Rocky Mountain Divide – Climate Change Impacts

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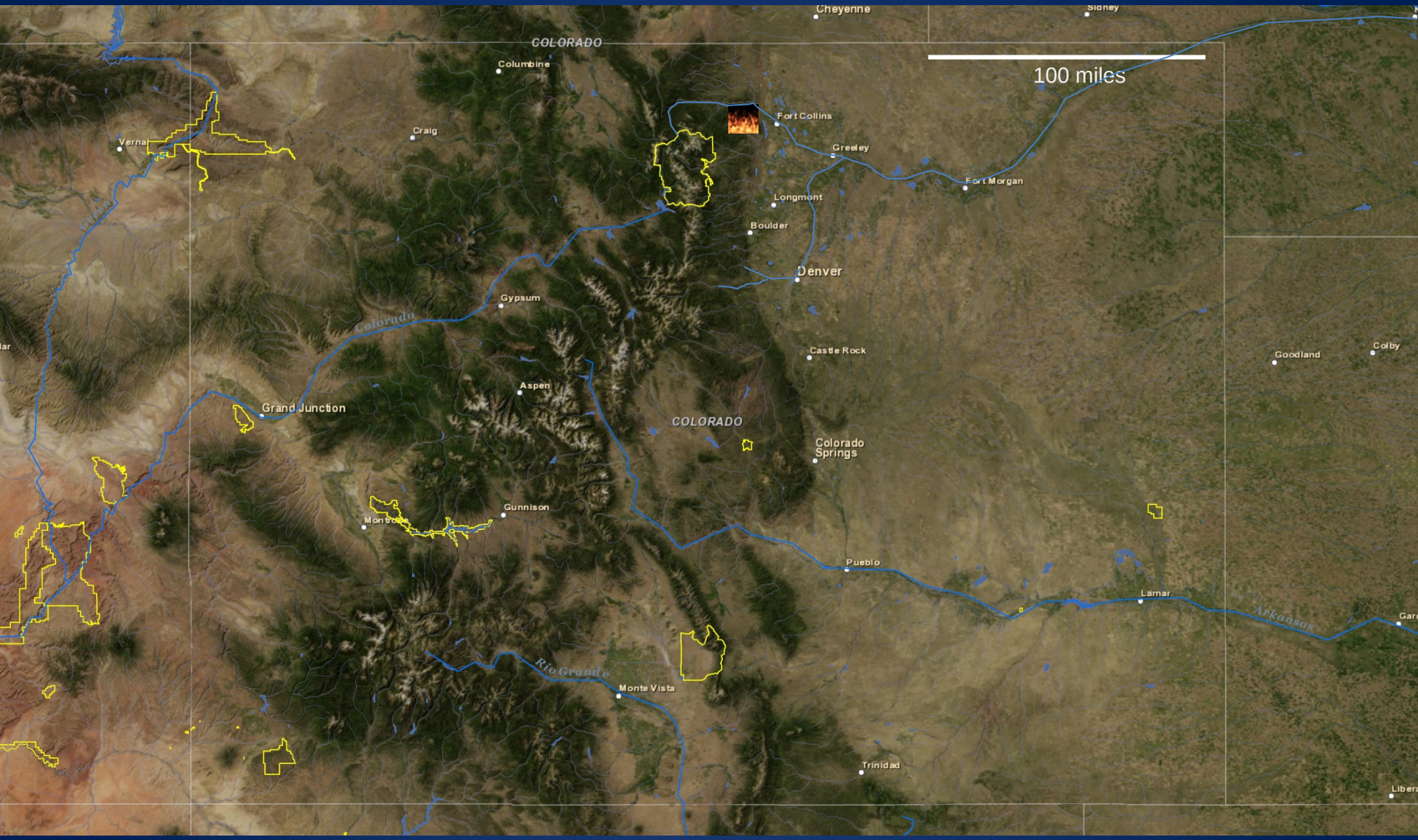
National Park Service
Ft Collins, CO

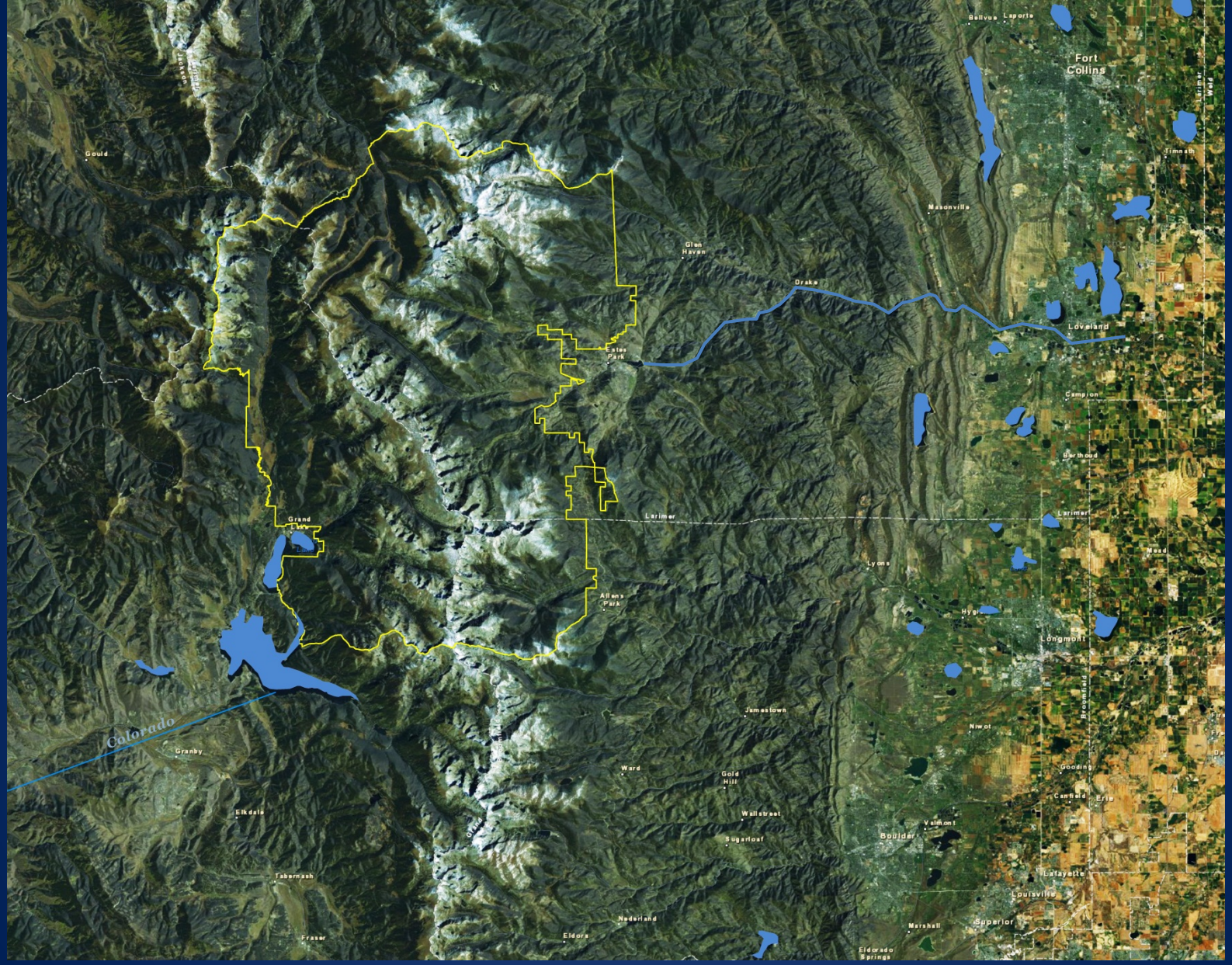
CC Scenario Workshop
Ft Collins, Colorado
June 19-21, 2012

2011/07/07 08:45

Roadmap …

- Orientation & context of the Rocky Mountain Divide area
- Conceptual model
- Observed and anticipated changes

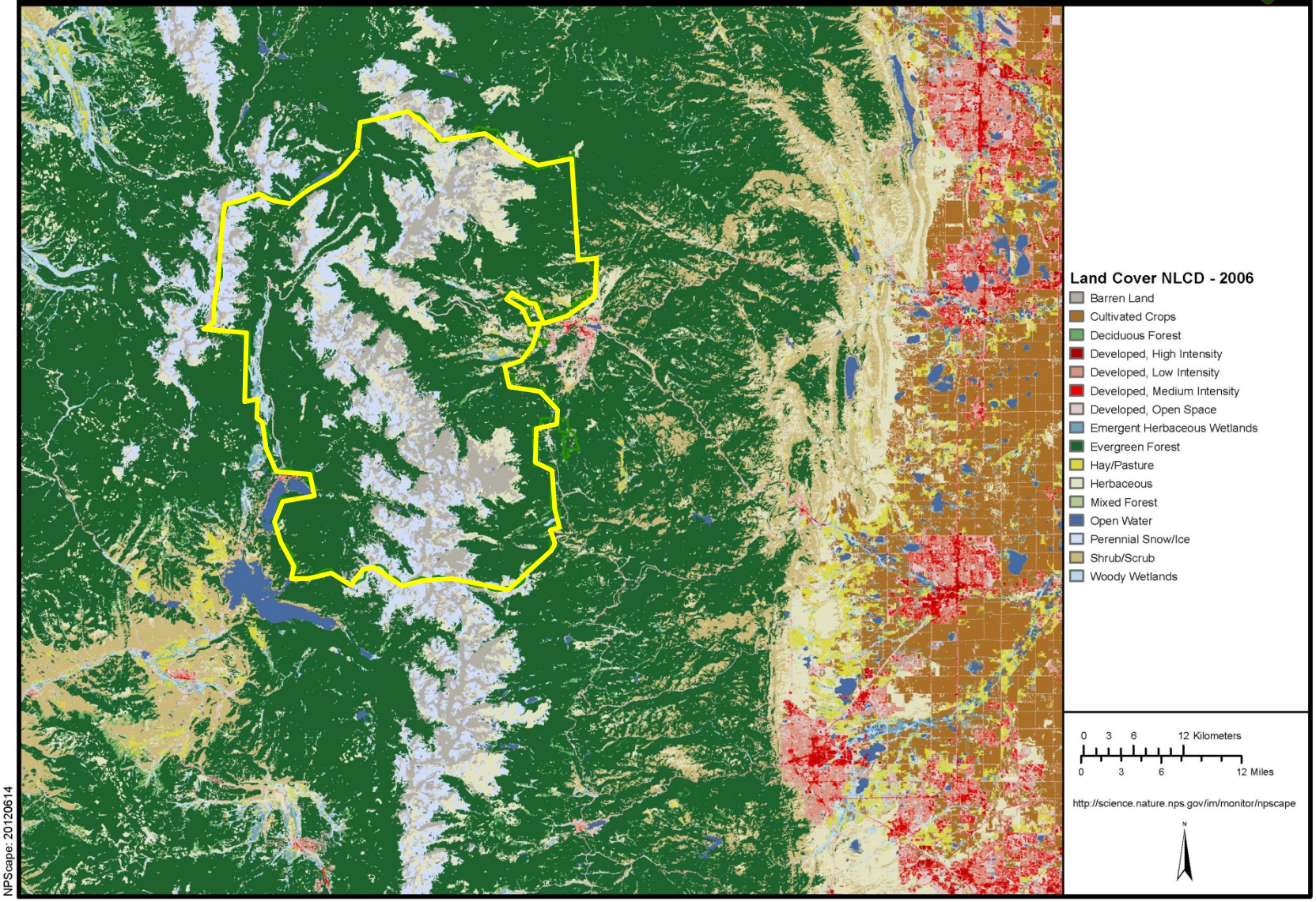

100 miles
COLORADO
Cheyenne
Sidney
Columbine
Craig
Vernal
Fort Collins
Greeley
Fort Morgan
Longmont
Boulder
Denver
Gypsum
Colorado
Castle Rock
Goodland
Colby
Aspen
Grand Junction
COLORADO
Colorado Springs
Gunnison
Montrose
Pueblo
Lamar
Arkansas
Rio Grande
Monte Vista
Trinidad


