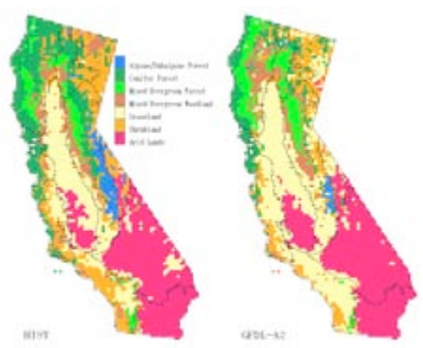

Climate change, fire, and forests

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Pacific Northwest Research Station

Forest Health Monitoring Workgroup 13 February, 2008

Hypotheses about ecosystem change in the West

- Increasing moisture limits on productivity will alter (tree and other) species composition by
  - locally favoring more xeric species.
  - exacerbating episodes of vegetation dieback.
  - altering mortality and turnover rates.
  - Underlying ecological mechanism = large-scale shift to a negative water balance.
- **Disturbance will be the principal agent of ecosystem change**
  - late 20th-century trends such as increasing insect mortality or fire area burned may be replaced by more abrupt changes.
  - underlying mechanisms here are complex, operate at multiple scales, and may be constrained by physical limits.

Western Mountain Initiative (WMI) 2006

Fire

Climate

Vegetation

Disturbance synergy

Disturbance drives ecosystem changes

Climatic change

25-100 yr

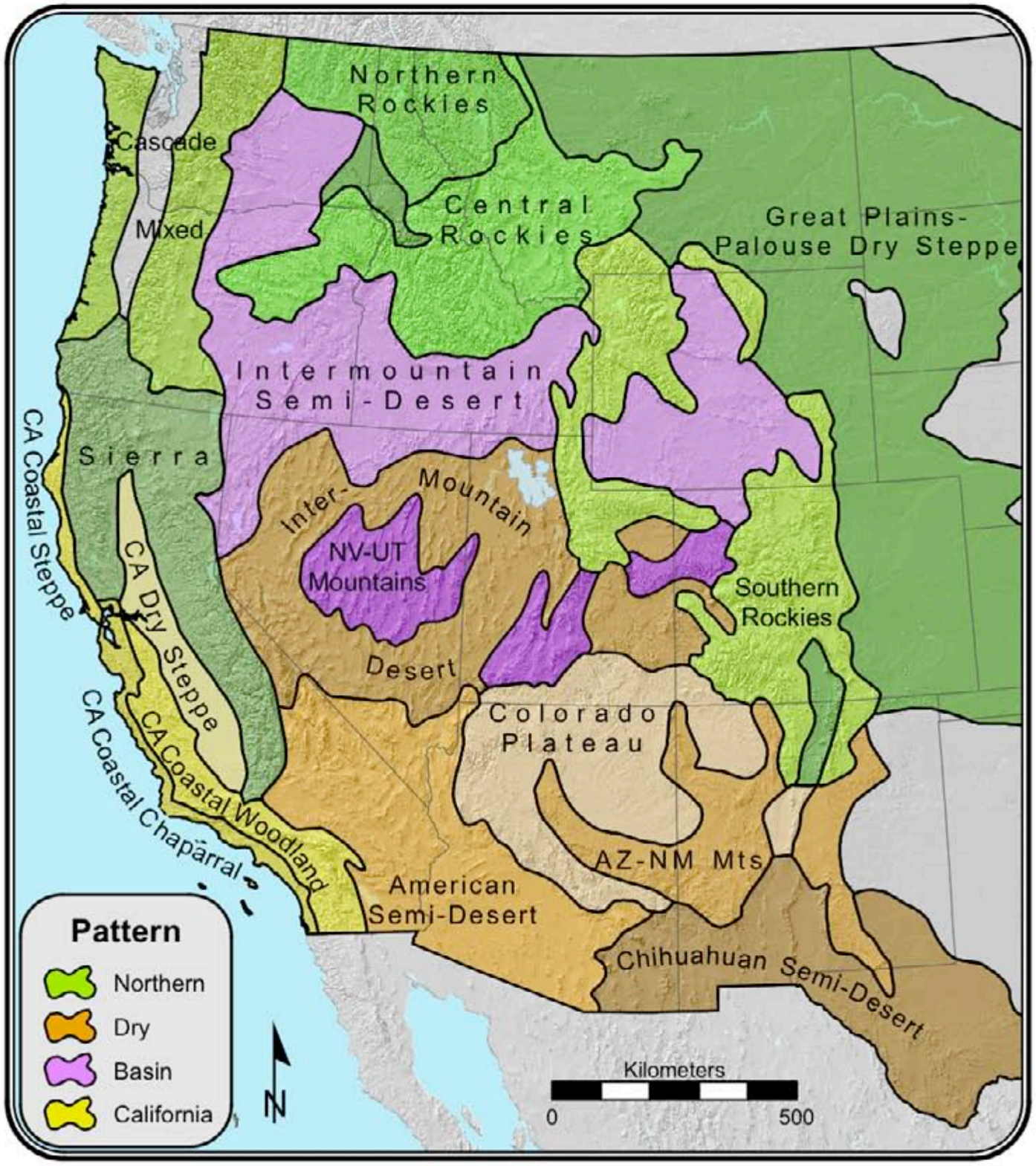
100-500 yr

New fire regimes
More frequent fire
More extreme events
Greater area burned

Habitat changes
Broad-scale homogeneity
Truncated succession
Loss of forest cover
Loss of refugia
Fire-adapted species

