; Dec thru Jan)

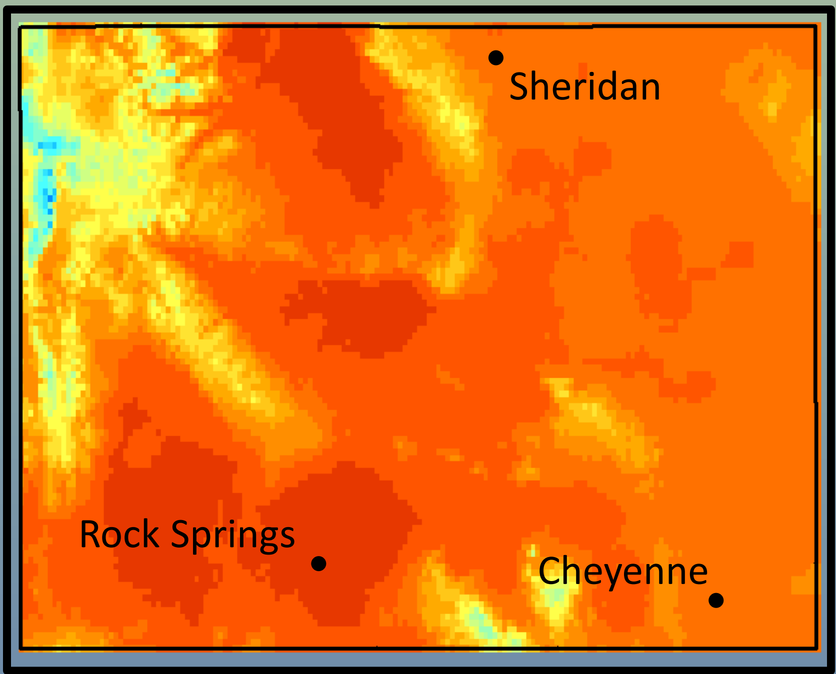


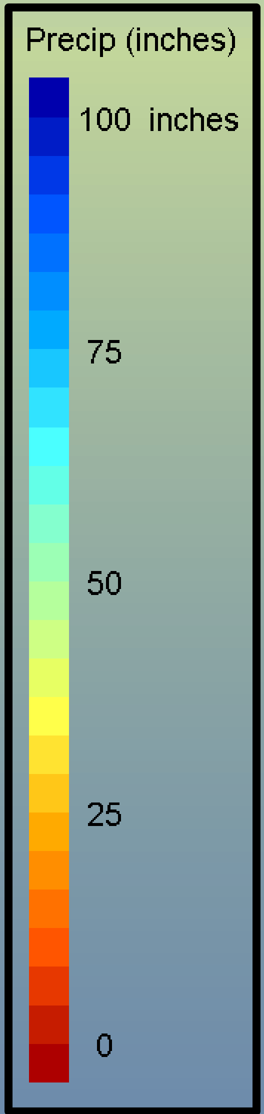
Mean summer temperature (1951-2006; June thru Aug)



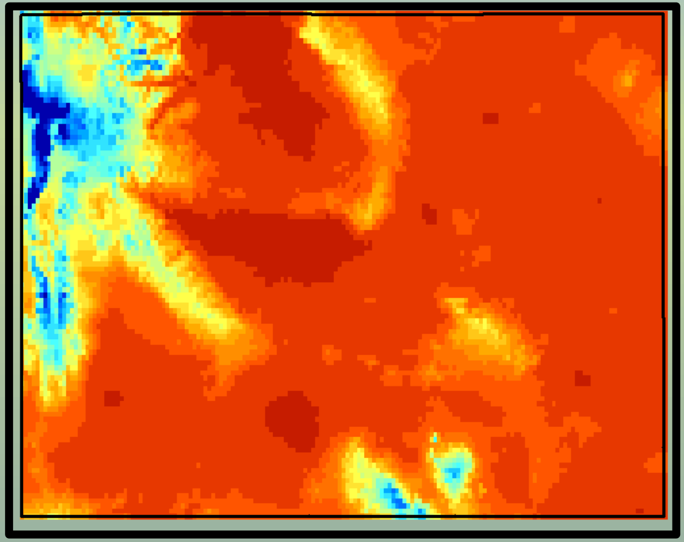
Mean Annual Precipitation

Mean annual precipitation (1951-2006)

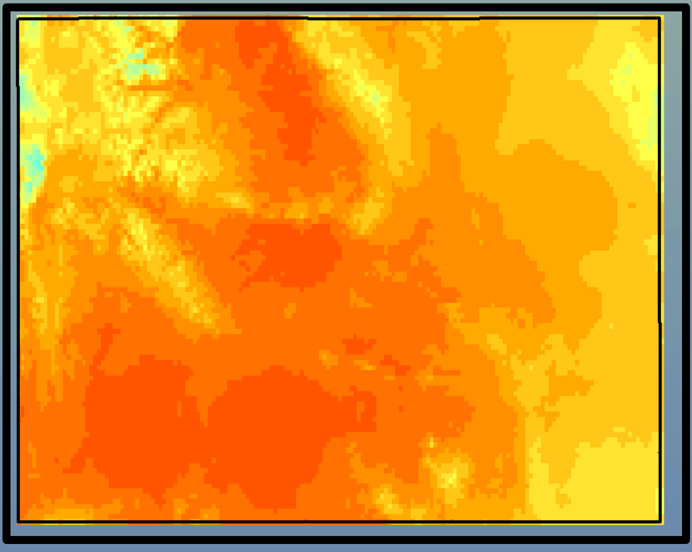




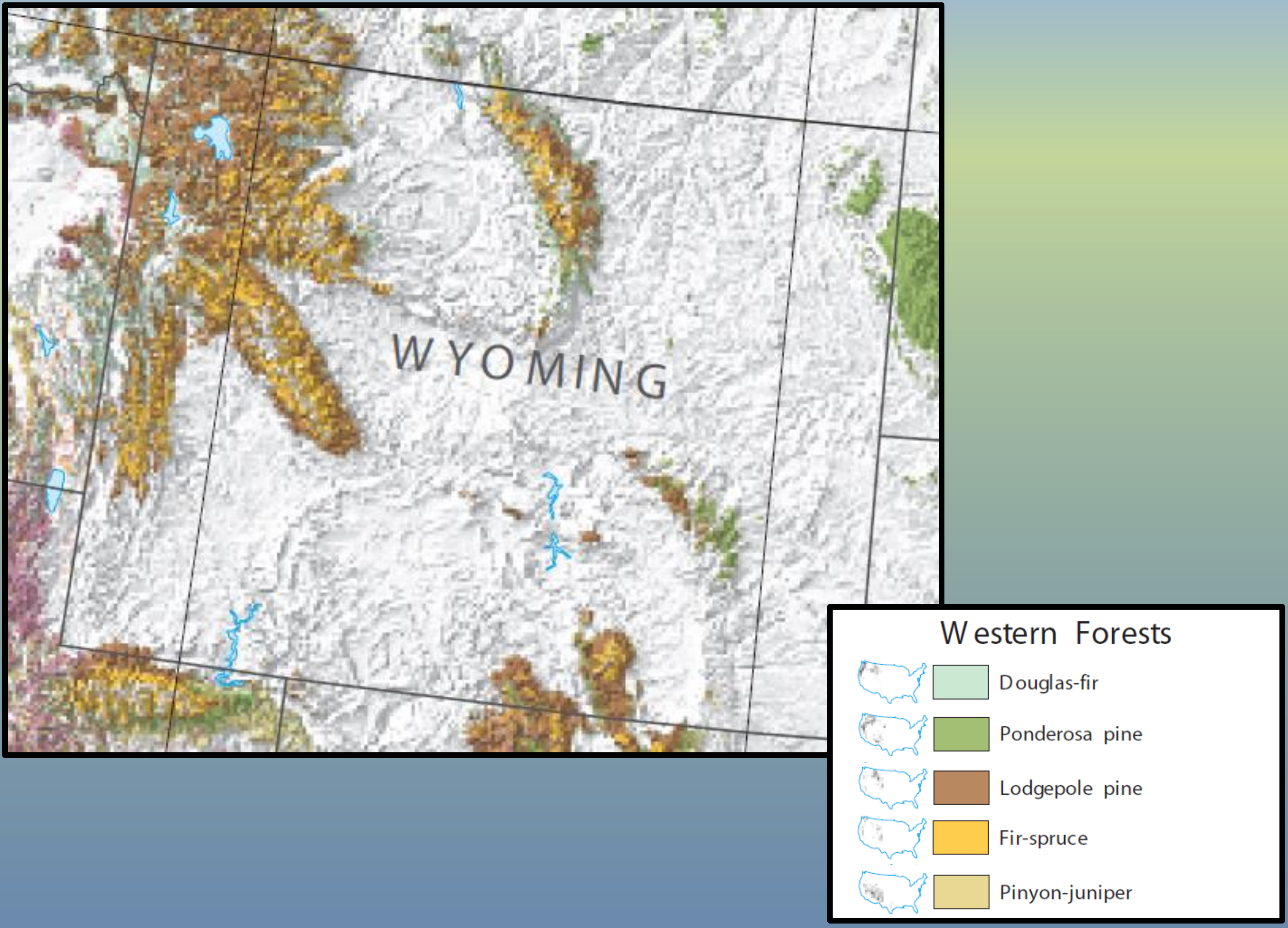
Mean winter precipitation (1951-2006; Dec thru Jan)



Mean summer precipitation (1951-2006; June thru Aug)



Maps produced by www.climatewizard.org © University of Washington and The Nature Conservancy (2009).


