Bonanza Creek LTER: What have we learned in 40 years?

All of us

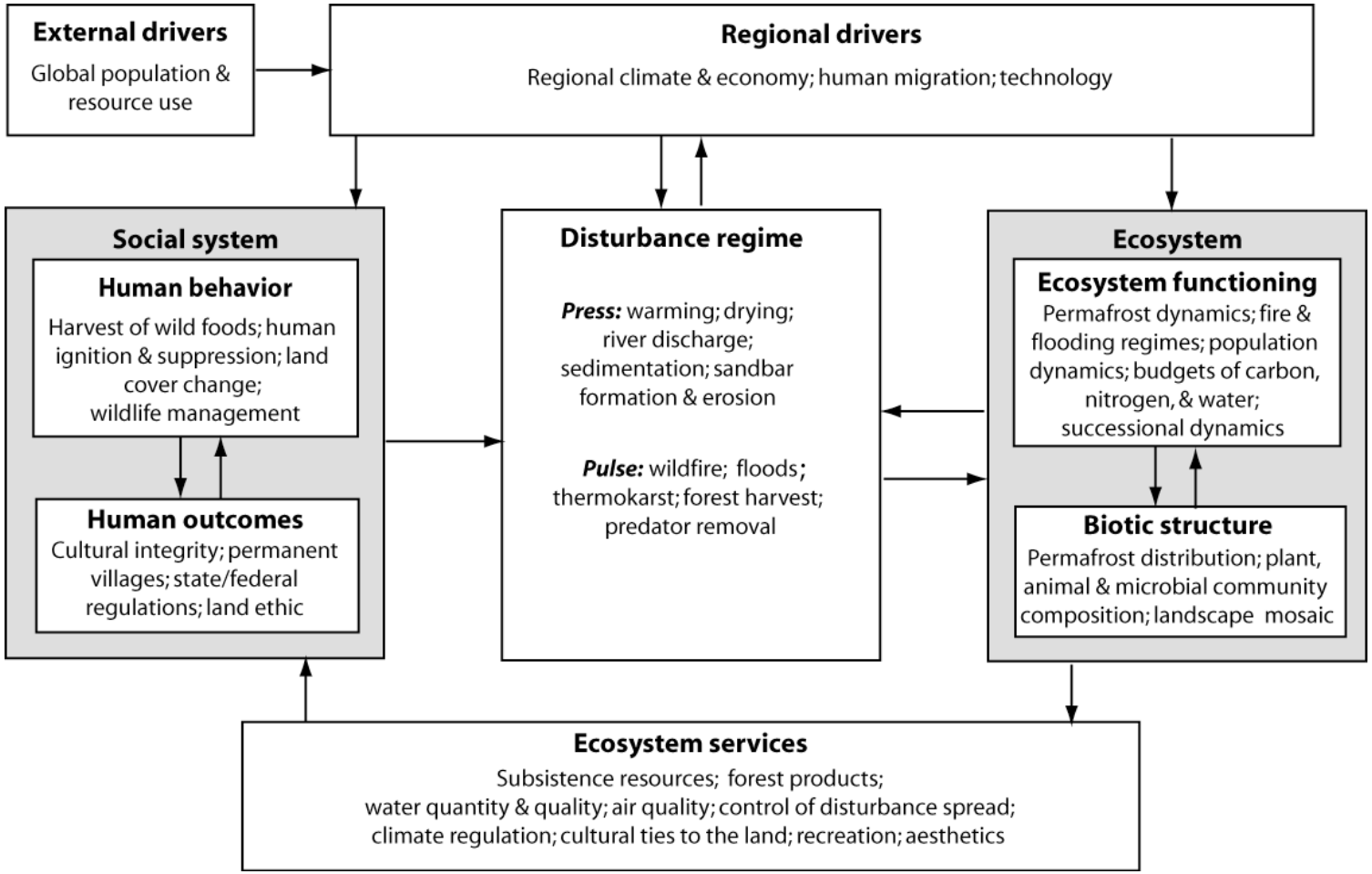
BNZ Symposium

Feb 26, 2010

Evolution of LTER network

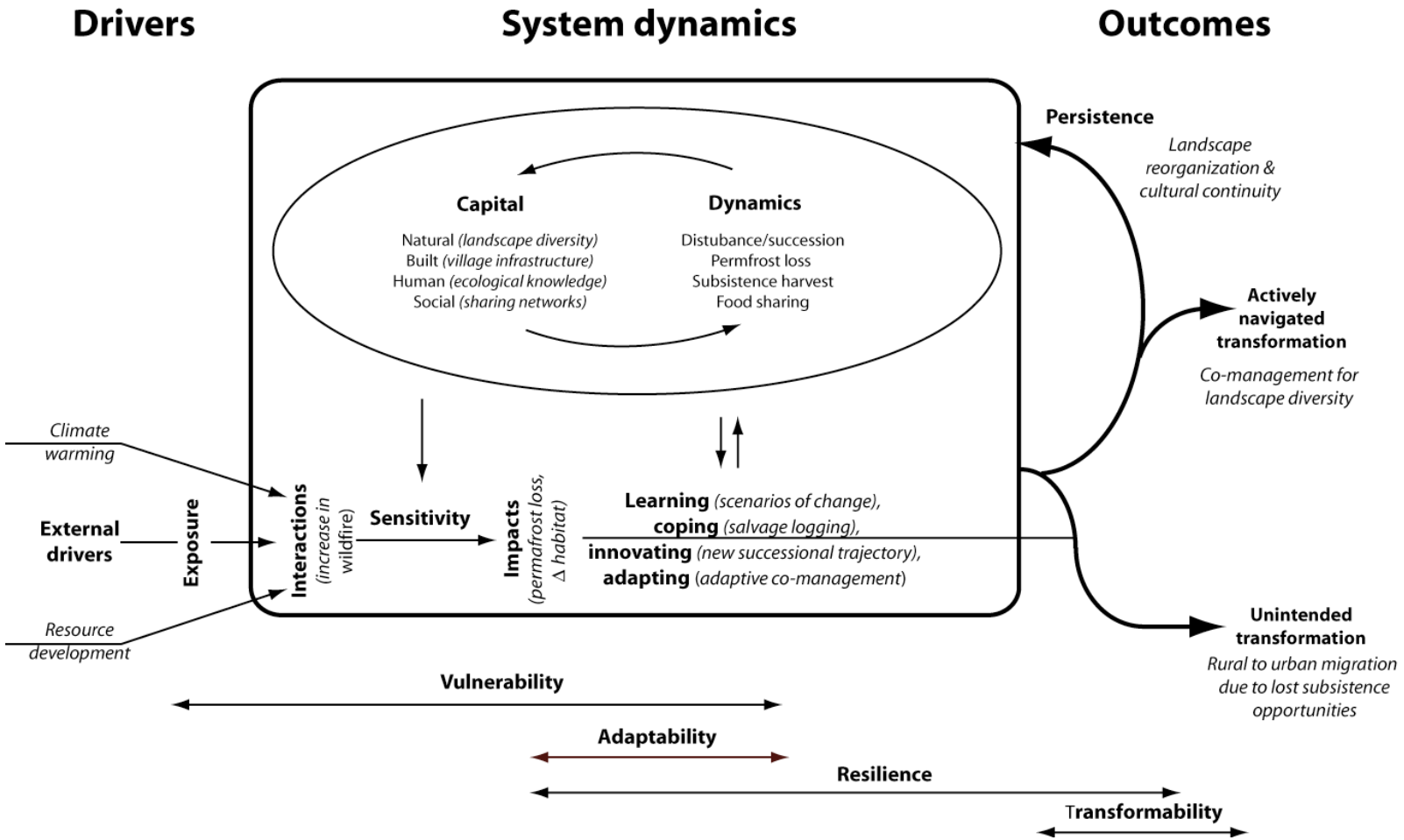
- Network of 26 sites chosen for scientific merit
  - Not geographically representative
  - No central theme or goal other than long-term research
- Now being morphed into an integrated network
  - Sites encouraged to lead and participate in cross-site observations and syntheses
- NEON has an explicitly national design and goals
  - Sites selected and measurements designed to meet these goals
  - BNZ is one of a relatively small number of LTER-NEON sites

