Concepts and strategies to address sustainability in a changing world

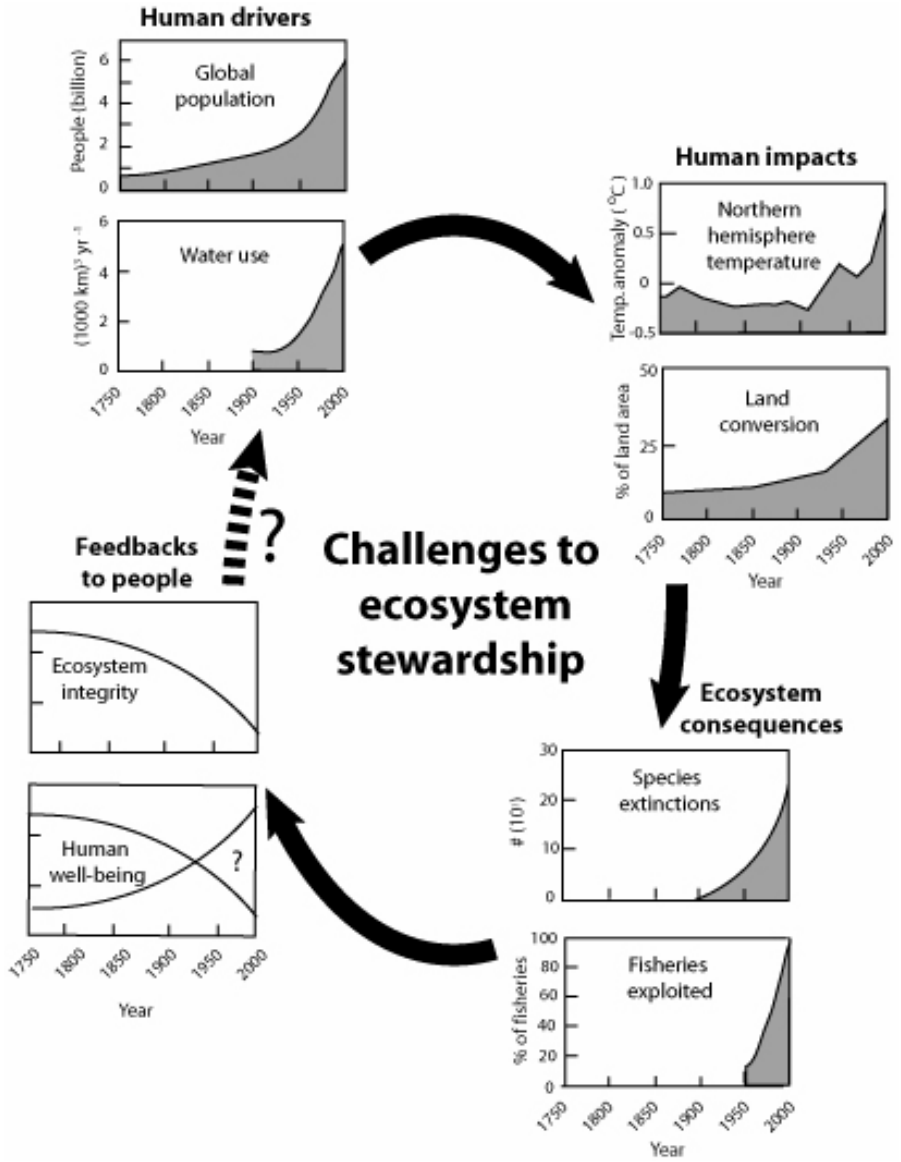
Terry Chapin

University of Alaska Fairbanks

Living on Earth: EPSCoR

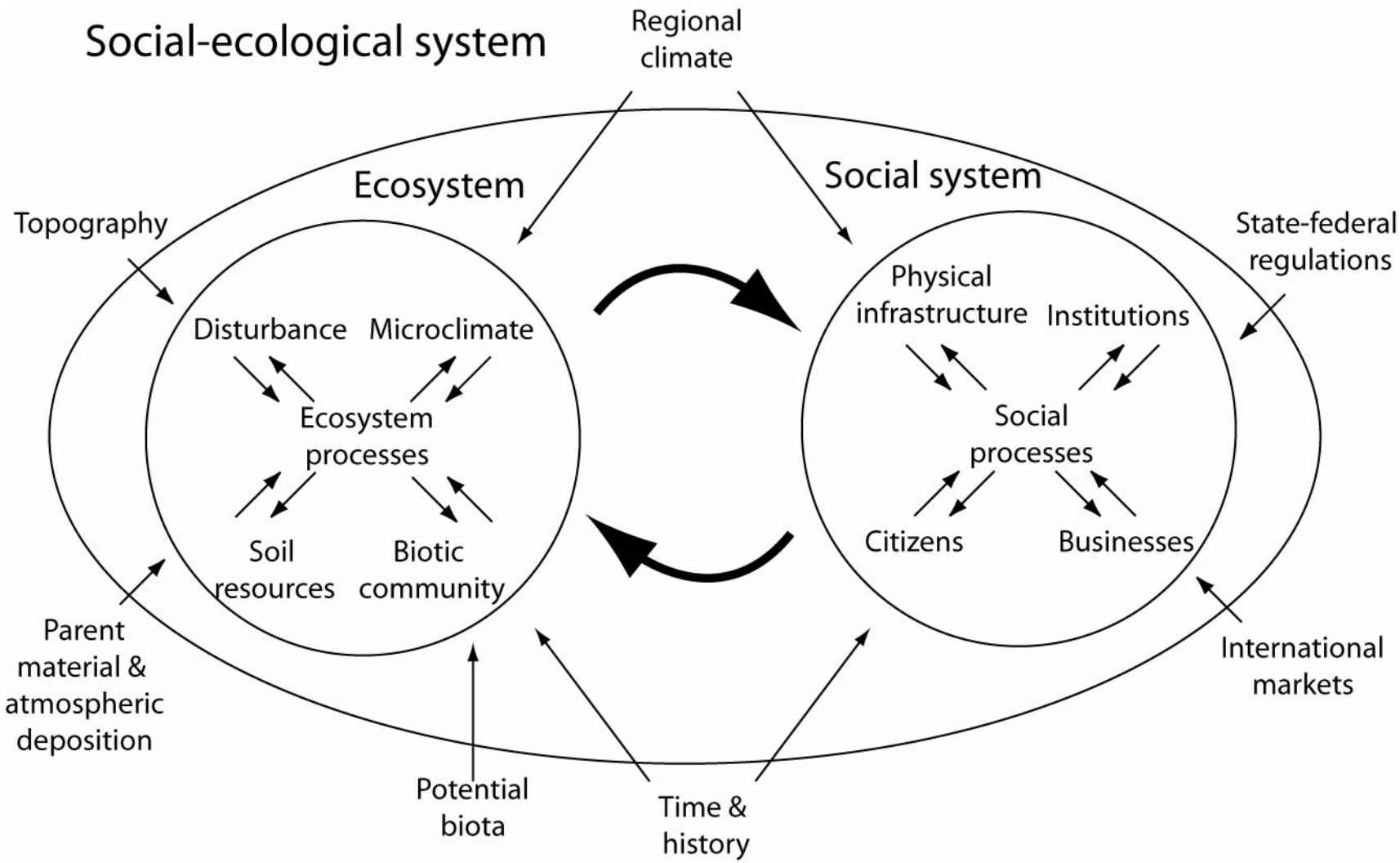
May 11, 2009

Earth is experiencing directional changes in many drivers of social-ecological processes

