Potential effects of altered fire frequency on carbon cycling on coniferous landscapes

Daniel M. Kashian
Colorado State University

Michael G. Ryan
USDA Forest Service

William H. Romme
Colorado State University

Daniel B. Tinker
University of Wyoming

Monica G. Turner
University of Wisconsin

The Yellowstone landscape

- Stand-replacing fires
- 100-300 year fire interval
- Large, “natural” landscape
- Mosaic of stand age and density

Questions:

- What key processes regulate carbon storage on landscapes?

- How sensitive is landscape carbon storage to large disturbances (short term)?

- How sensitive is landscape carbon storage to changes in disturbance regimes (long term)?

What affects landscape carbon storage?

- Balance between carbon accumulating in vegetation/forest floor and carbon lost through decomposition of dead wood.

What affects landscape carbon storage?

- Balance between carbon accumulating in vegetation/forest floor and carbon lost through decomposition of dead wood.

- Changes in the stand density distribution across the landscape following fires.

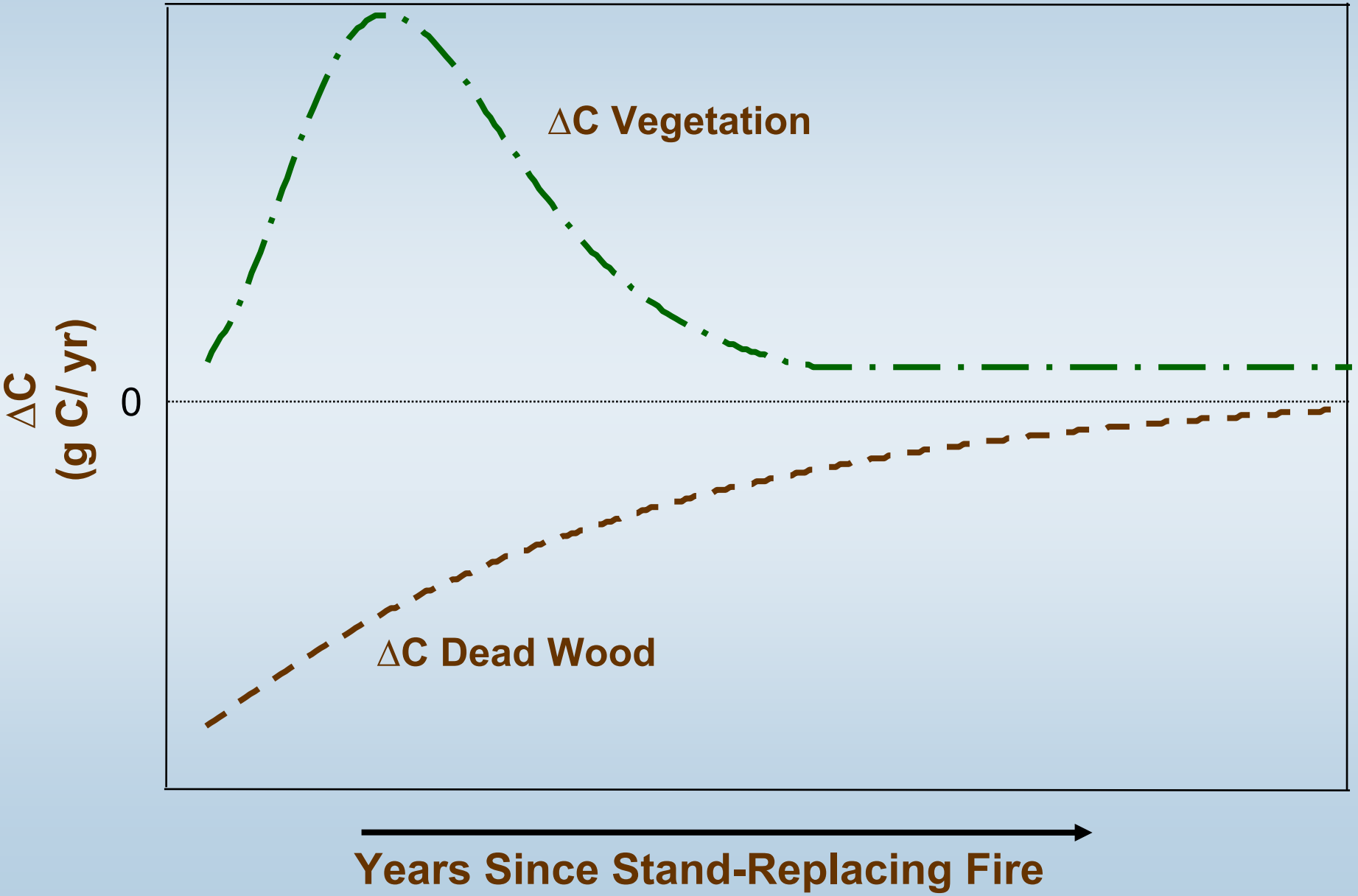
What affects landscape carbon storage?

- Balance between carbon accumulating in vegetation/forest floor and carbon lost through decomposition of dead wood.

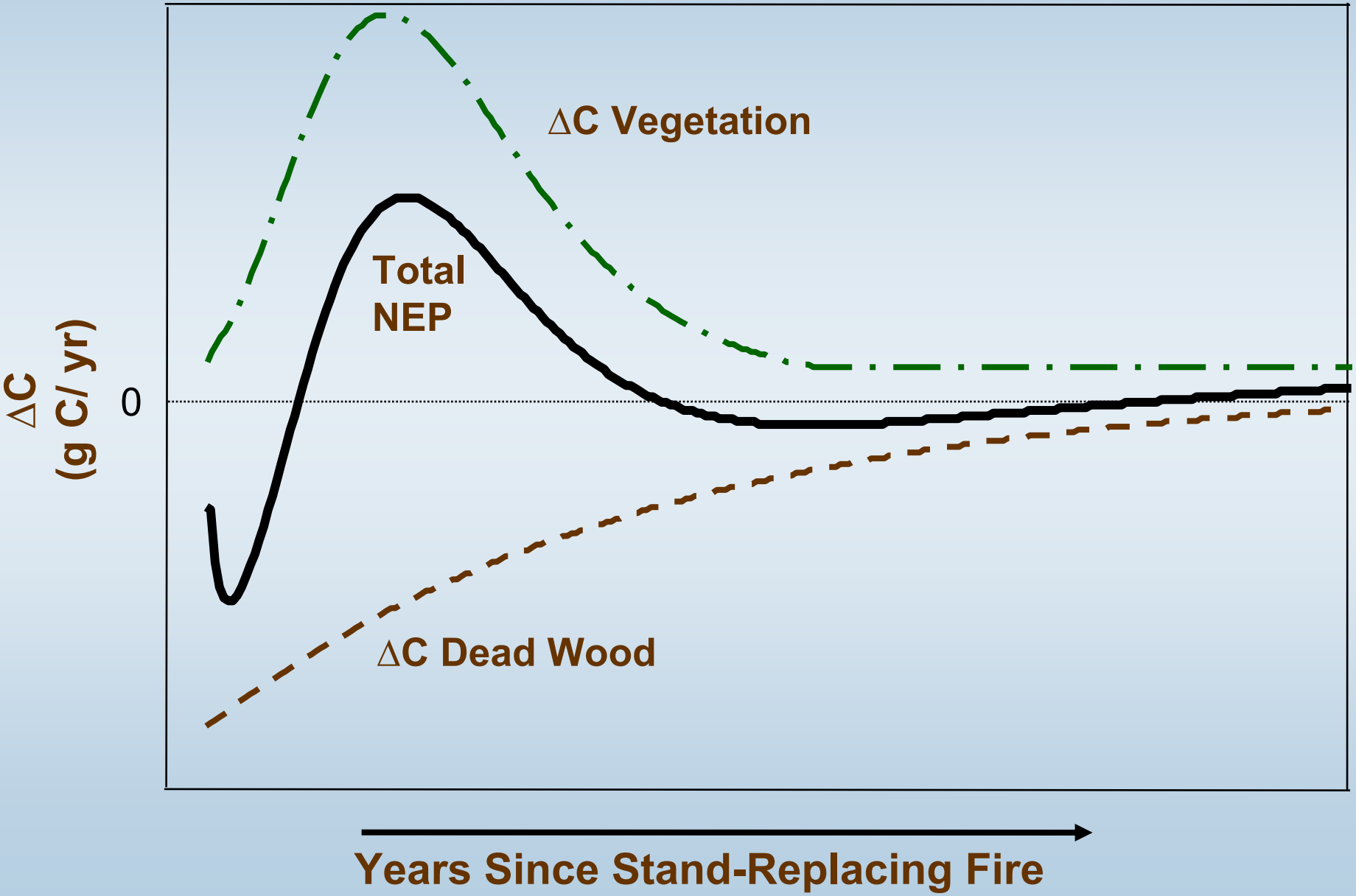
- Changes in the stand density distribution across the landscape following fires.

