Climate Feedback Research: Consequences of climate and disturbance changes for the Carbon feedback in Interior Alaska

Genet H., Zhang Y., McGuire A.D., He Y., Johnson K., D'Amore D., Zhou X., Bennett A., Biles F., Bliss N., Breen A., Euskirchen E.S., Kurkowski T., Pastick N., Rupp S., Wylie B., Zhu Z., Zhuang Q.

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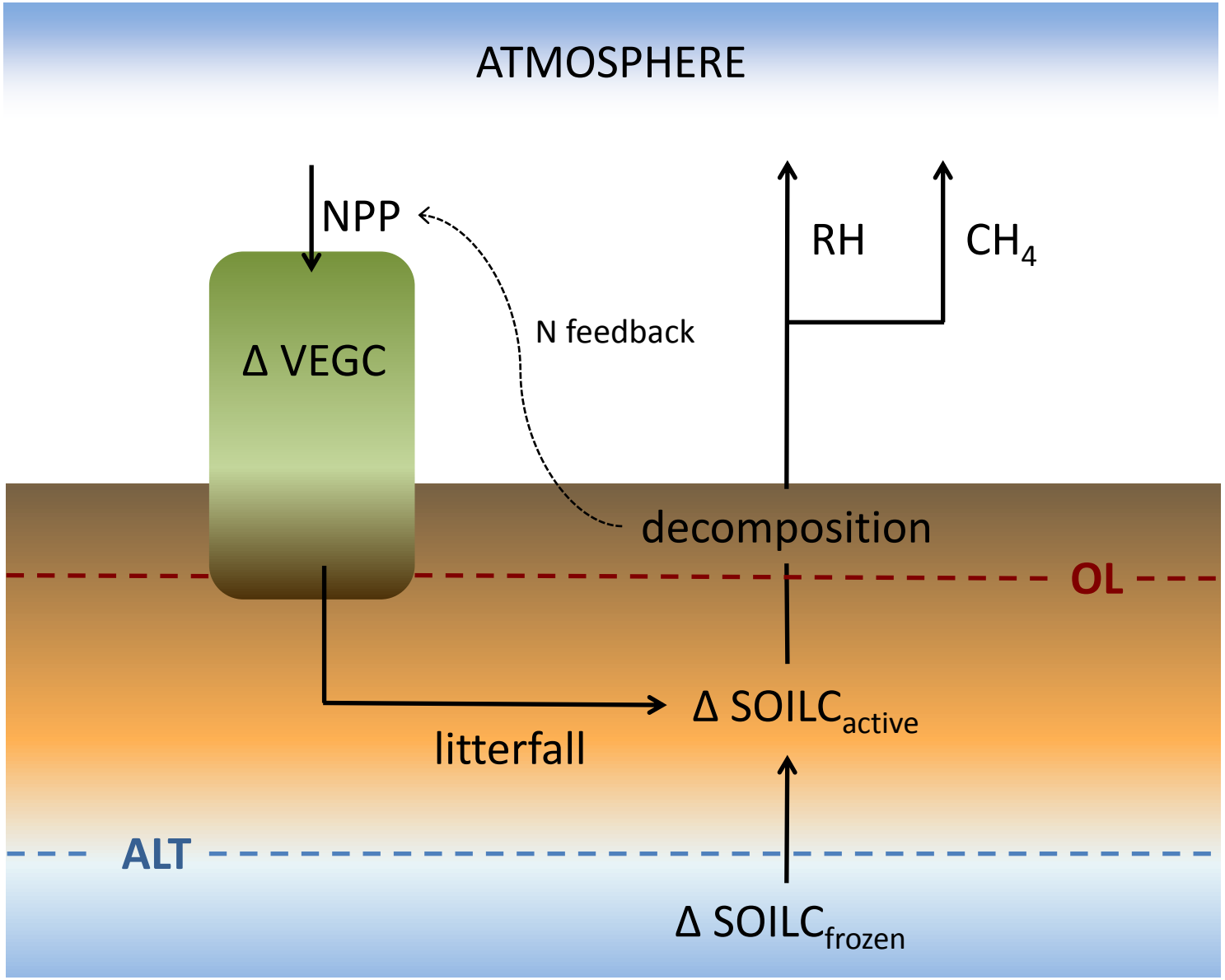
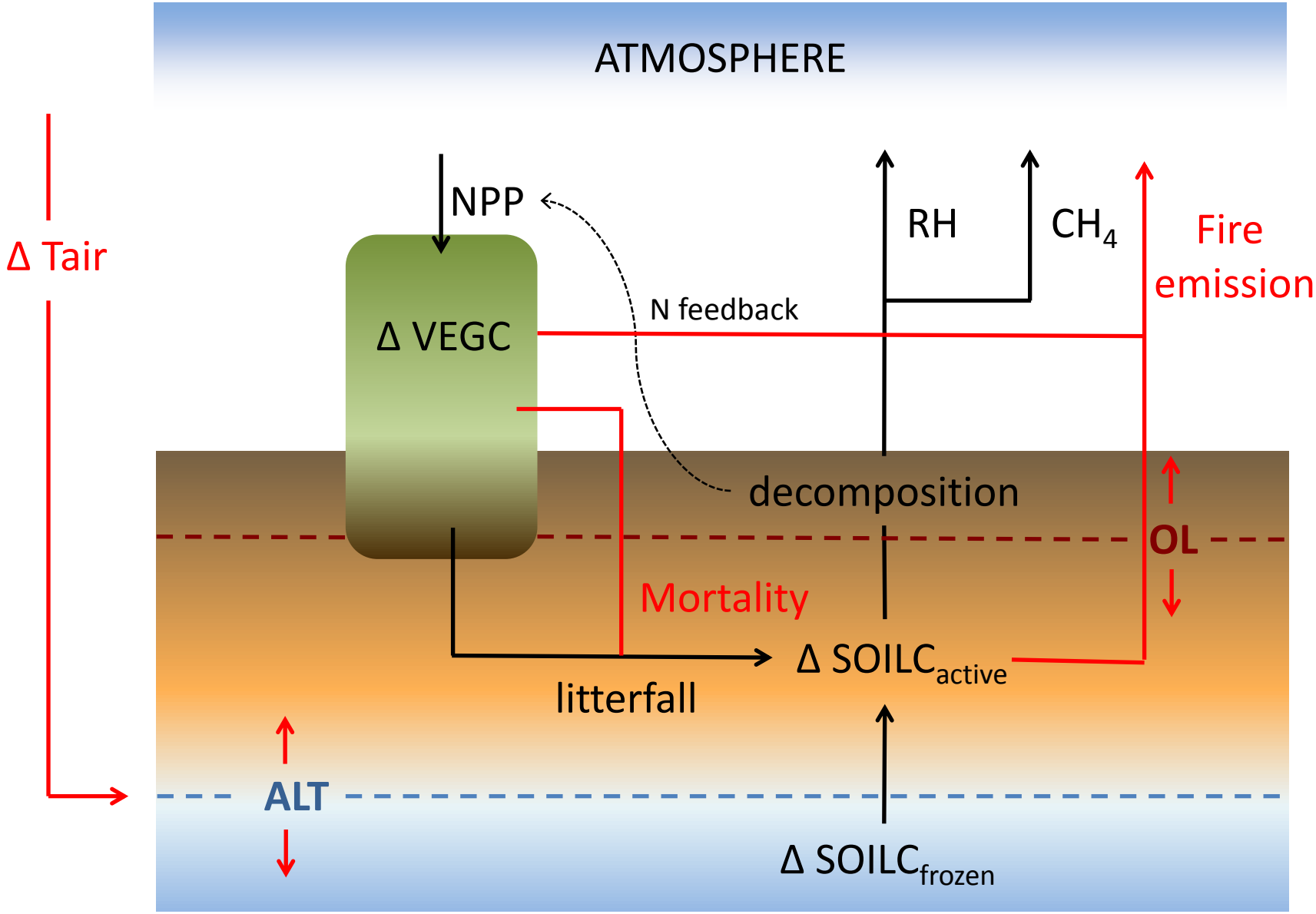
Patrick Endres, AK photographics