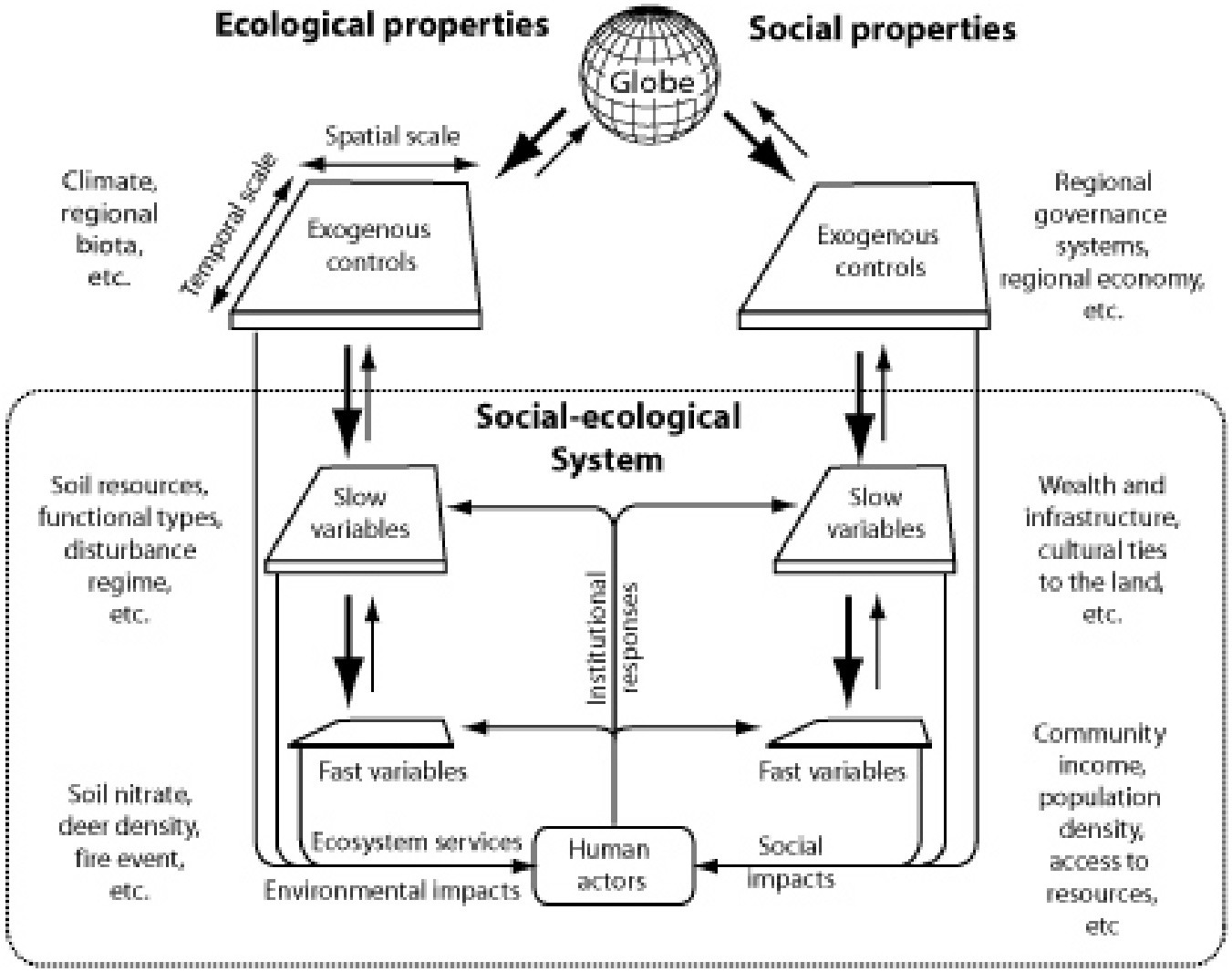


Steffen et al. 2004

System perspective
Components, interactions, and controls



If exogenous controls change substantially, social-ecological systems will inevitably change