- Changes in the stand age distribution across the landscape following fires.

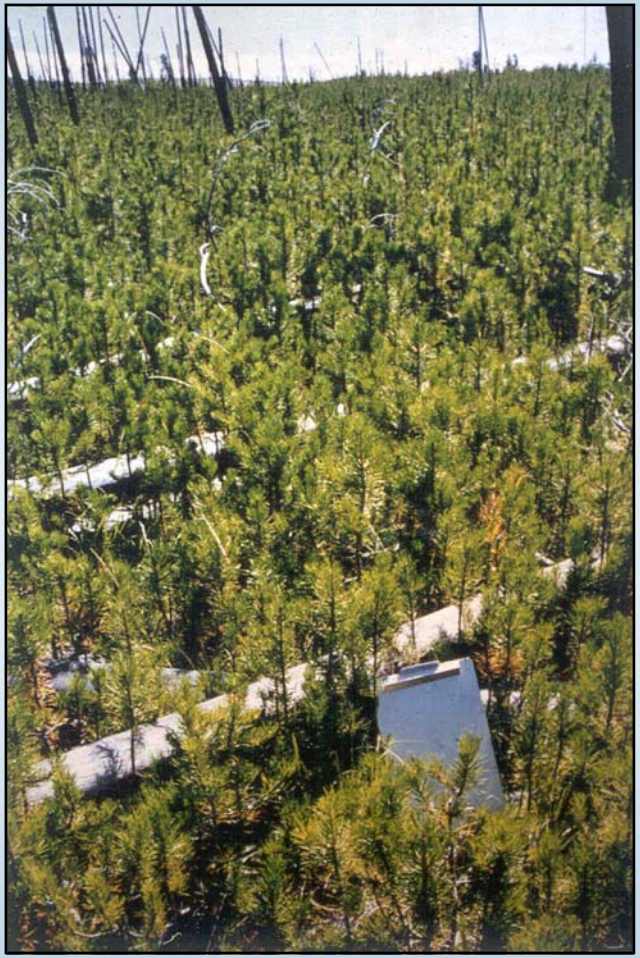
NEP = C gained (NPP) – C lost (decomposition)



NEP = C gained (NPP) – C lost (decomposition)



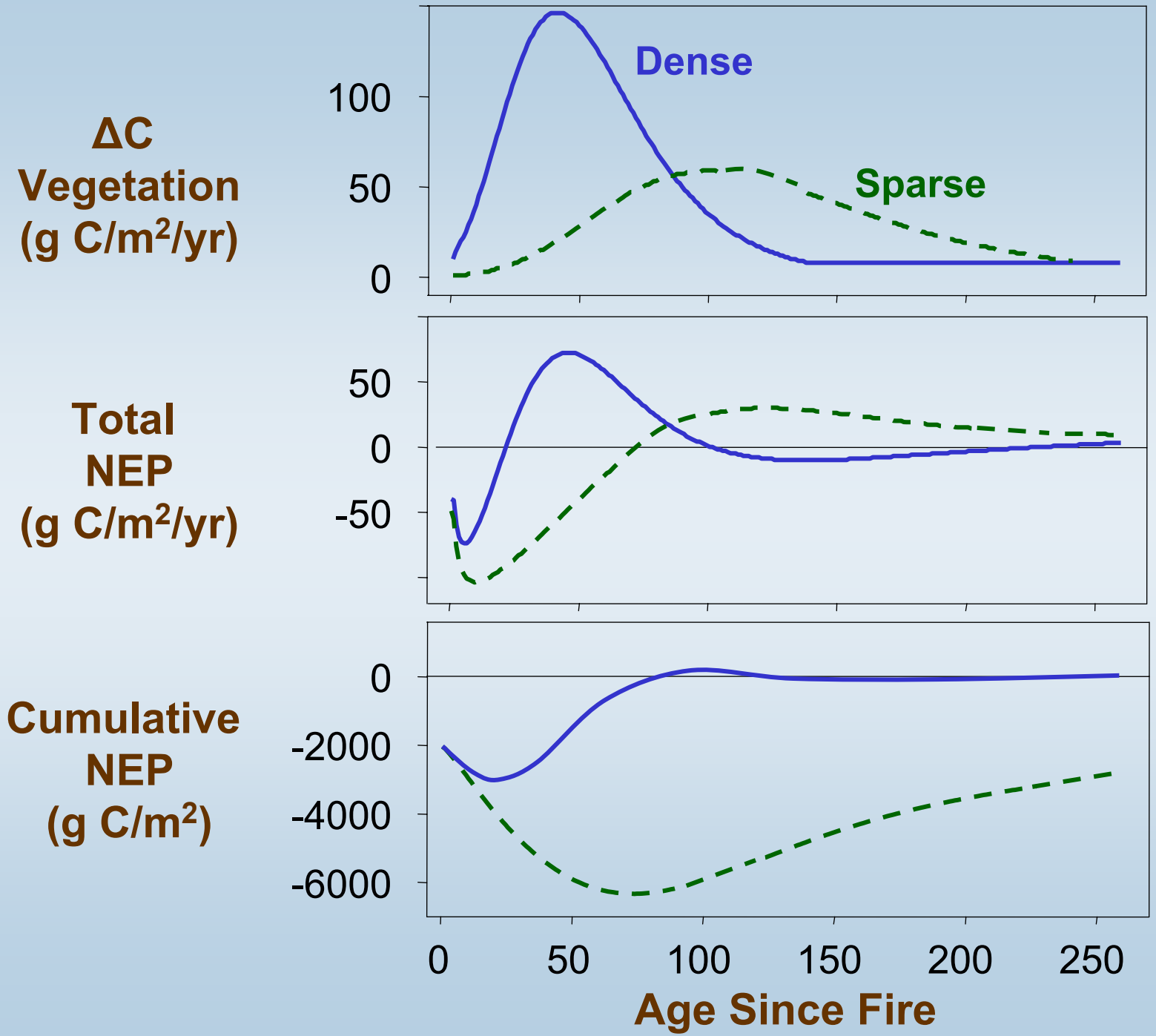
Variability in structure affects landscape NEP



>50,000 stems/ha

1,000 stems/ha

0 stems/ha


ΔC Vegetation (g C/m²/yr)
Total NEP (g C/m²/yr)
Cumulative NEP (g C/m²)
Dense
Sparse
100
50
0
50
0
-50
0
-2000
-4000
-6000
0
50
100
150
200
250
Age Since Fire

Do stand structures "replace themselves"?

Sparse pre-fire

Sparse post-fire

Little change = in C stored over fire cycle

Dense pre-fire

Dense post-fire

Little change = in C stored over fire cycle

Do stand structures "replace themselves"?

Sparse pre-fire

Sparse post-fire

= C lost over fire cycle

Dense pre-fire

Dense post-fire

= C gained over fire cycle

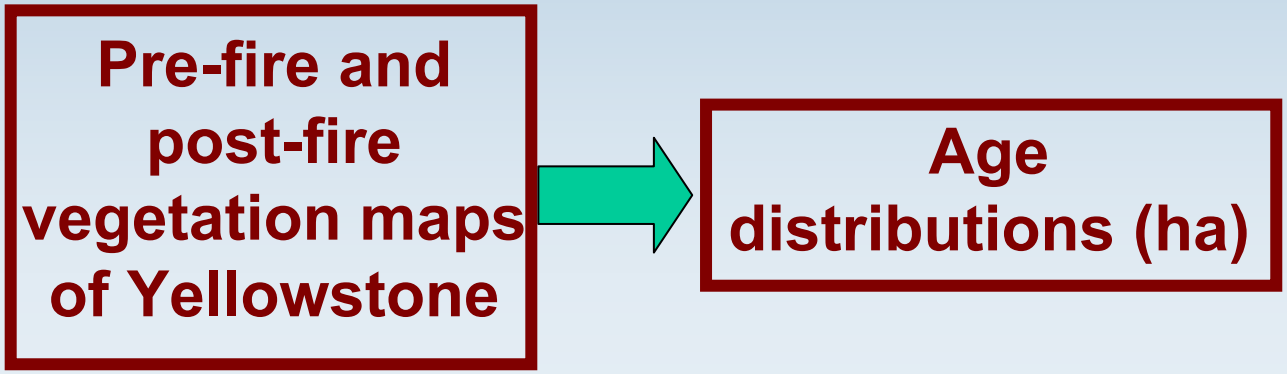
Stand age distributions affect landscape NEP