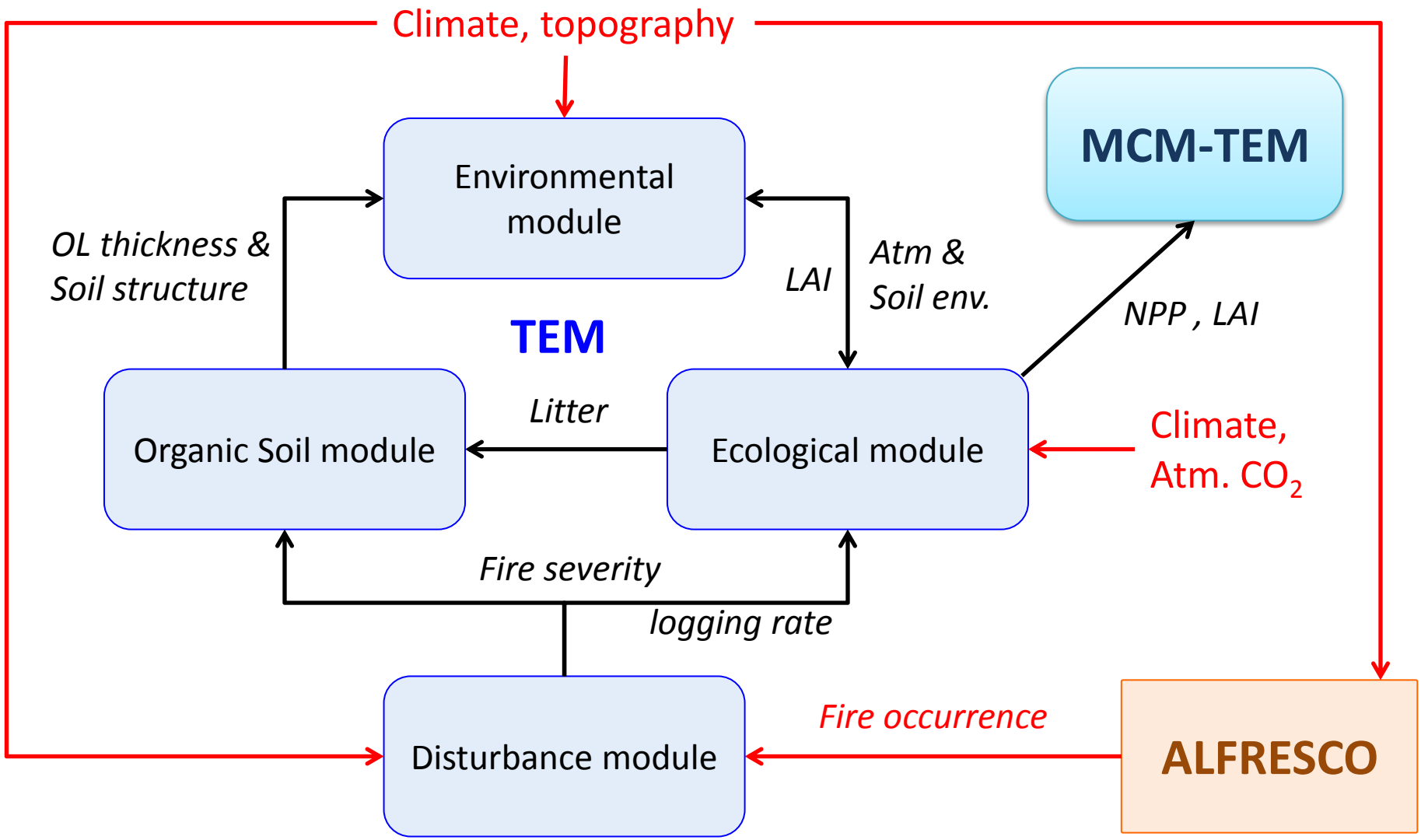


(modified from Hayes et al. 2014)

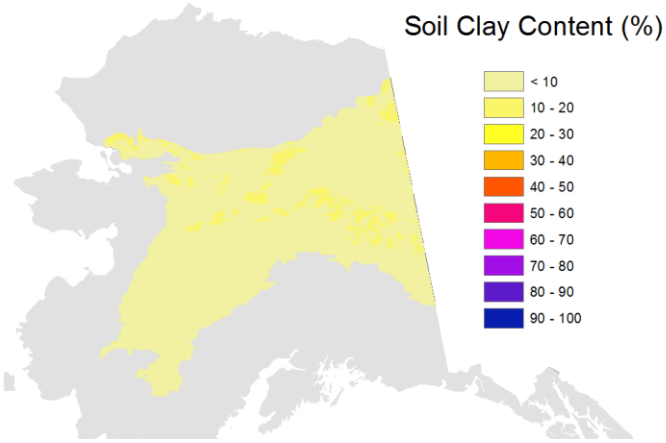


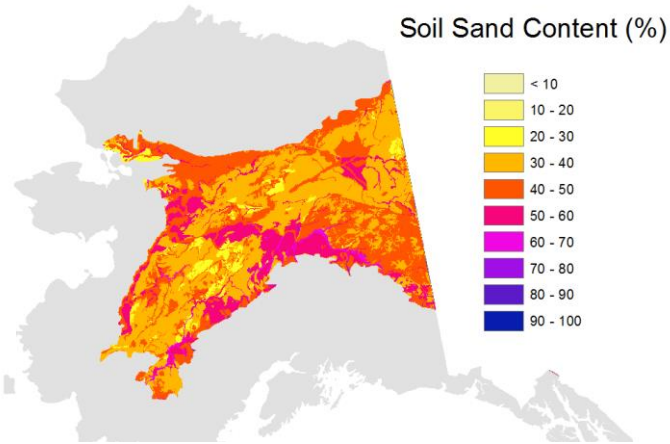
(modified from Hayes et al. 2014)