Chapin et al. 2006

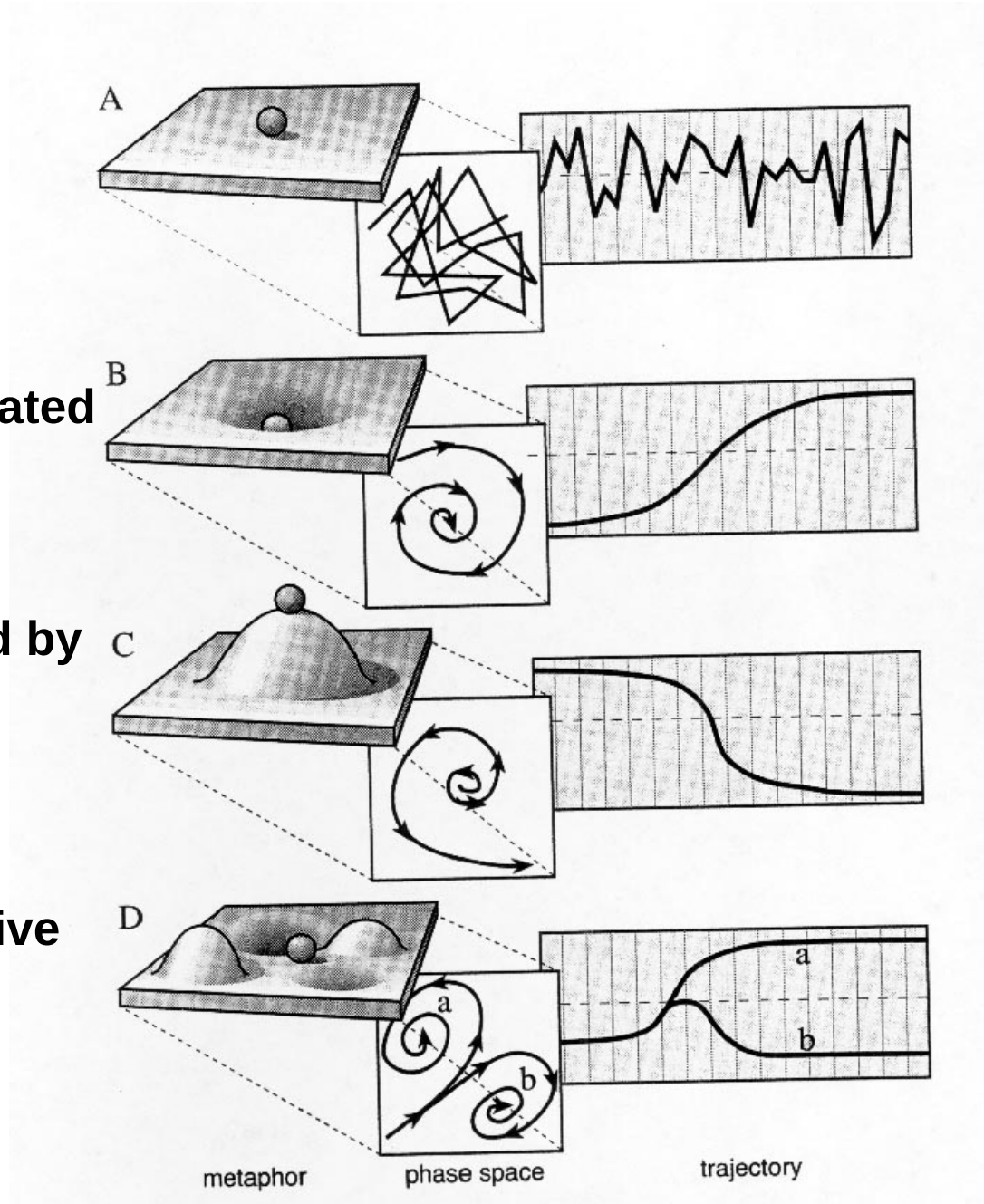
Gunderson and Holling 2002

Chaotic system:
no feedbacks

Steady-state system dominated by negative feedbacks

Unstable system dominated by Positive feedbacks

Complex system with positive and negative feedbacks

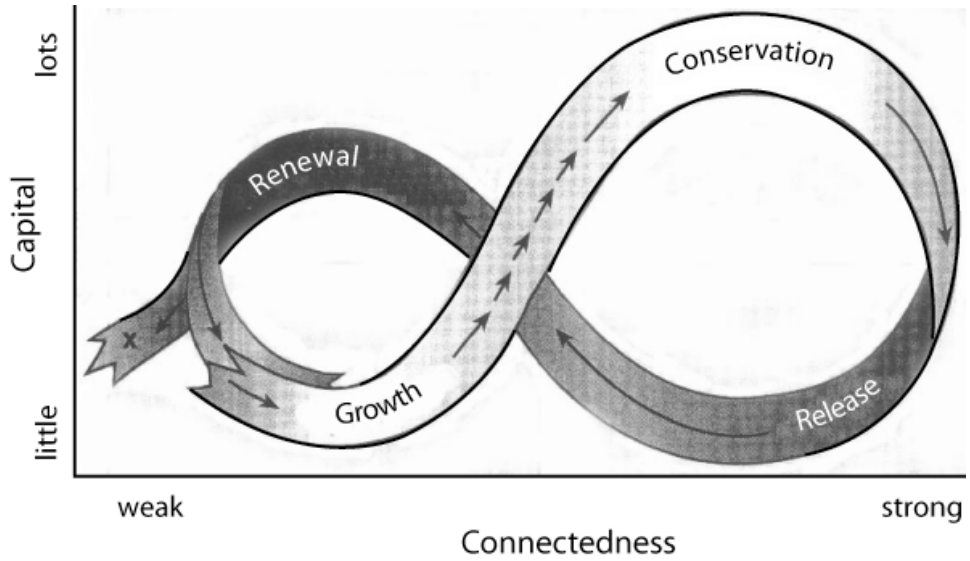


Brief review

- **The world is changing rapidly and in a directional fashion**
- **Many changes are social-ecological in nature**
- **Complex adaptive systems provides useful framework for understanding**

The dynamics of change

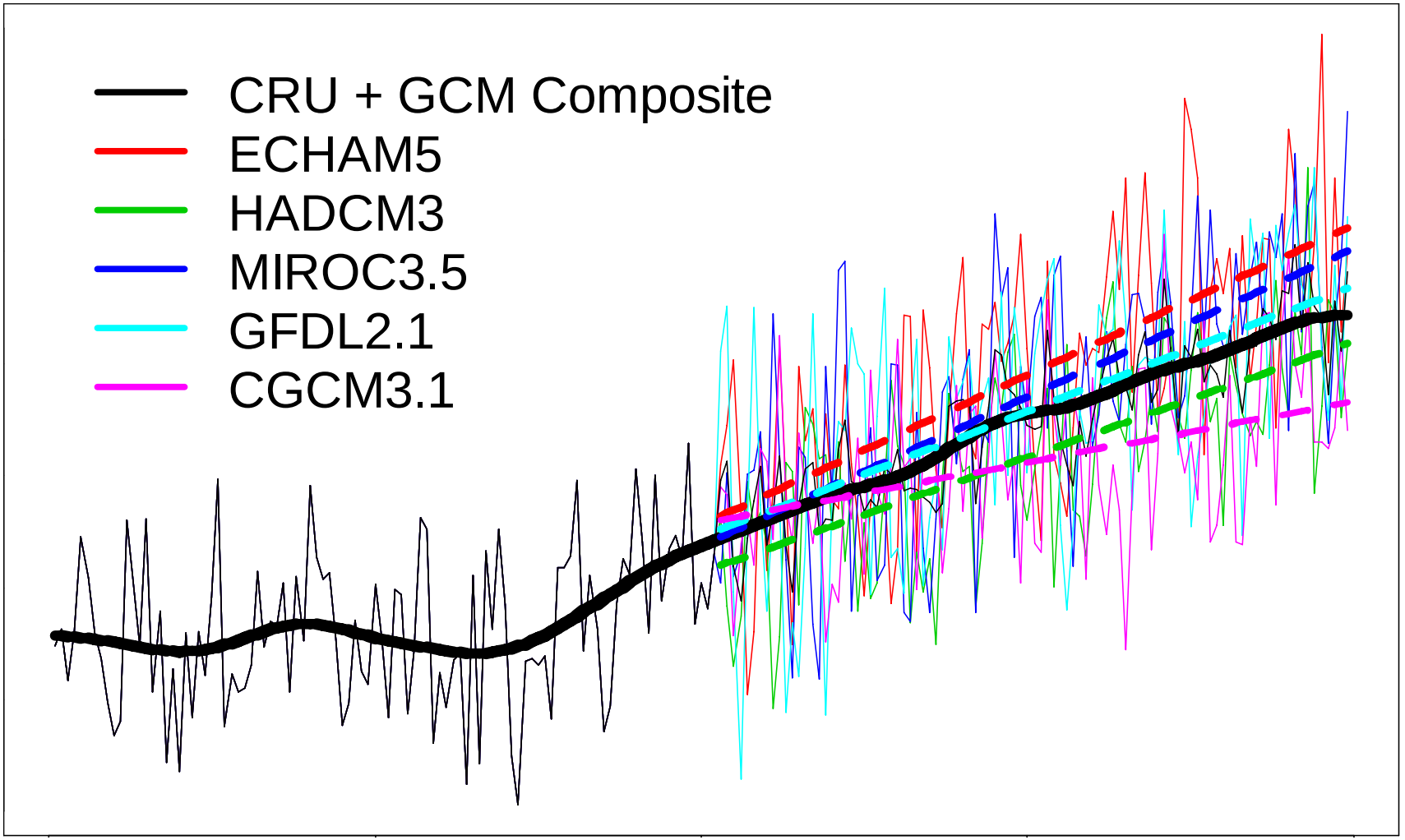
- **Fast vs. slow variables**
  - **Minimize changes in slow variables**
- **Adaptive cycles of change**
  - **Change is more likely to occur at specific times**