WYOMING
Western Forests
Douglas-fir
Ponderosa pine
Lodgepole pine
Fir-spruce
Pinyon-juniper

Wyoming's Forests

- Wyoming's forest types generally change over precipitation and temperature gradients.
  - Most commonly with elevation, aspect, and latitude.
- These factors can predispose or discourage forest health issues and result in fine geographic patterns in forest productivity and risk.

Outline

1. Wyoming's Forests
2. Criteria for Evaluating Forest Health
3. Natural Forest Disturbance Regimes
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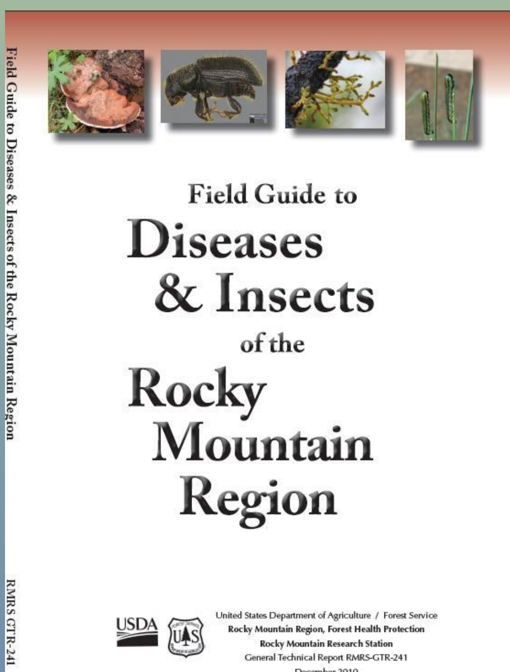
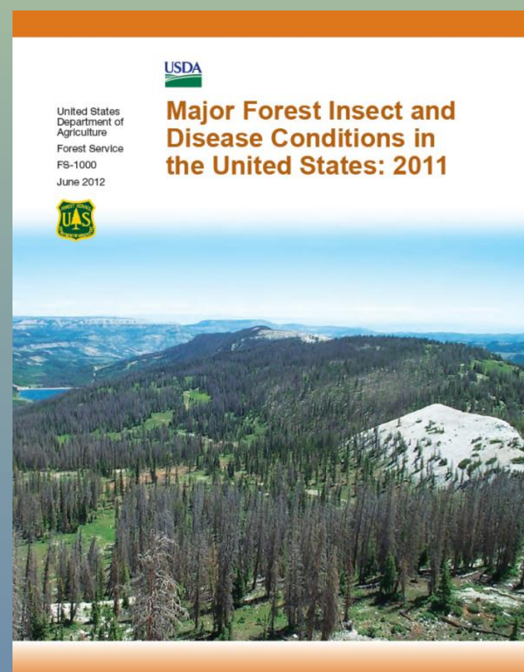
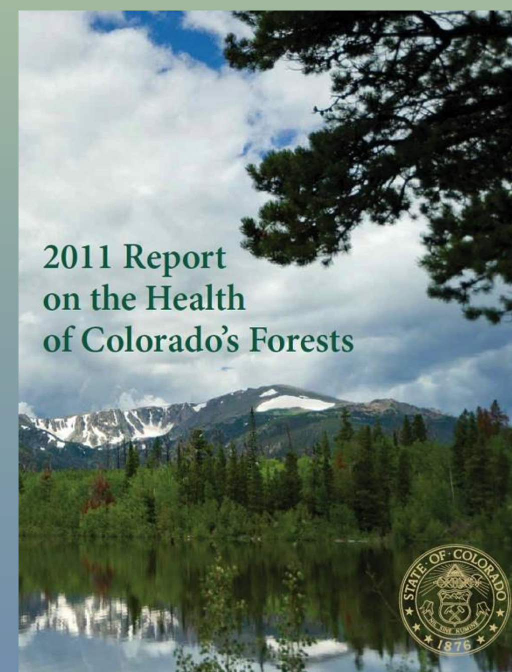
Forest Health

- The perceived condition of a forest….
  - Relevant factors: age, structure, composition, function, vigor, presence of unusual levels of insect and disease, and resilience.
  - Often influenced by cultural beliefs, land management objectives, visual appearance, geographic and temporal scale.







USDA Forest Service—Forest Health Protection (http://www.fs.fed.us/foresthealth/)

Evaluating Forest Health

What is at stake? **Ecosystem function and services**

Ecosystem Function

- The biophysical processes that take place within an ecosystem. They are typically characterized apart from society, but are generally affected by human activities.

Ecosystem Services

- The outcomes from ecosystem function that benefit humans as products or services.

Evaluating Forest Health

Key ecosystem services related to forest health

- Maintenance of water quality & quantity.
- Soil protection and erosion control.
- Provide habitat for wildlife including game species.
- Maintenance of sustained goods and services.
  - E.g., timber products, livestock, and recreation opportunities.
- Maintenance of biological and genetic diversity.
- Cultural values and the maintenance of resources for future generations.

Evaluating Forest Health

Some threats to forest health in Wyoming

- Forecasted increases in the frequency of severe drought and high temperatures from climate change.
- Wildfire associated with human and natural ignitions.
- Invasive species (e.g., white pine blister rust).
- Recreation pressure.
- Avoidance of fragmented landscapes.
  - Extractive resources such as timber, oil, and gas.
  - Development in the Wildland Urban Interface (WUI)

Evaluating Forest Health

Tree and Stand Indicators

- Crown condition
  - The overall condition of the tree crown.
  - Can be a quick evaluation of general tree health.
- Crown Ratio
  - The ratio of crown length to total tree height.
- Crown Density
  - The amount and compactness of foliage in the tree crown.
  - Often measured as the amount of skylight blocked.
- Crown Dieback
  - The progressive death of a portion of the tree crown.

Evaluating Forest Health

Landscape and regional indicators

- Broad-scale climate pressure
  - The occurrence and severity of drought and high temperatures.
- Diversity of stand conditions across the landscape.
  - Diversity of forest types and age, size, and density classes.
  - Avoid static, homogeneous conditions.
- Monitor the initiation, extent, and severity of nearby forest pests and diseases.
  - Early detection ensures the broadest range of options.
- Acknowledge that forest health issues can not be completely avoided and contribute to diverse landscape conditions.

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Characteristics of Disturbance Regimes

Disturbance

- Any relatively discrete event that disrupts ecosystem structure and/or changes the physical environment.

Frequency

- The frequency in which a disturbance returns to the same location.

Intensity

- The energy release from a disturbance event.

Severity

- The cumulative effect of disturbance on an ecosystem.

Resilience versus Resistance

Ecosystem

- A biological community of interacting organisms and their physical environment.

Resistance

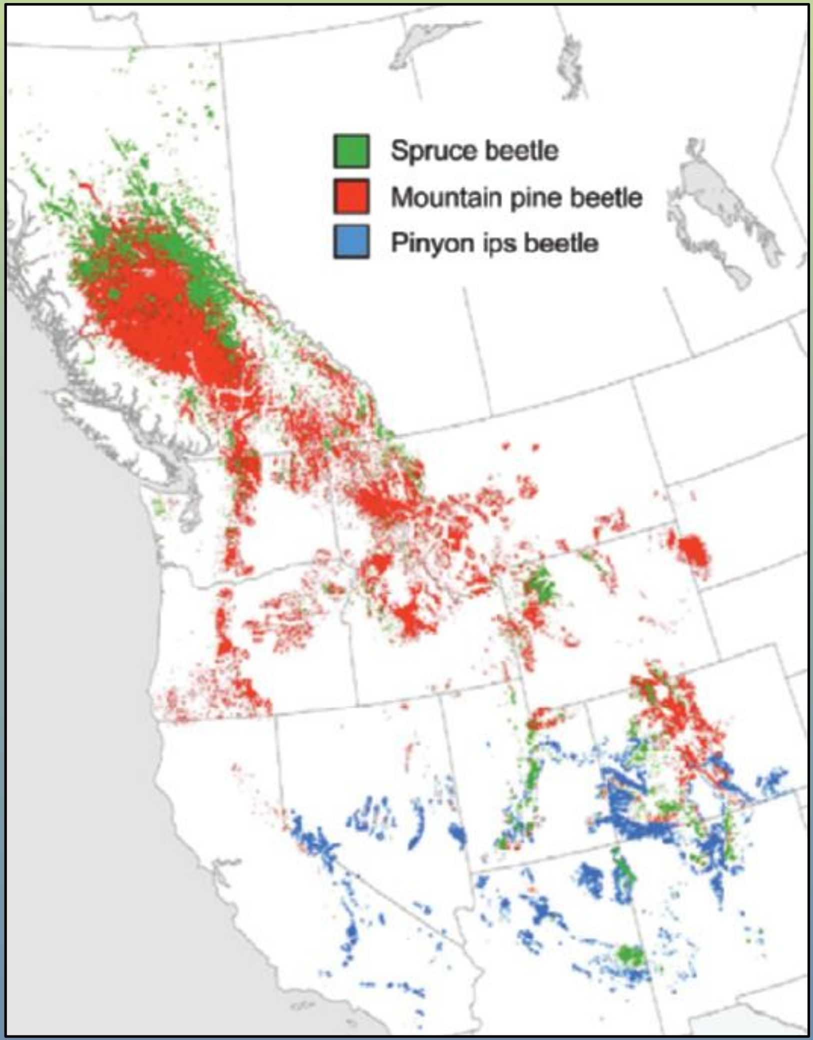
- The ability of an ecosystem to avoid disruption of its current state from disturbance.