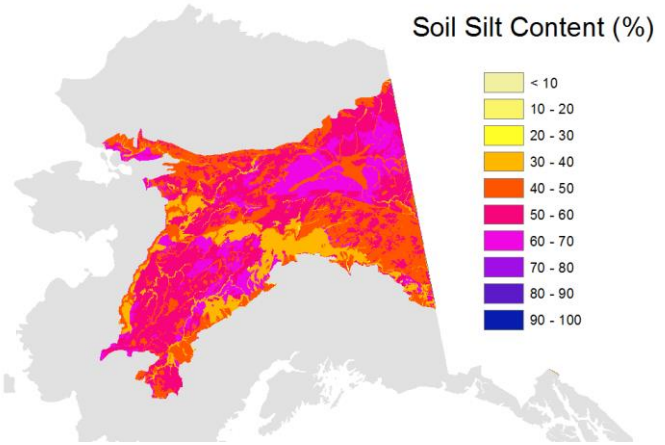
Modeling framework

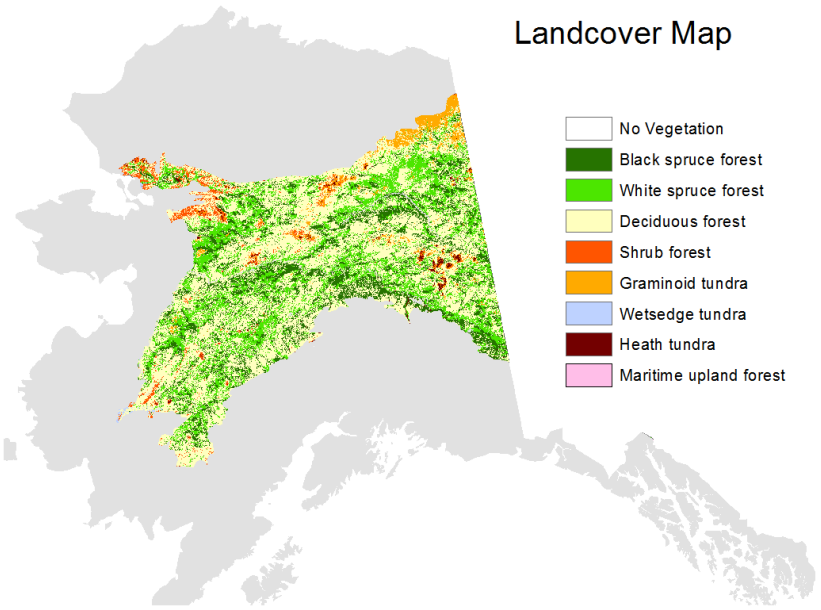


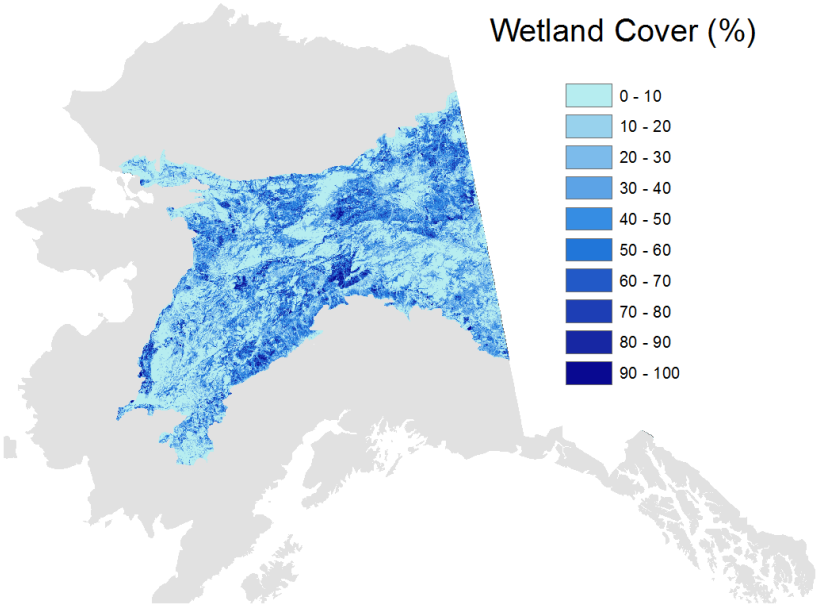
Environmental Drivers



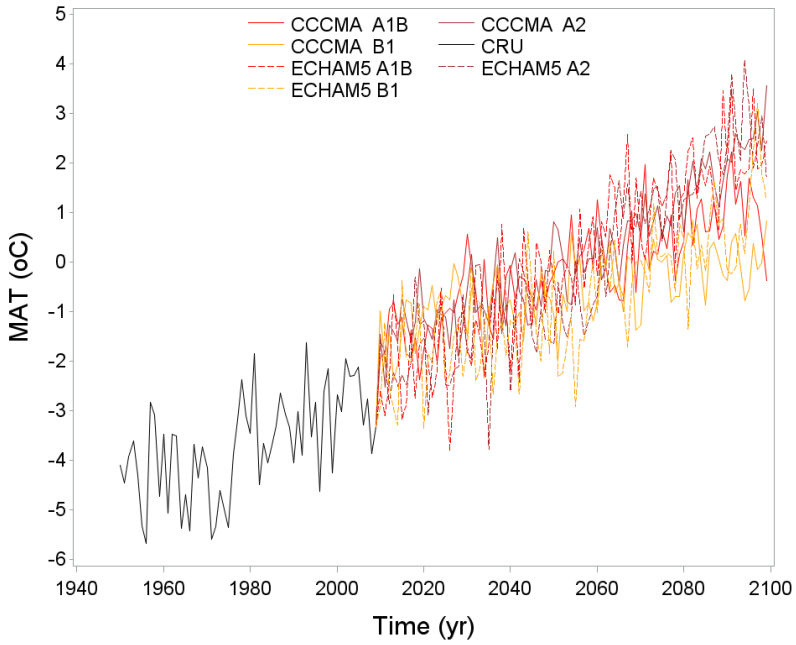


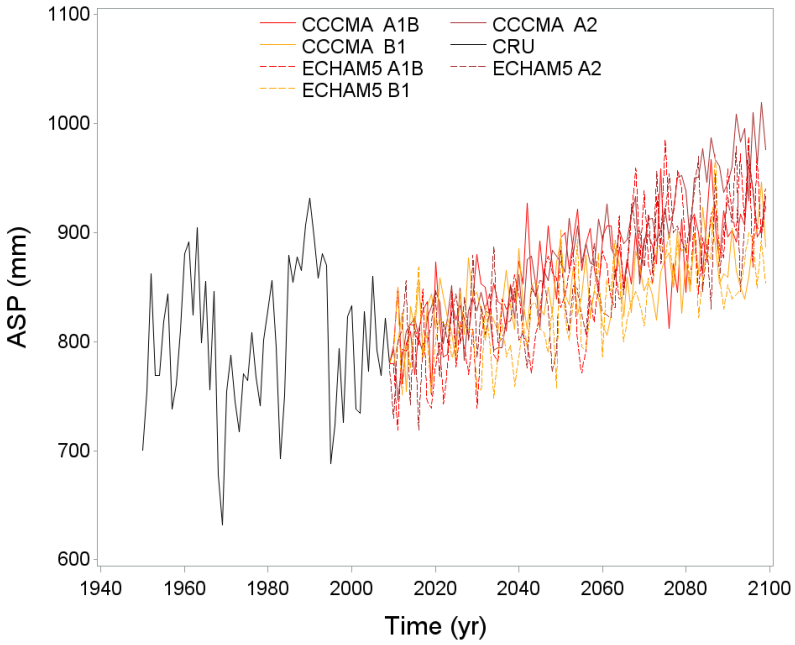






Climate Drivers

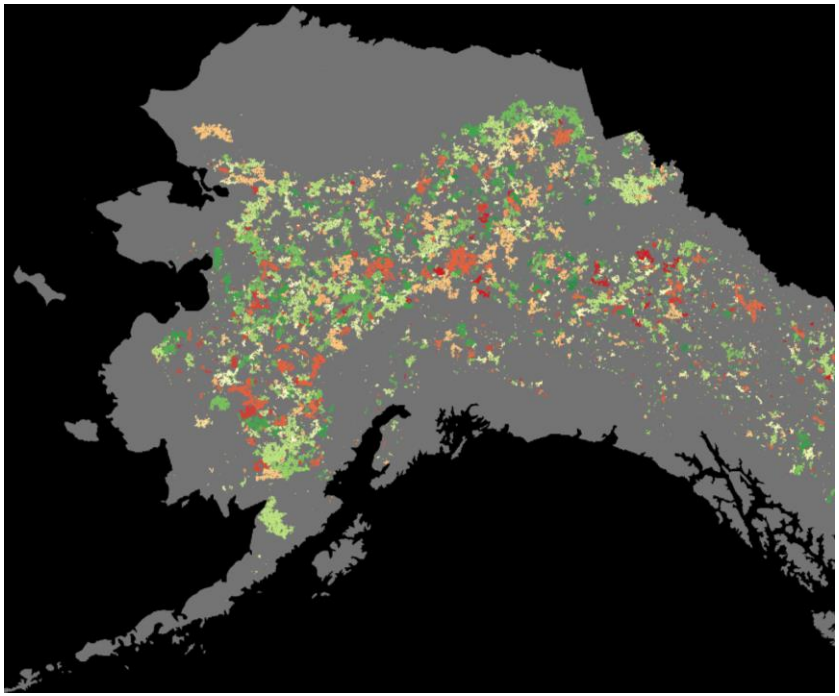




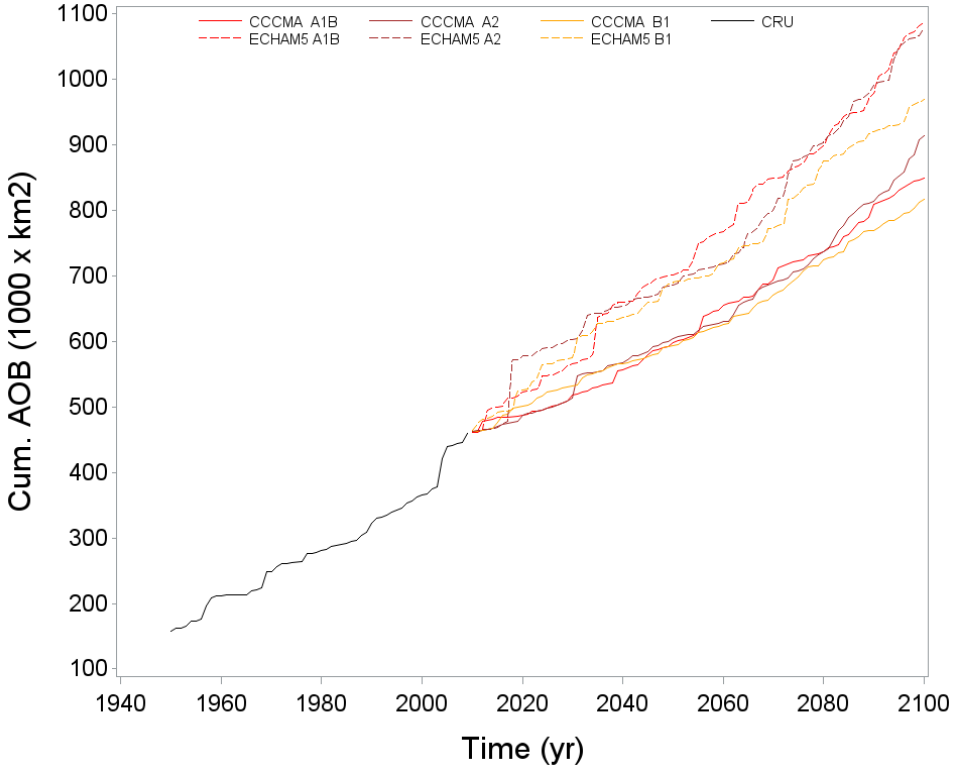
Mean Annual Temperature (MAT) and Annual Sum of Precipitation (ASP) from 1950 to 2100 summarized for the simulation extent. The black line represents the CRU data for the historical period and the colored lines represent the CCCMA (solid) and ECHAM5 (dotted) projections for the 3 emission scenarios.

SNAP

Disturbance regimes : Fire

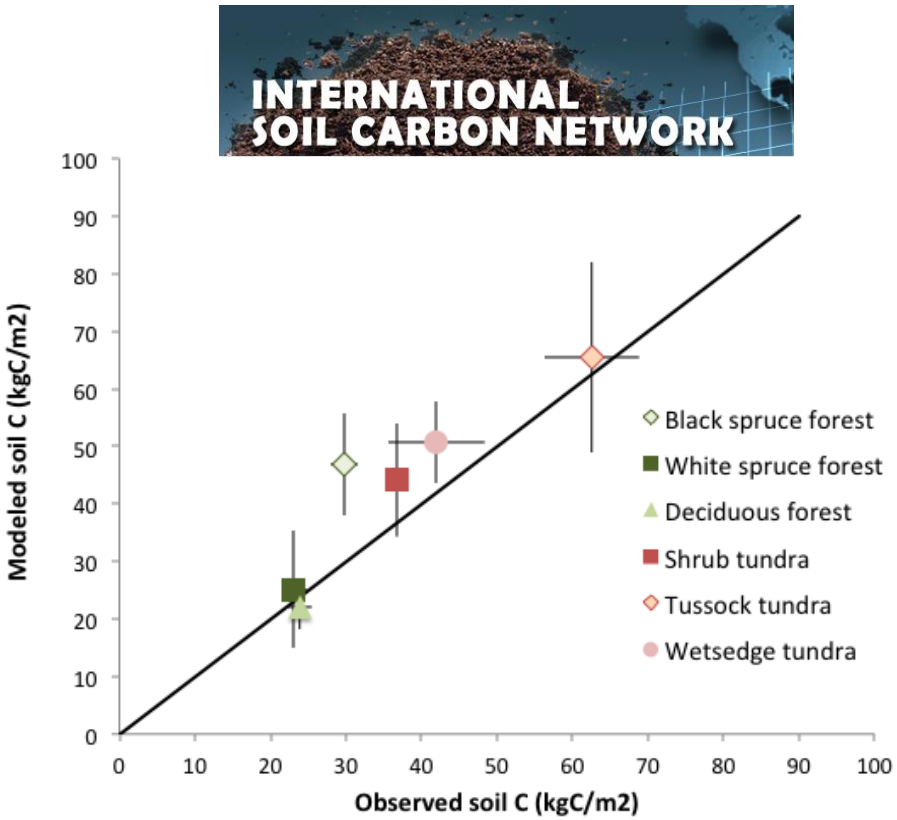


Simulated fire scars for the historical period 1950-2009. Individual fire scar colors indicate age of burn from oldest (red) to youngest (green).