Bellvue
Laporte
Fort Collins
Timnath
Gould
Masonville
Glen Haven
Drake
Loveland
Estes Park
Campion
Berthoud
Grand Lake
Larimer
Larimer
Mead
Lyons
Allens Park
Hygiene
Longmont
Jamestown
Niwot
Granby
Colorado
Ward
Gold Hill
Gooding
Canfield
Erie
Elkdale
Wallstreet
Valmont
Boulder
Sugarloaf
Tabernash
Lafayette
Louisville
Nederland
Marshall
Superior
Fraser
Eldora
Eldorado Springs

Land Cover NLCD - 2006

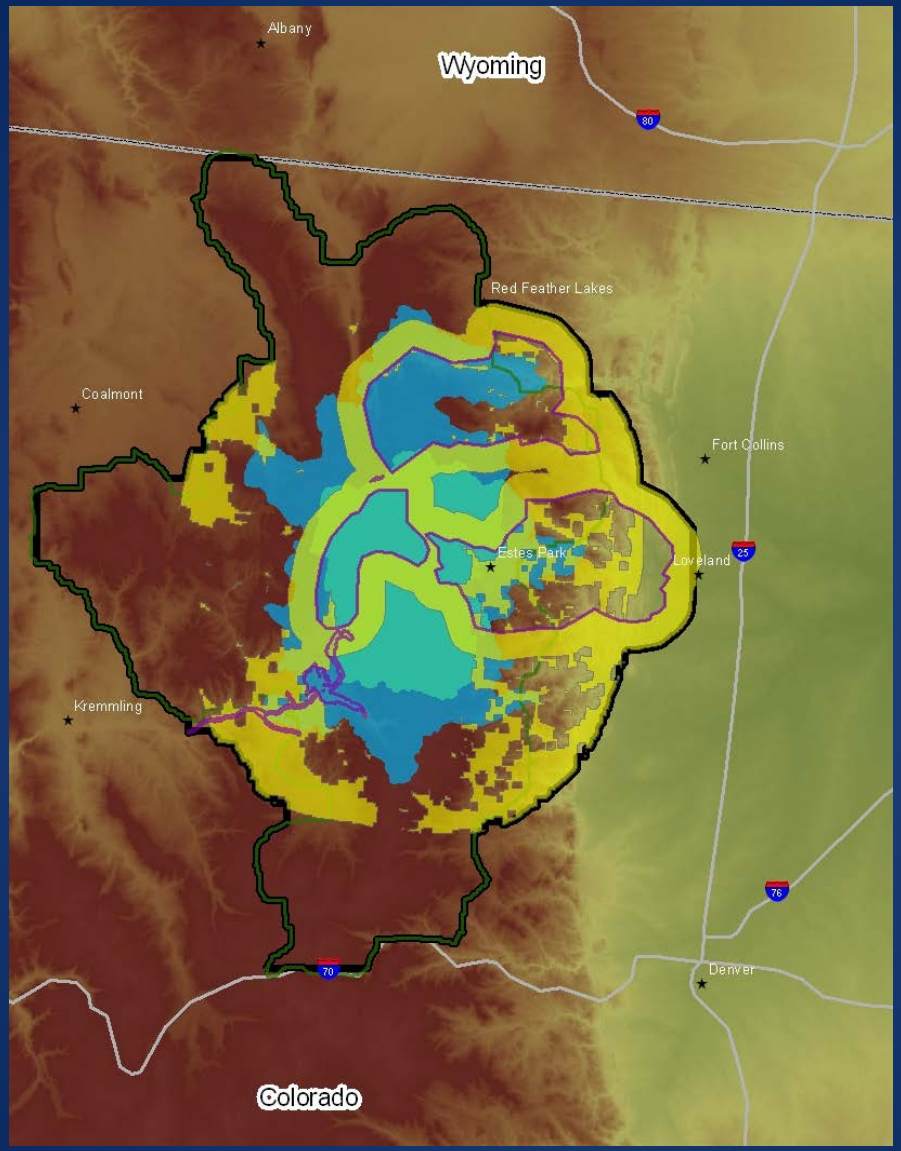
NPScape - NPS Inventory and Monitoring Division

National Park Service
U.S. Department of the Interior
Natural Resource Stewardship and Science