Resilience

- The capacity of an ecosystem to return to its original state following disturbance.

Bark Beetle Biology/Ecology

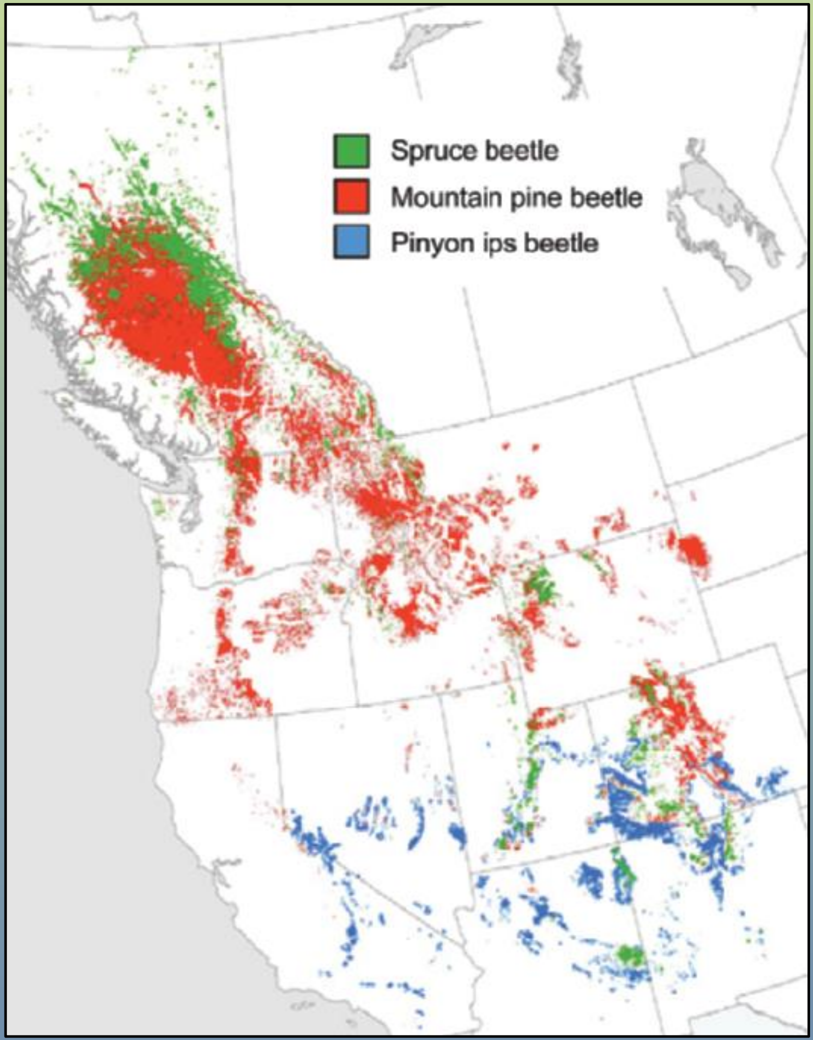
- Forest insects are the most important disturbance agents in the United States and impact an area 45 times greater than wildfire.
- Insects cause 90% of tree mortality in the United States.
- 60% of disturbed area by insects can be attributed to bark beetles.



(Map created by Raffa et al. 2008)

Bark Beetle Biology/Ecology

- Over 120 million acres of forests in North America were affected by bark beetles between 1996 and 2005.
- Extensive mortality has been attributed to…
  - Regional drought,
  - Warm winter temperatures,
  - Contiguous stands of susceptible host trees.



(Raffa et al. 2008)

Bark Beetle Biology/Ecology

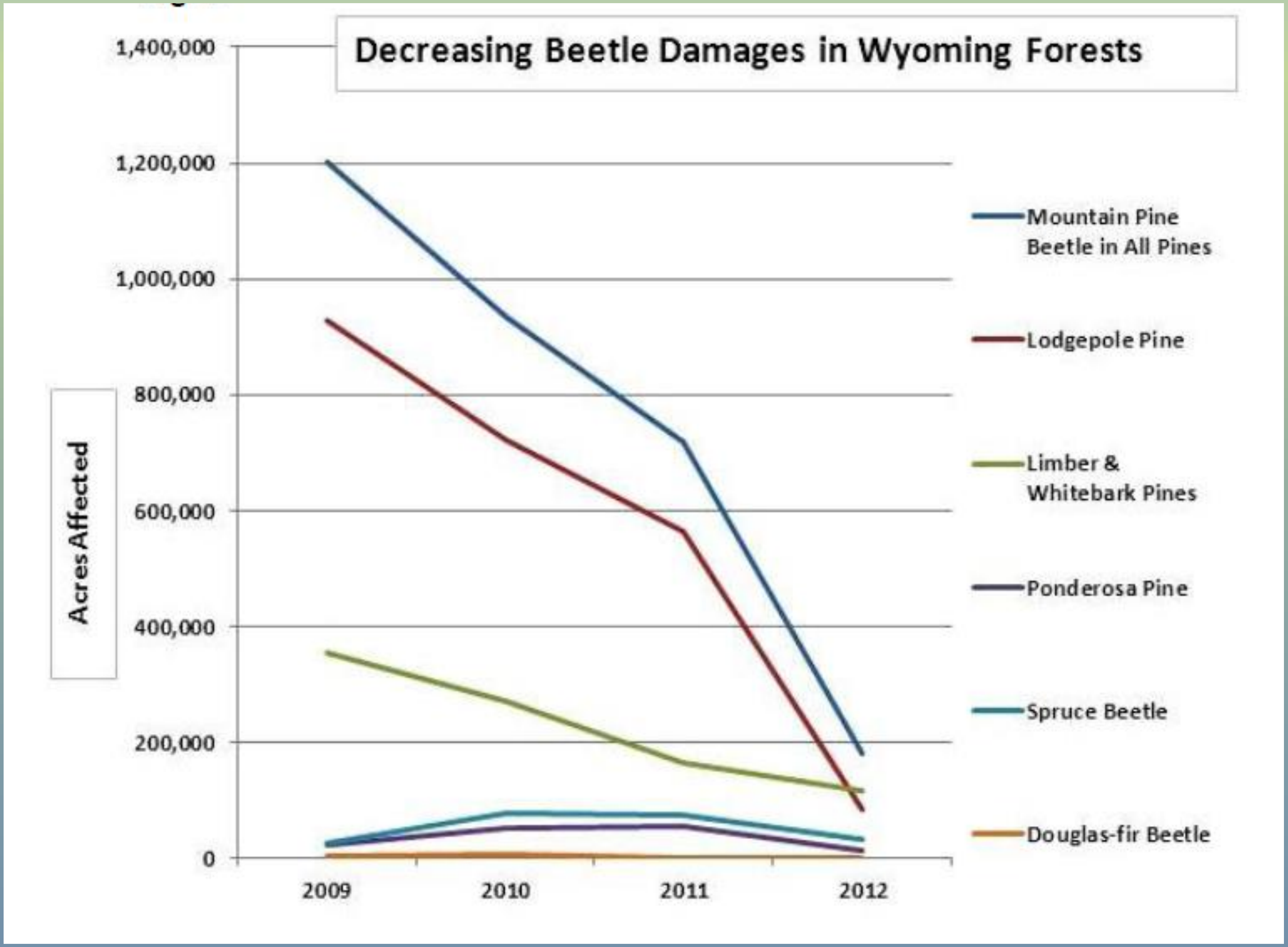
- The extent and severity of the current beetle outbreak is unprecedented in recorded history.
- Bark beetle outbreaks were reported in every decade over the last century in Rocky Mountain National Park and Yellowstone National Park.

Bark Beetle Biology/Ecology

Several native, “aggressive” bark beetle species are currently active in Western North America.