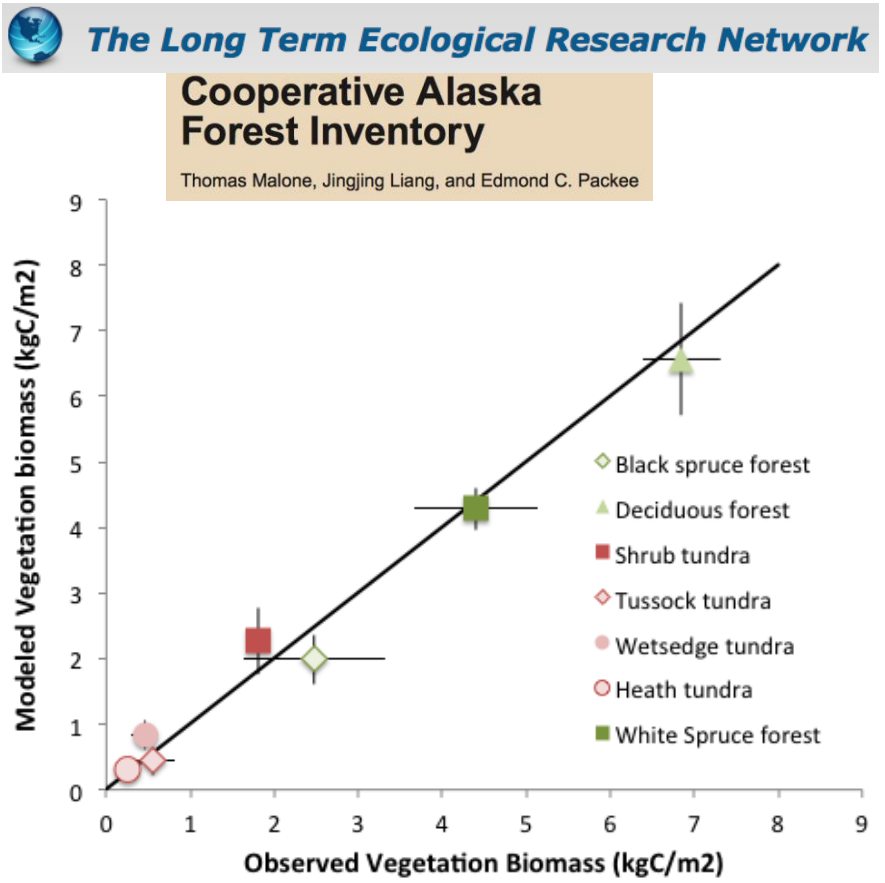


Cumulated area burned for the historical period (black line) are estimated from the Alaskan Large Fire Databases. Projections from 2009 to 2100 are simulated by ALFRESCO for the 6 climate scenarios.

Evaluate TEM performances

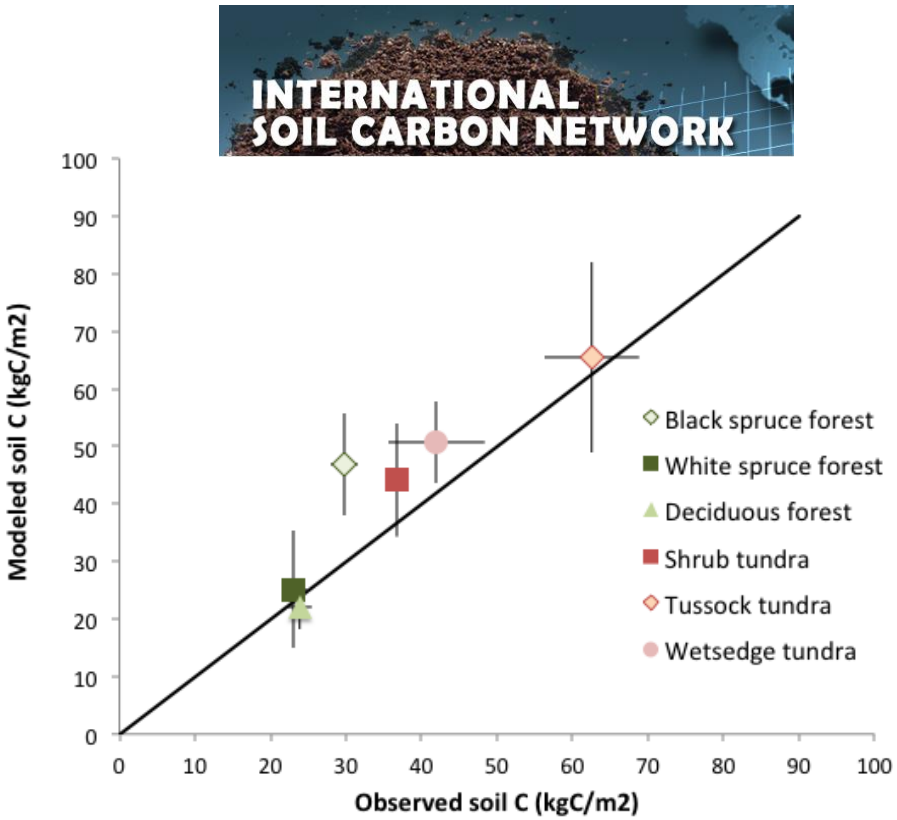


TEM soil C stocks compared with soil C stocks based on 315 samples collected in Alaska (Johnson et al. 2011). Both simulated and observed soil C stock estimates are for the organic and 0-1m mineral horizons.



Evaluation of TEM for vegetation biomass using data from 190 permanent study plots of the Cooperative Alaska Forest Inventory (CAFI) for boreal forest communities and LTER data for the arctic tundra communities.

Evaluate TEM performances



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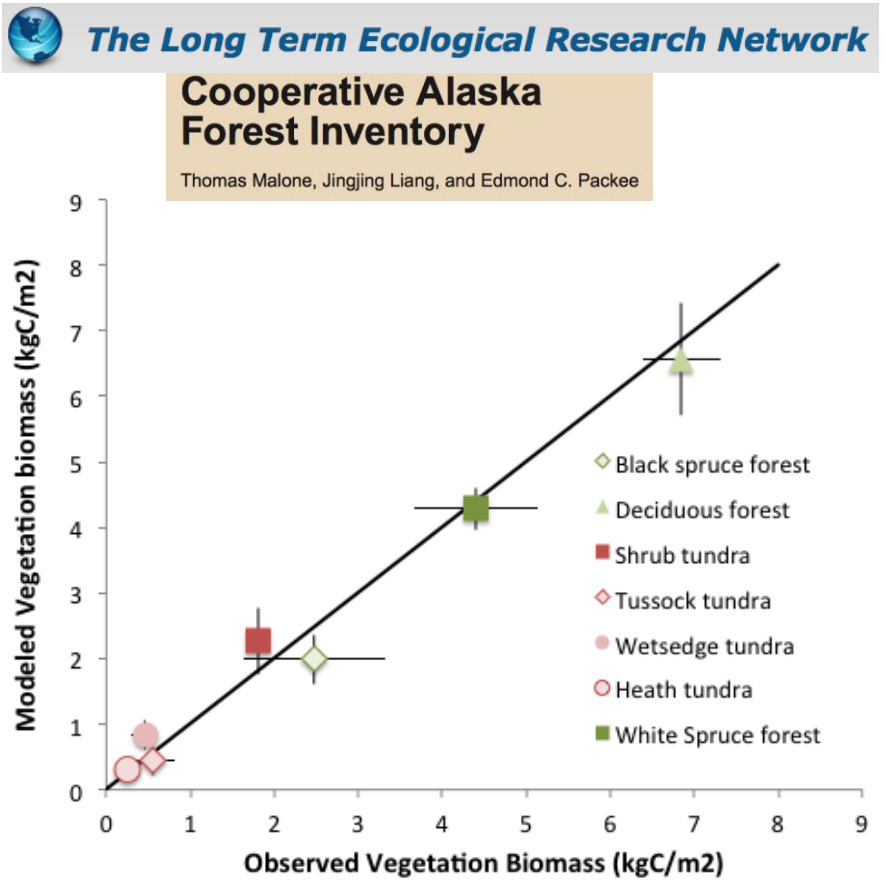
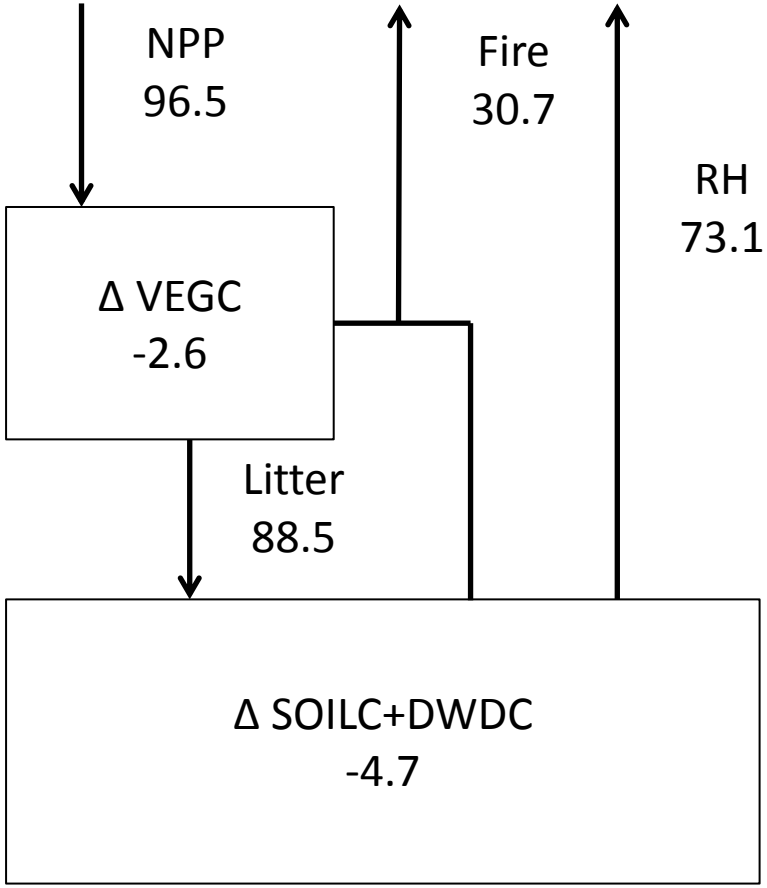