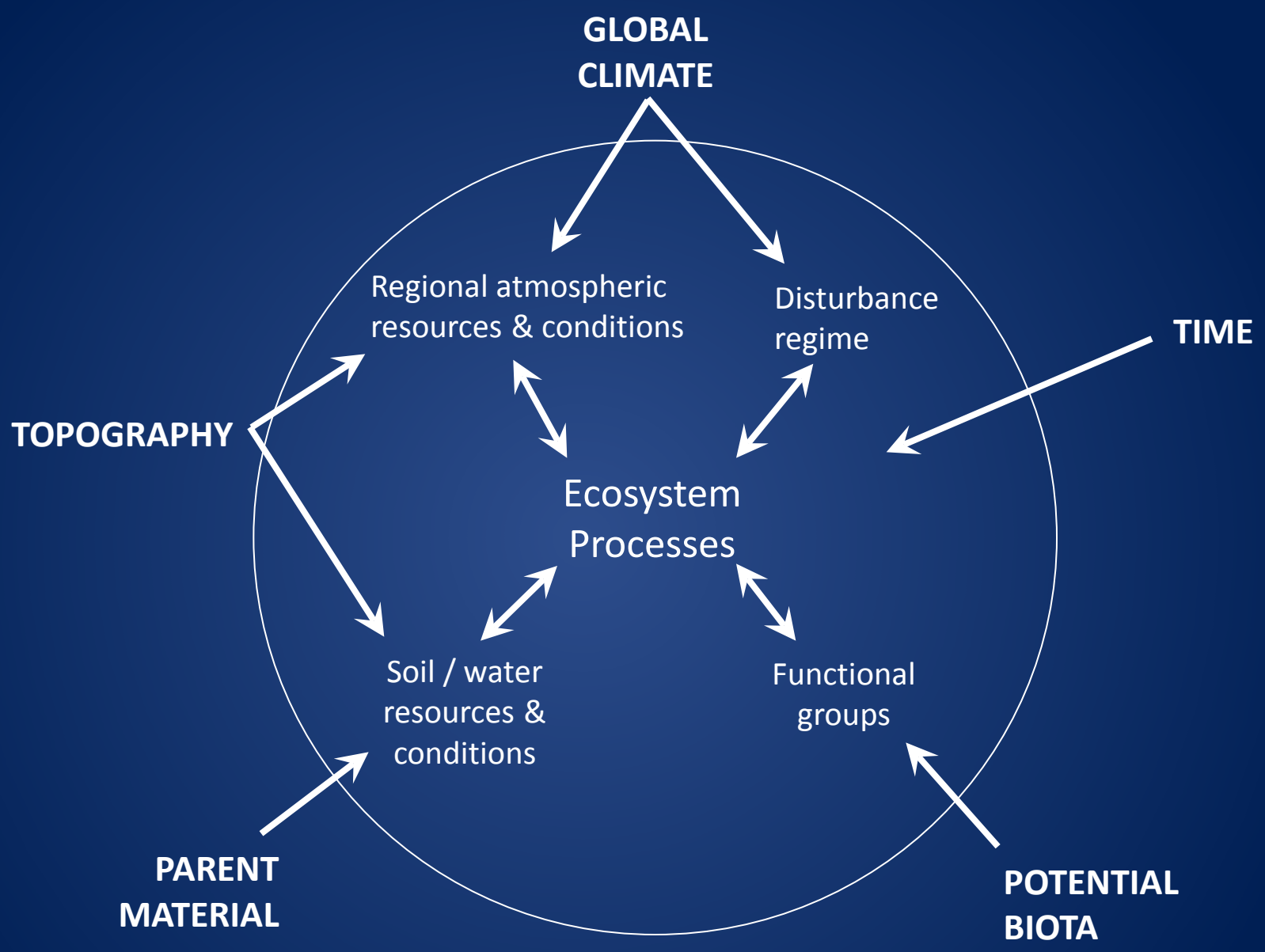
NPScape: 20120614

PACE – Protected Area Centered Ecosystem

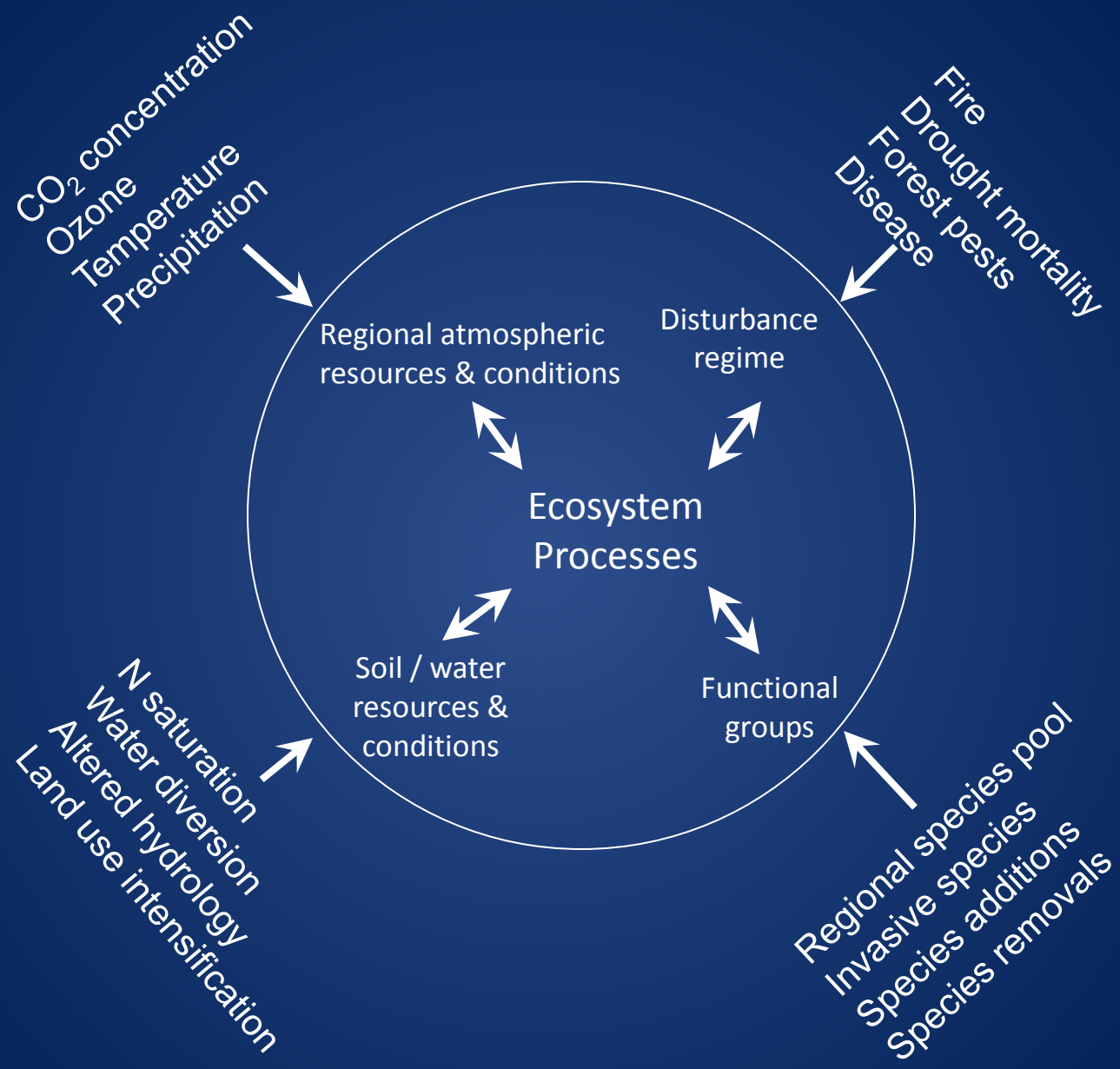


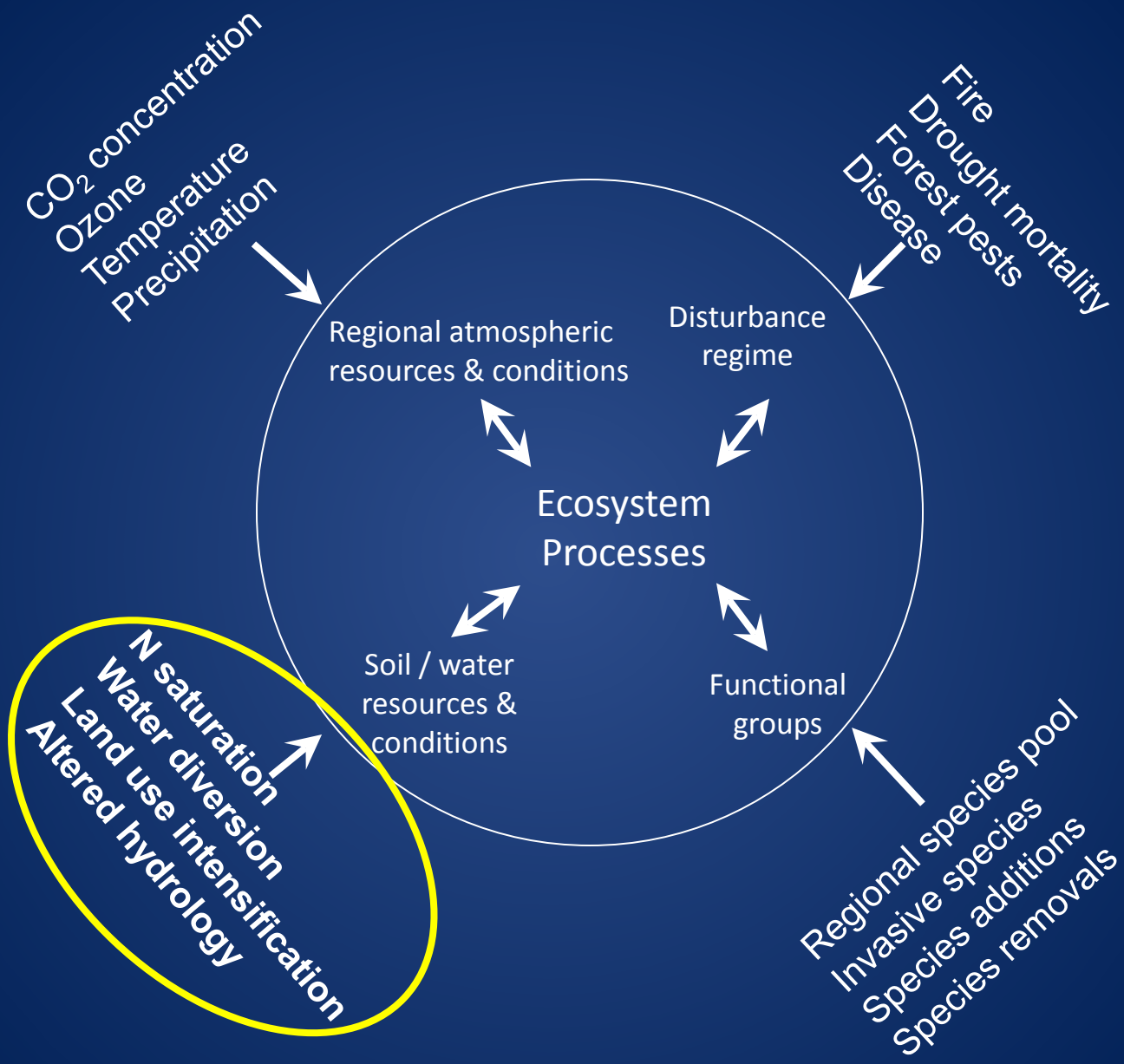
Park area 1,080 km^2
PACE 10,530 km^2

(Hansen et al. 2010 BioScience)



(Chapin et al. 1996; Miller 2005)


CO_2 concentration
Ozone
Temperature
Precipitation
Fire
Drought mortality
Forest pests
Disease
Regional atmospheric resources & conditions
Disturbance regime
Ecosystem Processes
Soil / water resources & conditions
Functional groups
N saturation
Water diversion
Altered hydrology
Land use intensification
Regional species pool
Invasive species
Species additions
Species removals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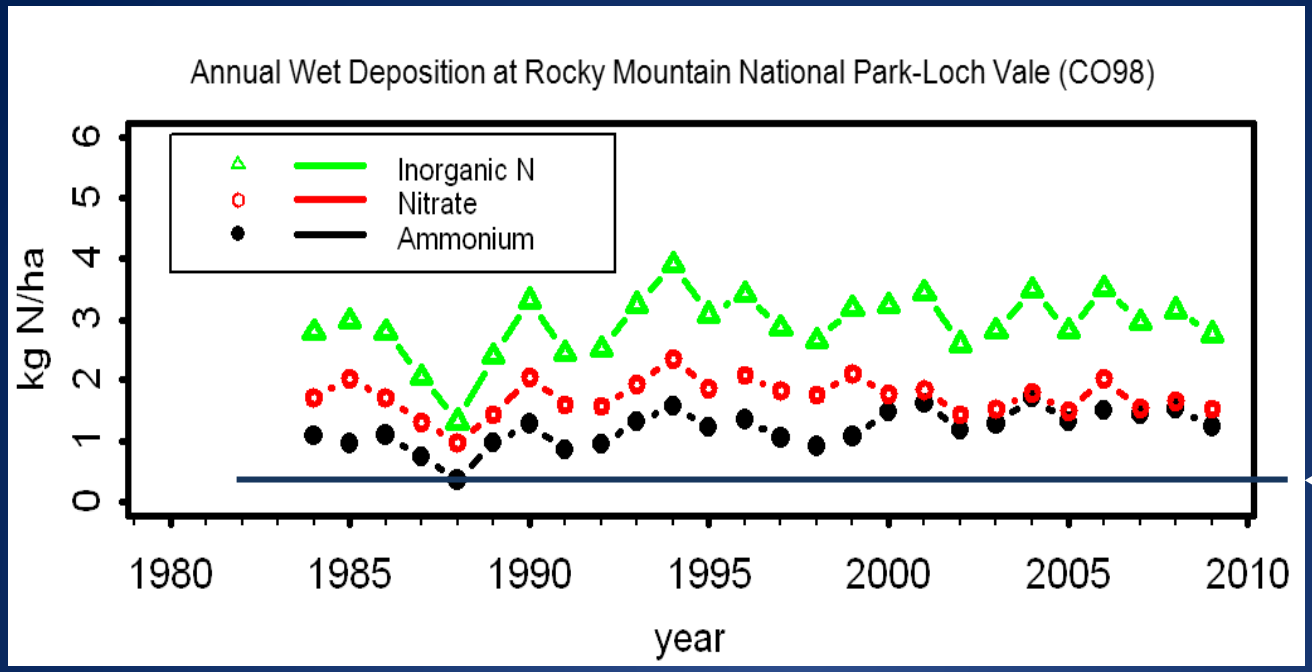
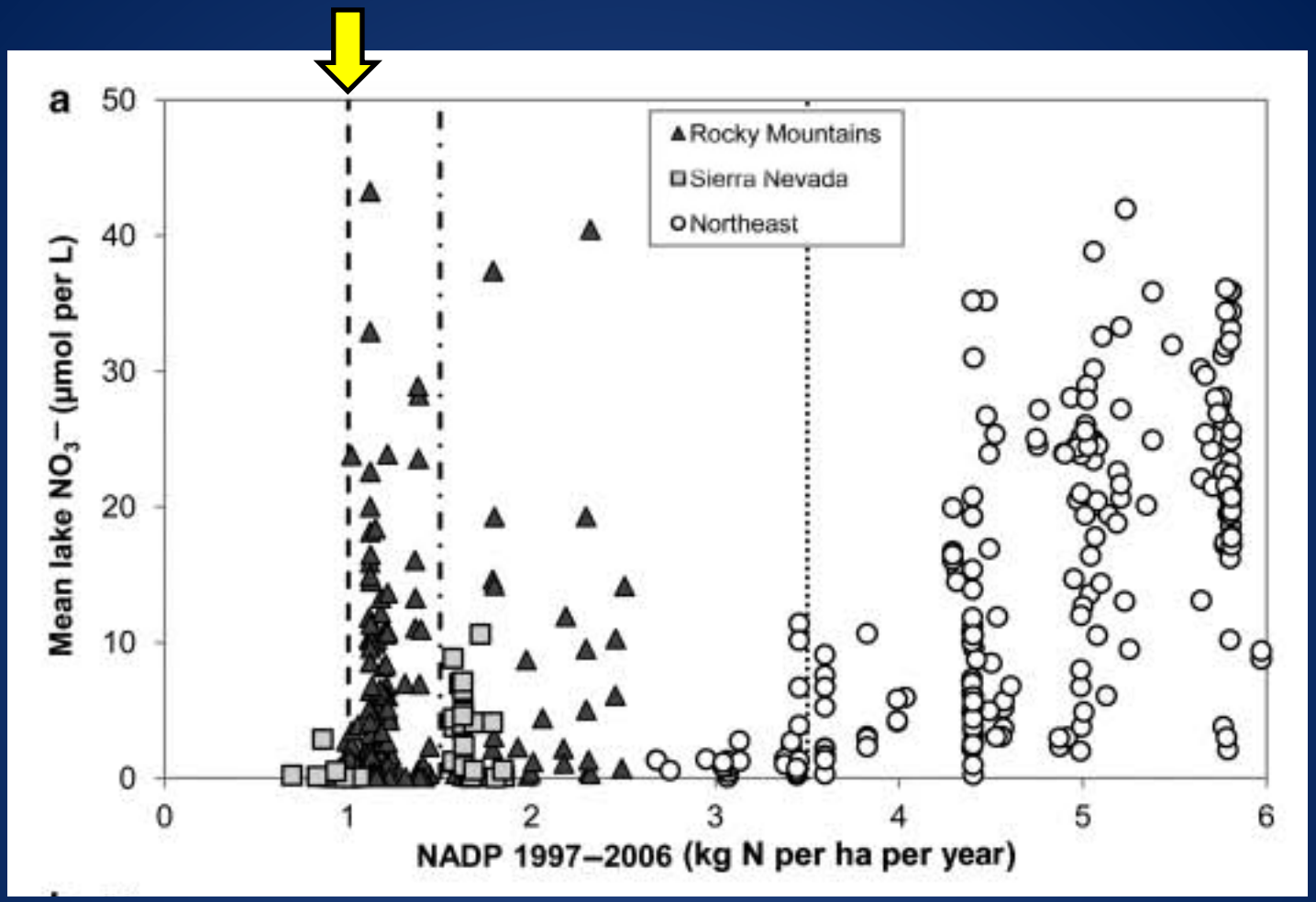