Implications for sustainability

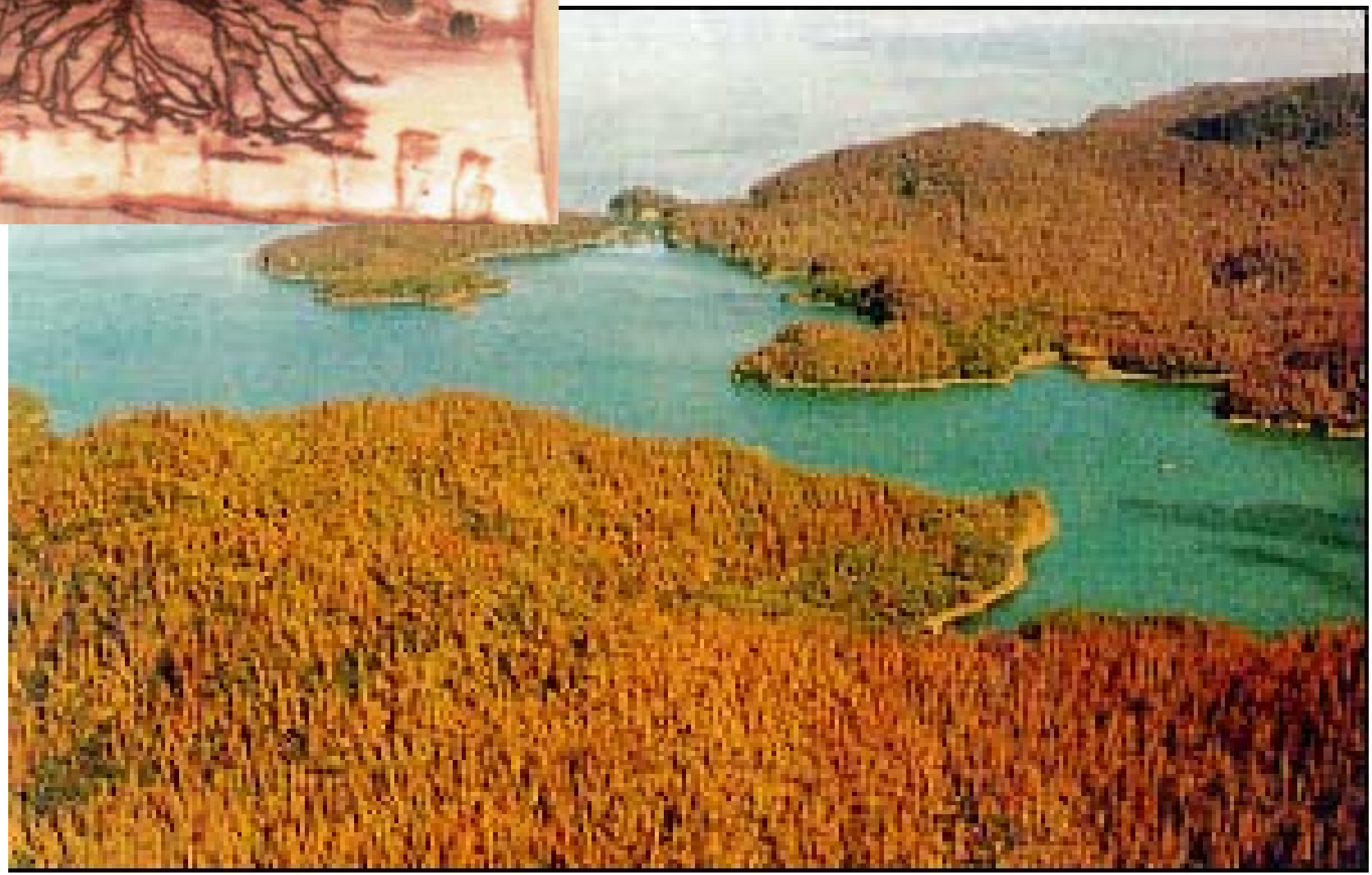
- **Most environmental planning assumes the future will be like the past**
  - **Conservation efforts**
  - **Disaster preparedness**
- **In this context, sustainability is a relatively straightforward concept**
  - **The reference state is well known**
- **BUT--How do we sustain systems in a directionally changing world?**
  - **Alaska is an excellent place to address that question because of rapid ecological and social change**

March-June Average Temperature (C°)
Alaska: 1901-2099



Torre Jorgenson

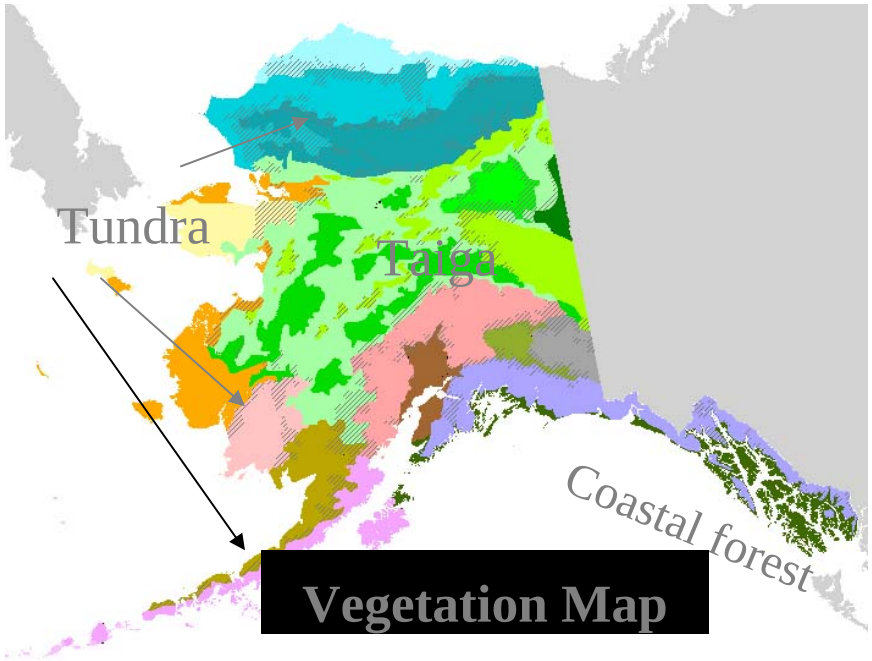
Kenai bark beetle outbreak



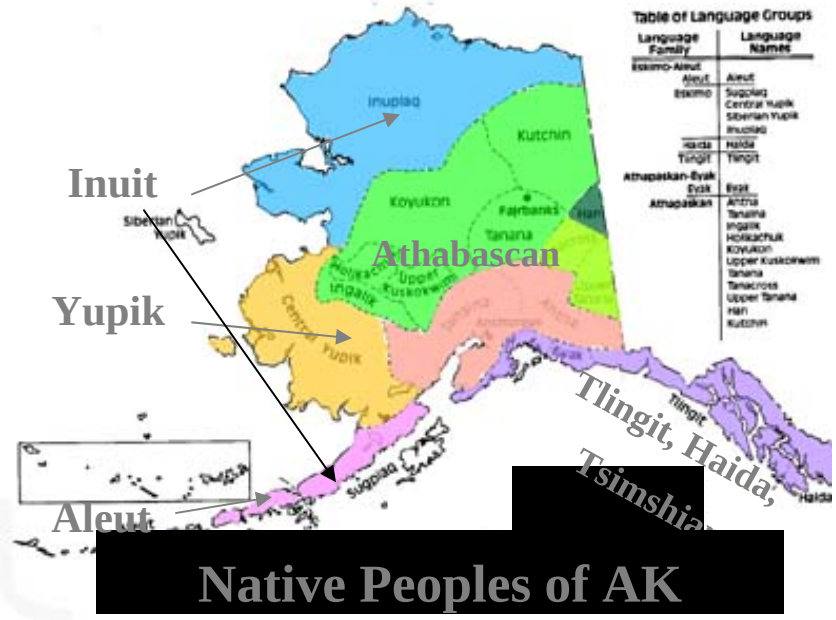

Area burned in W. North America has doubled in last 40 years

Close connection between ecology and culture

If we change ecology, what happens to culture?