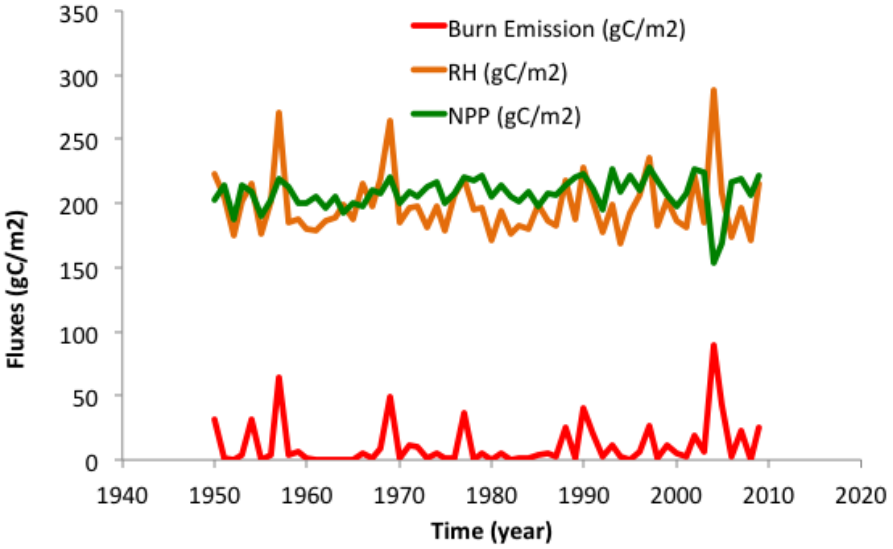
Evaluation of TEM for vegetation biomass using data from 190 permanent study plots of the Cooperative Alaska Forest Inventory (CAFI) for boreal forest communities and LTER data for the arctic tundra communities.

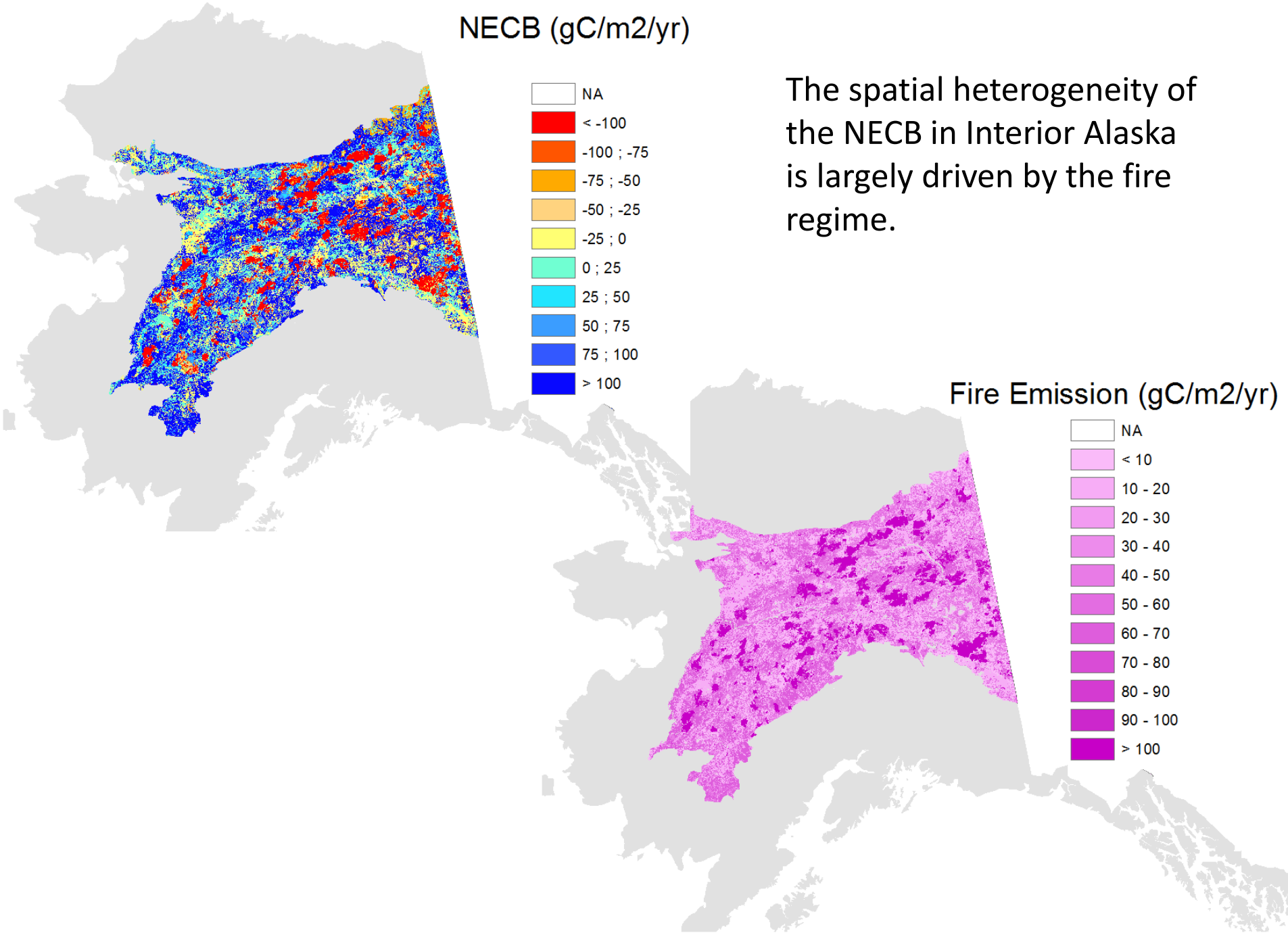
Historical change in Net Ecosystem C balance [1950-2009]



Unit = *TgC*/yr

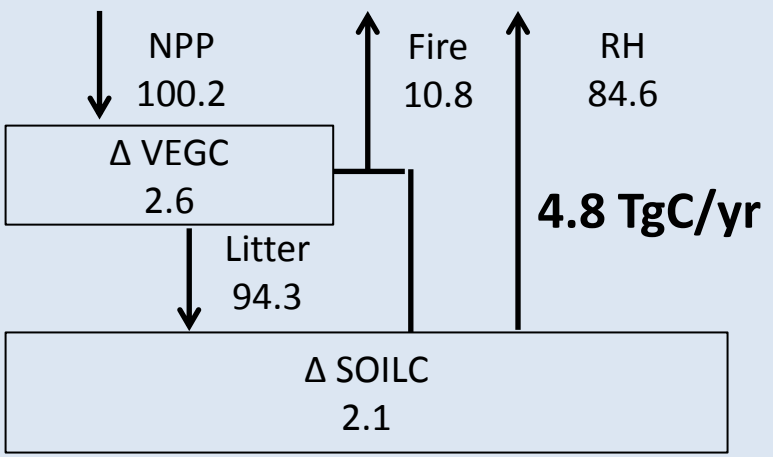
- -7.3 TgC/yr were lost on average between 1950 and 2009 in Interior Alaska.
- The loss over the 60 year period is primarily driven by unprecedented fire emissions during the decade of 2000s (record fire years in 2004 and 2005).

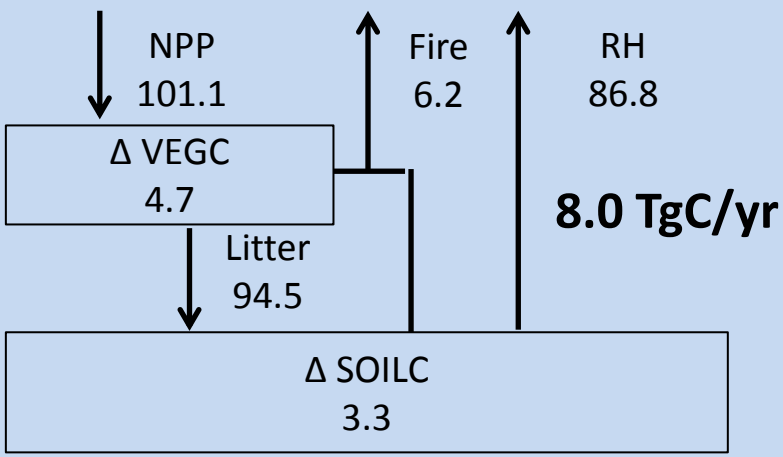




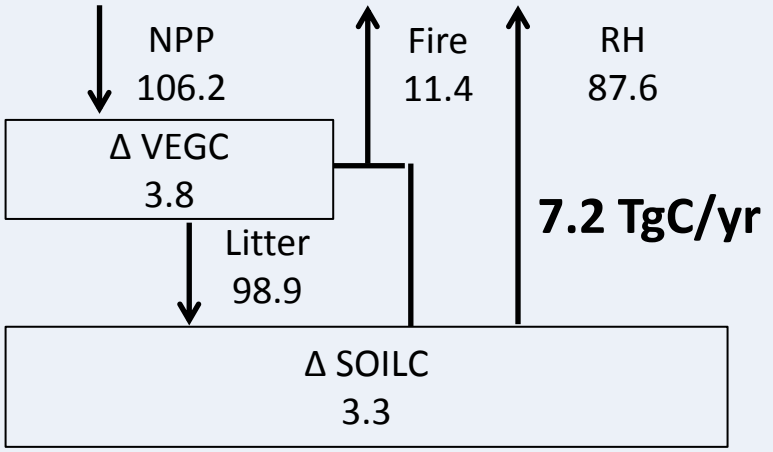
The spatial heterogeneity of the NECB in Interior Alaska is largely driven by the fire regime.