Estimated natural condition (0.2 kg N/ha-yr)

(Morris et al. 2009; data from Baron/NADP)

Rocky Mountains estimated critical load



(Baron et al. 2011 BioScience)

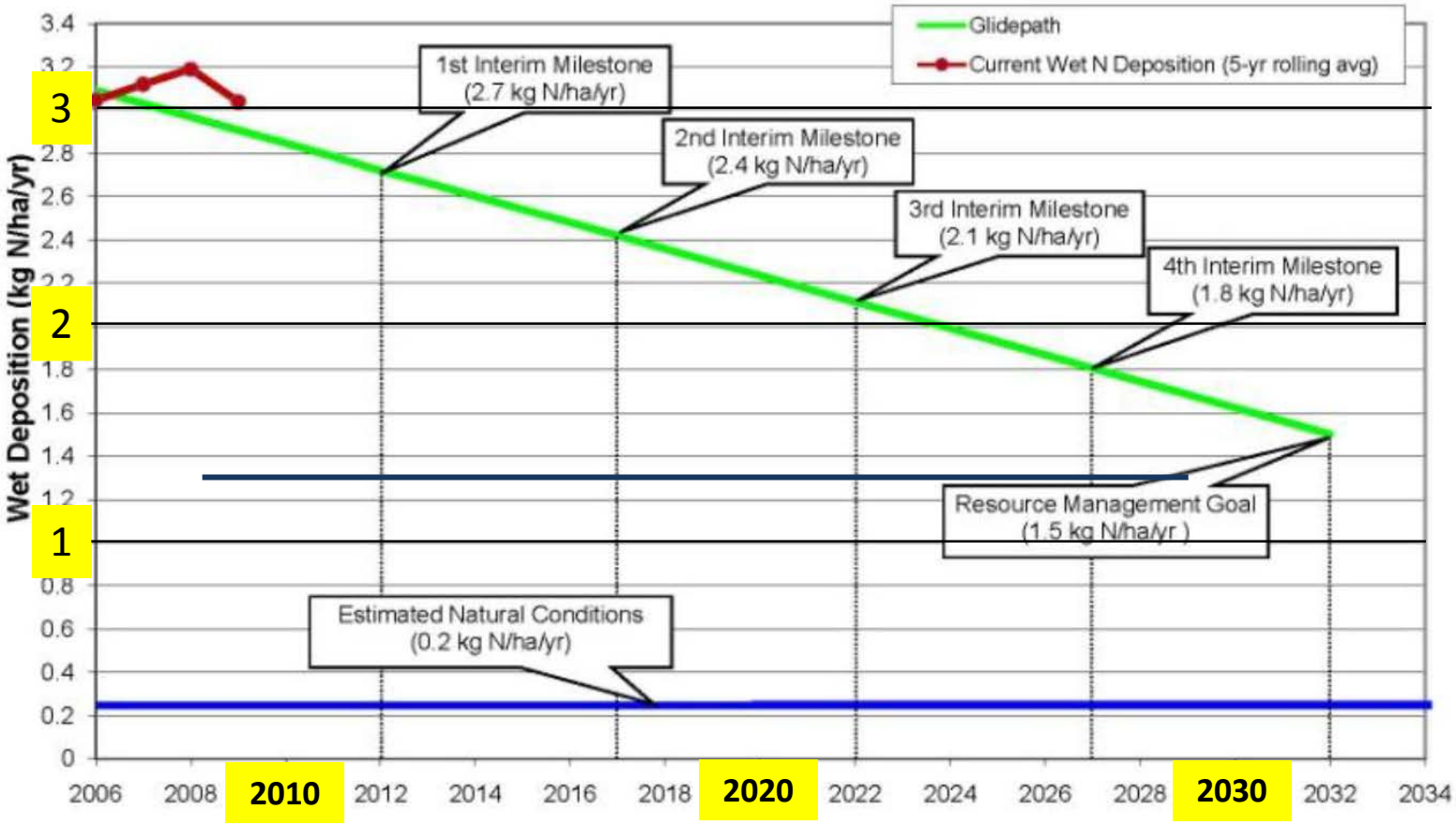
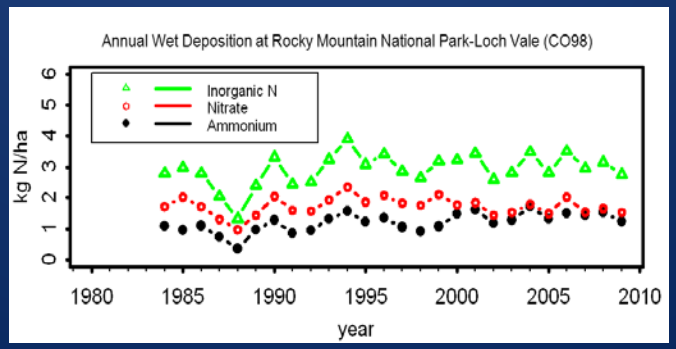


Figure 1. Glidepath and current wet nitrogen deposition at Loch Vale in Rocky Mountain NP.



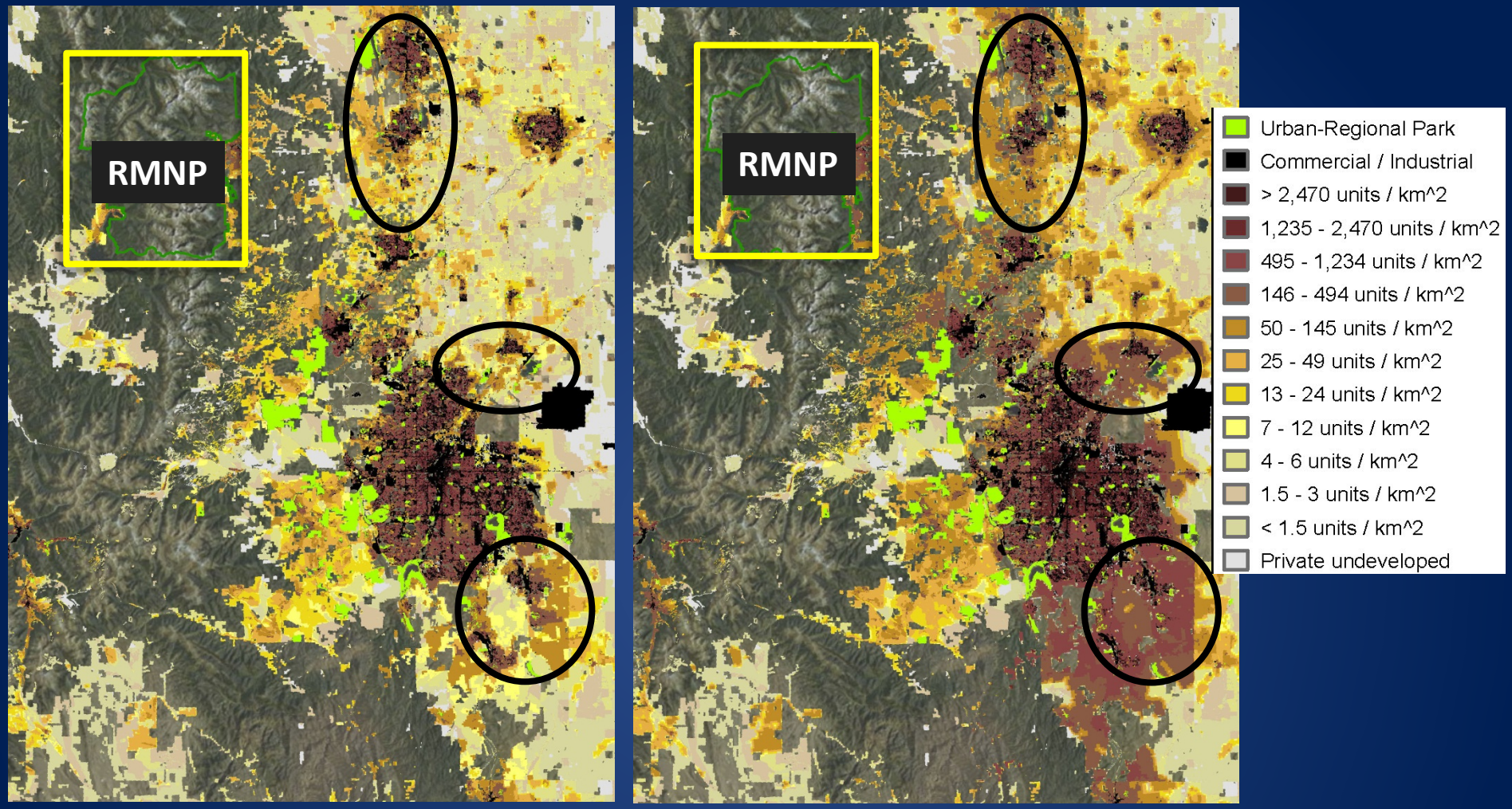
Arapahoe Glacier 1898

Arapahoe Glacier 2004

Boulder Daily Camera

Water transfers from the west to east slope

(*Atlas of the New West* – Riebsame et al. 1997)