Vegetation Map



Native Peoples of AK

Mimi Chapin

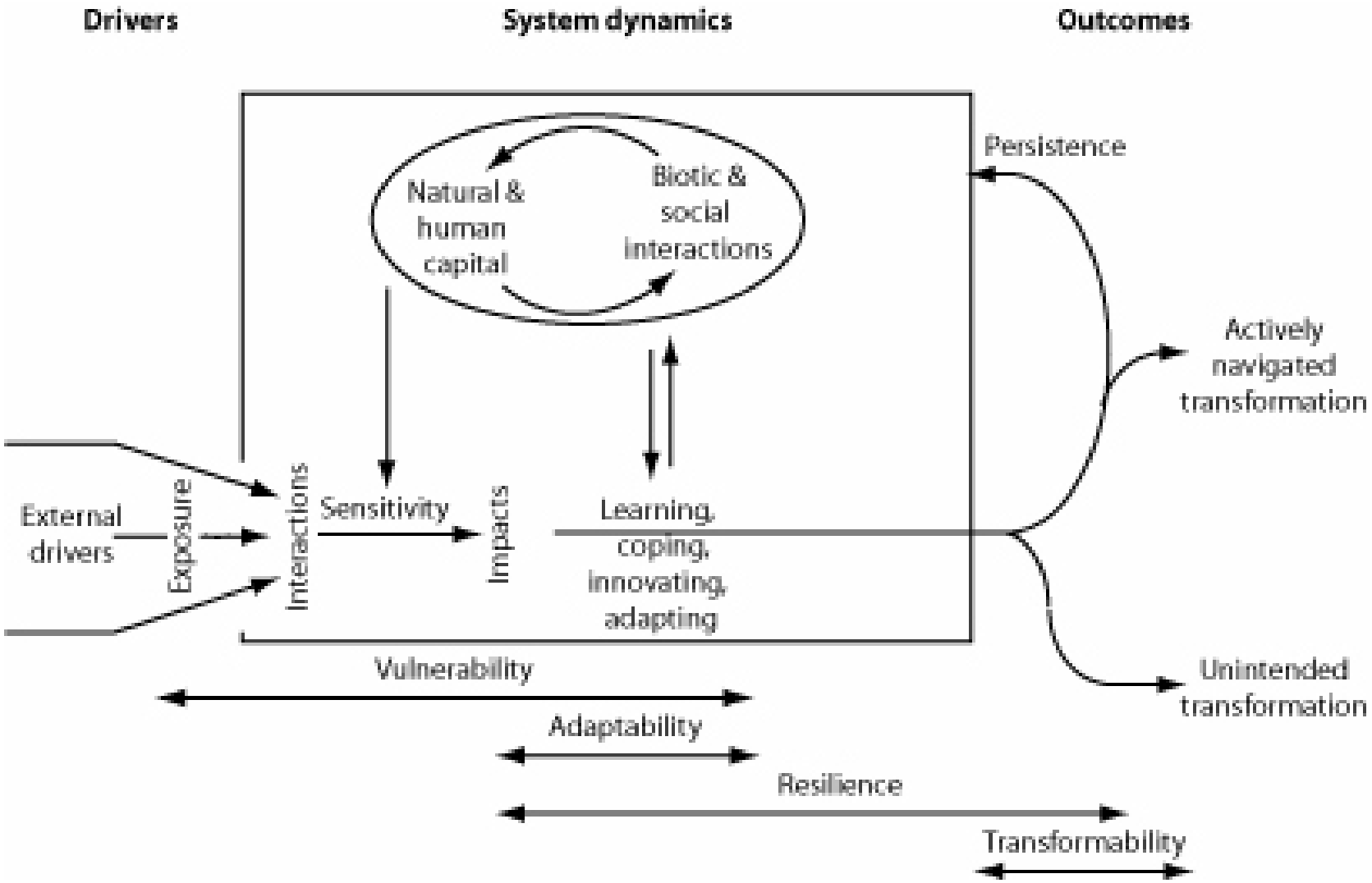
Systems are changing.

What should we do?

A new management paradigm

Characteristic	Steady-State Ecosystem Management	Ecosystem Stewardship
Reference point	Historic condition	Trajectory of change
Central goal	Ecological integrity	Social-ecological benefits
Role of uncertainty	Research reduces uncertainty before taking action	Actions maximize flexibility to adapt to an uncertain future
Role of manager	Decision maker who sets course of sustainable management	Actor who responds to and shapes social-ecological change
Disturbance response	Minimize disturbance probability and impact	Incorporate disturbance into management
Resources of concern	Species composition & ecosystem structure	Biodiversity, livelihoods, & adaptive capacity

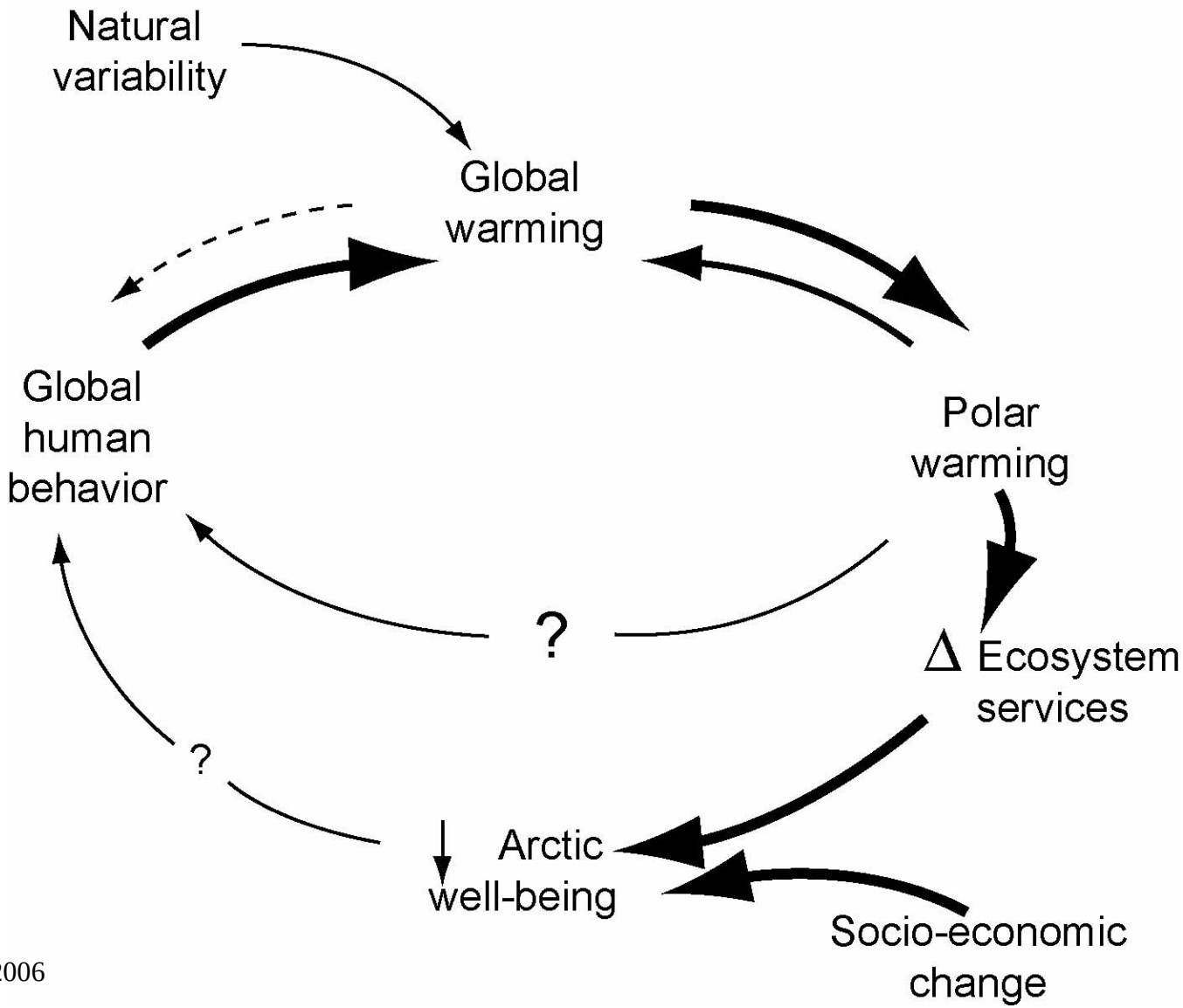
Integrate vulnerability, adaptability, and resilience approaches