Species responses
Fire-sensitive species ↓
Annuals & weedy species ↑
Specialists with restricted ranges ↓
Deciduous and sprouting species ↑

Climate and fire area burned, 1977-2003: an ecologically based study in the American West

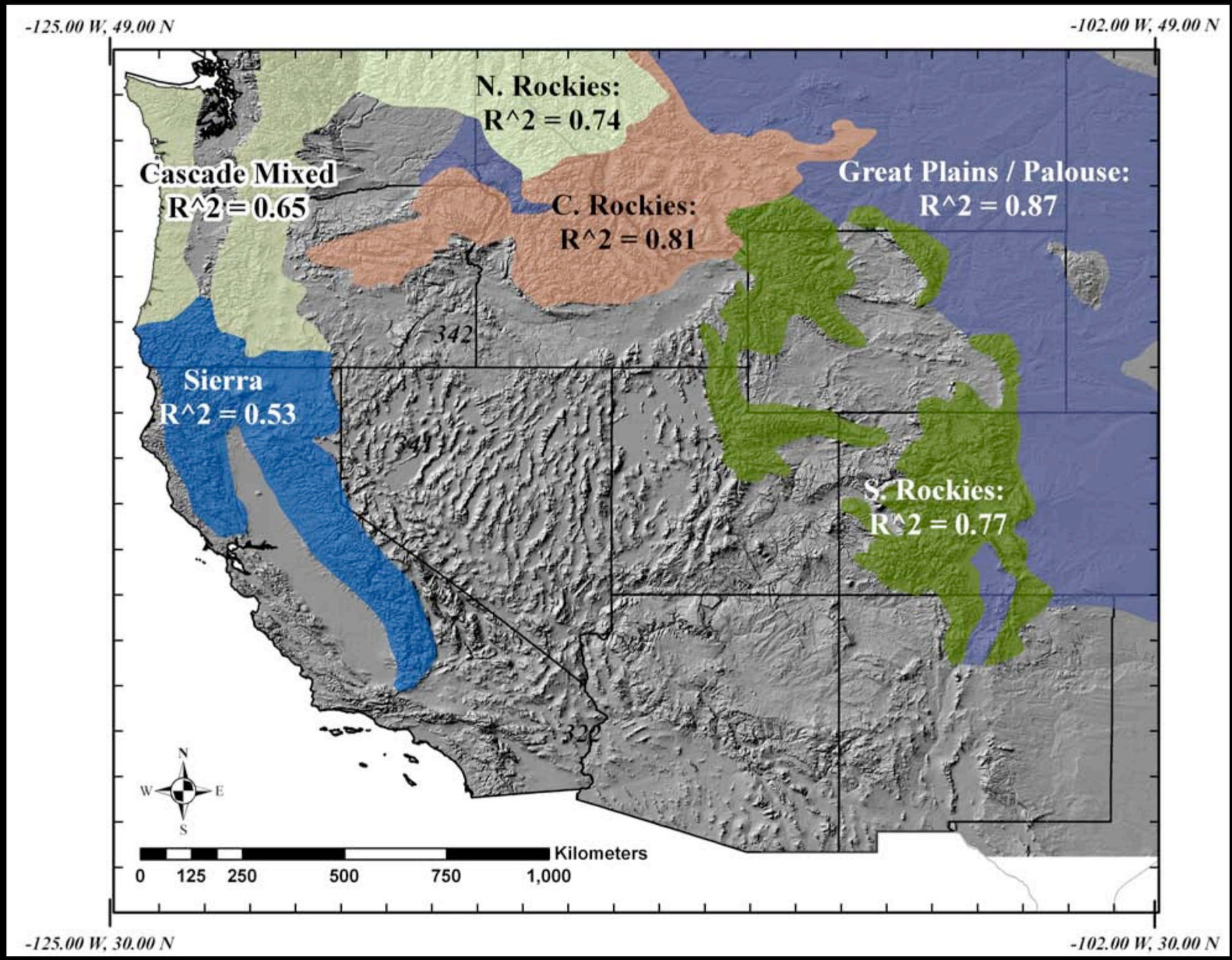


- Generalized linear models to scale area-burned statistics to ecoprovinces.
- Predictive models of fire area burned based on climatology.
- Potential for ecologically meaningful future projections.