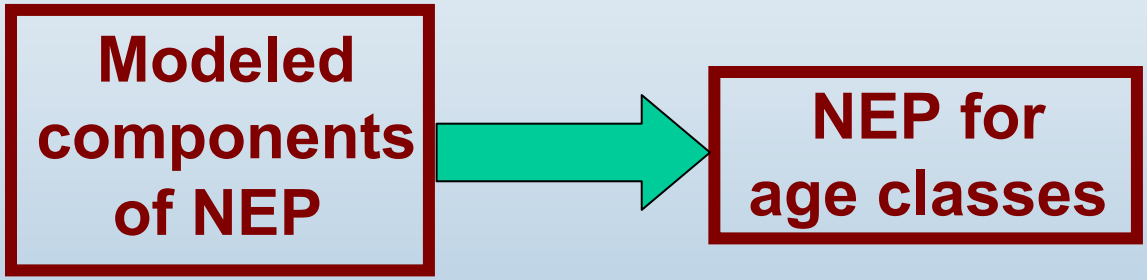
Modeling future landscape C storage for Yellowstone after 1988

Pre-fire and post-fire vegetation maps of Yellowstone

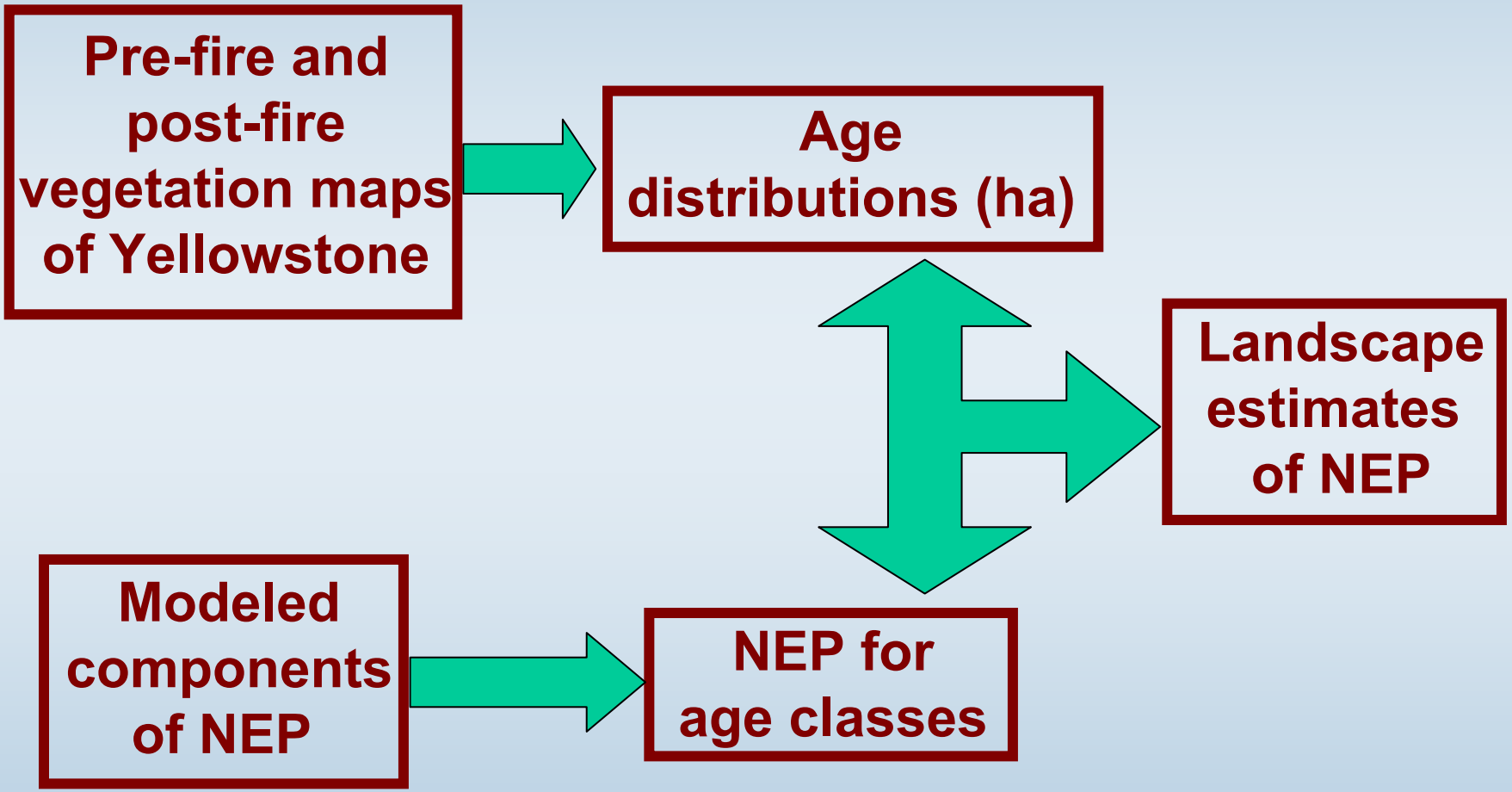
Modeled components of NEP

Modeling future landscape C storage for Yellowstone after 1988