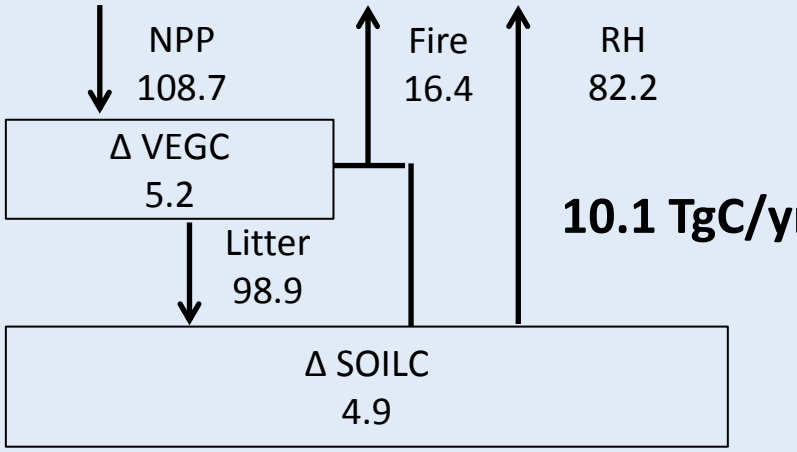
B1


NPP
100.2
Fire
10.8
RH
84.6
Δ VEGC
2.6
Litter
94.3
4.8 TgC/yr
Δ SOILC
2.1

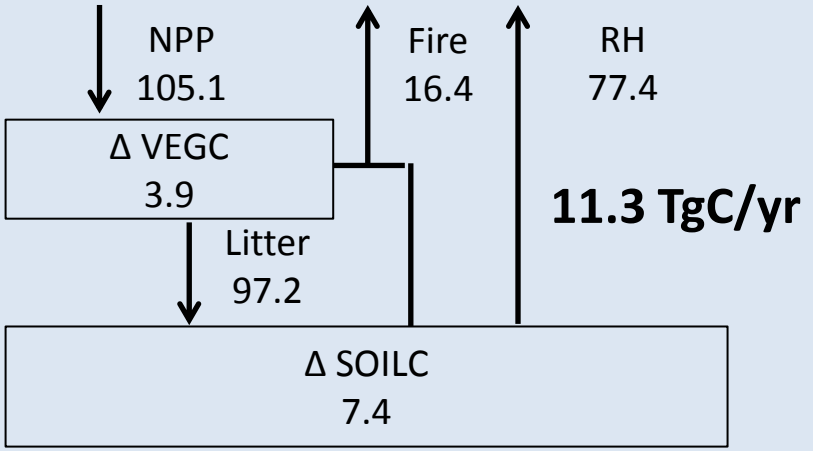

NPP
101.1
Fire
6.2
RH
86.8
Δ VEGC
4.7
Litter
94.5
8.0 TgC/yr
Δ SOILC
3.3

A1B


NPP
106.2
Fire
11.4
RH
87.6
Δ VEGC
3.8
Litter
98.9
7.2 TgC/yr
Δ SOILC
3.3


NPP
108.7
Fire
16.4
RH
82.2
Δ VEGC
5.2
Litter
98.9
10.1 TgC/yr
Δ SOILC
4.9

A2


NPP
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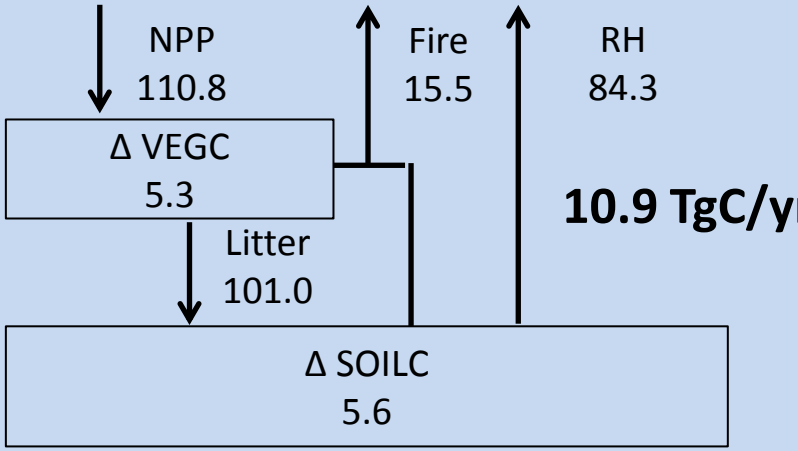
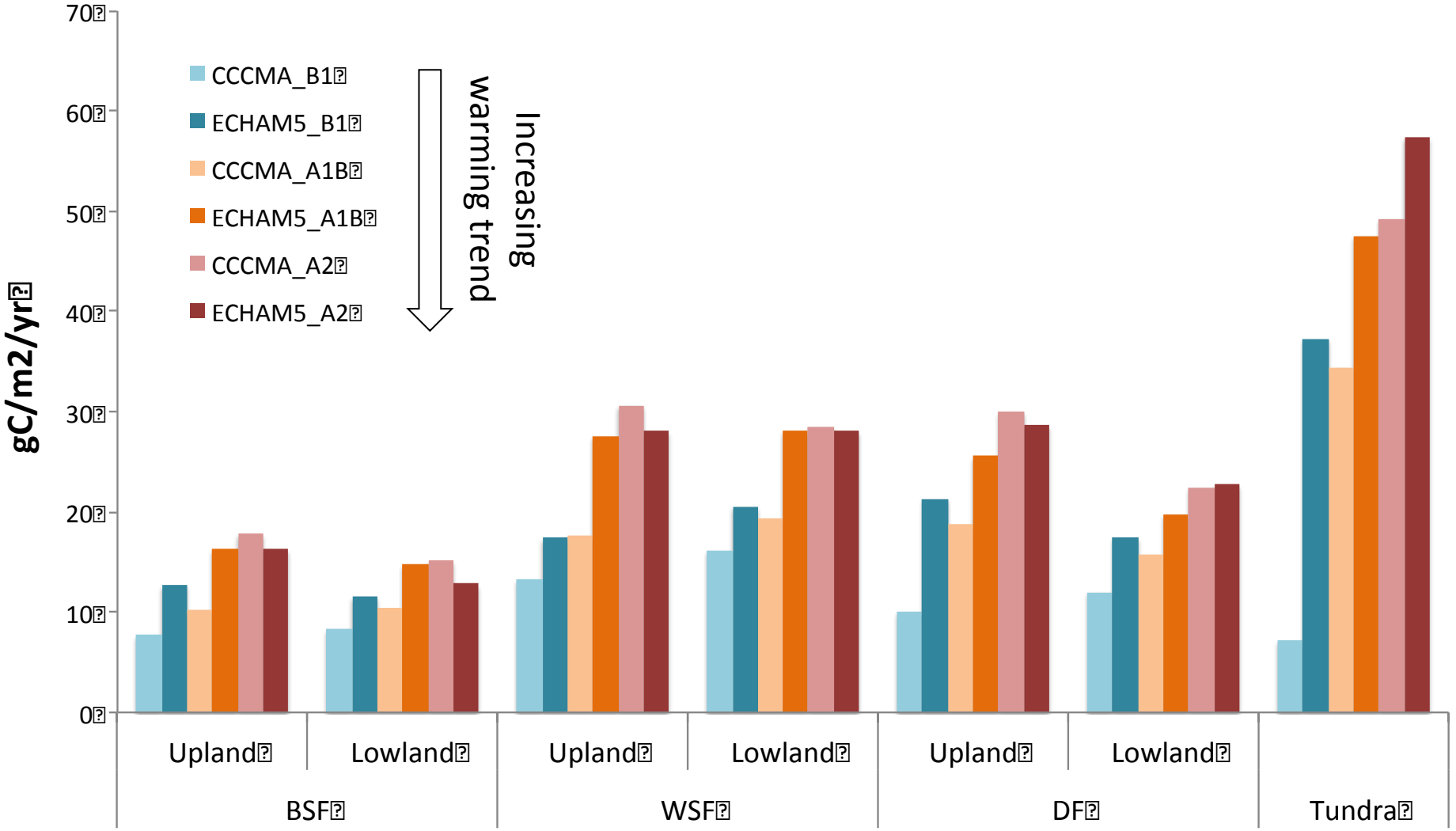
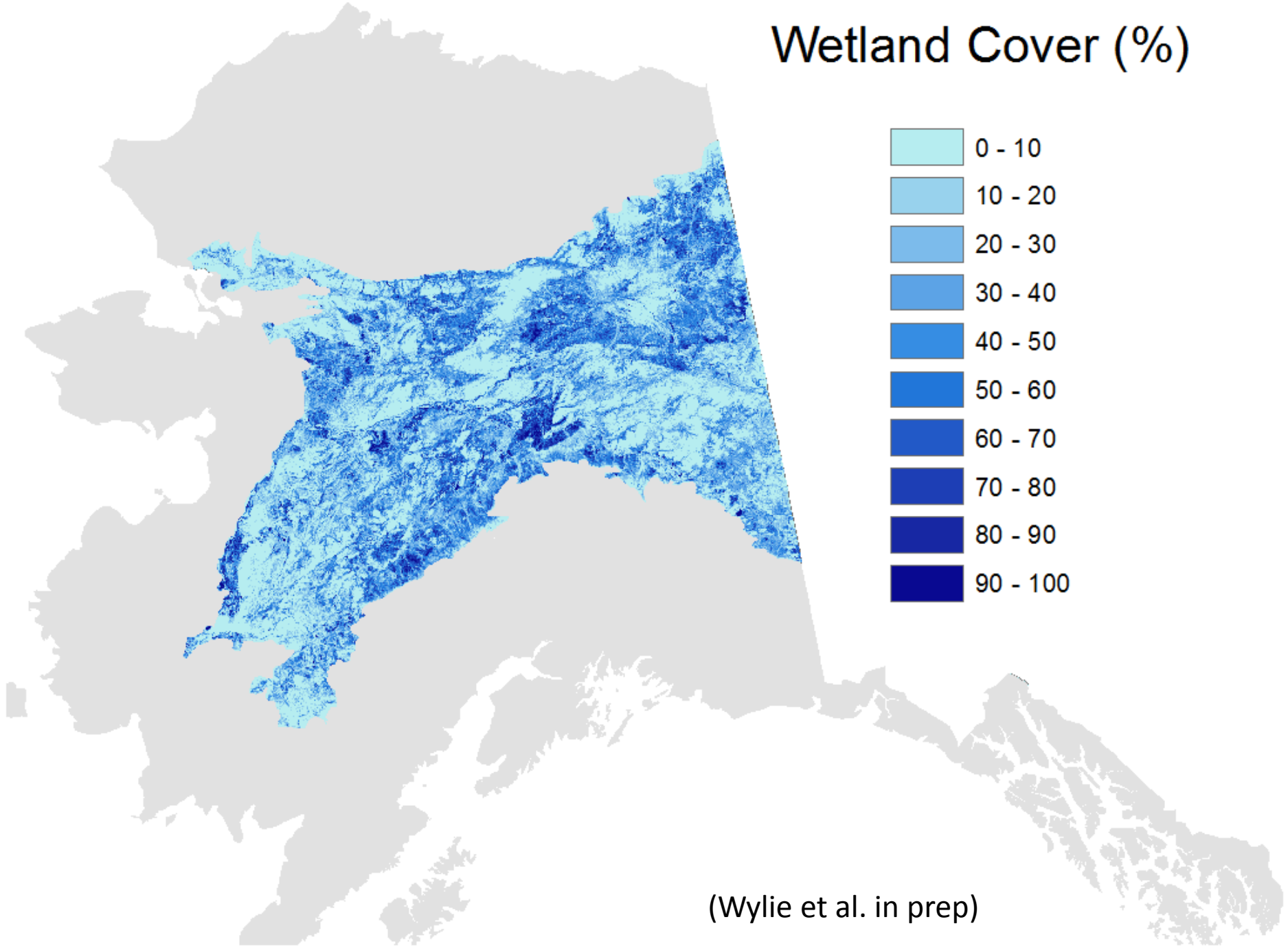
Fire
16.4
RH
77.4
Δ VEGC
3.9
Litter
97.2
11.3 TgC/yr
Δ SOILC
7.4