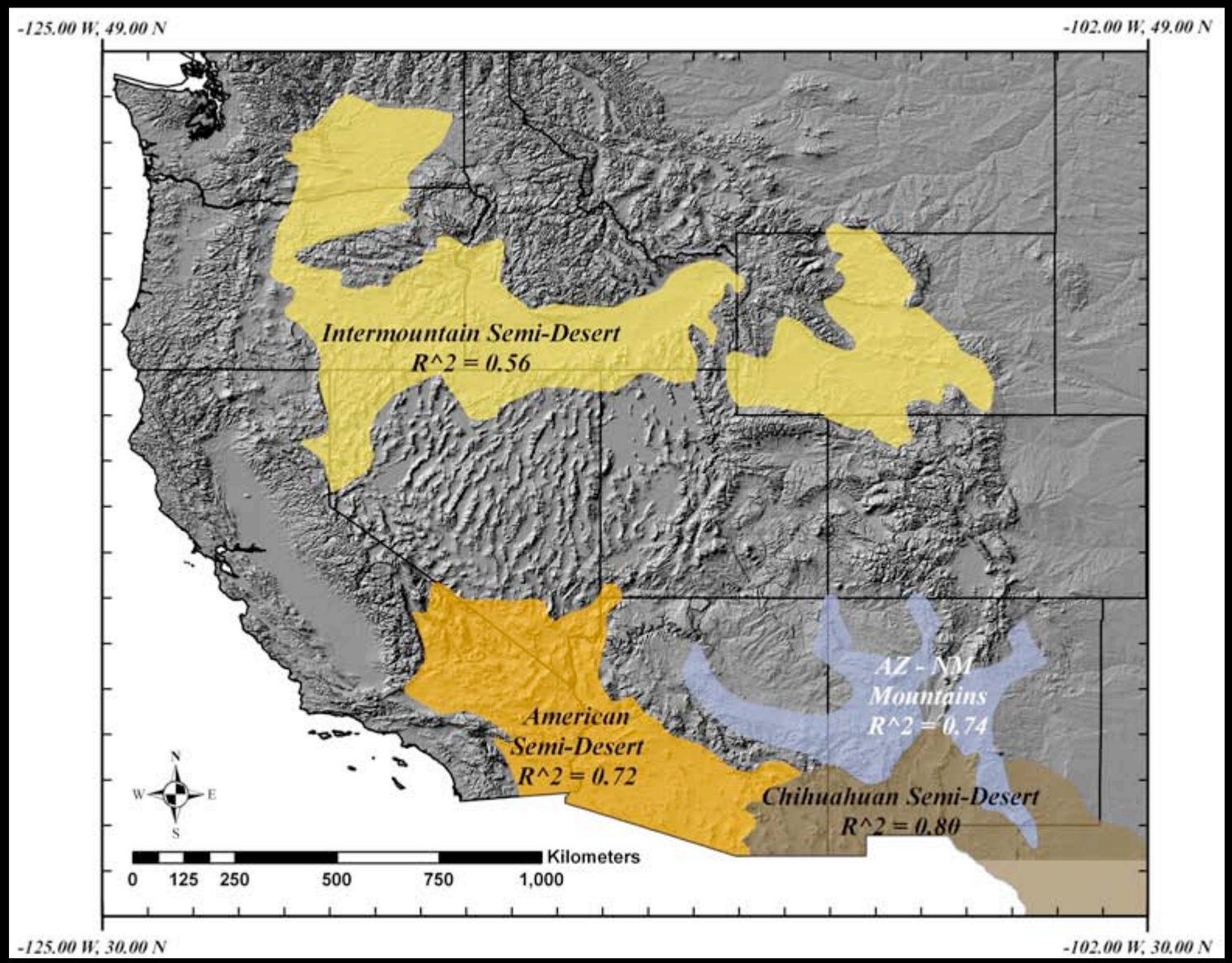
Littell et al. (2008)

Northern mountain pattern

Current climate variables are the key predictors.