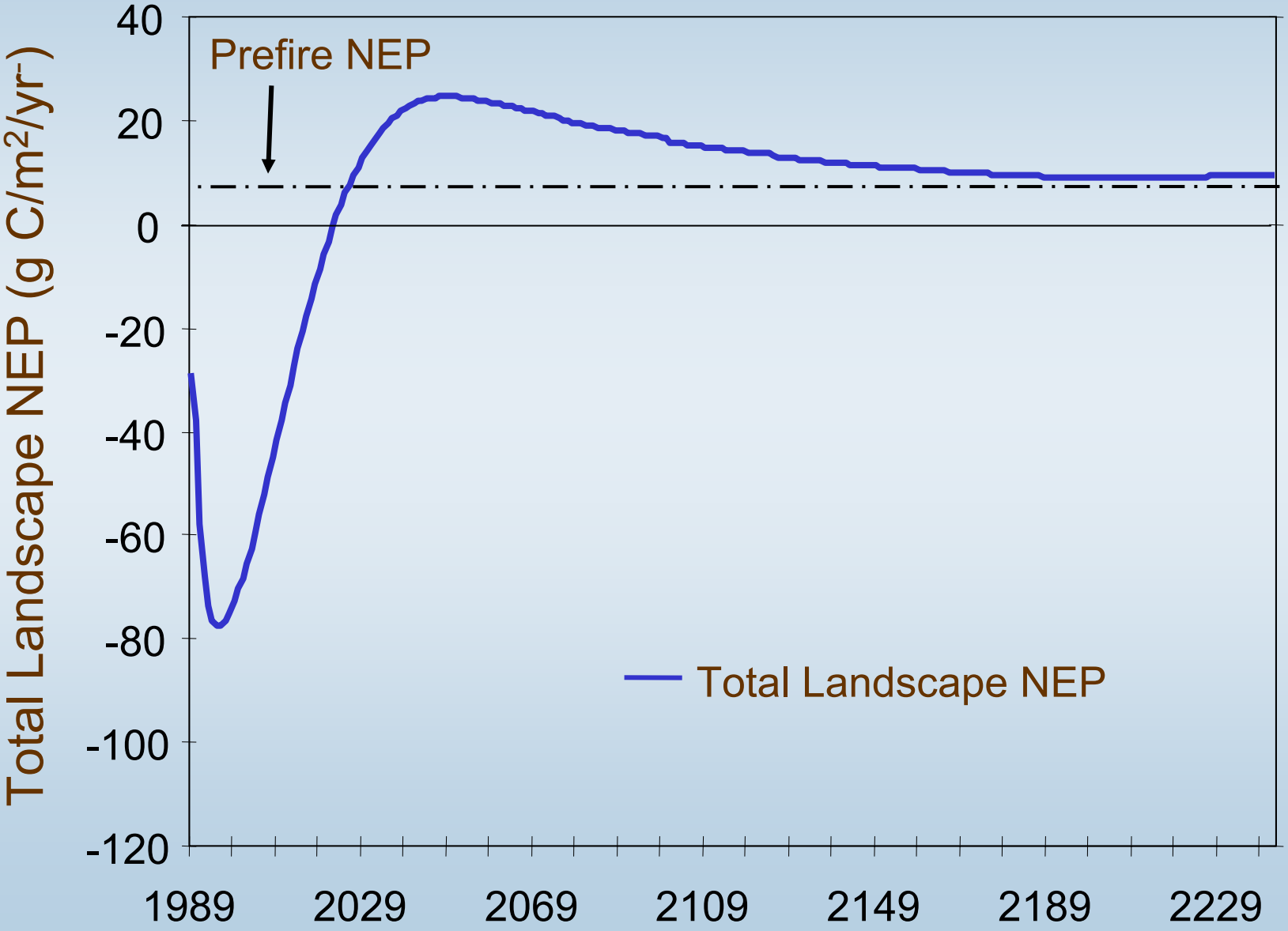




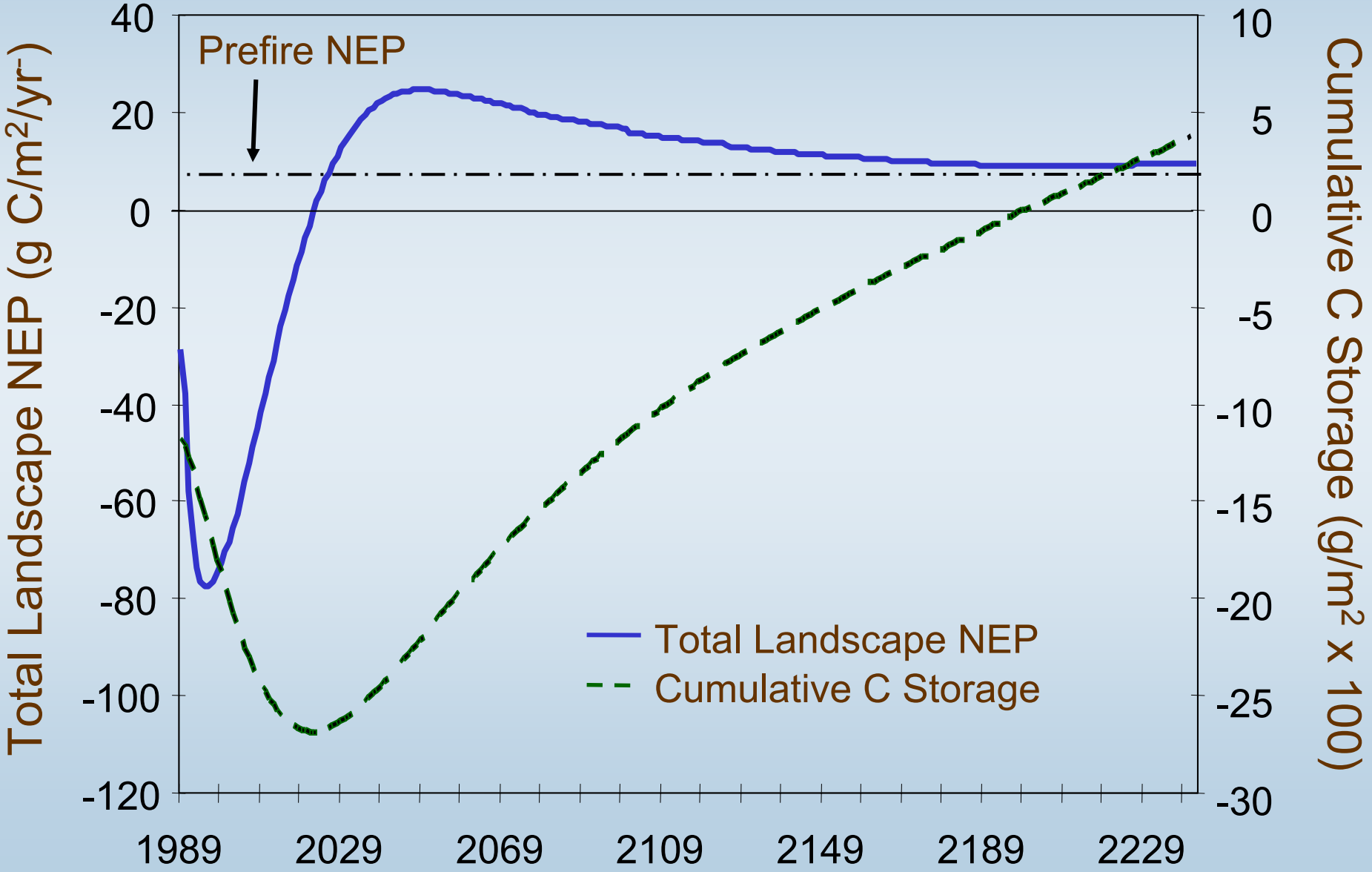
Modeling future landscape C storage for Yellowstone after 1988



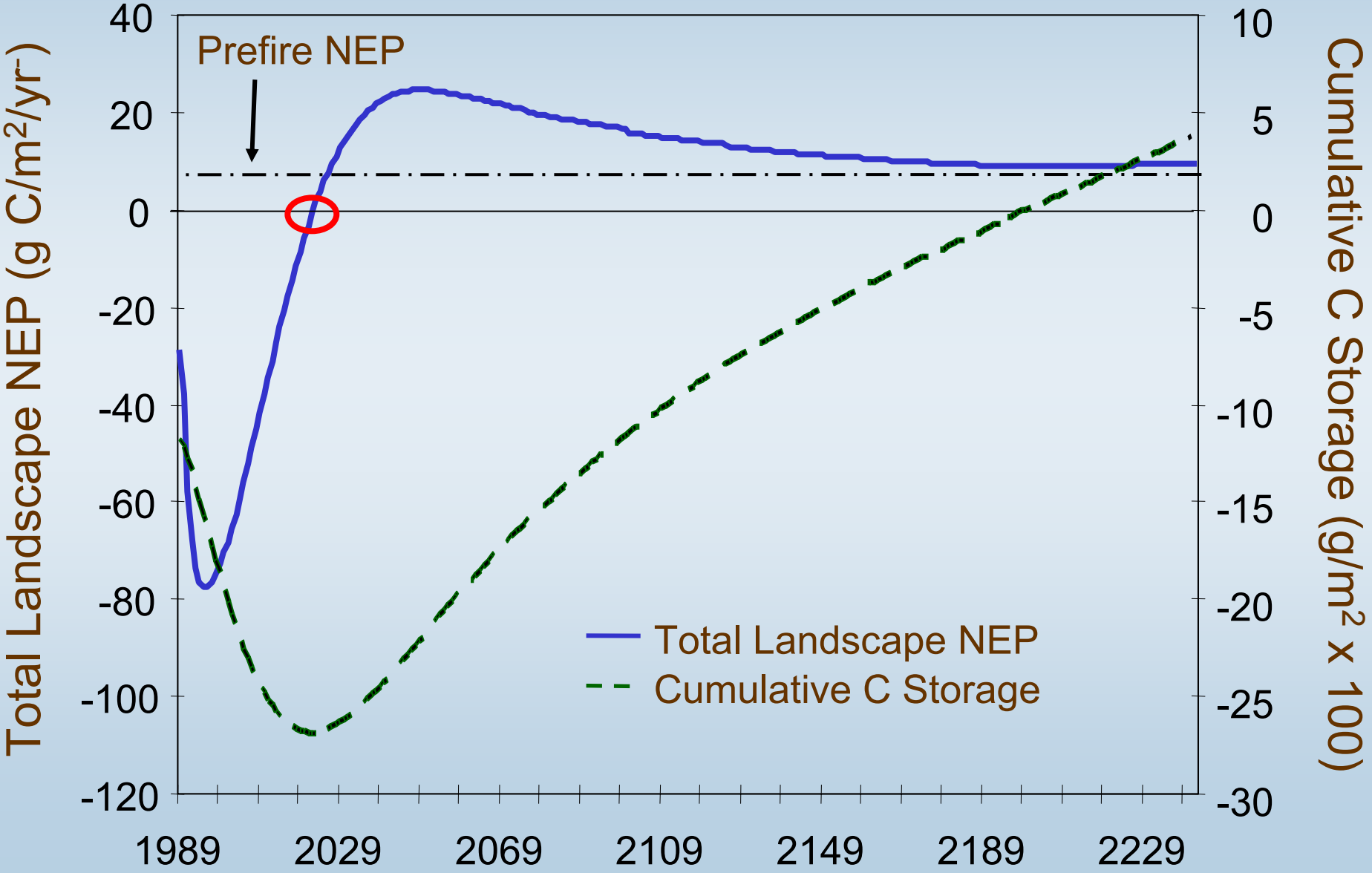
Long-term changes in C storage for Yellowstone