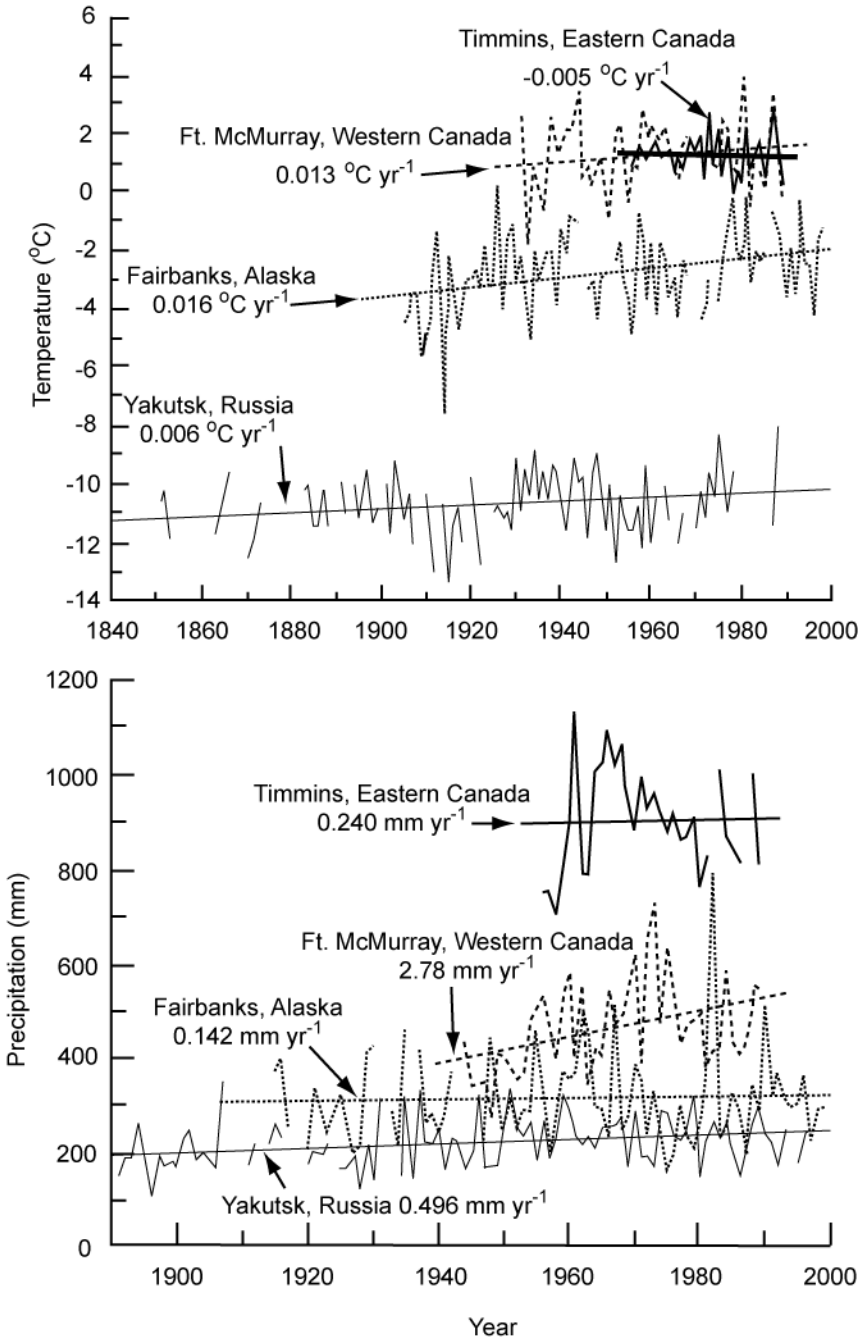
LTER Network framework (ISSE)