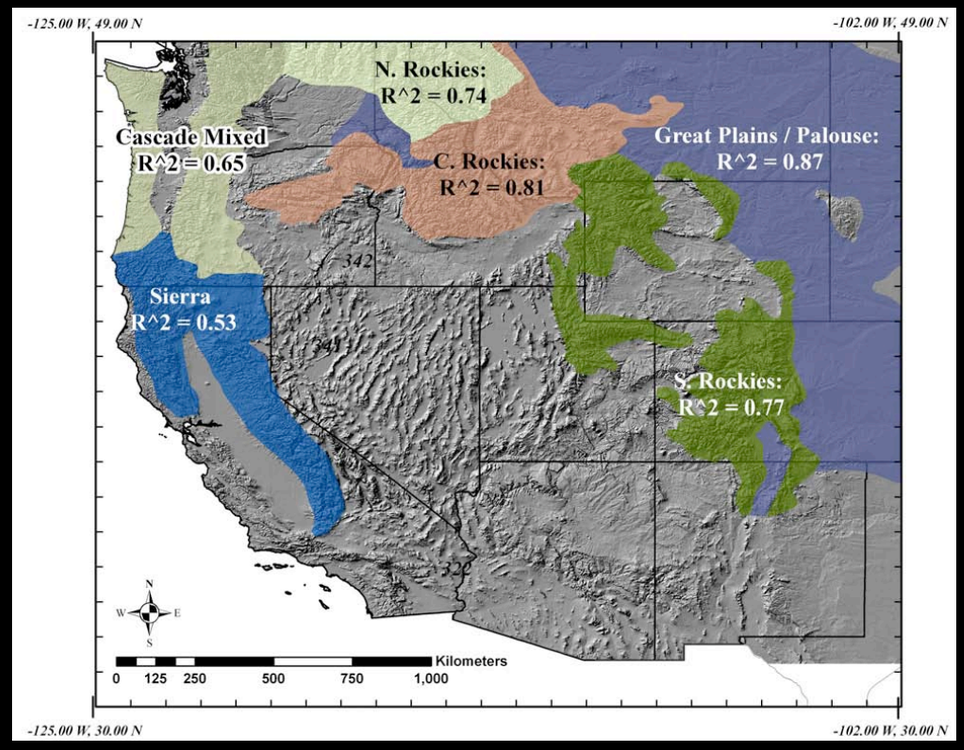
Arid ecosystem (Southwest) pattern



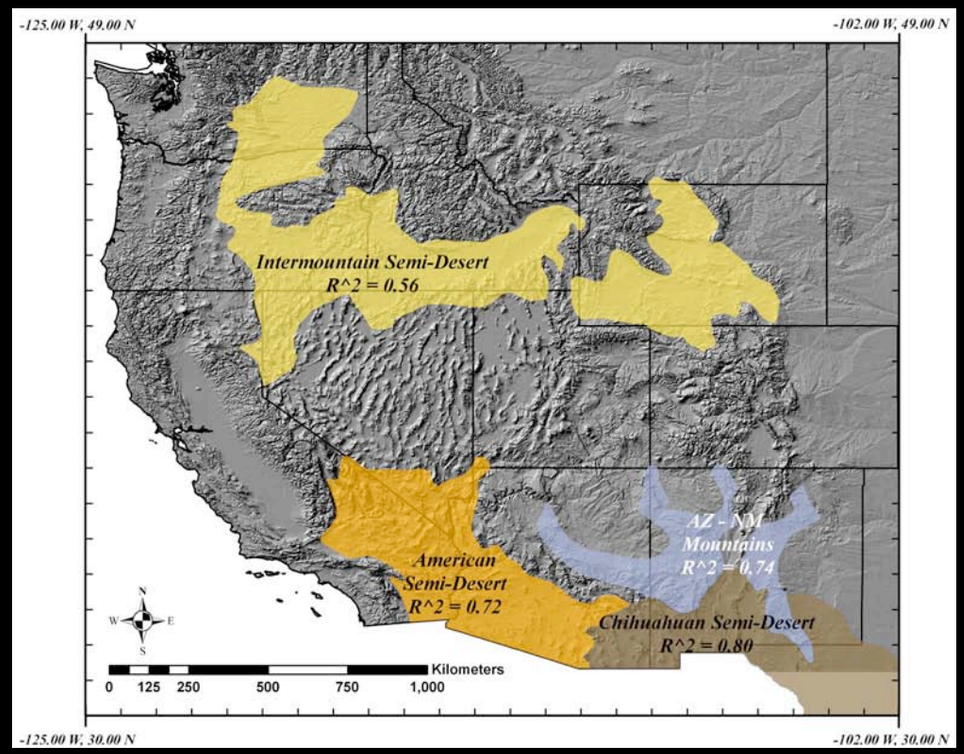
- Previous winter's precipitation is a key predictor.
- Current climate is less important.

Climate, vegetation, and fuels

Fuel **moisture** associated with current climate is the limiting factor.



Fuel **abundance** and **continuity** associated with previous climate is the limiting factor.