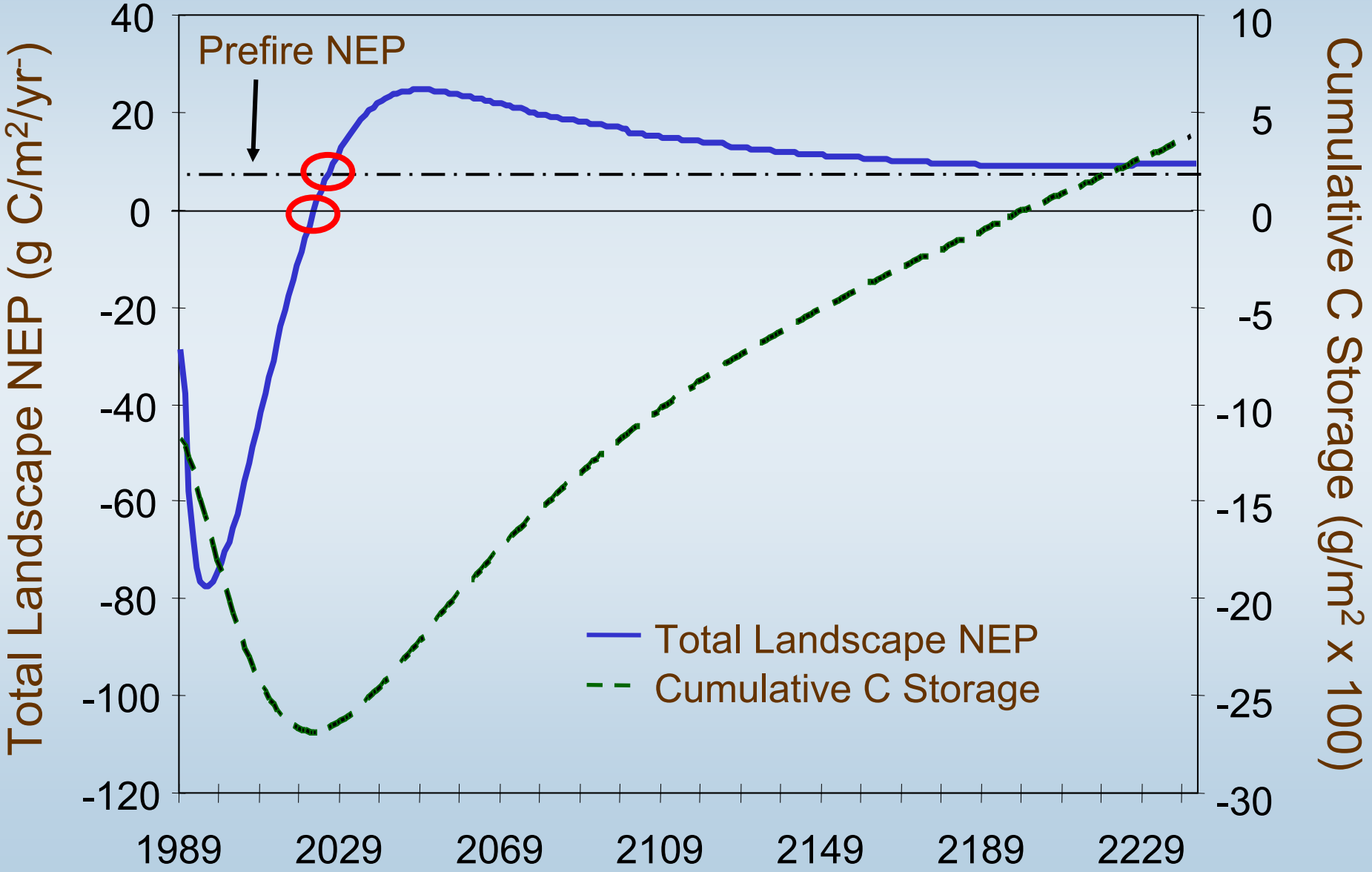
Long-term changes in C storage for Yellowstone



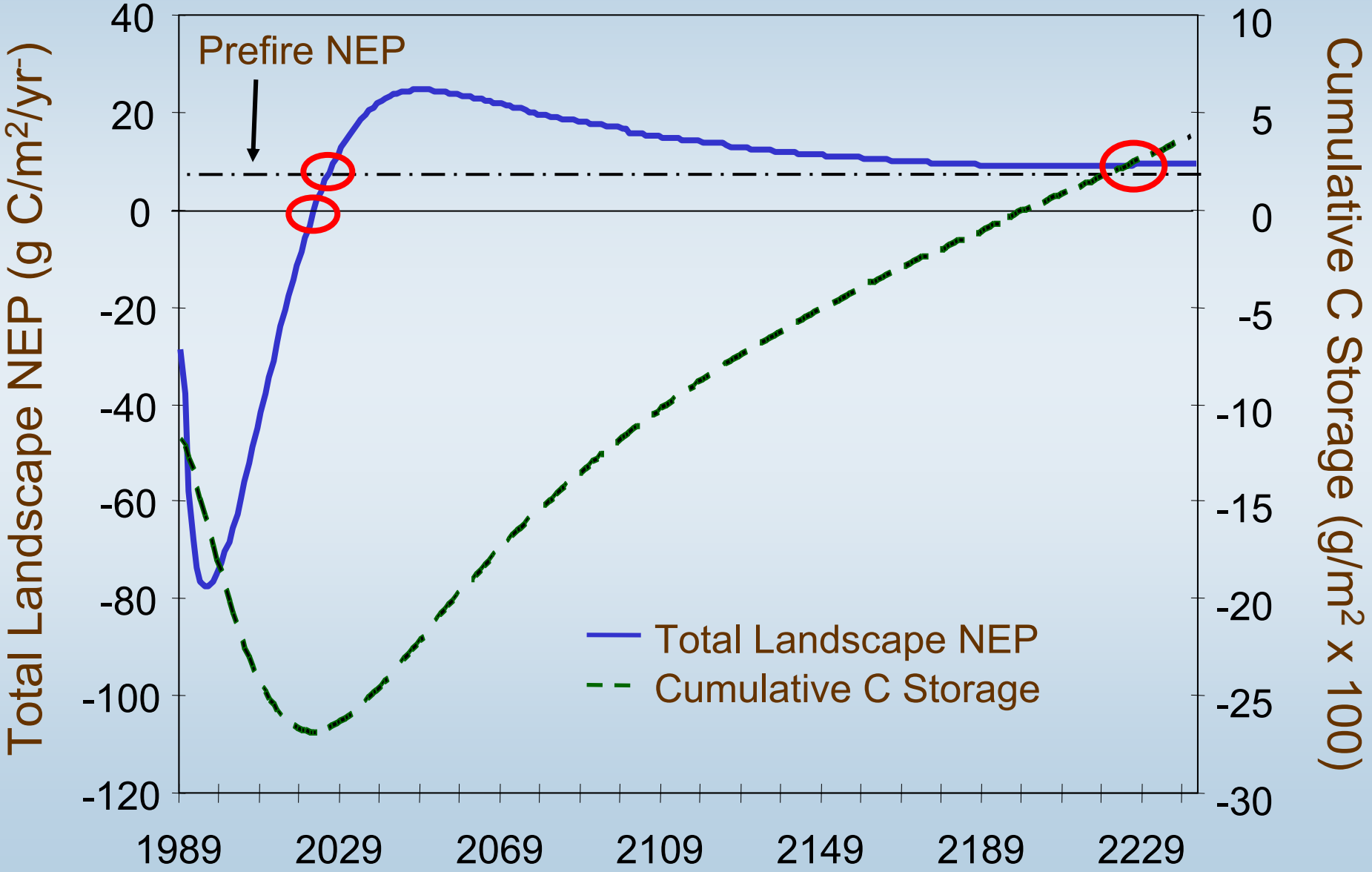
Long-term changes in C storage for Yellowstone



Long-term changes in C storage for Yellowstone



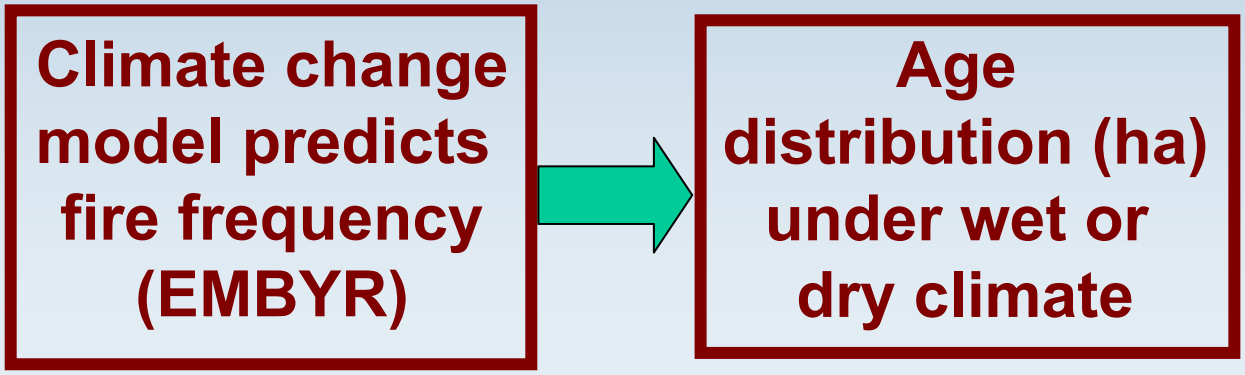
Long-term changes in C storage for Yellowstone