Reduce vulnerability

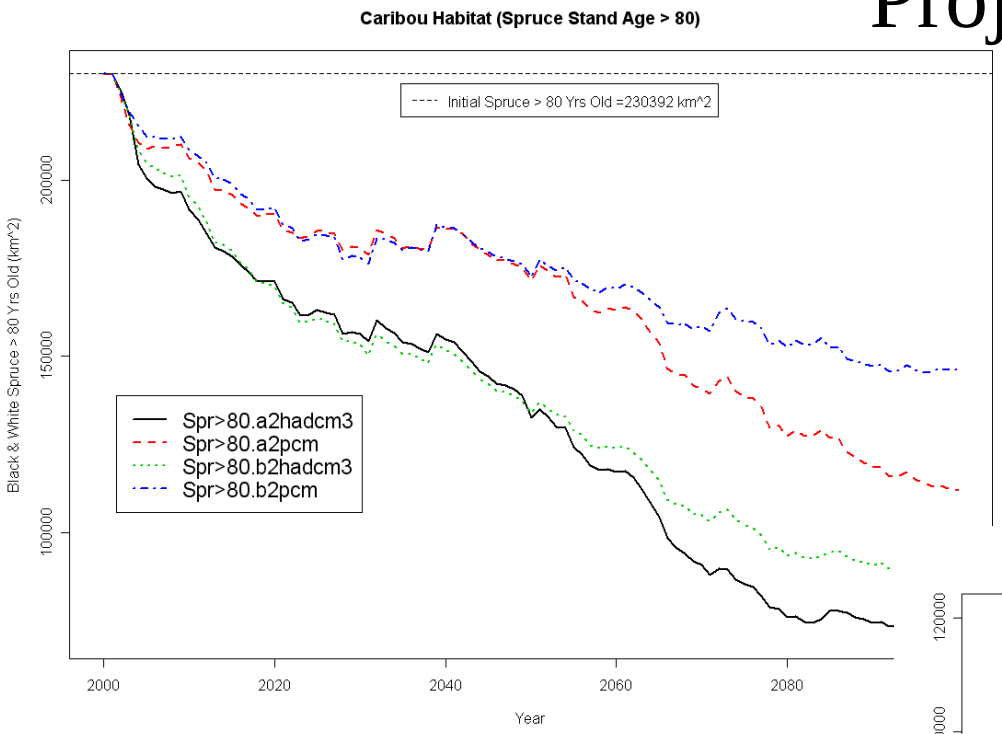
- **Reduce exposure to hazards and stresses**
  - **Minimize known stresses and avoid new ones**
  - **Develop institutions to reduce large-scale stresses**
  - **Manage for projected changes (not history)**
- **Reduce social-ecological sensitivity**
  - **Sustain or enhance natural and social capital**
  - **Address tradeoffs among ecosystems and multiple segments of society**

An arctic example of incomplete feedbacks due to lack of cross-scale institutions

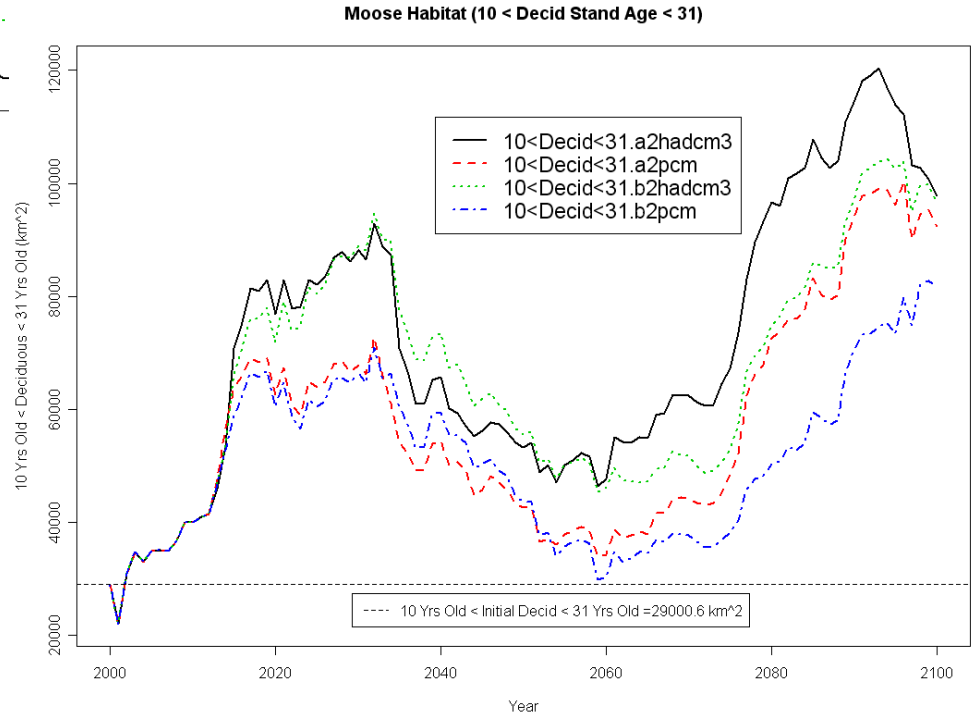


Chapin et al. 2006

Projected habitat changes



Caribou



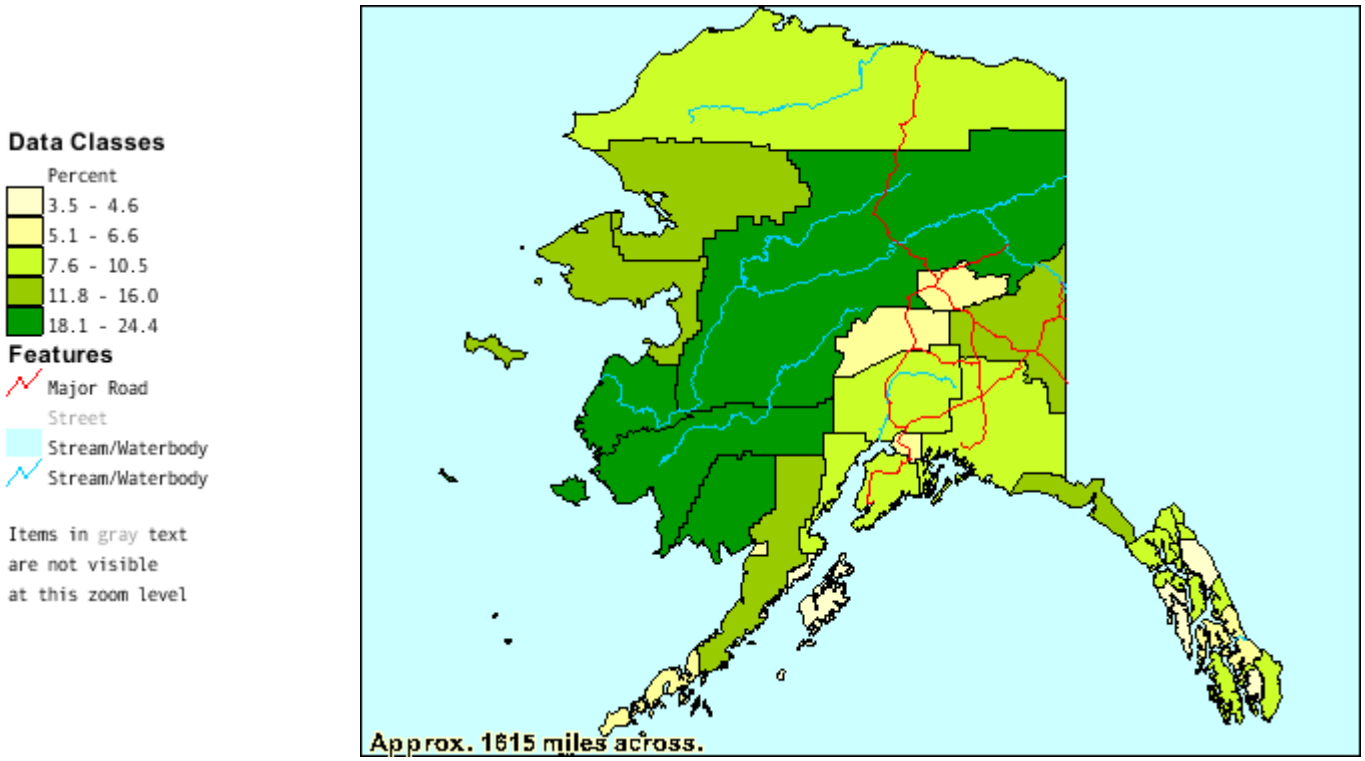
Moose

Rupp

Reduce vulnerability

- Reduce exposure to hazards and stresses
  - Minimize known stresses and avoid new ones
  - Develop institutions to reduce large-scale stresses
  - Manage for projected changes (not history)
- **Reduce social-ecological sensitivity**
  - **Sustain or enhance natural and social capital**
  - **Address tradeoffs among ecosystems and multiple segments of society**

Percent of Families Below the Poverty Level in 1999: 2000



U.S. Census, **TM-P069.**

Social and environmental injustices?