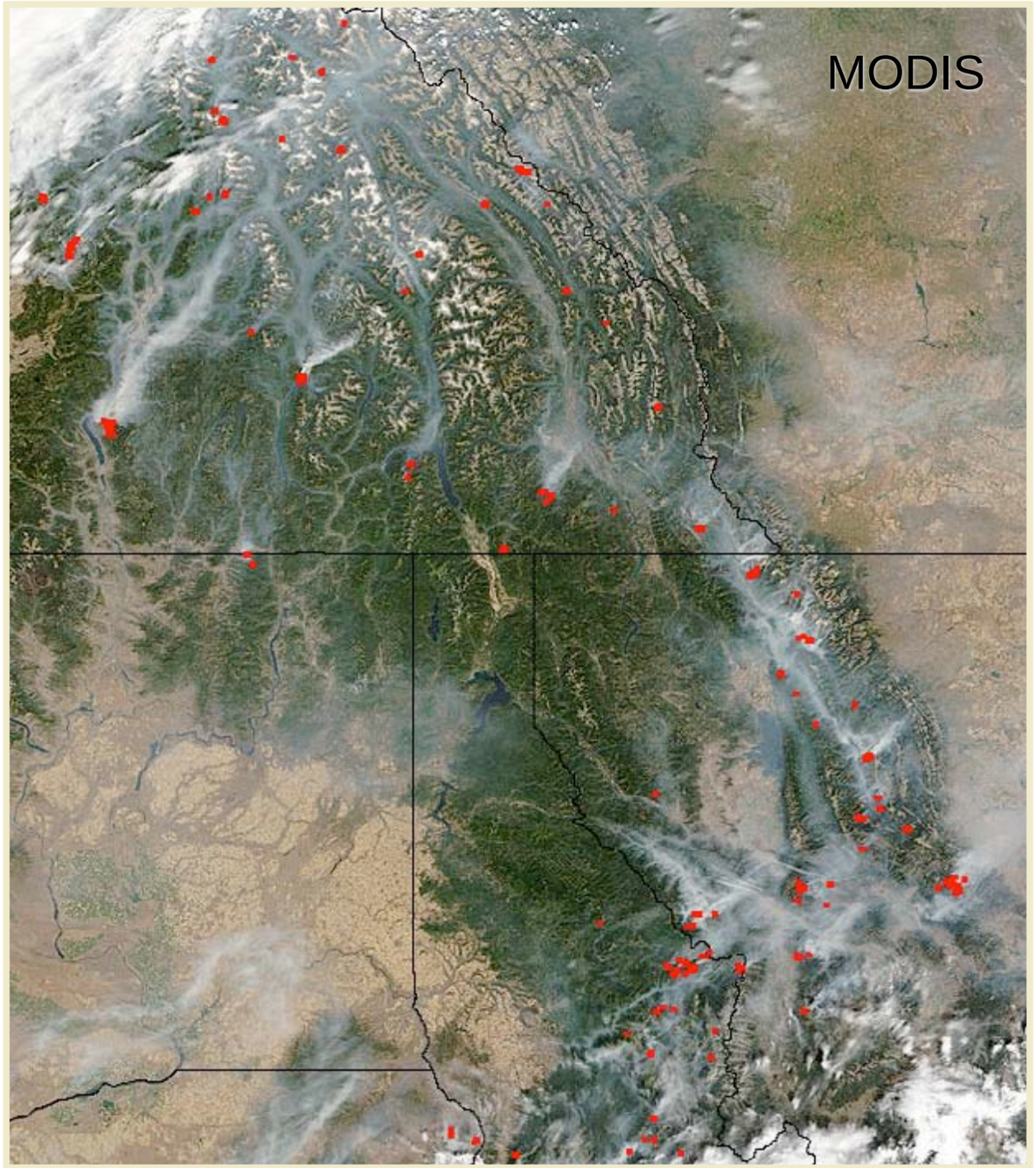


Northern mountain provinces, regional fire episodes, and climatic change

- As temperature increases, the atmosphere evaporates more water from the landscape and plant tissues.

- This produces larger than normal areas of depleted fuel moisture during the fire season.

- Regional synchronization of fires occurs.



Northern Rockies, July 2003

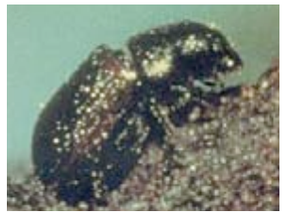
Arid Southwestern provinces, regional fire synchrony, and climatic change

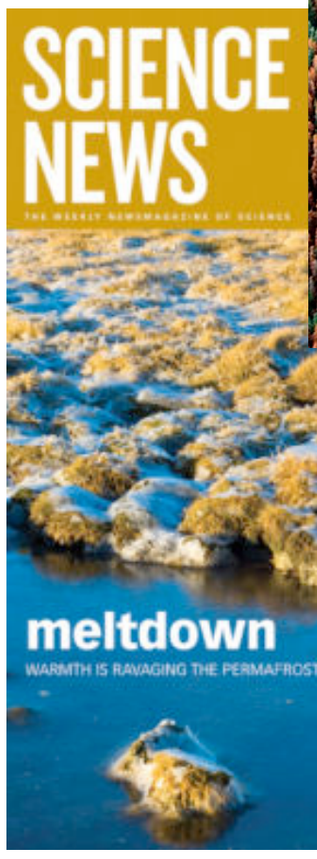
- Increasingly severe and prolonged droughts are expected.

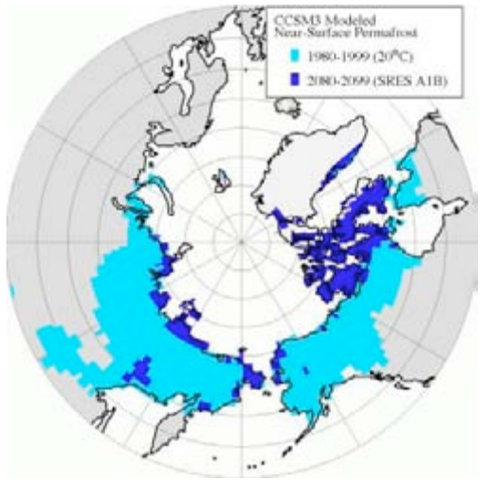
- But interannual cycles, e.g., ENSO, can maintain the pattern of fuel continuity.

- Invasives like cheatgrass and buffelgrass could change everything.