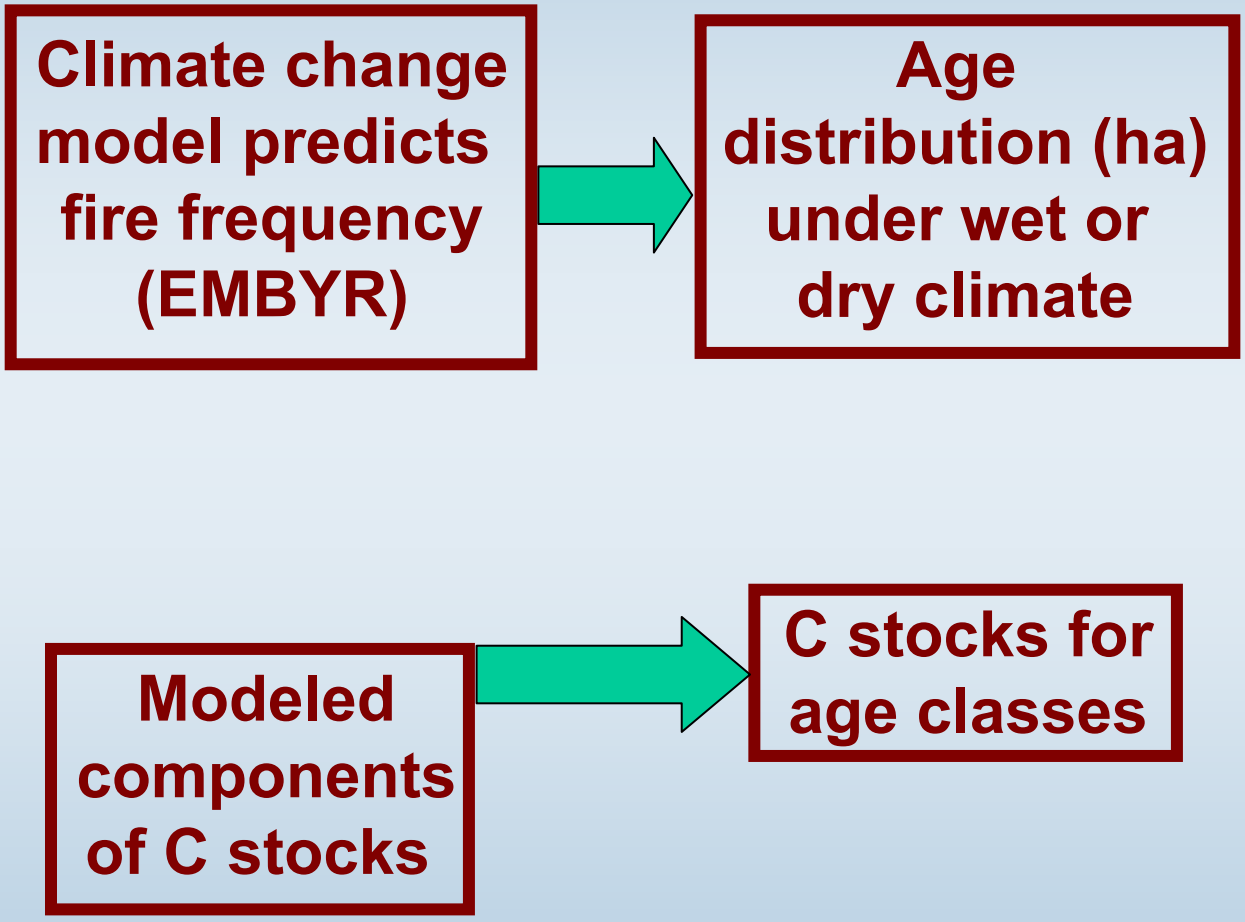
Modeling stand age and density effects on landscape C storage

Climate change model predicts fire frequency (EMBYR)

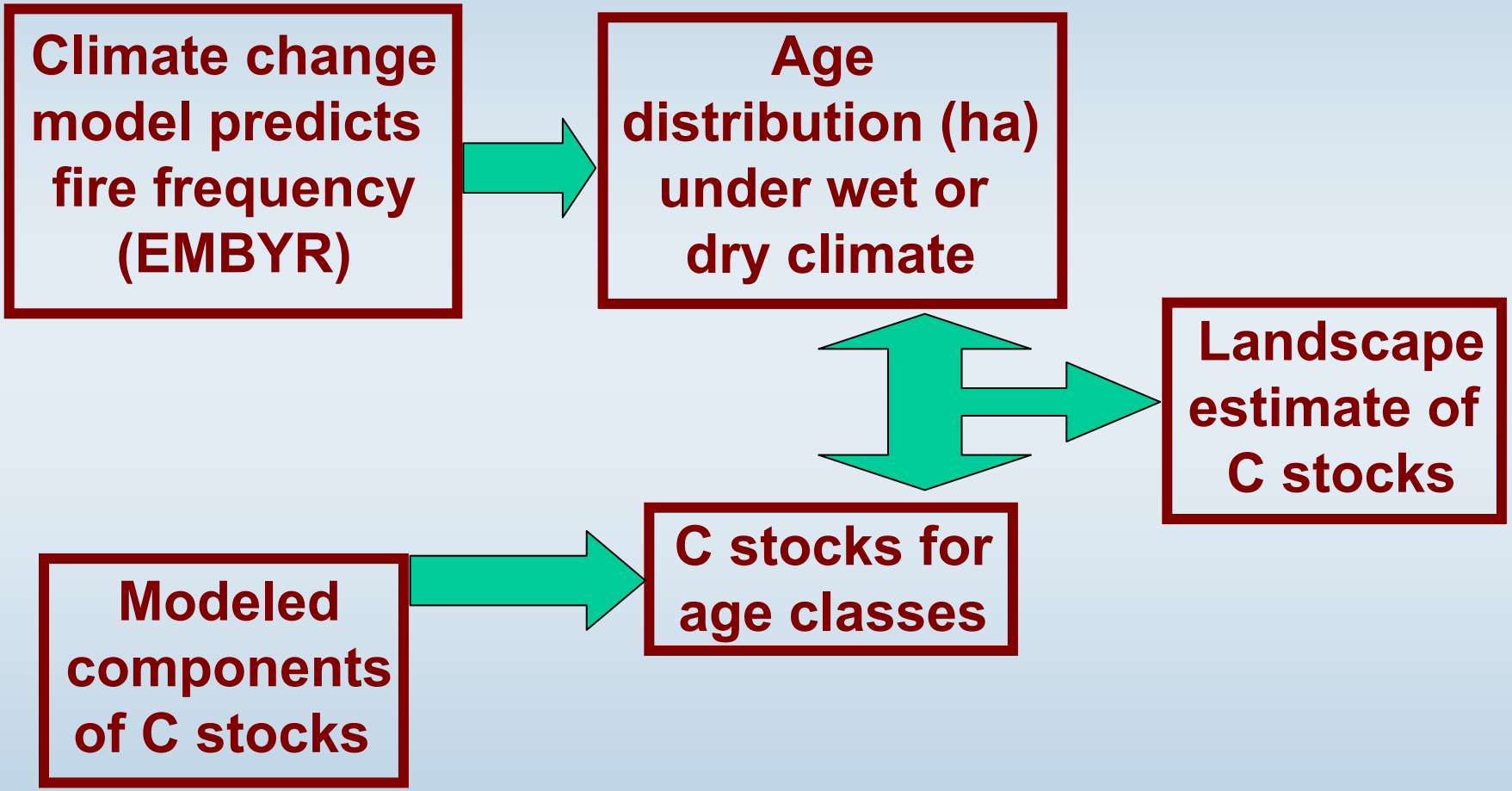
Modeling stand age and density effects on landscape C storage



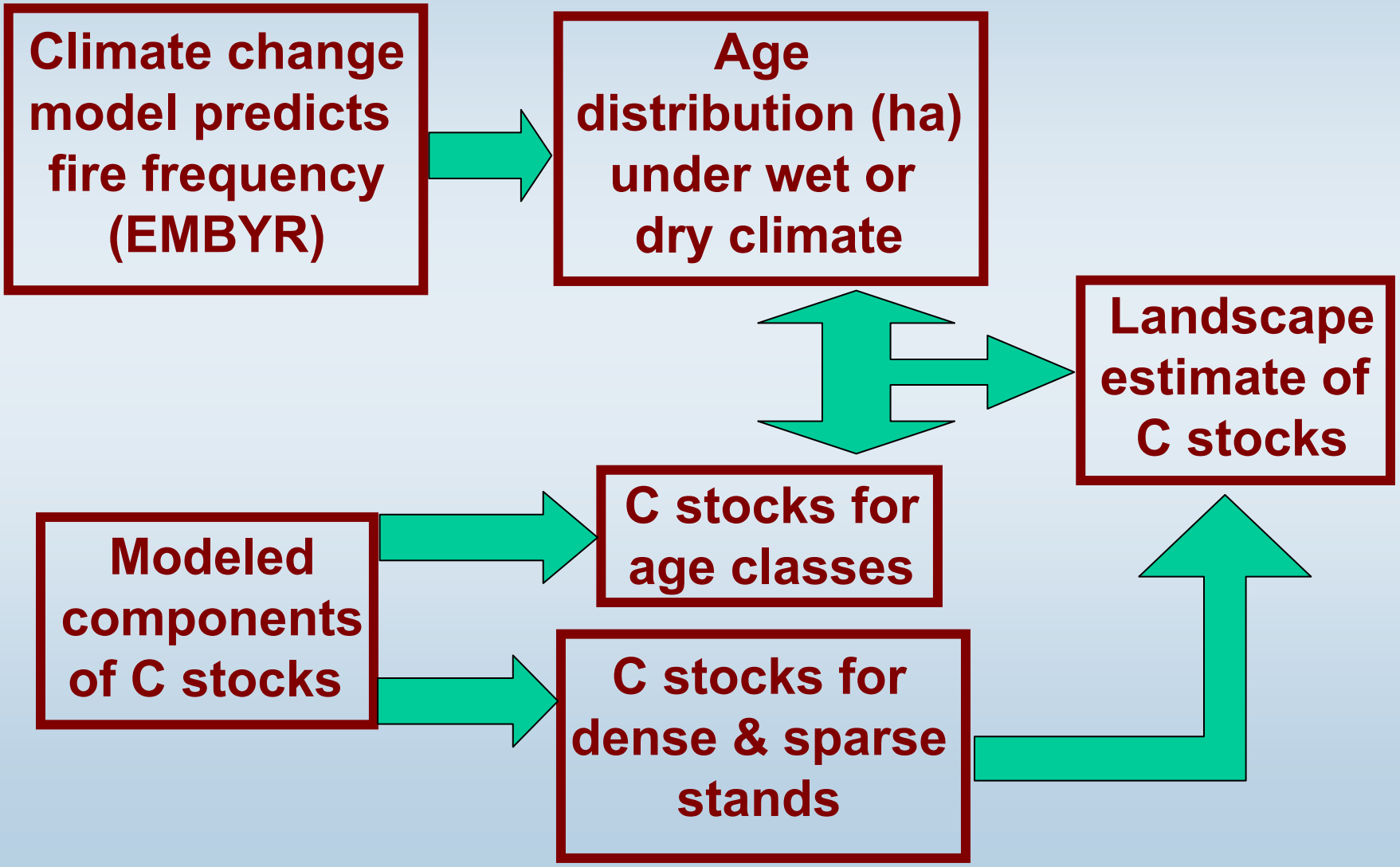
Modeling stand age and density effects on landscape C storage