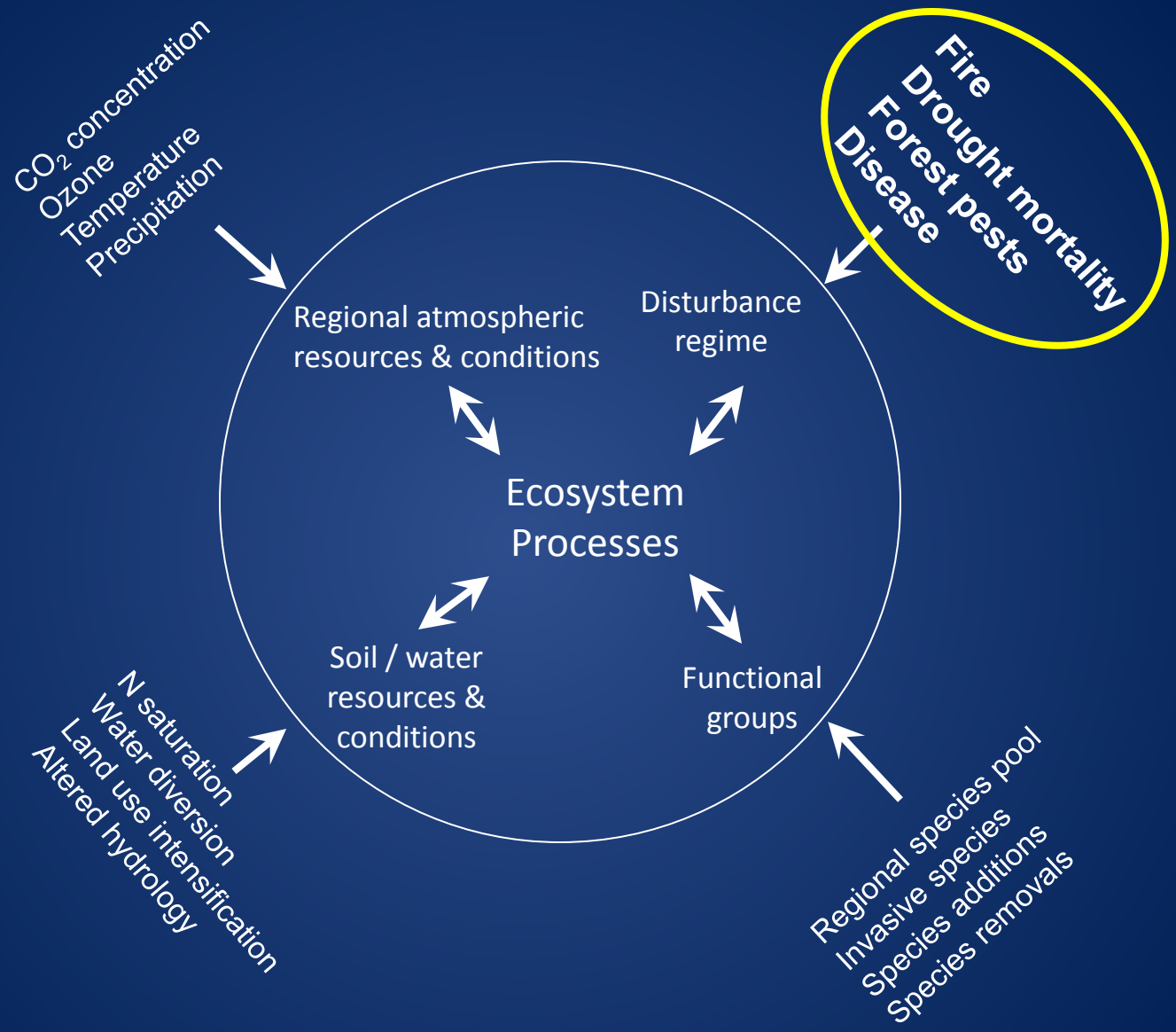
2010 **Housing Density** 2050

Projected increase from 43,000 to 96,000 in 30 km buffer

Images from NPScape. Data: D. Theobald

Land Use Intensification

- Altered material and energy flows
  - Water pollution → Nutrient, chemical, & sediment runoff
  - Altered flow regime → Dams, runoff from less permeable surfaces
- Habitat conversion
  - Isolation
  - Loss
  - Pattern
  - → Residential development, roads, crops, grazing, flooding
- Land development → Direct impacts, edge effects → Activity level and disturbance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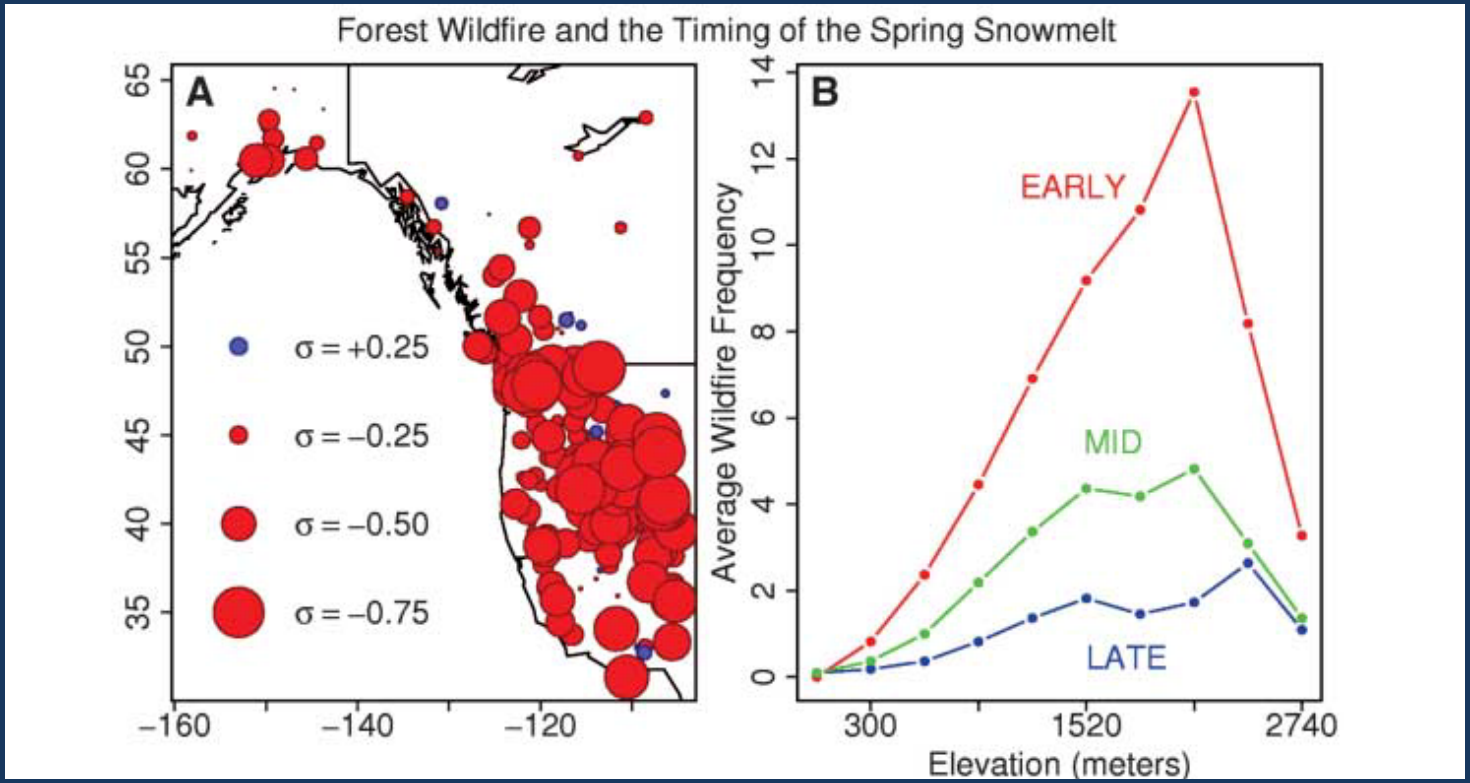
Denver Post photo – June 14, 2012

Cache la Poudre Canyon, June 12 2012



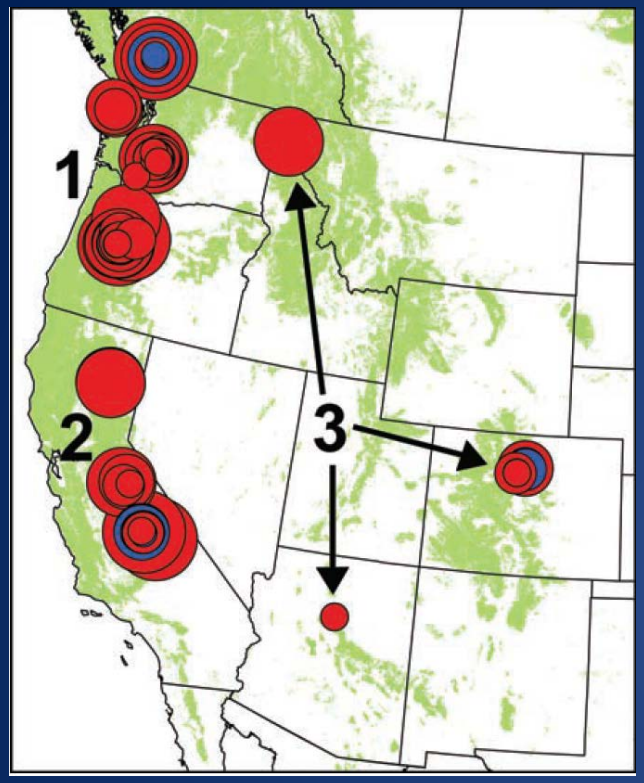
A. Correlation between snowmelt and large fire frequency.
B. Average frequency of wildfire by elevation and snowmelt 1970-2002.
(Westerling et al. 2006)

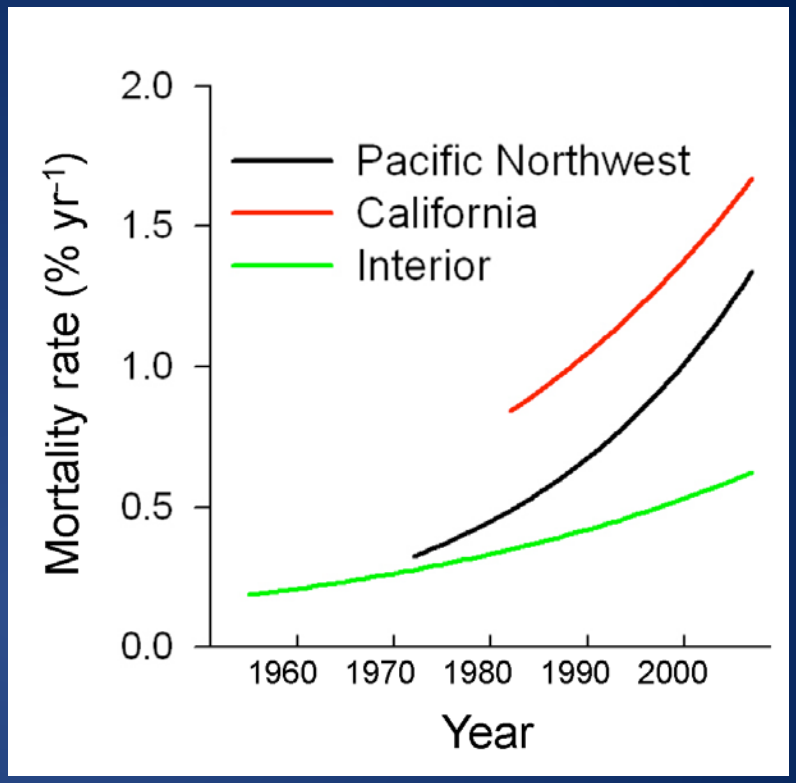
“High fire activity always occurred during warmer-than average years, and this pattern was clear within the GYE (Fig. S4). The relationship between temperature and fire was nonlinear, and only ~0.5 °C above the 1961–1990 average spring and summer temperature (March–August) distinguished large-fire years from most other years in the GYE.”

“All models predicted substantial increases in fire by midcentury, with fire rotation (the time to burn an area equal to the landscape area) reduced to <30 y from the historical 100–300 y for most of the GYE.”