Stress complexes: synergistic effects on ecosystems





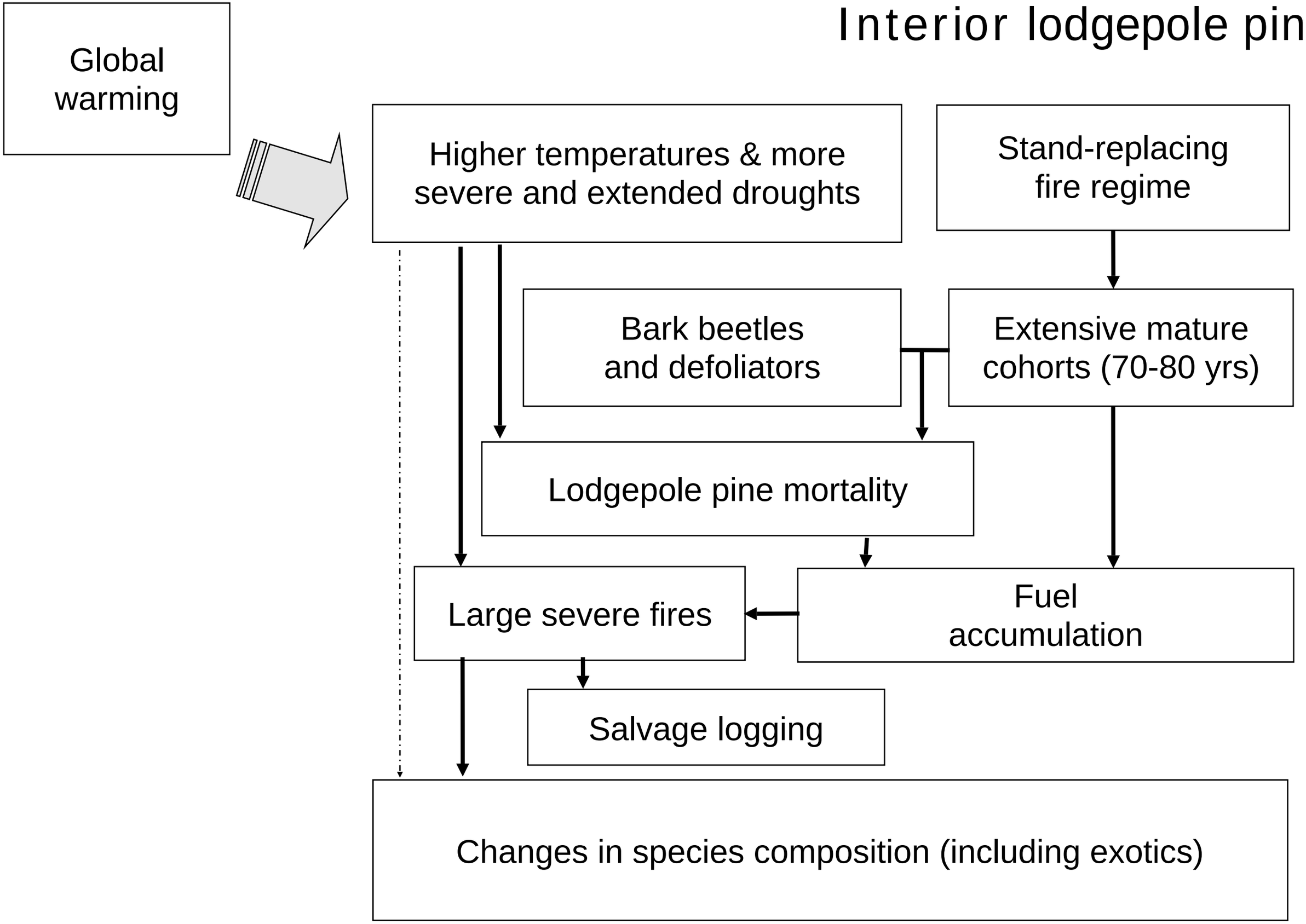


McKenzie, D., D.L. Peterson, & J.S. Littell. *In press*. Global warming and stress complexes in forests of western North America. In "*Forest Fires and Air Pollution Issues*", eds. A. Bytnerowicz, M. Arbaugh, C. Andersen, & A. Riebau. Elsevier Science, Ltd.

Lodgepole pine

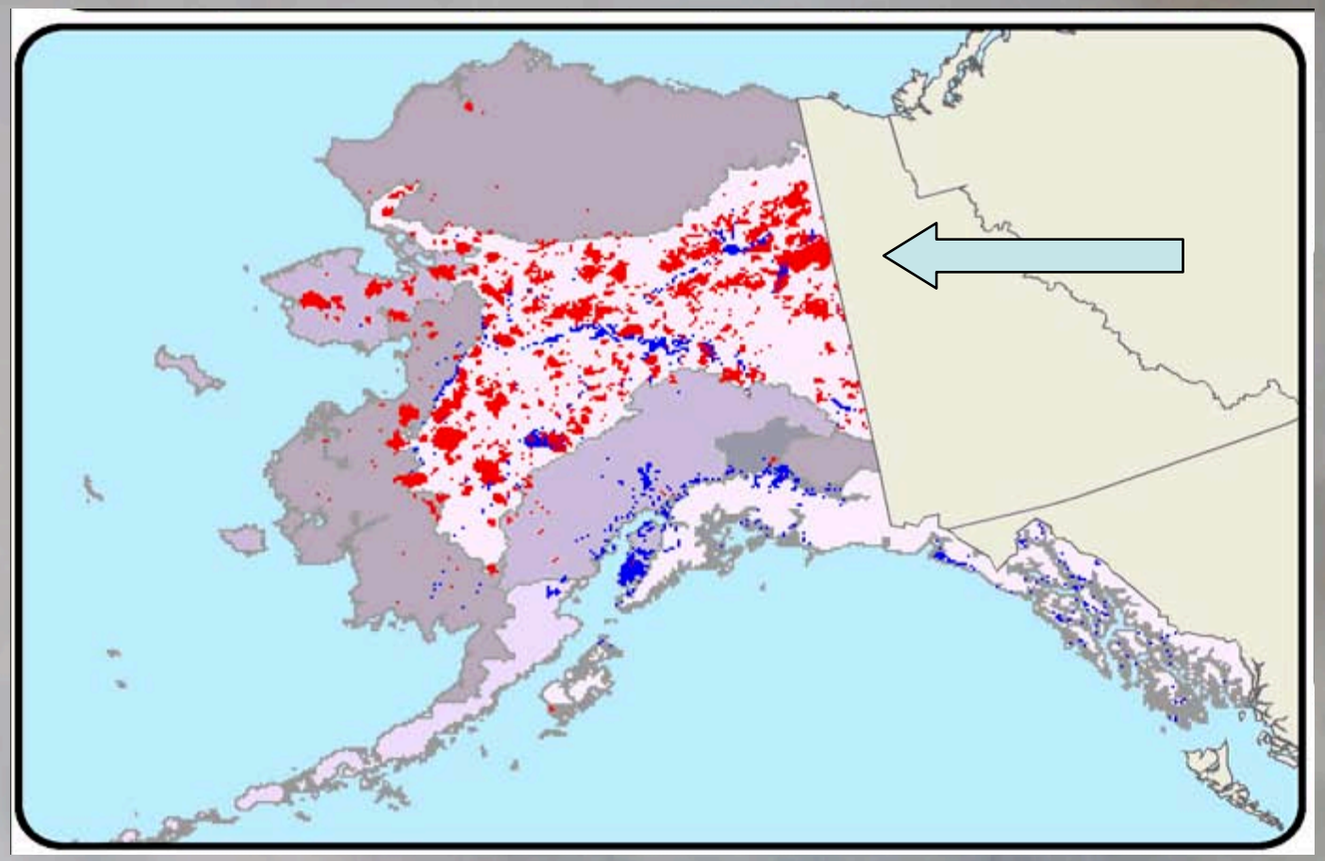
Extended warm period, insects, pines die, fuels accumulate, sets up for large fires. Vulnerable age classes.