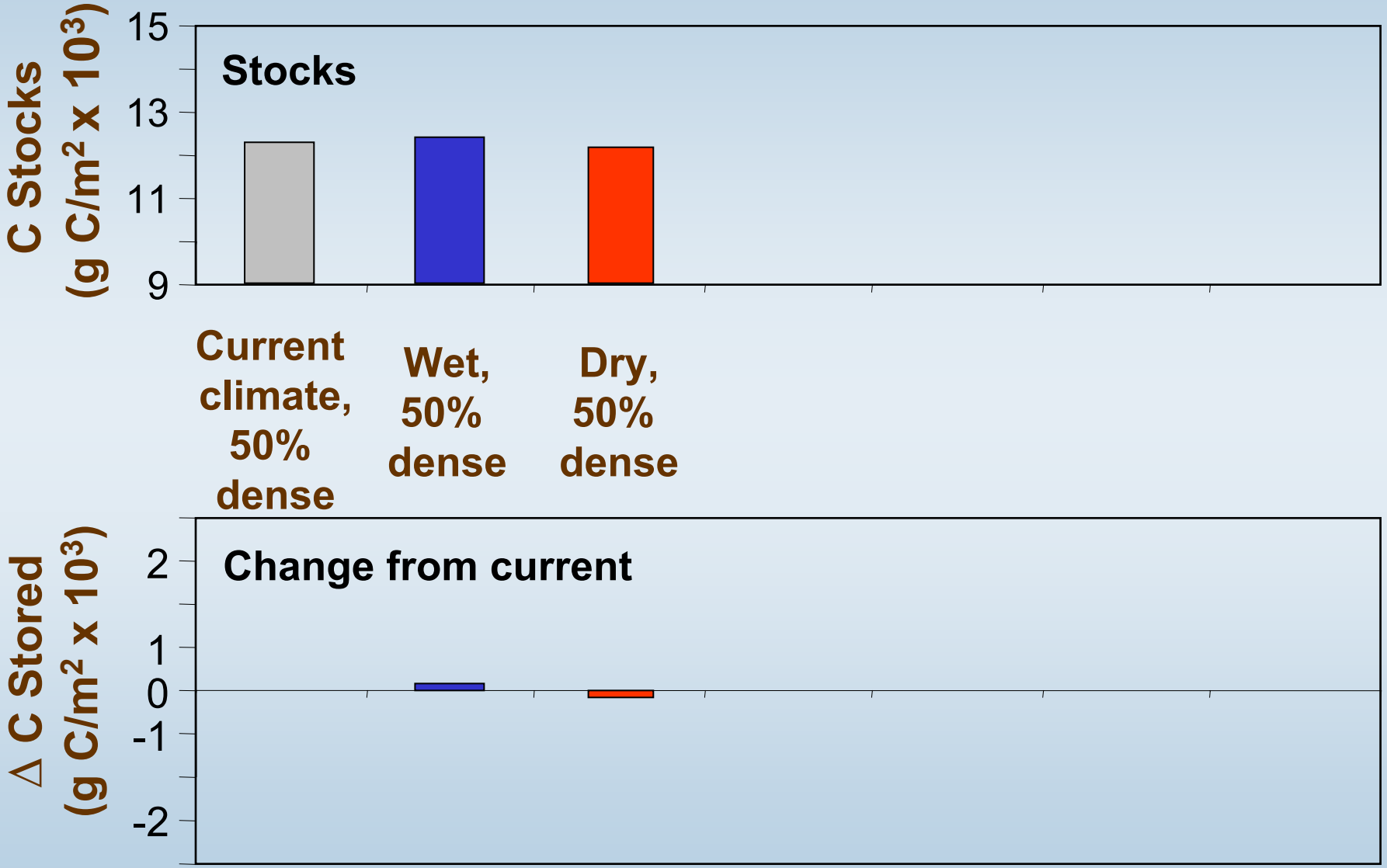
Modeling stand age and density effects on landscape C storage



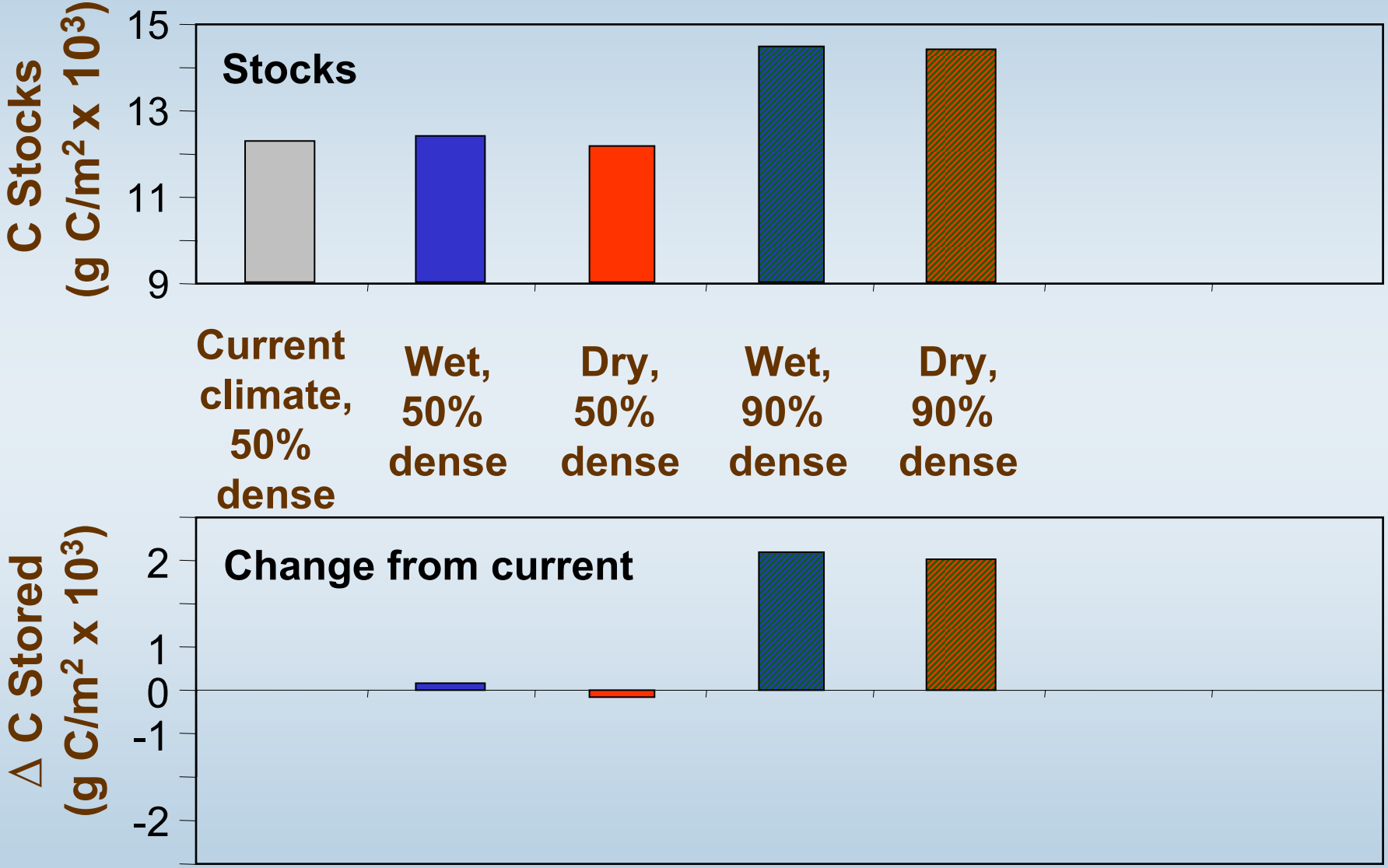
Modeling stand age and density effects on landscape C storage