- **Mountain Pine Beetle** (*Dendroctonus ponderosae*)
  - Infests most native and introduced species of pines (lodgepole, ponderosa, limber, whitebark, bristlecone, western white).
- **Spruce Beetle** (*Dendroctonus rufipennis*)
  - Infests Engelmann spruce/Colorado blue spruce.
- **Douglas-fir Beetle** (*Dendroctonus pseudotsugae*)
  - Infests Douglas-fir.
- **Western Balsam Bark Beetle** (*Dryocoetes confusus*)
  - Infests Subalpine fir.

Bark Beetle Outbreak in Wyoming



Wyoming 2012—Forest Health Highlights (http://fhm.fs.fed.us/fhh/fhh_12/WY_FHH_2012.pdf)

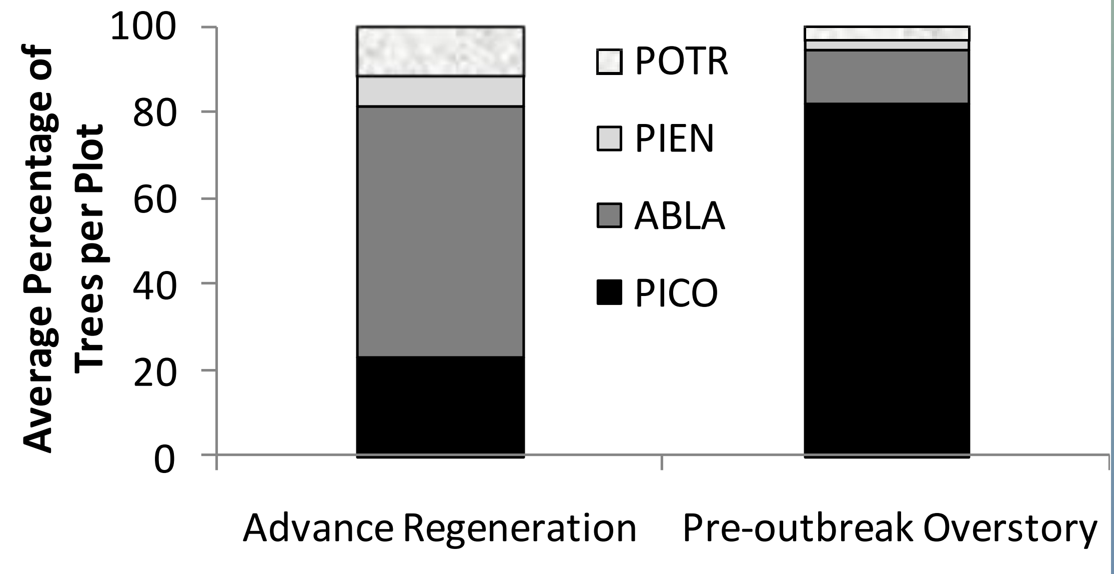
Effects of Bark Beetles
Recent Research Results

- Mortality of overstory lodgepole pine ranged from 0 - 70% (average = 37%).
- The density of advance regeneration varied widely, from 240 to 32,000 stems per acre for all species combined.
- The density of advance regeneration exceeded 2400 stems per acre in all but three stands.

Kayes and Tinker 2012 Forest Ecology and Management

Effects of Bark Beetles
Recent Research Results

- Pre-outbreak overstory was comprised of 82% lodgepole pine.
- Advance regeneration was only 23% lodgepole pine, and was dominated by subalpine fir.

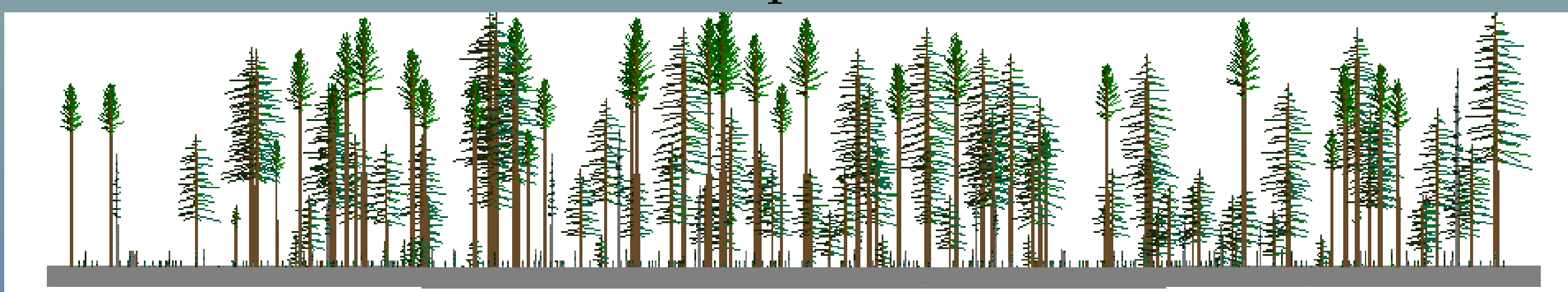


Kayes and Tinker 2012 Forest Ecology and Management

Within Stand Complexity Increases

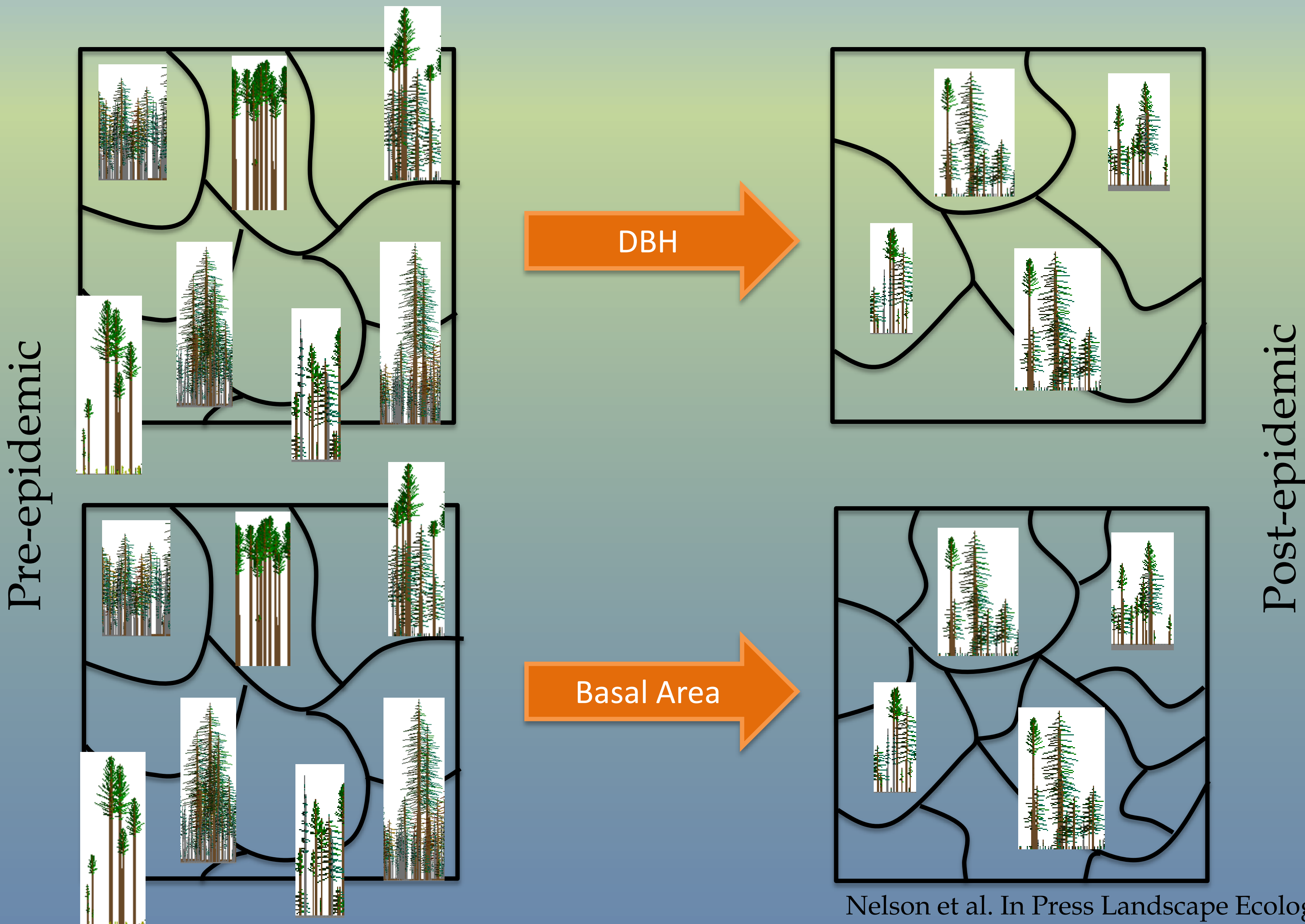
Pre-epidemic

Post-epidemic



Nelson et al. In Press Landscape Ecology; Illustrations by Matt Diskin

Landscape Patches Become More Similar



Nelson et al. In Press Landscape Ecology

Bark Beetle Biology/Ecology

- Bark beetles have been active in every decade of the last century at stand and watershed scales.
- The recent sub-continental outbreak is unprecedented in our historical record and was largely caused by warm, dry conditions and contiguous stands of host trees.
- Despite substantial reductions in basal area, density and tree size, high densities of surviving trees are available for forest recovery.