(Westerling et al. 2011 – projections for Yellowstone)

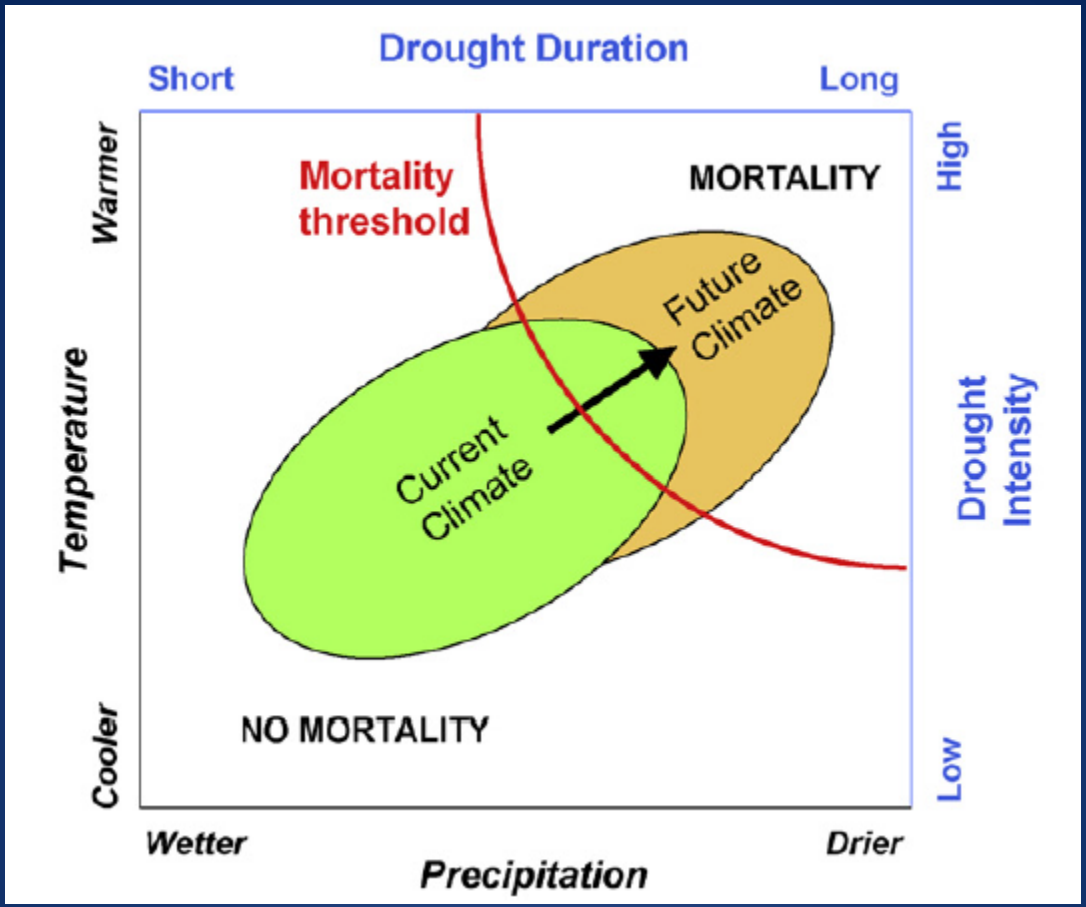
Warmer, drier conditions are associated with increasing tree mortality





Observed recent tree mortality.
Largest red circles > 0.1 yr^{-1}. 87% of sites had increased mortality rates.

van Mantgem et al. 2009 *Science*



(Allen et al. 2010)

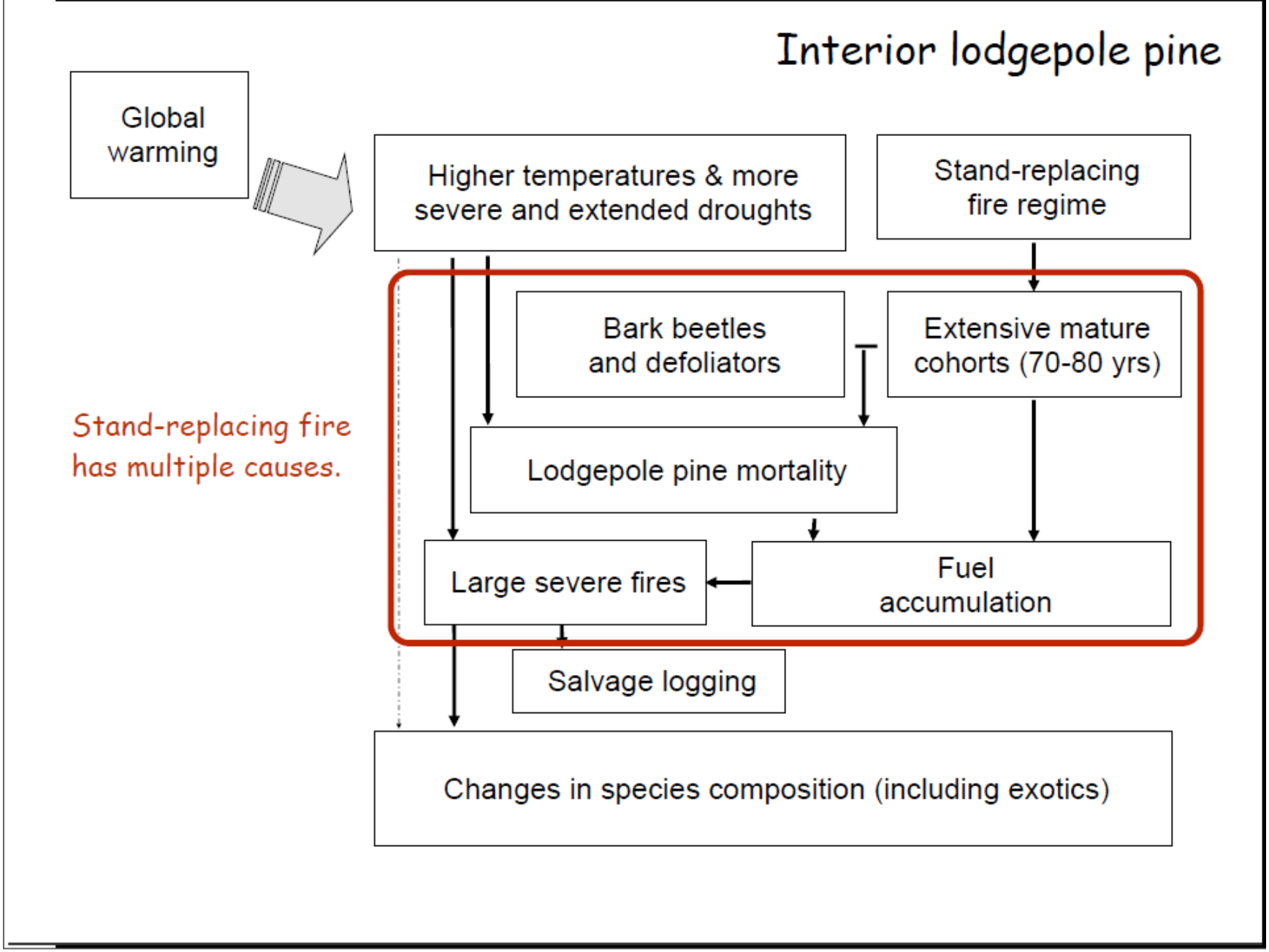
Climate Change and Bark Beetles of the Western United States and Canada: Direct and Indirect Effects

BARBARA J. BENTZ, JACQUES RÉGNIÈRE, CHRISTOPHER J. FETTIG, E. MATTHEW HANSEN, JANE L. HAYES, JEFFREY

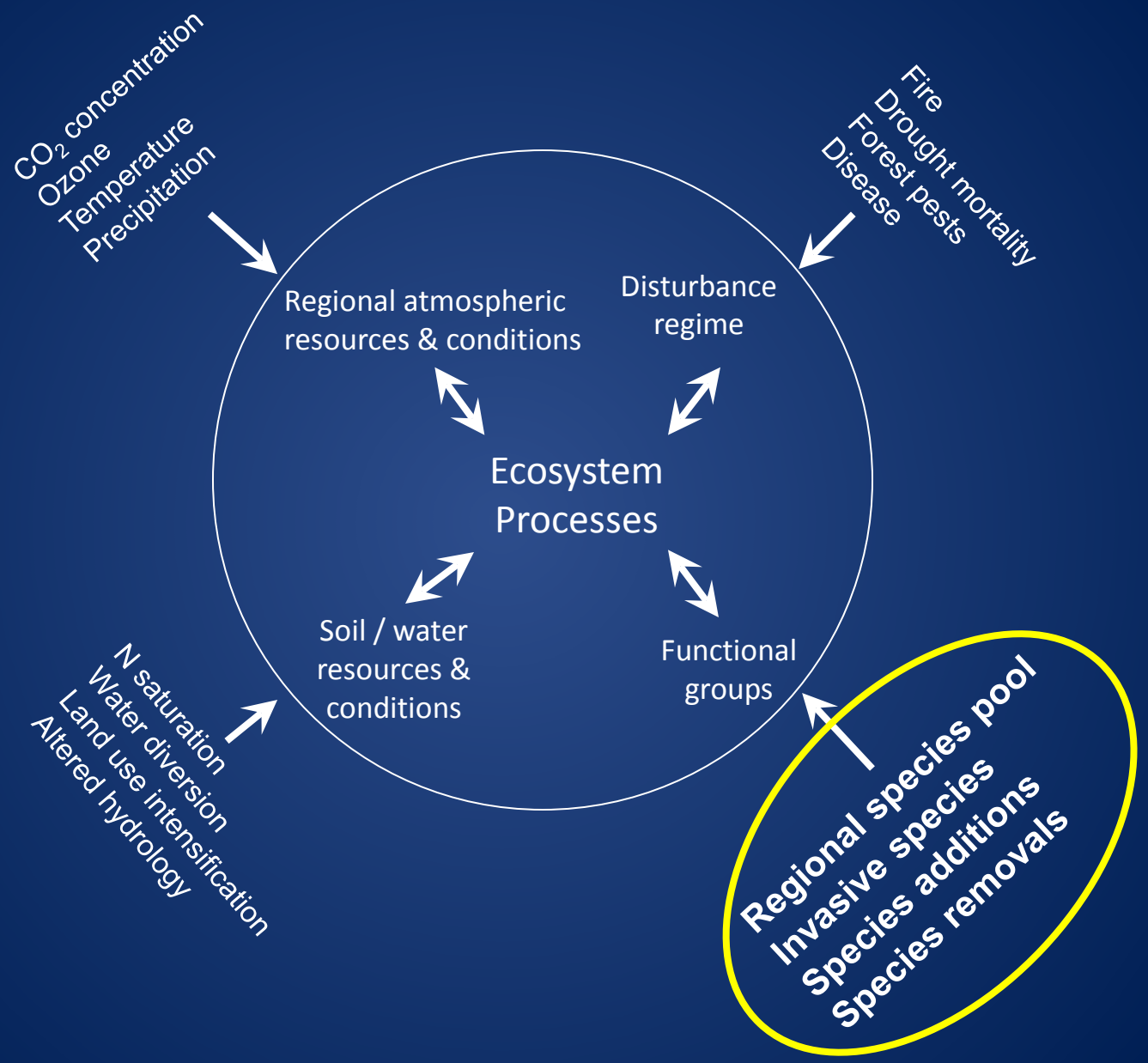
Table 1. Bark beetle species that have the capacity to cause landscape-scale tree mortality in the western United States and Canada.