NPP
110.8
Fire
15.5
RH
84.3
Δ VEGC
5.3
Litter
101.0
10.9 TgC/yr
Δ SOILC
5.6

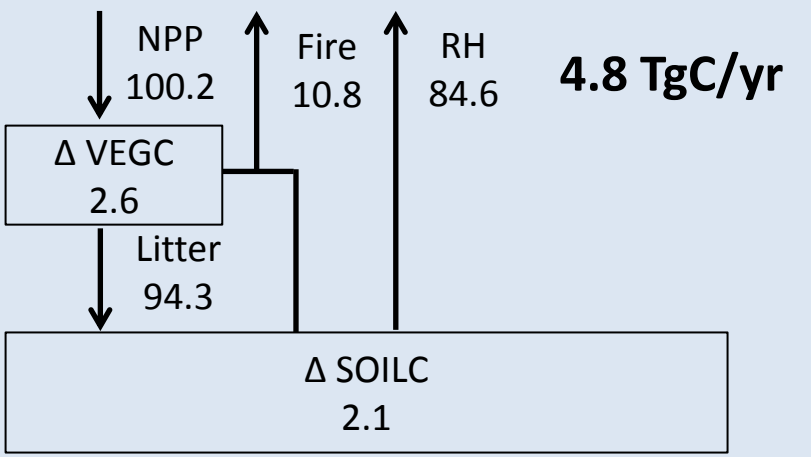
Annual Change in NECB [2010-2099]



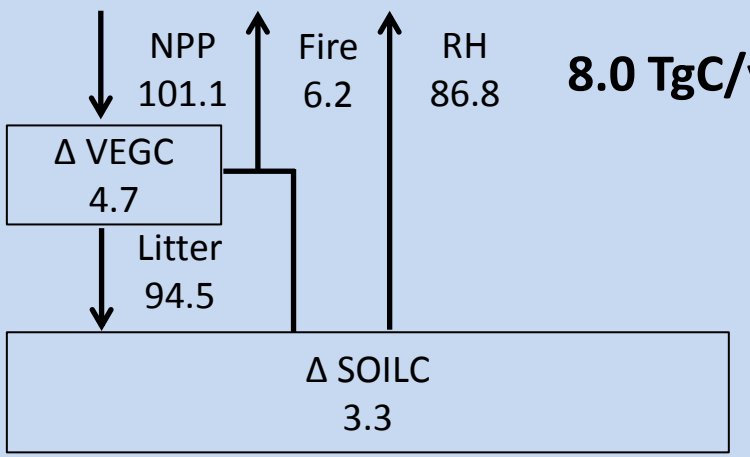


(Wylie et al. in prep)