Wildfire regimes

- Fire regimes vary with forest type and location.
- In Wyoming, fires are primarily driven by climate and weather conditions.

Wildfire regimes

Two general types of natural fire regimes

1) Low intensity understory fires
   a. 2-20 year return interval.
   b. Fuel limited—widespread suitable climate conditions.
   c. Low elevation ponderosa pine forests
2) Crown fire
   a. 60 to 600 year return interval
   b. Climate limited—ubiquitously high fuel loads
   c. High-elevation ponderosa pine forests, lodgepole pine forests, Engelmann spruce/subalpine fir forests

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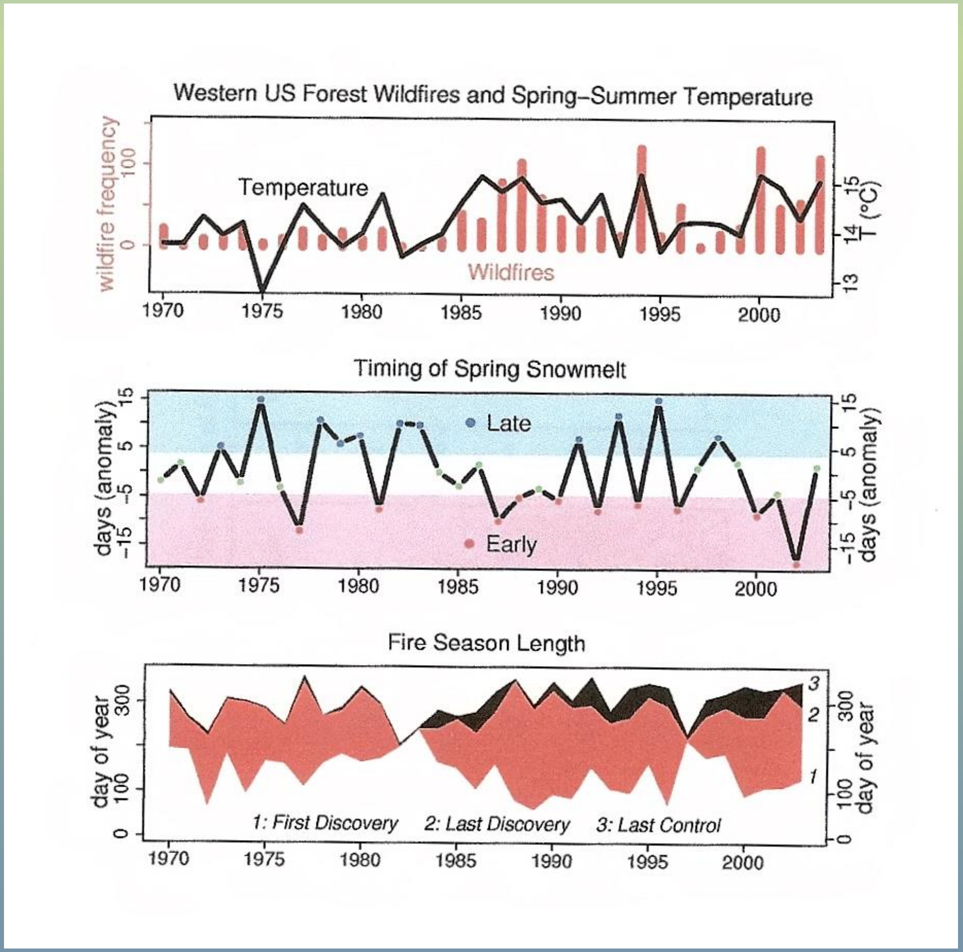
3) Absence of Fire
   a. Generally climate and fuels limited.

Wildfire regimes

- INCREASE in wildfire occurrence in past three decades (Westerling et al. 2006)
- Westerling et al. examined 1166 large (> 400 ha) wildfires from 1970-2003
  - Wildfires suddenly increased in mid-1980s (almost 4X more than 1970-1986)
  - Length of wildfire season increased

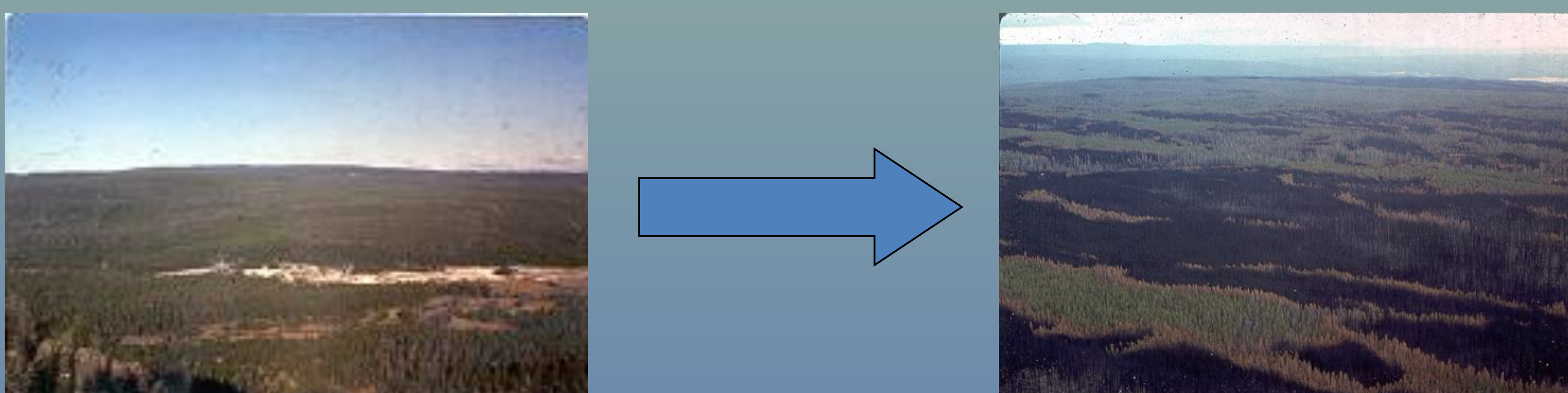


Westerling et al. 2006 Science

Wildfire regimes

Lodgepole pine is adapted to infrequent, high intensity fire

- Generally characterized by high fuel loads.
- Resilient to high intensity fire via serotinous cones that release seeds when exposed to heat.
- Lodgepole pine regenerates with incredible variability after fire
  - 0 - >500,000 stems per hectare in Yellowstone NP (Turner et al. 2004)

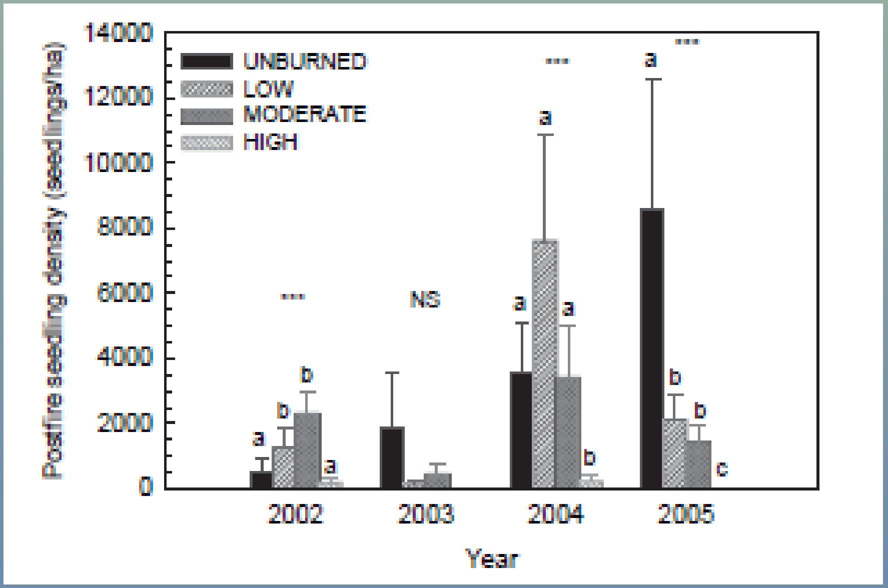


Wildfire regimes

Ponderosa pine is adapted to surface fire.

- Low elevation forests with grass understory historically had low intensity surface fuels.
- High elevation forests historically accumulated greater fuel loads and higher intensity fires.
- Resistant to surface fire via thick, flaking bark and self-pruning of low limbs.

- Ponderosa pine has variable regeneration after fire but is much lower than lodgepole pine.



Results from the Jasper Fire in the Black Hills; Keyser et al. 2008 Forest Science

Wyoming’s wildfire regimes

- Wildfires are a natural disturbance agent in western forests.
- Most of Wyoming’s forests are climate limited and have sufficient fuels available to burn under suitable weather.
- Fuel accumulation due to fire suppression has generally not altered fuel loads in Wyoming's high elevation forests.
  - Some low elevation ponderosa pine forests may have been affected.