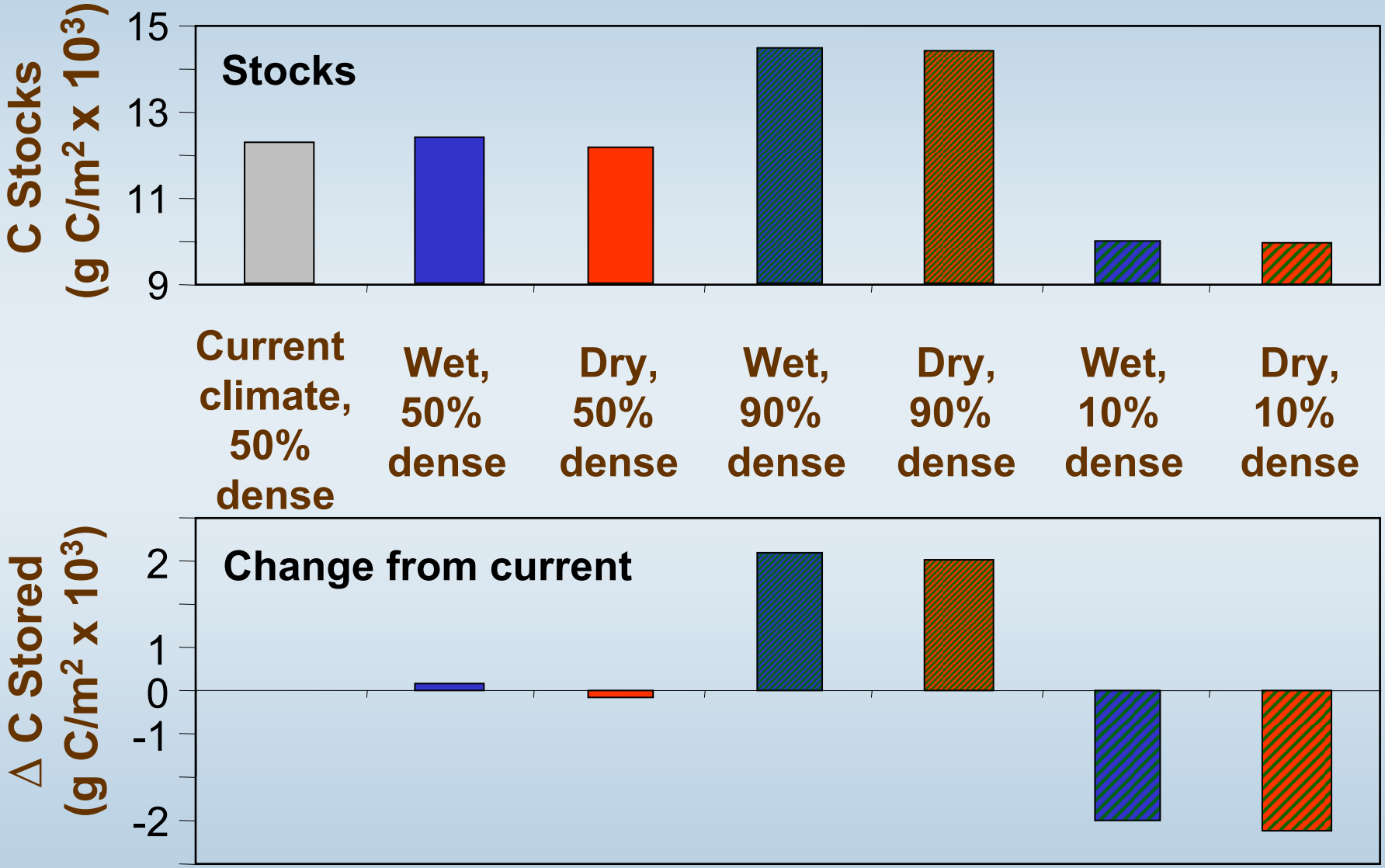
Stand age and density effects on C storage



Stand age and density effects on C storage



Stand age and density effects on C storage



Conclusions:

- The post-1988 Yellowstone landscape will recover all carbon lost within the fire cycle (~230 years), but it is currently a large source of C to the atmosphere.

Conclusions:

- The post-1988 Yellowstone landscape will recover all carbon lost within the fire cycle (~230 years), but it is currently a large source of C to the atmosphere.

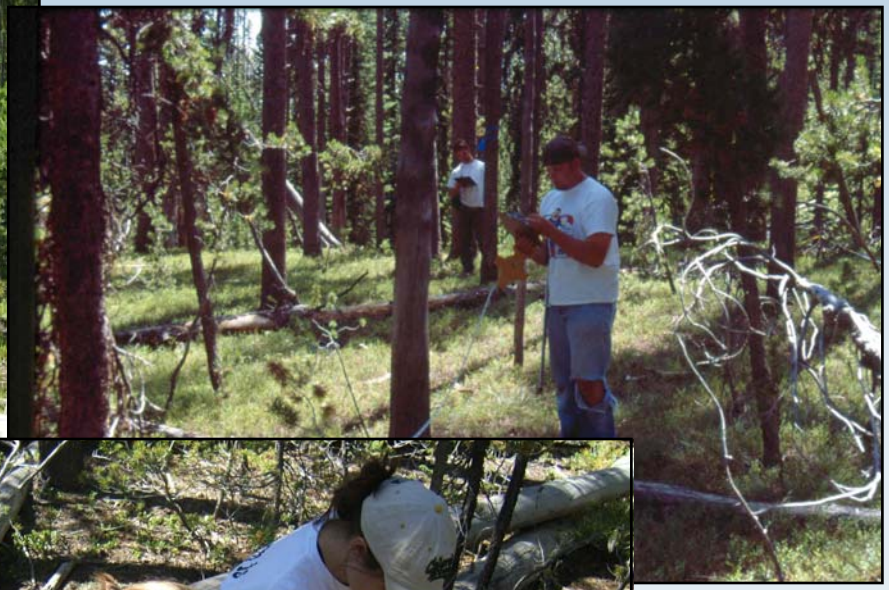
- Equilibrium C storage is resistant to changes in disturbance regimes at landscape scales.

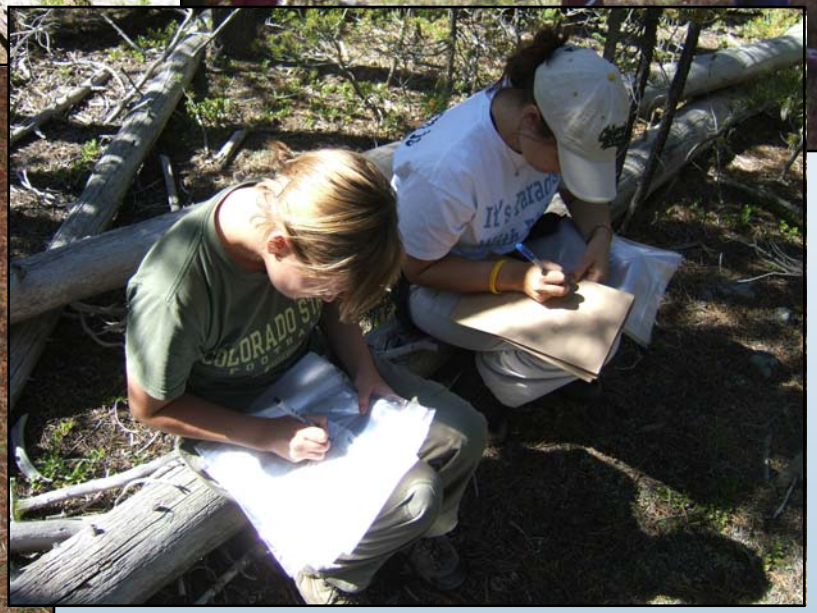
Conclusions:

- The post-1988 Yellowstone landscape will recover all carbon lost within the fire cycle (~230 years), but it is currently a large source of C to the atmosphere.

- Equilibrium C storage is resistant to changes in disturbance regimes at landscape scales.

- Large changes in the distribution of stand densities on the landscape are necessary to shift its ability to store carbon.





Modeling C storage for Yellowstone

Area: 525,000 ha of lodgepole pine forests

Prefire NEP:
~ 4.82 g C/m^2/yr

C lost during 1988 fires:
1360 g C/m^2 (275 cars)

Post-fire C loss though decomposition:
1530 g C/m^2