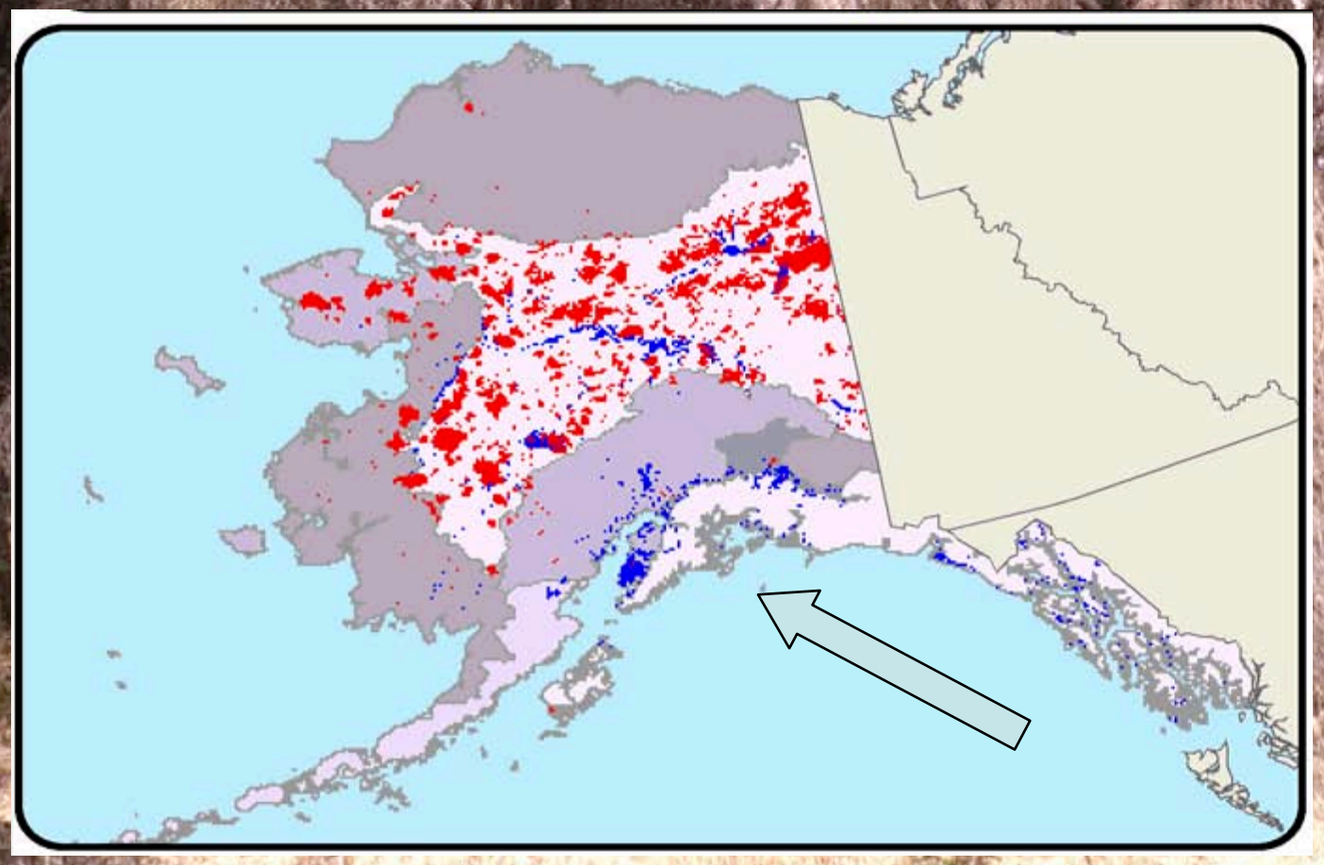
Interior lodgepole pine



Boreal black spruce

Stand-replacing fire





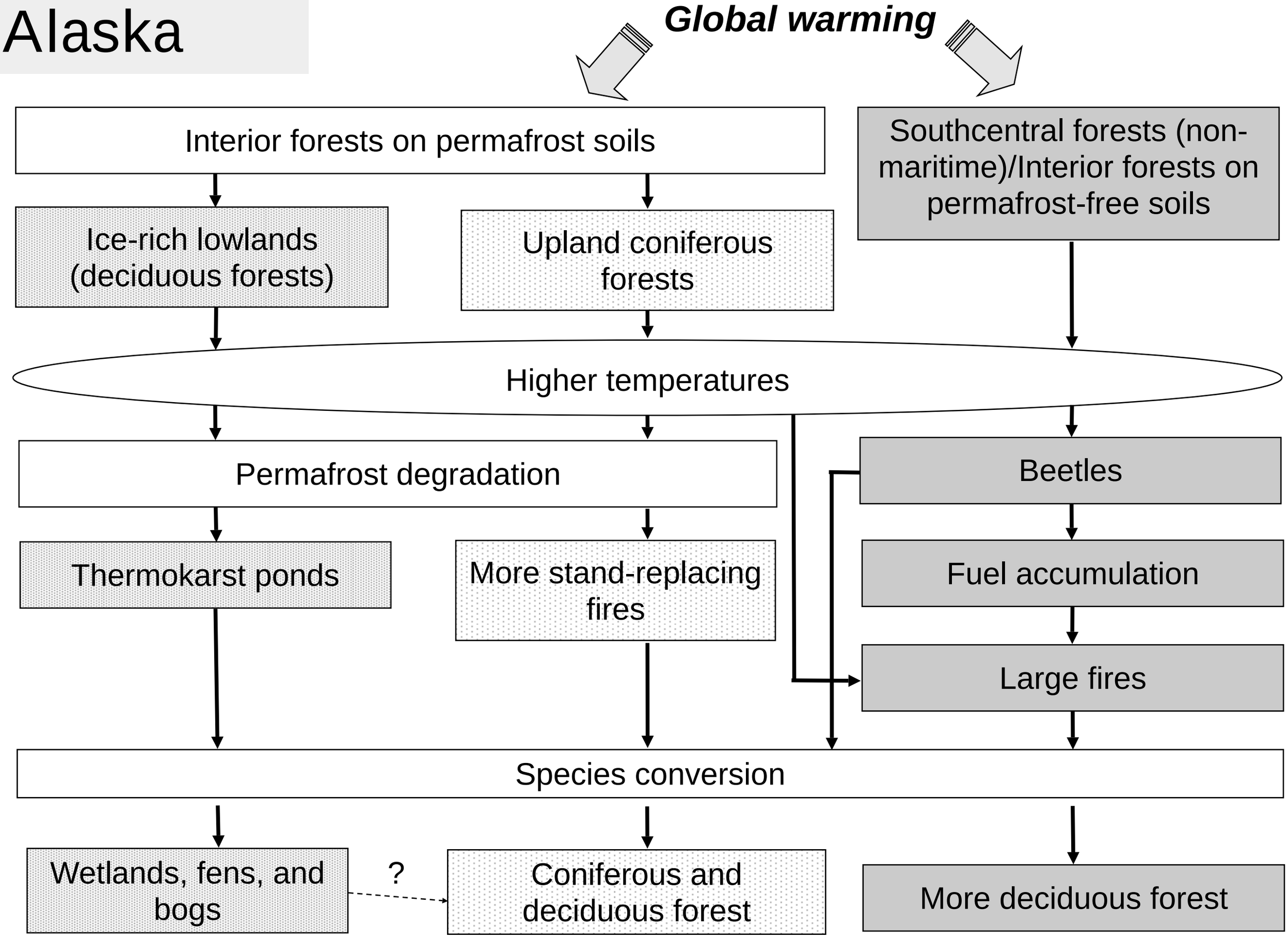
Stand-replacing beetles

Stand replacing fire +
global warming

Ecosystem change

Stand replacing insect
kill + global warming

Alaska


Global warming
Interior forests on permafrost soils
Southcentral forests (non-maritime)/Interior forests on permafrost-free soils
Ice-rich lowlands (deciduous forests)
Upland coniferous forests
Higher temperatures
Permafrost degradation
Beetles
Thermokarst ponds
More stand-replacing fires
Fuel accumulation
Large fires
Species conversion
Wetlands, fens, and bogs
?
Coniferous and deciduous forest
More deciduous forest

Summary

- **Projected climate changes favor increased fire extent and severity.** The West will continue warming through the 21st century even if greenhouse gas emissions were stopped today. Fire regimes may change in unexpected ways.

- **Regional-scale and "landscape-scale" patterns will differ.** Other disturbances, land use and management, and invasives will make a difference.

- **Generic management recommendation.** Anticipate disturbance regimes and landscape patterns associated with future climate.