Enhance adaptive capacity for resilience

- **Foster diversity**
  - **(ecological, economic, cultural)**
- **Foster social learning through innovation**
- **Foster mix of stabilizing feedbacks and disturbance**
- **Adaptive governance to respond to changing conditions**

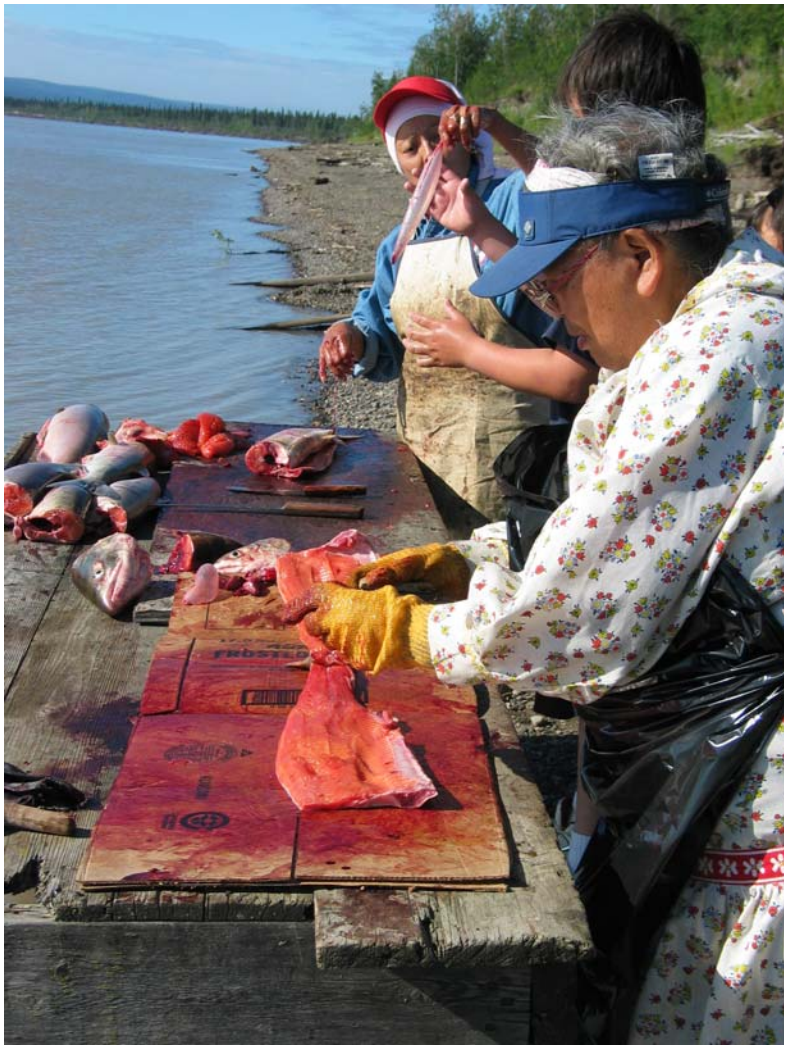
Fostering diversity of Sweden's managed forests

- **Use climate change to restore species diversity**
  - **Protect current diversity**
    - **especially diversity hotspots**
  - **Promote processes that generate diversity**
    - **Disturbance: diversity of stand ages and types**
    - **Manage migration corridors**
- **Foster landscape diversity**
  - **Use unproductive lands for non-forest functions**
    - **Peatlands for carbon sequestration and berries**
    - **Northern areas for reindeer and grazing**
- **Promote economic diversity**
  - **Non-timber forest products (e.g., berries, moose)**
  - **Recreation**

Enhance adaptive capacity for resilience

- Foster diversity (ecological, economic, cultural)
- **Foster social learning through innovation**
- Foster mix of stabilizing feedbacks and disturbance
- Adaptive governance to respond to changing conditions

Interior Athabascan culture is tied to salmon



Subsistence now uses modern technology (cultural context)

Enhance adaptive capacity for resilience

- Foster diversity (ecological, economic, cultural)
- Foster social learning through innovation
- **Foster mix of stabilizing feedbacks and disturbance**
- **Adaptive governance to respond to changing conditions**

Resilience to a triple threat: Climate change, energy crisis, cultural integrity

- **Climate change increases fire risk**
  - **Communities surrounded by late-successional fire-prone vegetation**
- **Fuel costs $6-12/gallon**
  - **Drives rural-urban migration**
  - **Threatens viability of indigenous communities**
- **Biomass harvest to reduce fire risk and provide fuel for heating**
  - **Ecologically sustainable (90% of communities)**
  - **Economically viable (95% of communities**
  - **90% of costs retained locally as wages**
  - **Improved moose habitat near villages**

Fire costs are rising
(Positive feedbacks)

- **Rising human population (50% increase in last 25 years)**
  - **Driven by migration from lower 48**
    - **More human ignitions**
    - **More demand for suppression**
- **Climate Change**
  - **Longer Season**
  - **Bigger fires**
  - **Greater overlap with lower 48 fire season**
- **Increased aircraft use**
- **Training/Safety Costs**
  - **Driven by fire events in lower 48**

Resilience or transformation?

Two resilience options

- Maintain same fire regime as today?
  - ~20-fold increase in cost
- Maintain same budgetary allocation to suppression?
  - Maintain or reduce area protected despite rising population

Transformation option

- Change landscape pattern of fire?
  - Increase landscape heterogeneity through wildland fire use
  - Severe fires switch to deciduous forest trajectory

Arctic marine reserves?