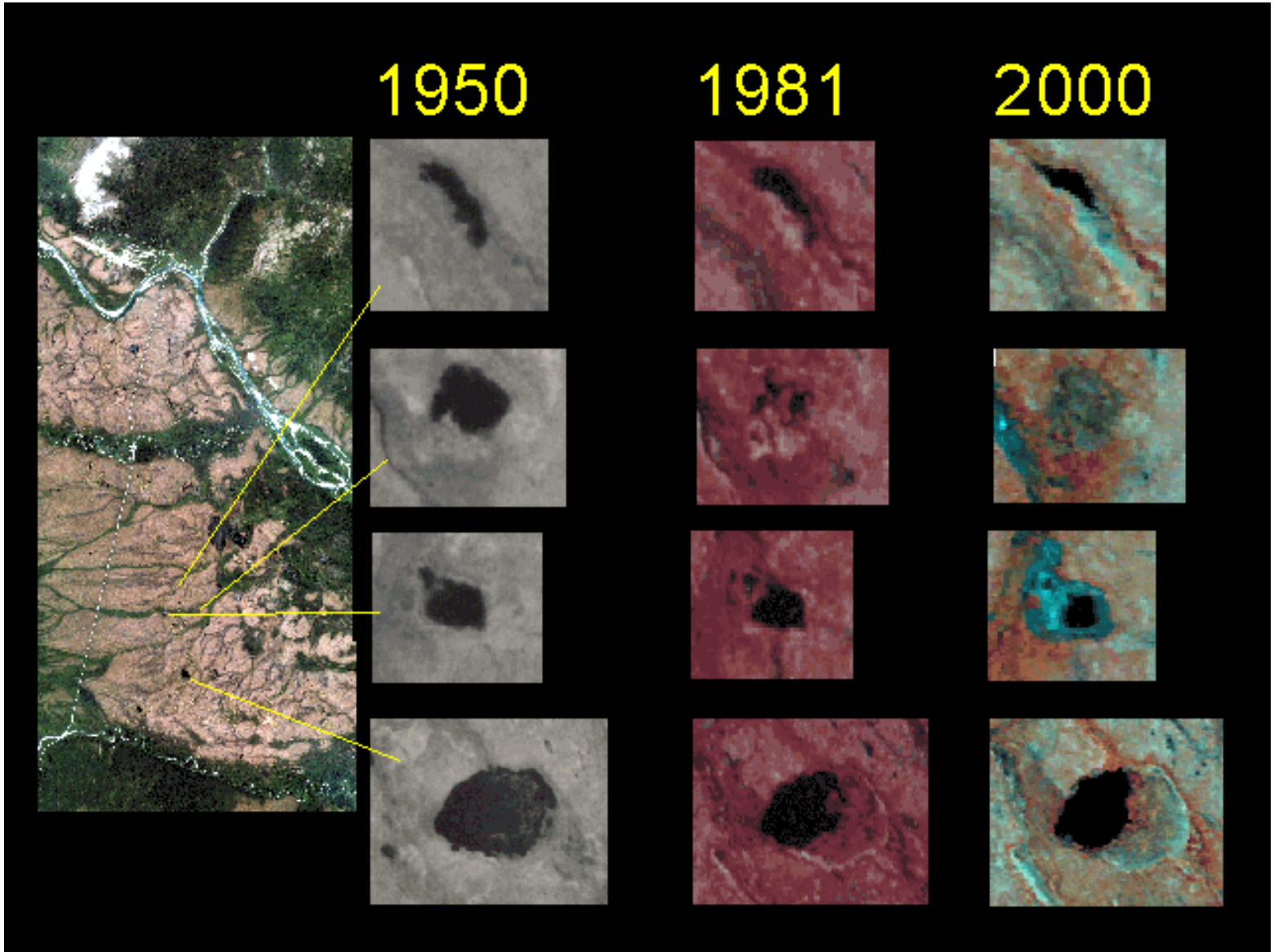
Phases of LTER succession research

- Description of successional patterns
  - US Forest Service Research
- Tests of mechanisms of succession
  - First 12 years of LTER
  - Observations of changes in turning points
  - Field experiments to test mechanisms
- Dynamics of boreal forest change
  - Last 12 years of LTER research
  - Effects of climate change
  - Resilience or transformation?