Common name	Scientific name	Major host species
Arizona fivespined ips	*Ips lecontei*	*Pinus ponderosa*, and others
California fivespined ips	*Ips paraconfusus*	*Pinus attenuata, Pinus contorta, Pinus coulteri, Pinus jeffreyi, Pinus lambertiana, P. ponderosa, Pinus radiata, Pinus torreyana*, and others
Douglas-fir beetle	*Dendroctonus pseudotsugae*	*Pseudotsuga menziesii*
Eastern larch beetle	*Dendroctonus simplex*	*Larix laricina*
Fir engraver	*Scolytus ventralis*	*Abies concolor, Abies grandis, Abies magnifica*
Jeffrey pine beetle	*Dendroctonus jeffreyi*	*P. jeffreyi*
Mountain pine beetle	*Dendroctonus ponderosae*	*Pinus albicaulis, Pinus aristata, Pinus balfouriana, P. contorta, Pinus flexilis, P. lambertiana, Pinus monticola, P. ponderosa*, and others
Northern spruce engraver	*Ips perturbatus*	*Picea engelmannii, Picea glauca, Picea × lutzii, Picea mariana, Picea sitchensis*
Pine engraver	*Ips pini*	*P. contorta, P. jeffreyi, P. ponderosa, and others*
Piñon ips	*Ips confusus*	*Pinus edulis, Pinus monophylla*
Roundheaded pine beetle	*Dendroctonus adjunctus*	*Pinus arizonica, Pinus engelmannii, P. flexilis, Pinus leiophylla, P. ponderosa, Pinus strobiformis*
Southern pine beetle	*Dendroctonus frontalis*	*Pinus engelmannii, P. leiophylla, P. ponderosa*
Spruce beetle	*Dendroctonus rufipennis*	*Picea engelmannii, Pi. glauca, Pi. sitchensis*
Western balsam bark beetle	*Dryocoetes confusus*	*Abies lasiocarpa*, and others
Western pine beetle	*Dendroctonus brevicomis*	*P. coulteri, P. ponderosa*

(Bentz et al. 2010 – BioScience)



(Jill Baron 2010)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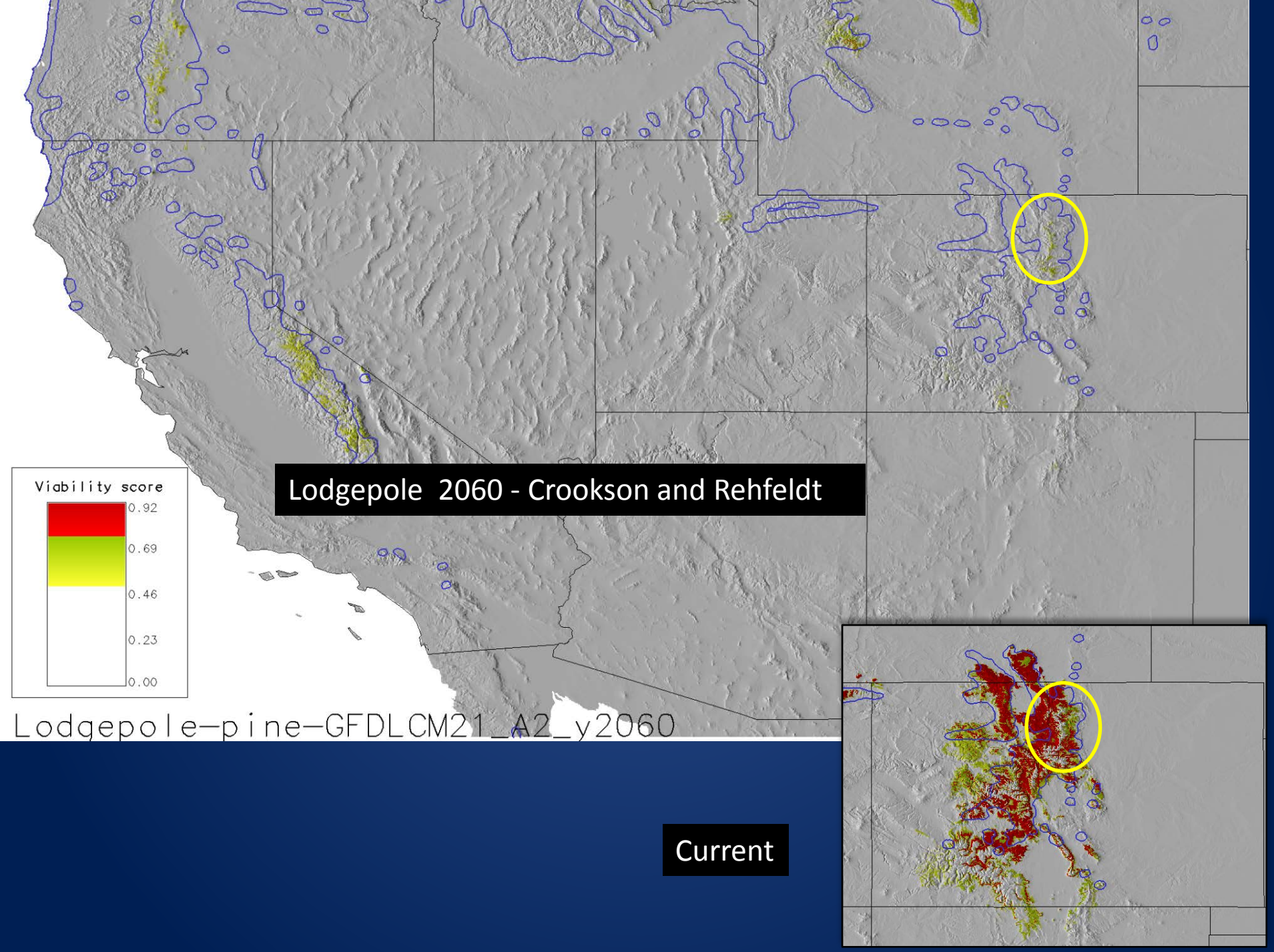
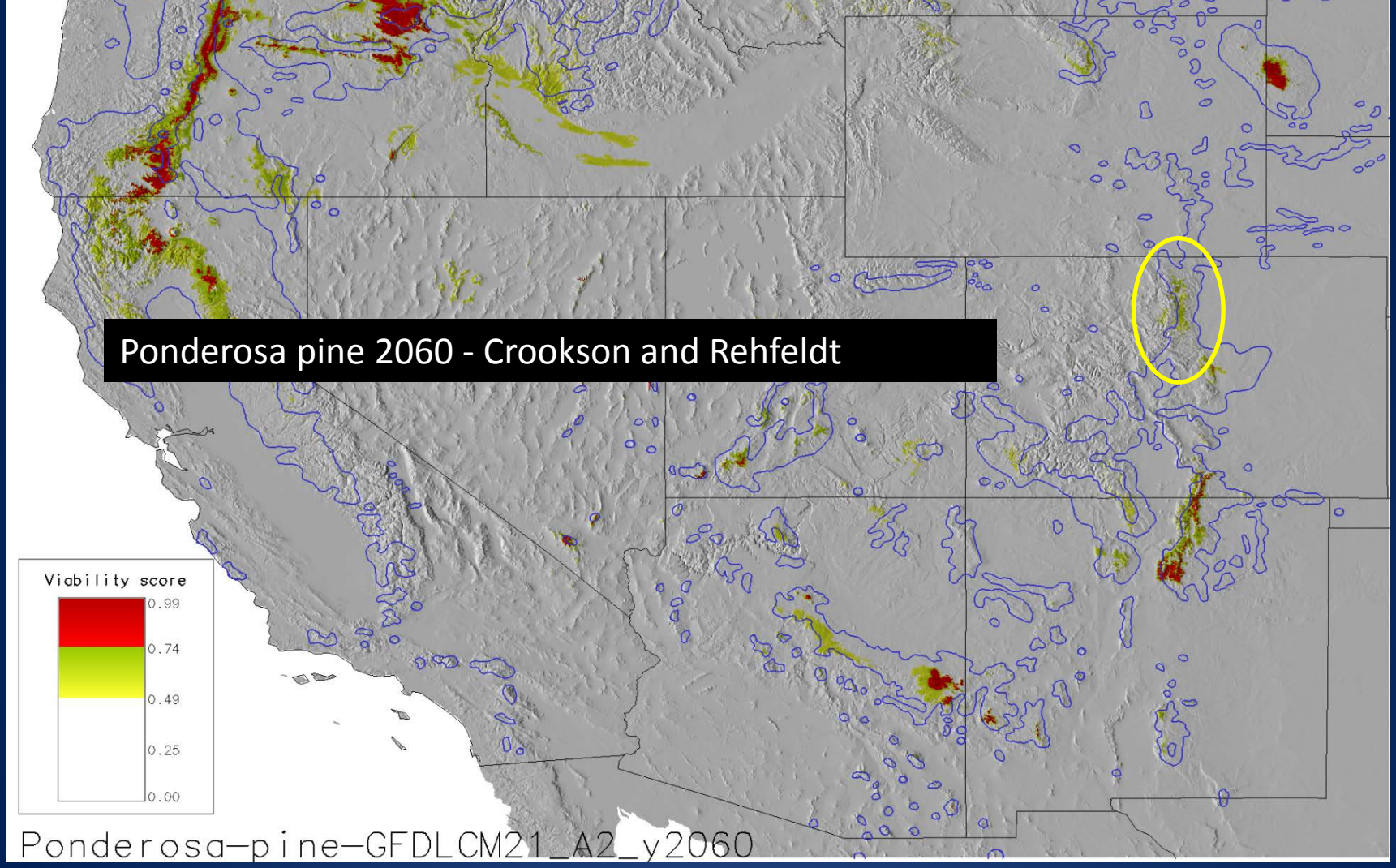
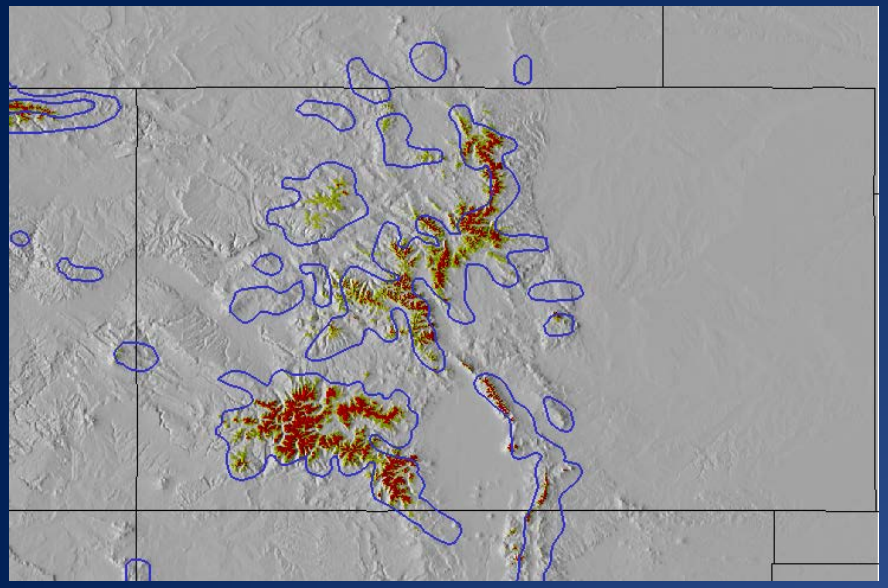
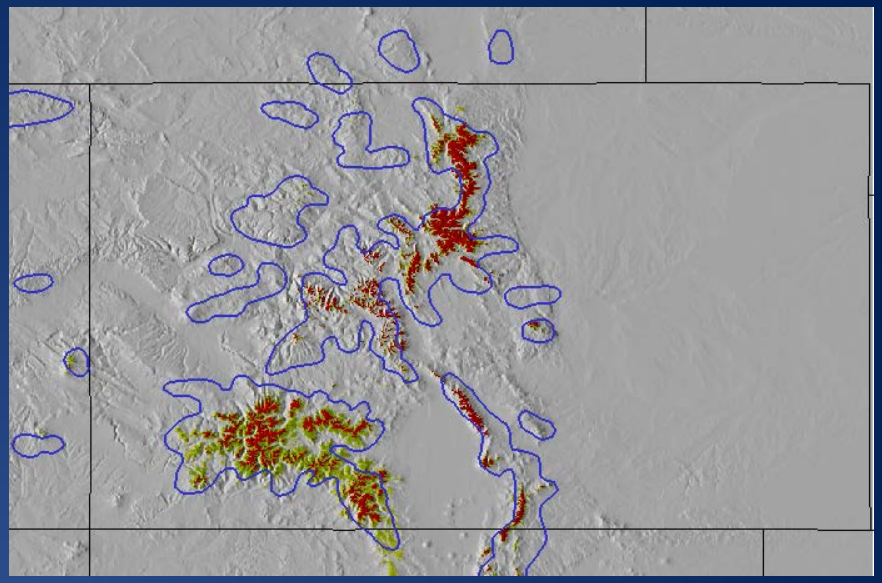