Disturbance Interactions

- How do various natural and anthropogenic disturbances interact?
  - Beetle/ fire

  - Beetle/ blister rust
  - Fire/ salvage logging
  - Beetle/ salvage logging

Beetle Outbreaks and Fire Occurrence/Severity

Lynch et al. 2006

– 1972-75 outbreak statistically increased odds of burning in 1988 by 11% (MINOR EFFECT).

Bebi et al. 2003

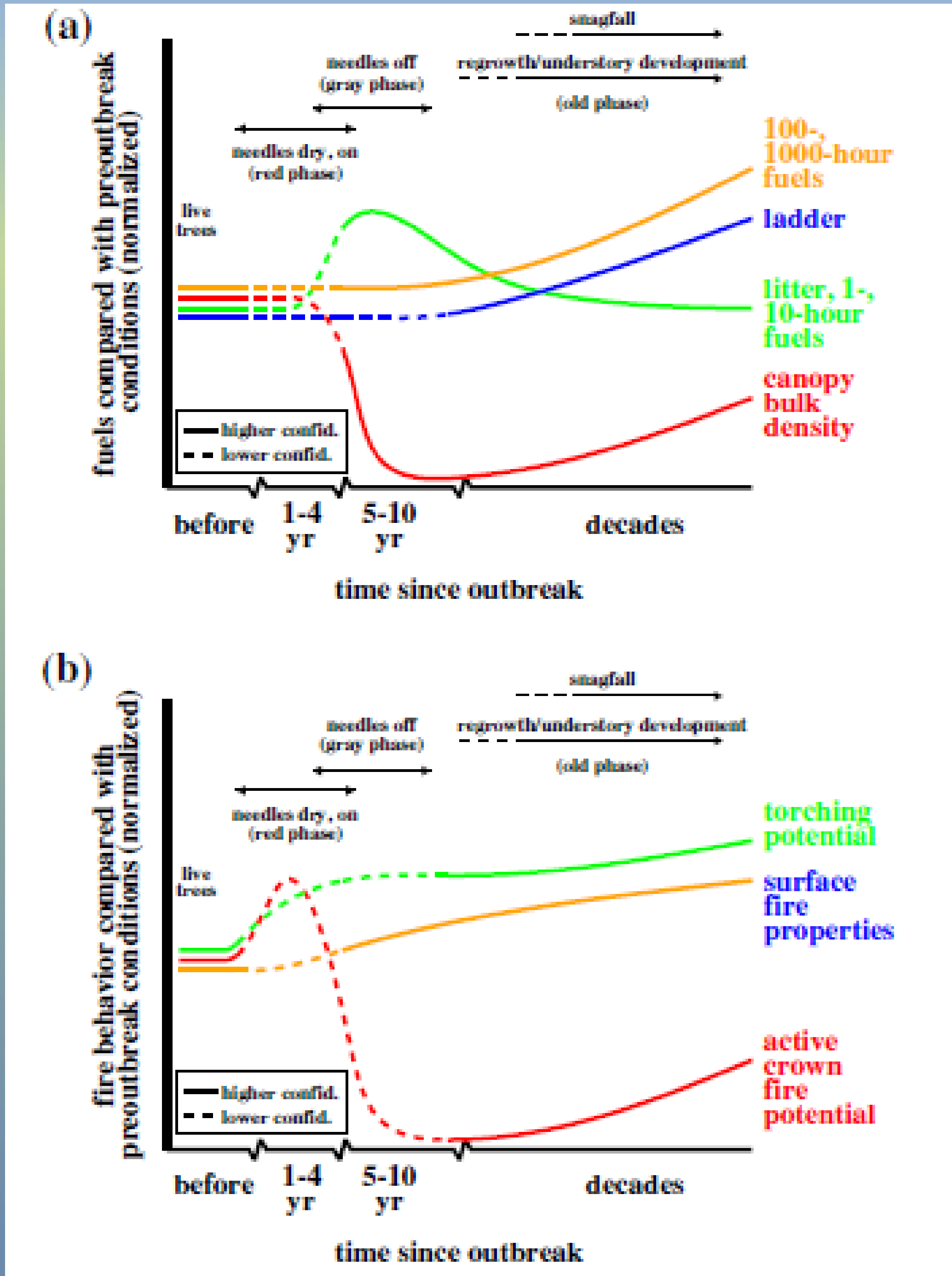
– Stands affected by 1940s beetle outbreak did not exhibit higher susceptibility to subsequent fires (NO EFFECT).

Page and Jenkins 2007

– Crown fires were more likely in post-epidemic stands, but harder to sustain (INCREASE IN RISK OF FIRE).

Simard et al. 2011

– Reduced risk of active crown fires (LOWER RISK OF ACTIVE CROWN FIRE).



<u>Surface Fire Potential</u>:
The probably that sufficient surface fuels exist to allow surface fire spread.

<u>Torching potential</u>:
The probability that a surface fire will spread into tree crowns but not actively spread to adjacent tree crowns.

<u>Active Crown Fire Potential</u>:
The probability that a fire that has spread into tree crowns will actively move to adjacent tree crowns.

<u>Fire Risk</u>: The chance that a fire may start considering the potential for ignition and the status of climate and fuels.

(Hicke et al. 2012 Forest, Ecology and Management)

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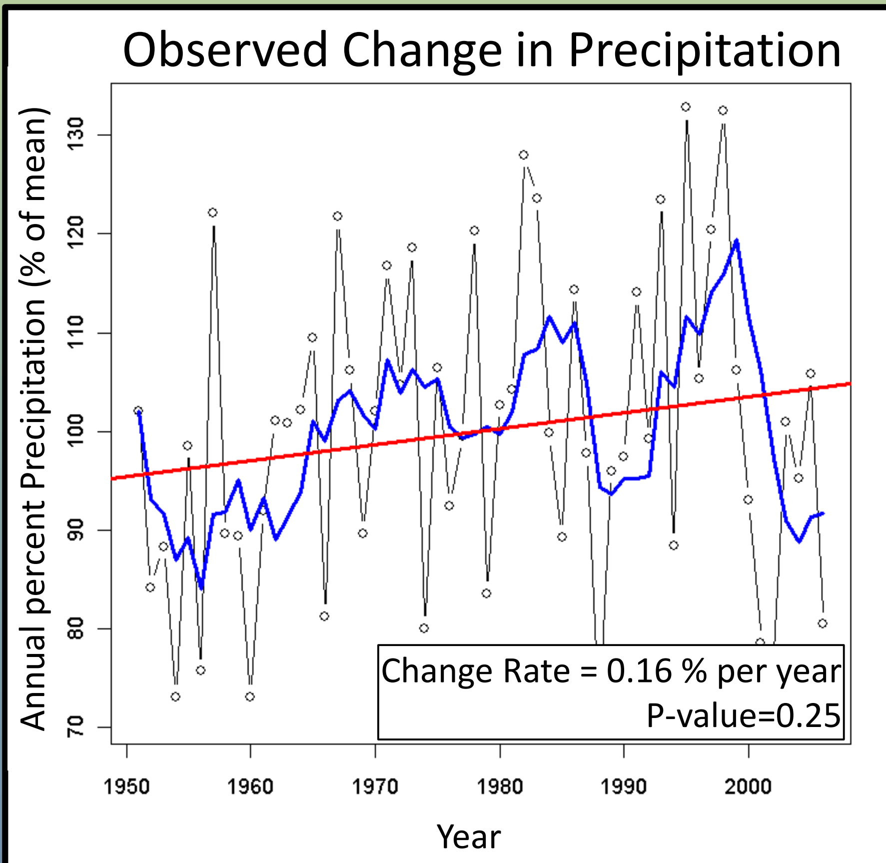
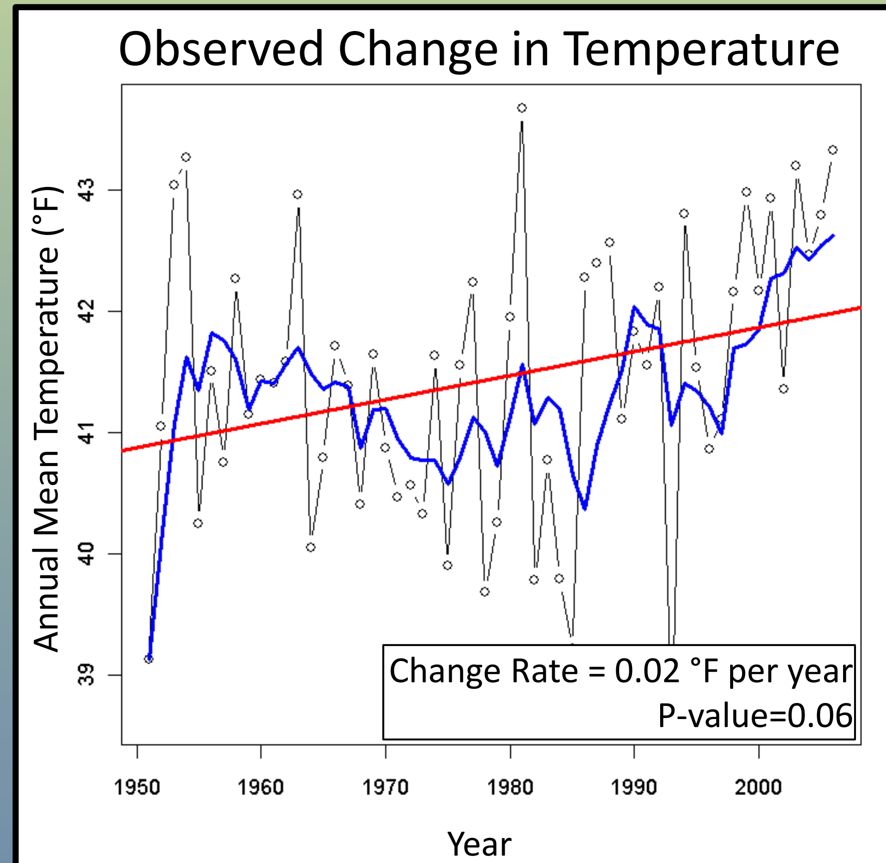
Observed Changes in Wyoming's Climate 1950 to 2006