Drivers
System dynamics
Outcomes
Capital
Natural (landscape diversity)
Built (village infrastructure)
Human (ecological knowledge)
Social (sharing networks)
Dynamics
Distubance/succession
Permfrost loss
Subsistence harvest
Food sharing
Climate warming
External drivers
Exposure
Resource development
Interactions (increase in wildfire)
Sensitivity
Impacts (permafrost loss, Δ habitat)
Learning (scenarios of change),
coping (salvage logging),
innovating (new successional trajectory),
adapting (adaptive co-management)
Persistence
Landscape reorganization & cultural continuity
Actively navigated transformation
Co-management for landscape diversity
Unintended transformation
Rural to urban migration due to lost subsistence opportunities
Vulnerability
Adaptability
Resilience
Transformability


Timmins, Eastern Canada
-0.005 °C yr-1
Ft. McMurray, Western Canada
0.013 °C yr-1
Fairbanks, Alaska
0.016 °C yr-1
Yakutsk, Russia
0.006 °C yr-1
Temperature (°C)
6
4
2
0
-2
-4
-6
-8
-10
-12
-14
1840
1860
1880
1900
1920
1940
1960
1980
2000
Timmins, Eastern Canada
0.240 mm yr-1
Ft. McMurray, Western Canada
2.78 mm yr-1
Fairbanks, Alaska
0.142 mm yr-1
Yakutsk, Russia 0.496 mm yr-1
Precipitation (mm)
1200
1000
800
600
400
200
0
1900
1920
1940
1960
1980
2000
Year