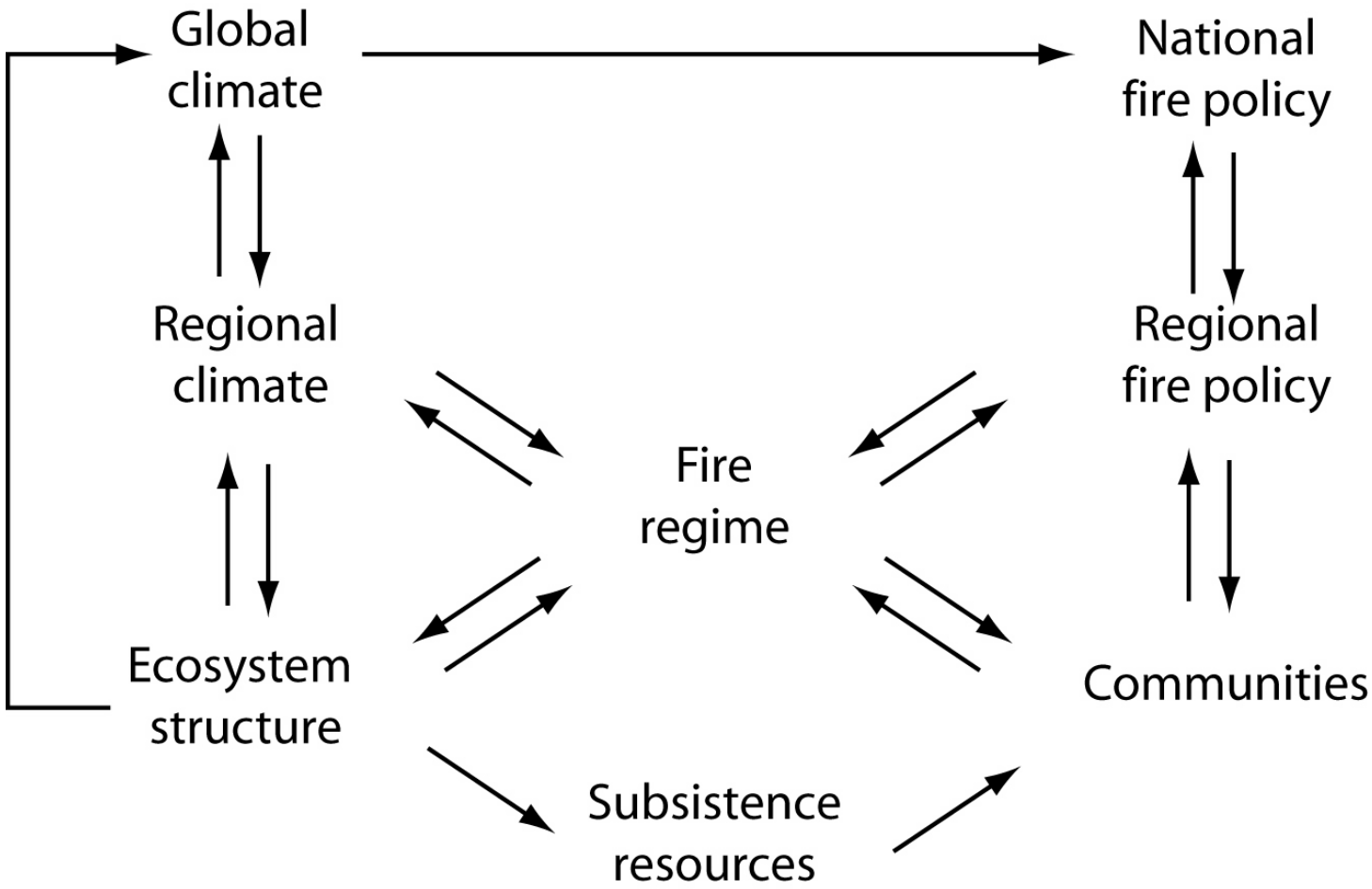
- **Crisis: Disappearing arctic sea ice**
  - **Walrus, seals, polar bears require sea ice**
  - **Coastal community subsistence based on sea mammals**

- **Salmon as an alternative subsistence resource?**
  - **Salmon are migrating north as sea ice retreats**
  - **Design marine reserves for fishery that does not yet exist**
  - **Manage oil development to protect stream gravels**
    - **Ice roads rather than gravel roads**

- **No vested interests opposed to reserves**

Conclusions

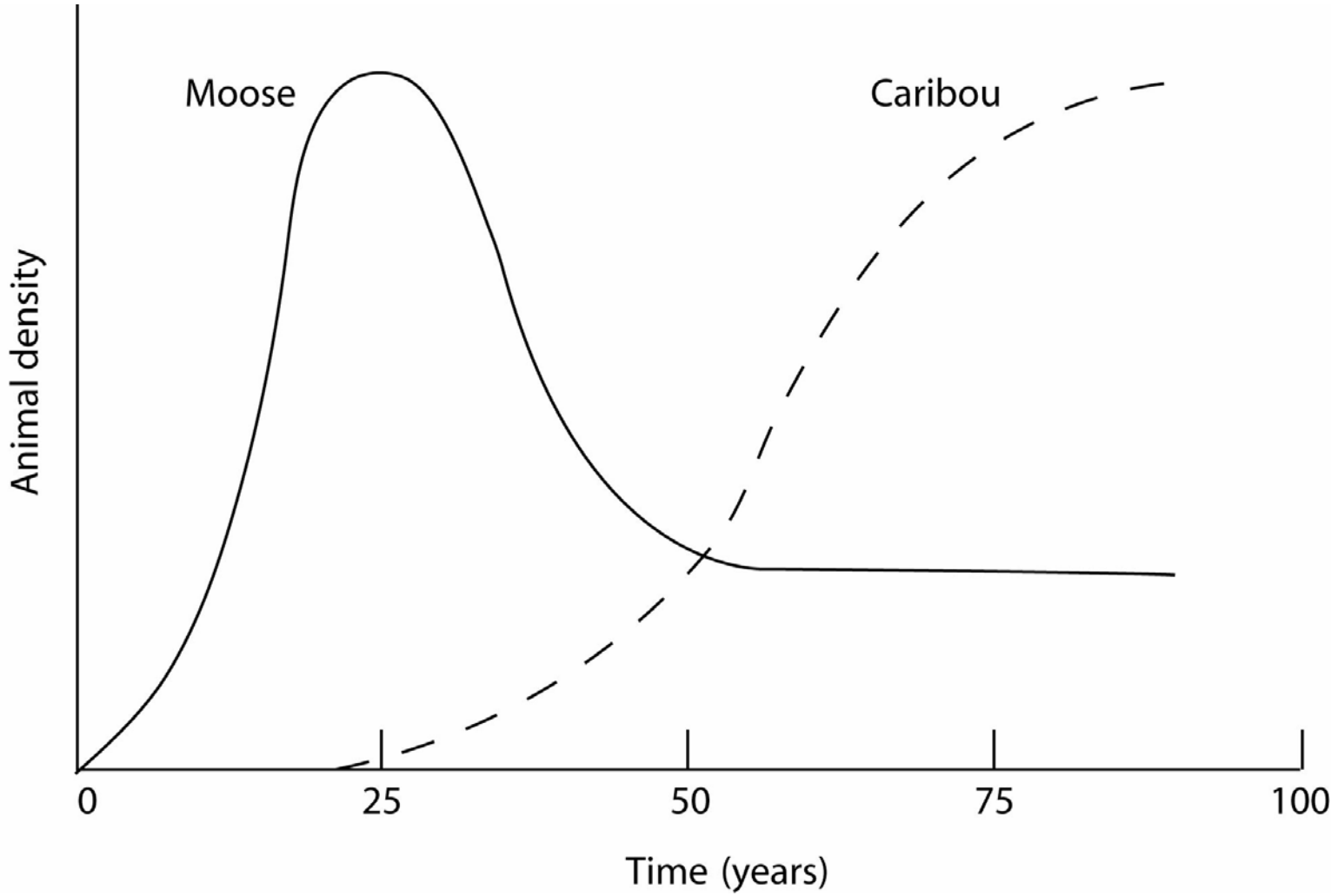
- **Alaska is vulnerable to climate change**
- **Has important sources of resilience**
- **Opportunities for transformations**
- **Social-ecological stewardship provides broad guidelines for actions**


Global climate
National fire policy
Regional climate
Regional fire policy
Fire regime
Ecosystem structure
Communities
Subsistence resources

Rural communities have locations fixed by infrastructure

People's fine-scale relationship with fire has changed over time

- **Pre-contact: Mobile family groups**
  - **People adjust to fire regime**
- **1950s: Consolidation in permanent settlements**
  - **Fire affects communities**


Moose
Caribou
Animal density
0
25
50
75
100
Time (years)