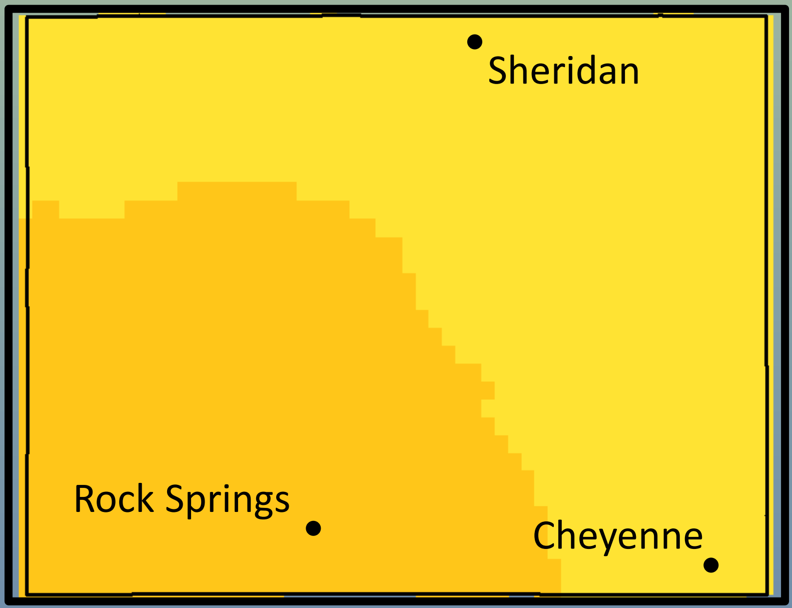


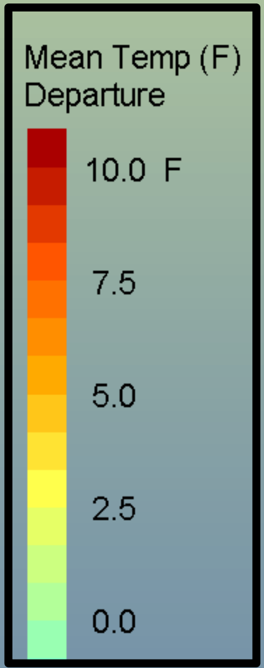


Graphs produced by www.climatewizard.org

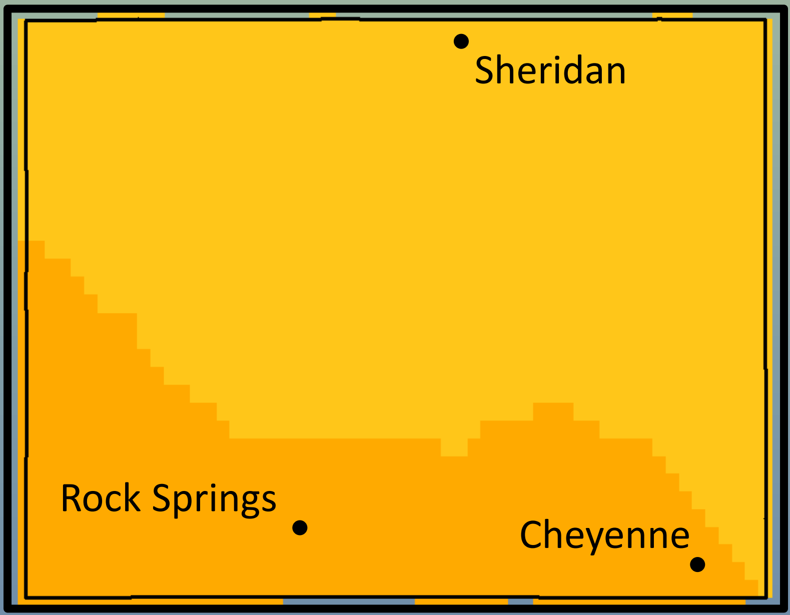
Forecasted departure in mean annual temperature

Low Emissions Scenario (B1)
2040-2069
Compared to 1961-1990





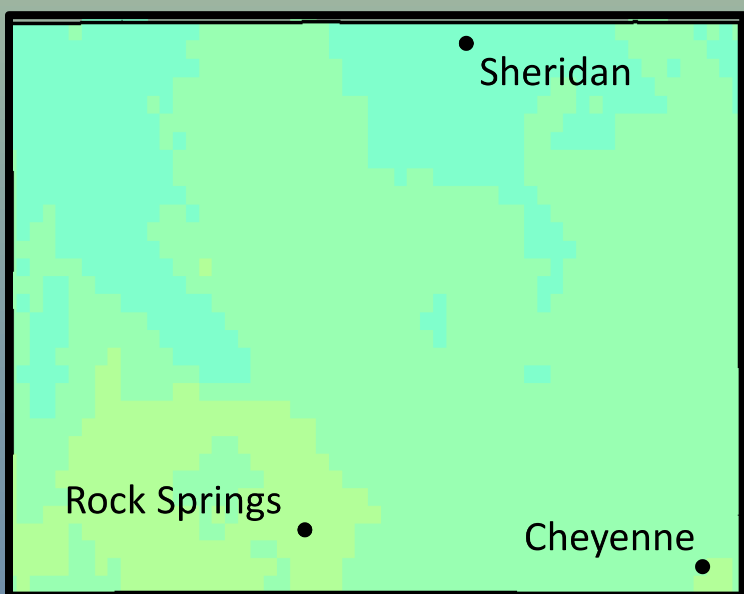
High Emissions Scenario (A2)
2040-2069
Compared to 1961-1990

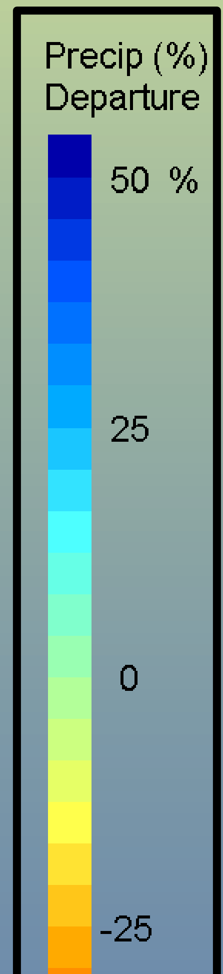


Maps produced by www.climatewizard.org © University of Washington and The Nature Conservancy (2009).