Permafrost thaw:
The land is getting drier in places



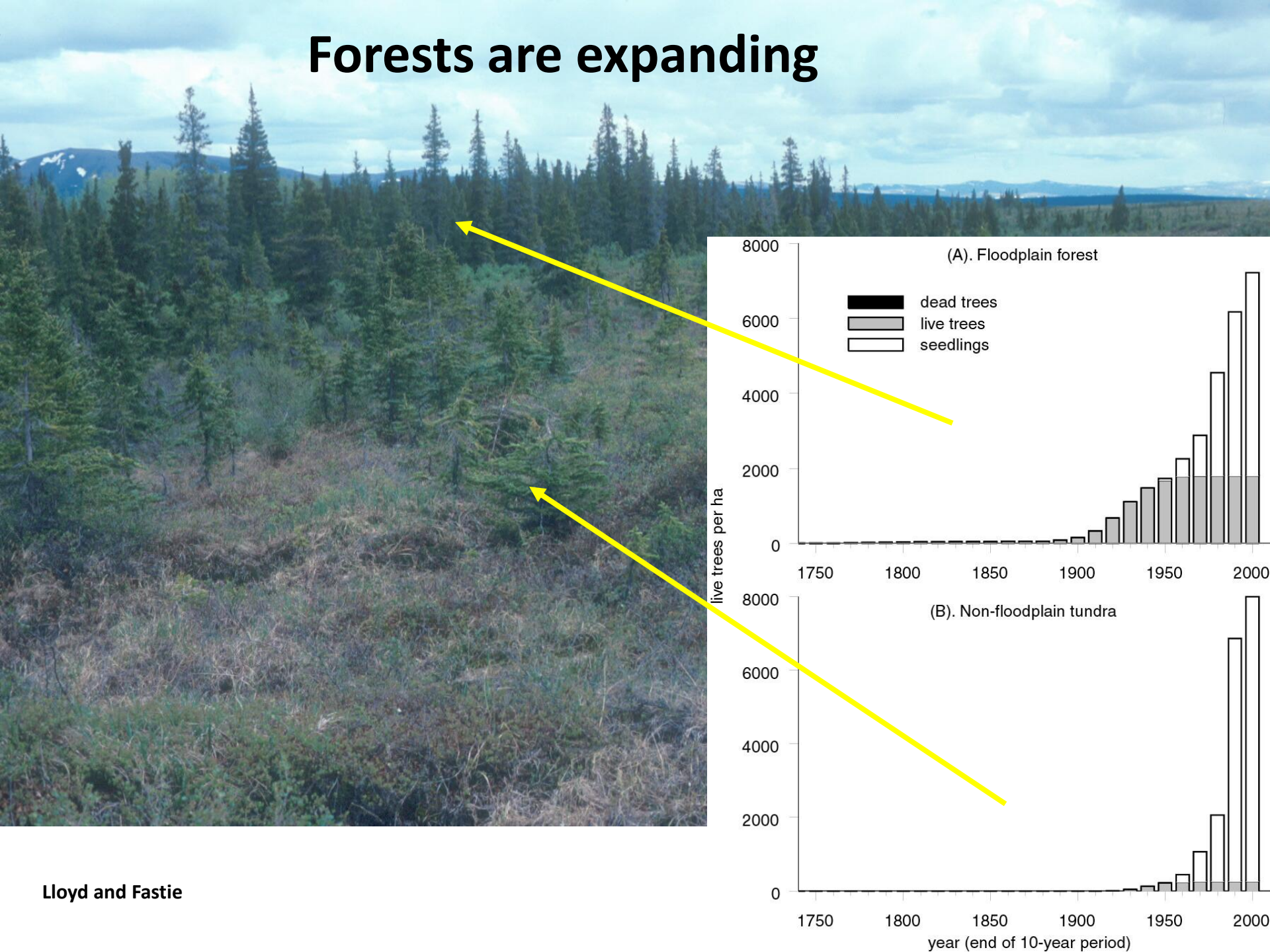
Hinzman et al. 2005

Ice-rich wetlands become wetter

Kenai bark beetle outbreak

Fires are more extensive and severe

Forests are expanding



Lloyd and Fastie

Are we about to see the end of the Alaskan boreal forest?

- What aspects are resilience and what is likely to change?
- What are some of the potential surprises?

Shift from nutrient to drought limitation??

- First phase of LTER documented widespread nutrient limitation of plant growth
- Now tree growth appears to be drought-limited
- Questions:
  - Has the nature of environmental limitation changed?
  - Or, are we finally making the measurements needed to detect drought limitation?
  - Or,…?

Will permafrost disappear?

- First phase of LTER emphasized permafrost as driver of ecosystem dynamics
- Now view changes in permafrost properties as primarily a function of ecosystem change
- Questions:
  - Is climate warming sufficient to thaw permafrost everywhere?
  - Will altered fire regime cause shift to a new (no-permafrost) stability domain?
  - What is the role of permafrost in causing paludification or drying?

Is river discharge changing?

- Discharge records are too short in western N. America to detect significant trends
- But:
  - River discharge is increasing in N. Russia (trend weakens from west to east)
  - Discharge at CPCRW is greatest in cool, wet years
  - Alaska has warmer summers and no change in ppt
  - Alaska Natives report dropping river levels

Is boreal succession always the same?

- LTER began with the assumption of one successional trajectory per site type
- Questions:
  - How variable is succession?
  - What can shift succession to a new trajectory?
    - Disease?
    - Fire severity?
    - Herbivores?
    - Invasive species?

How will microbes and biogeochemistry change with warming?

- First phase of LTER assumed microbes were temperature-limited and that their slow mineralization of N limited plant production
- But:
  - Most fungi are mycorrhizal and respond more strongly to soil horizon and forest type than to climate
  - Plants and microbes compete for N (especially amino acid N)
  - Mineralization probably not the rate-limiting step

Will the boreal forest disappear?

- Is the boreal forest doomed to be eliminated by drought, pests, and wildfire?
- Questions:
  - Where will critical transformations occur?
  - Where (and how) will landscape reorganization occur (resilience of forest)

Will boreal change be a positive or negative feedback to warming?

- First phase of LTER thought of boreal forest as being very sensitive to climate (temperature) but didn't consider climate feedbacks
- Questions:
  - Will changing season length (albedo) be the predominant change in climate forcing?
  - Will the boreal forest sequester or lose carbon?
  - What about methane?

Can indigenous people adapt to the changing boreal forest?

- First phase of LTER focused on forest production but otherwise largely ignored people
- People depend strongly on current ecosystem services of the boreal forest
- Questions:
  - Can people adapt to the new conditions?
  - Will policies facilitate or inhibit this adaptation
  - Can BNZ research inform these policies?

Some surprising lessons

- Permafrost is relatively resilient except in ice-rich lowlands and with severe fires.
- New successional trajectories contribute to resilience of floodplain forests
- Current upland forests have low resilience to climate-driven disturbances, leading to both landscape transformation and reorganization
- Human and other animal communities may substantially reorganize but resilience is quite sensitive to policy choices.