Lodgepole 2060 - Crookson and Rehfeldt
Viability score
0.92
0.69
0.46
0.23
0.00
Lodgepole-pine-GFDLCM21_A2_y2060
Current


Ponderosa pine 2060 - Crookson and Rehfeldt
Viability score
0.99
0.74
0.49
0.25
0.00
Ponderosa-pine-GFDLCM21_A2_y2060

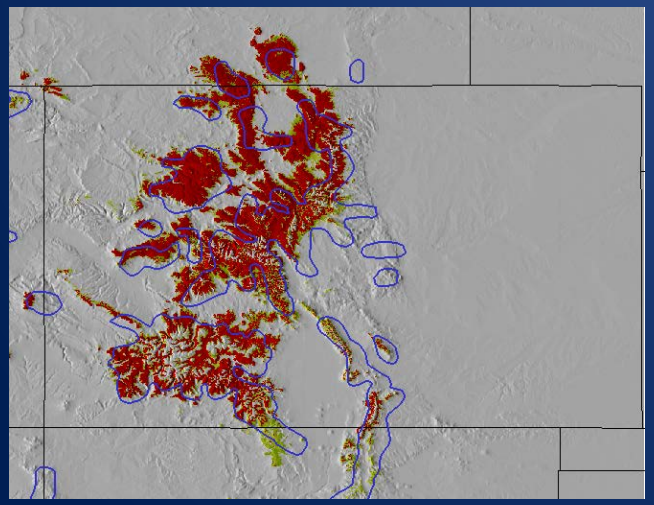


Subalpine fir - 2060

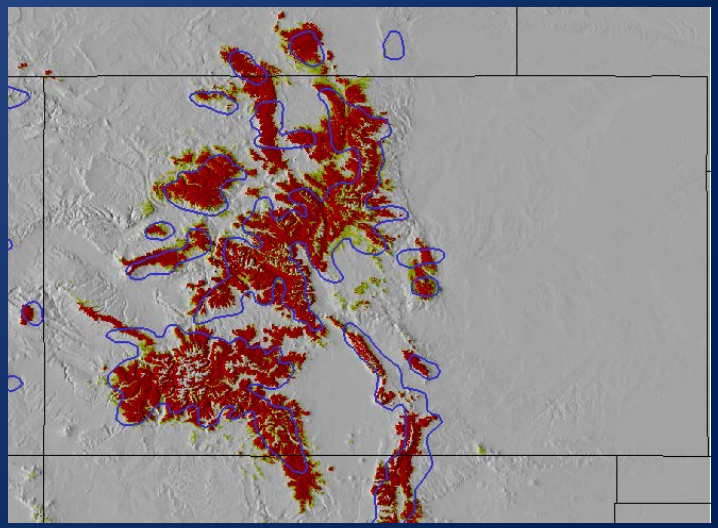


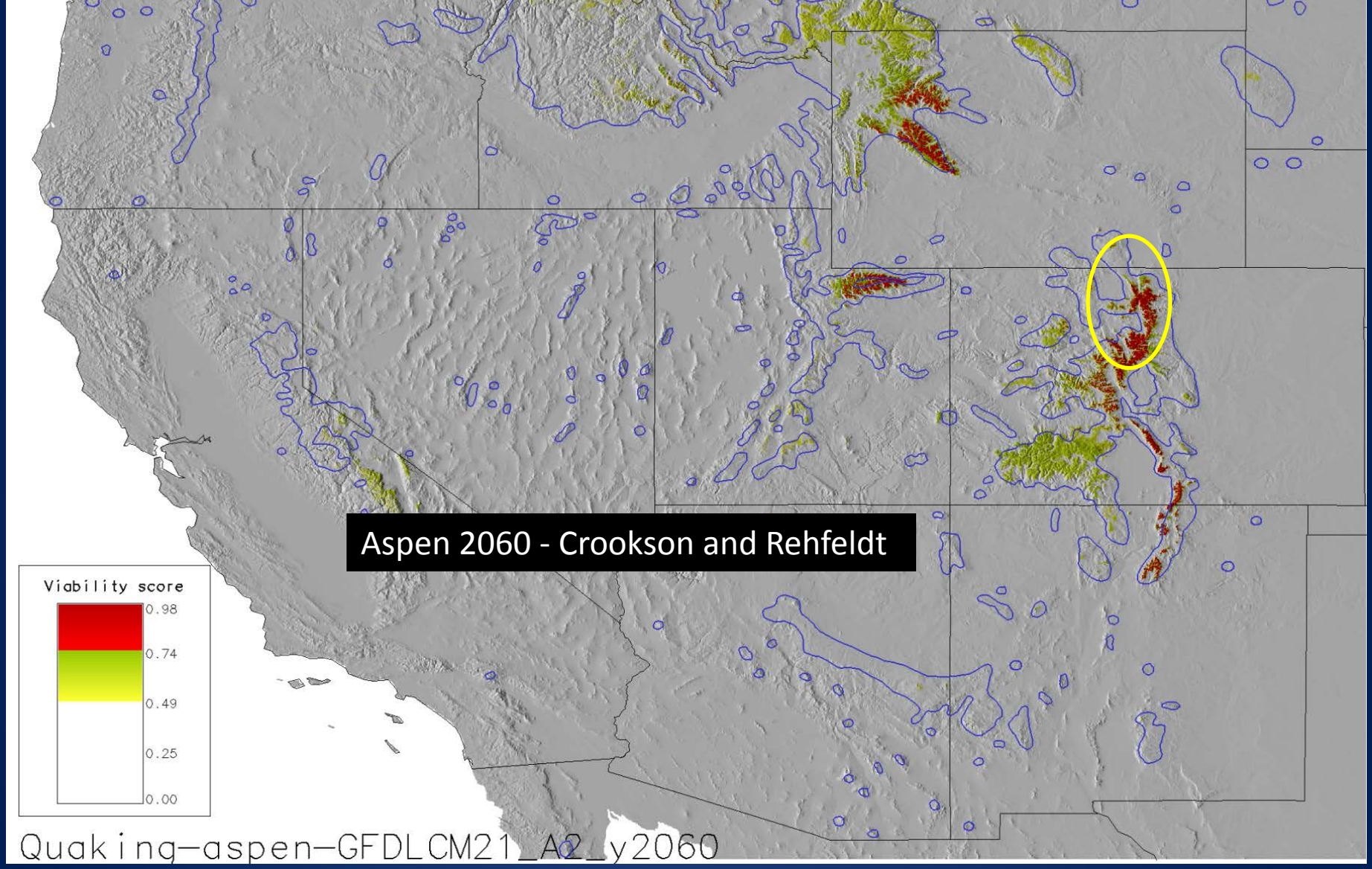
Engelmann spruce - 2060

Current

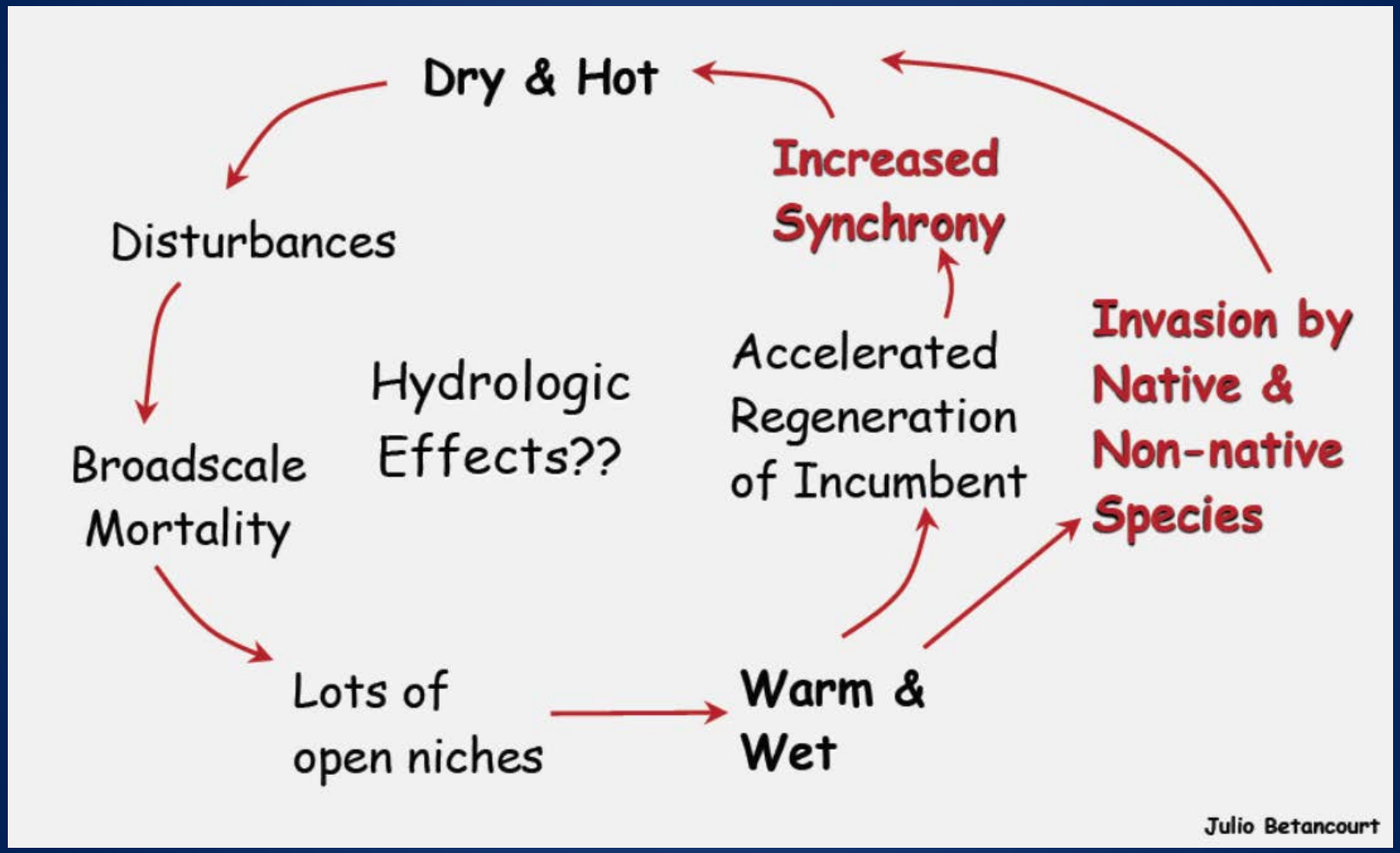


Current




Aspen 2060 - Crookson and Rehfeldt
Viability score
0.98
0.74
0.49
0.25
0.00
Quaking-aspen-GFDLCM21_A2_y2060

Feedbacks between climate, disturbance, and succession (& species replacements) may produce broad-scale ecological synchrony. How will we prepare for and manage the products of succession?



We're already seeing big changes:

- land use intensification
- high rates of N deposition
- earlier snow melt and altered hydrology
- large forest pest outbreaks
- increased fire frequency and size

Where are thresholds and key vulnerabilities?

- soil moisture and drought
- shifting climate envelopes
- fire regimes – for species and people
- water quantity and quality

What institutional capabilities are necessary to cope with anticipated and ***unanticipated*** futures?

What management actions are robust to high rates of change and high uncertainty?