Forecasted departure in mean annual precipitation

Low Emissions Scenario (B1)
2040-2069
Compared to 1961-1990





High Emissions Scenario (A2)
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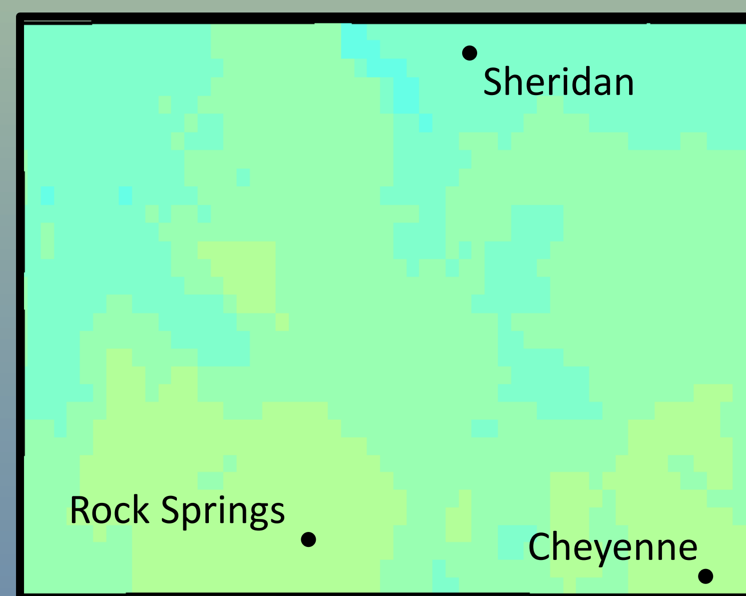
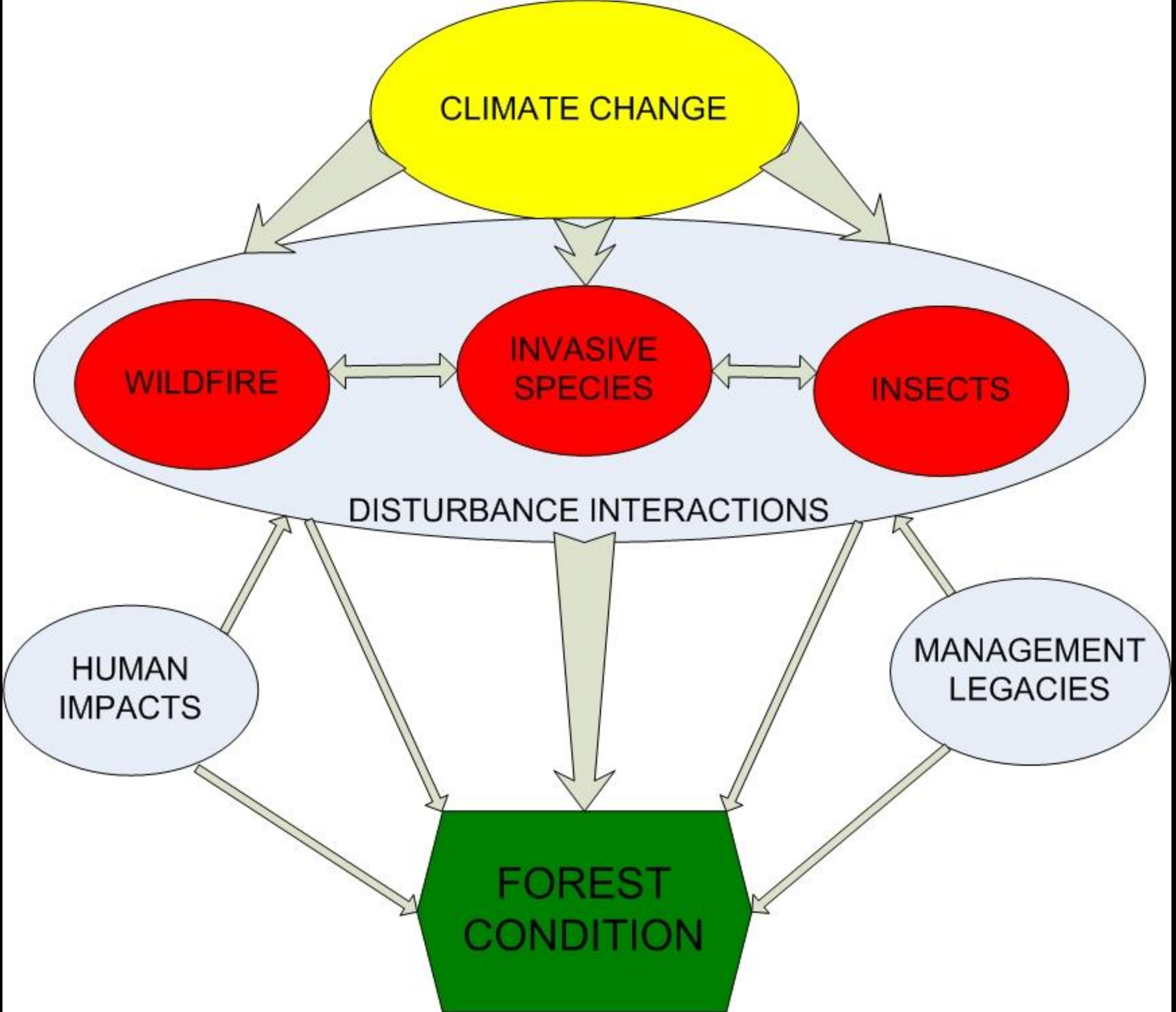


Maps produced by www.climatewizard.org © University of Washington and The Nature Conservancy (2009).


CLIMATE CHANGE
WILDFIRE
INVASIVE SPECIES
INSECTS
DISTURBANCE INTERACTIONS
HUMAN IMPACTS
MANAGEMENT LEGACIES
FOREST CONDITION

Climate Change and Future Forests

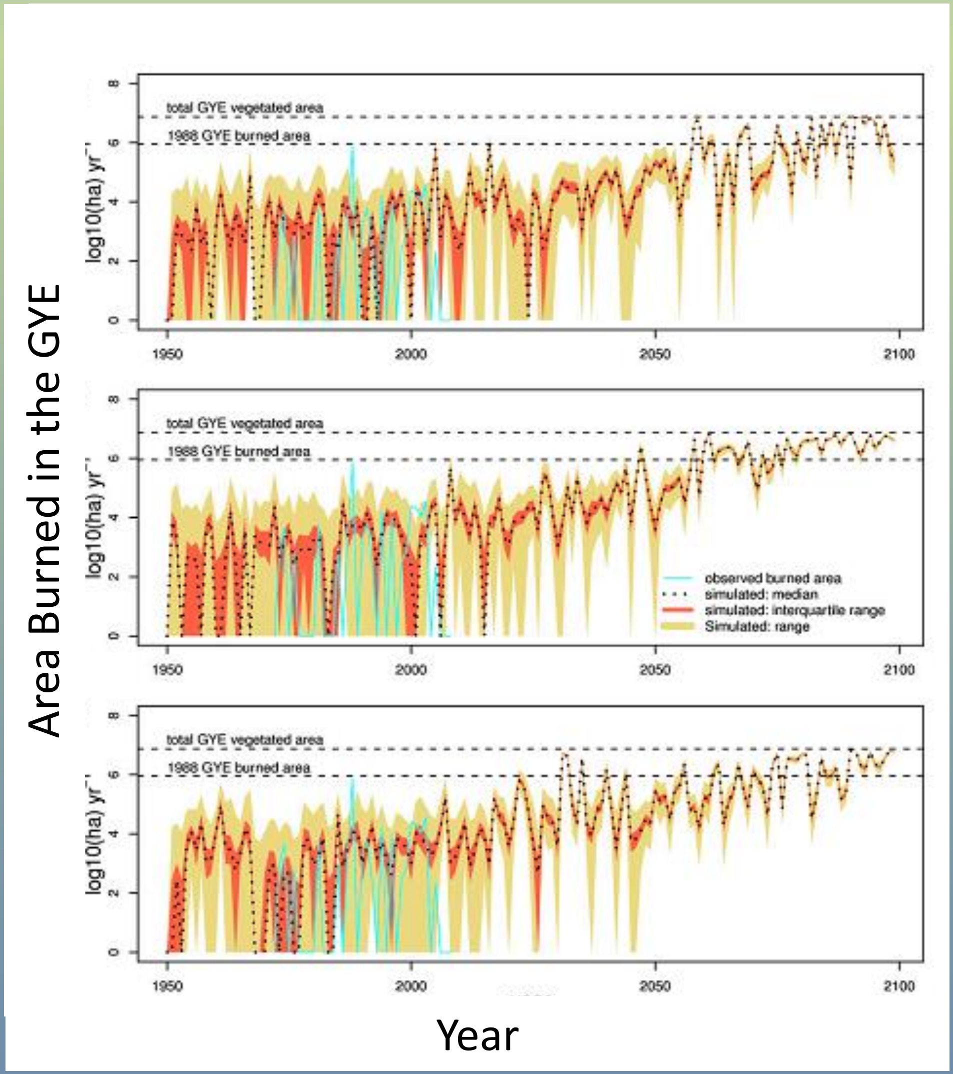
- Increases in temperature are generally associated with increased tree stress.
- More precipitation is expected to fall under warmer conditions.
  - Possible increase in rainfall but decrease in snowpack.
- Disturbance regimes will catalyze slow changes in forest structure and condition.

Climate Change and Future Forests

- Increased tree stress is generally associated with insect and disease success.
- Increased temperature is generally associated with longer fire seasons, increased area burned, and increased fire frequency.
- Additional precipitation is not expected to completely mitigate these effects.

Wildfire regimes

- Forecasted changes in climate (3 GCMs) indicate increased area burned in the GYE
- Fire rotations are expected to decrease in the next century
  - Pre-1990 ~ 120 year rotation
  - 2005-2024 ~ 60 year rotation
  - 2050 ~ < 20 year rotation
- Despite forecast uncertainty, we expect the mean age of GYE forests to decrease over the next century.



Westerling et al. 2011 PNAS

Climate Change and Future Forests

- Forest vegetation will persist—although shifts in species are likely.
- Forest recovery after disturbance is crucial for sustaining forest health.
- Resilience should be our focus—resistance is too risky.
- Restoration, where appropriate, may be effective.


Questions?

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