B1

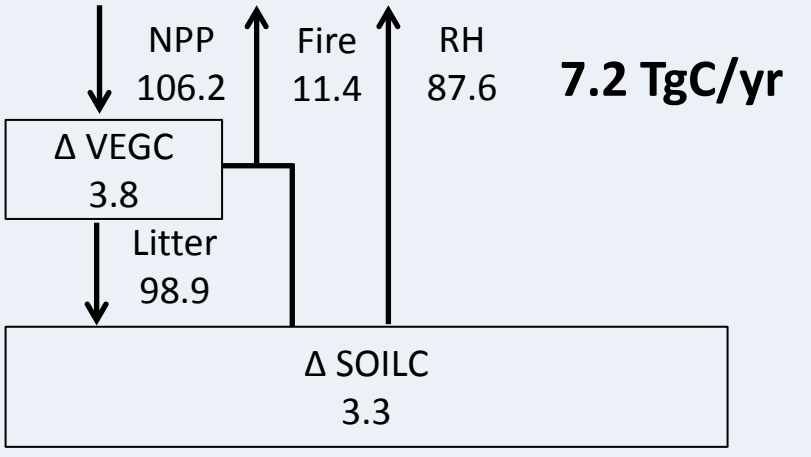


4.8 TgC/yr

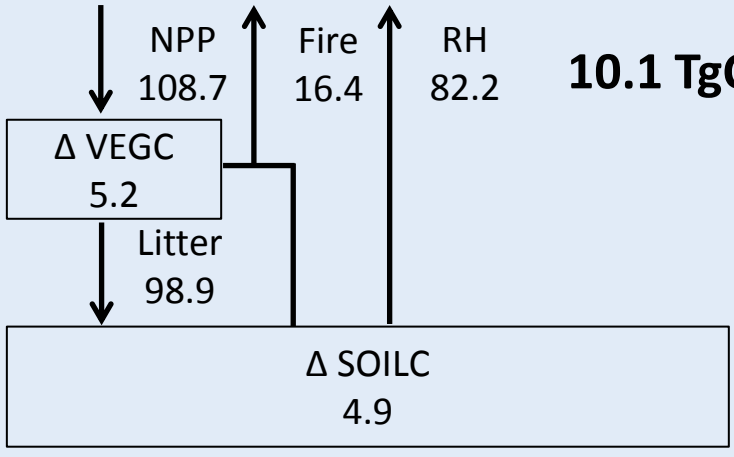


8.0 TgC/yr

A1B

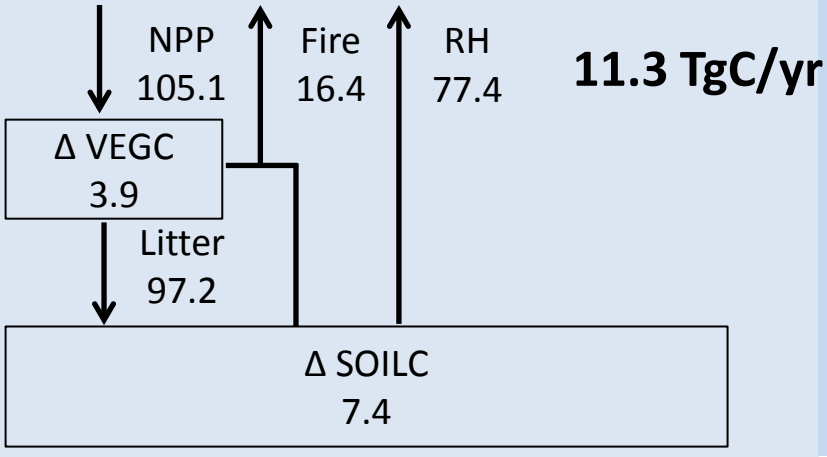


7.2 TgC/yr

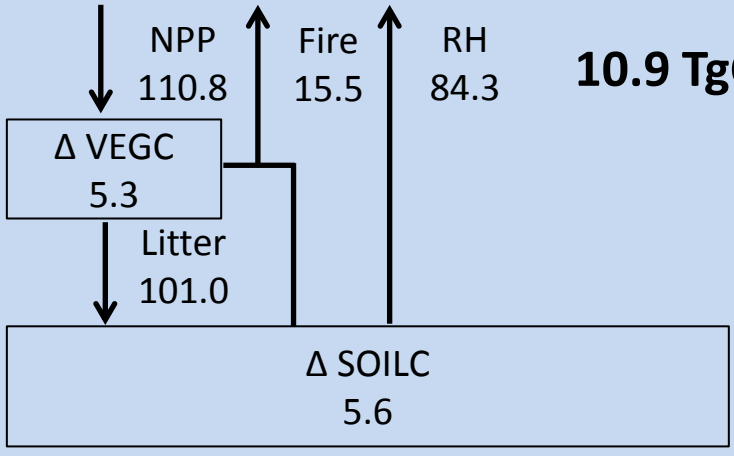


10.1 TgC/yr

A2

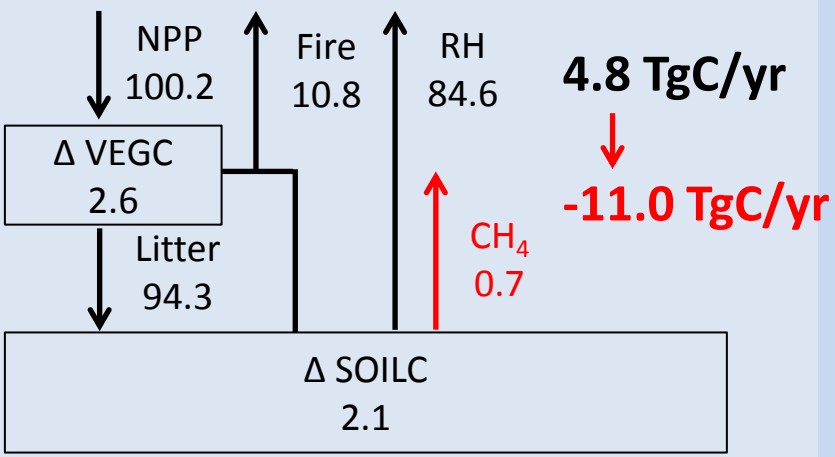


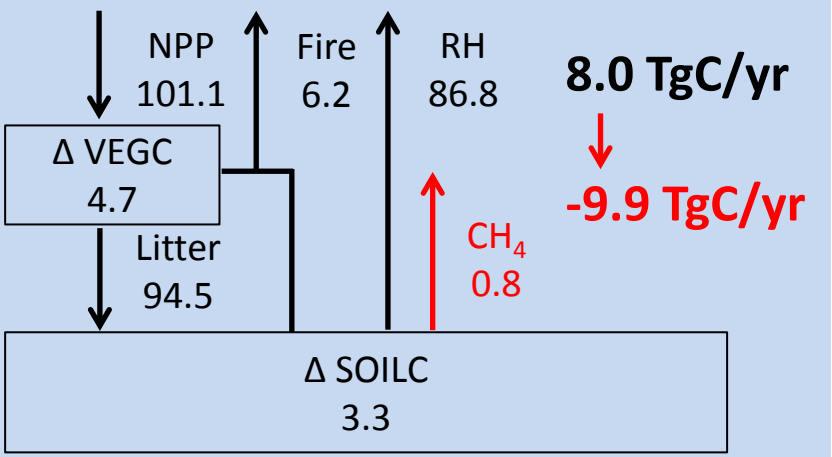
11.3 TgC/yr



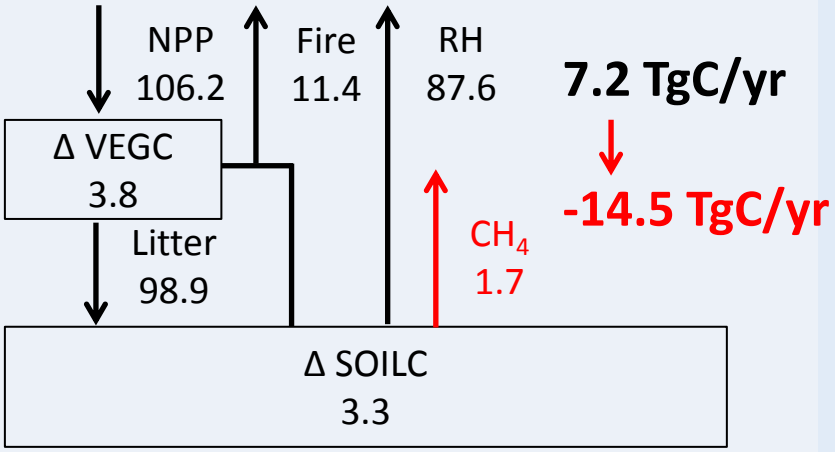
10.9 TgC/yr

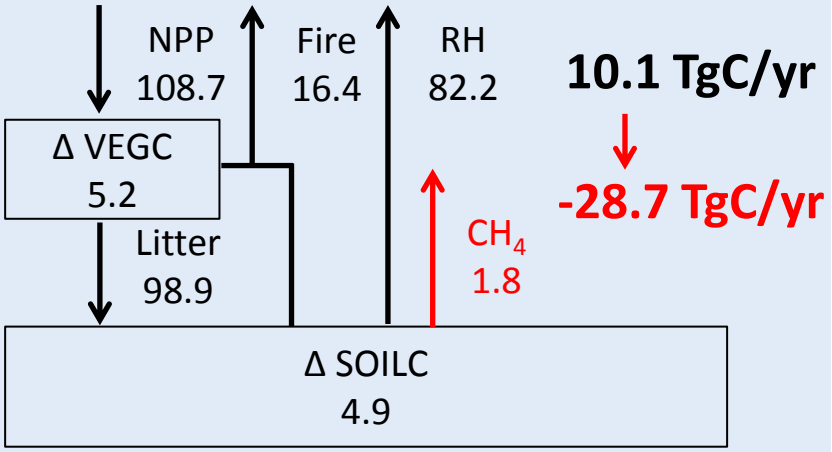
B1


NPP
100.2
Fire
10.8
RH
84.6
Δ VEGC
2.6
Litter
94.3
CH4
0.7
Δ SOILC
2.1
4.8 TgC/yr
-11.0 TgC/yr

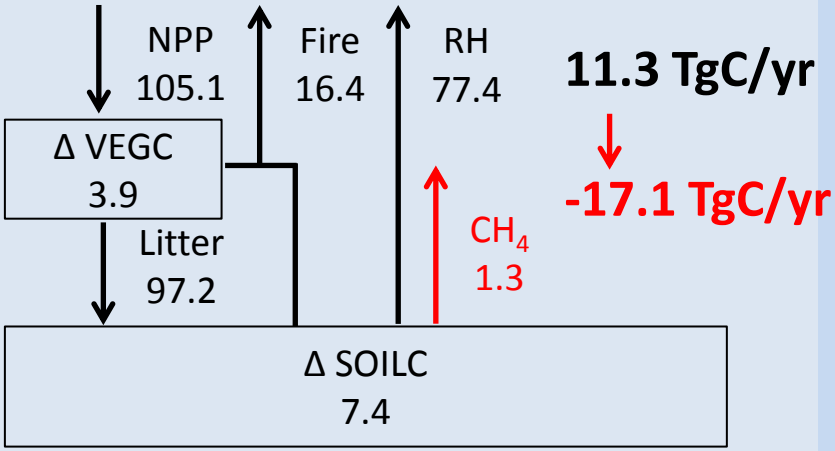

NPP
101.1
Fire
6.2
RH
86.8
Δ VEGC
4.7
Litter
94.5
CH4
0.8
Δ SOILC
3.3
8.0 TgC/yr
-9.9 TgC/yr

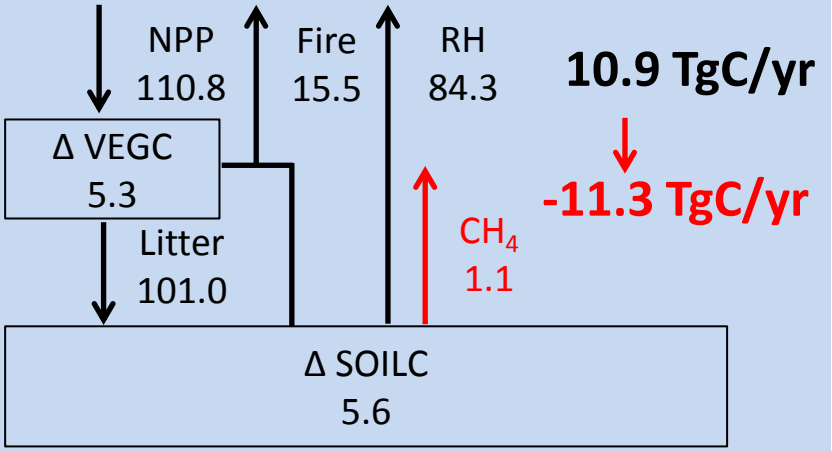
A1B


NPP
106.2
Fire
11.4
RH
87.6
Δ VEGC
3.8
Litter
98.9
CH4
1.7
Δ SOILC
3.3
7.2 TgC/yr
-14.5 TgC/yr


NPP
108.7
Fire
16.4
RH
82.2
Δ VEGC
5.2
Litter
98.9
CH4
1.8
Δ SOILC
4.9
10.1 TgC/yr
-28.7 TgC/yr

A2


NPP
105.1
Fire
16.4
RH
77.4
Δ VEGC
3.9
Litter
97.2
CH4
1.3
Δ SOILC
7.4
11.3 TgC/yr
-17.1 TgC/yr


NPP
110.8
Fire
15.5
RH
84.3
Δ VEGC
5.3
Litter
101.0
CH4
1.1
Δ SOILC
5.6
10.9 TgC/yr
-11.3 TgC/yr

Conclusion

- Interior Alaska lost 365 TgC from soil respiration and wildfire burn from 1950 to 2010 that represents 3.4% of the total C stocks in the region in 1950 (10.6 PgC).

- In addition, 30 Tg CH_4 were emitted, mainly in wetlands. CH_4 warming potential being 21 times higher than CO_2, the total C loss in CO_2eq. was 1.4 PgC, i.e. 13% of the C stocks in 1950.

- Upland ecosystems in interior Alaska are C sinks over the 21st Century: the increase of productivity with projected climate warming offset increased carbon loss from soil respiration and wildfire emission for all climate scenarios.

- However, this sinks become strong sources when taken into consideration methane emissions from the wetlands. By 2100, Interior Alaska is projected to gain between 0.43 and 1.01 Pg C in uplands and loose between 0.07 and 0.17 PgC of CH_4 in wetlands. In CO_2eq., the total loss would range from 0.89 to 2.6 PgC by 2100.

To what extent post-fire succession will offset C loss ?

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Changes in fire regime break the legacy lock on successional trajectories in Alaskan boreal forest

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*Department of Biology, University of Saskatchewan, Saskatoon, SK, Canada S7J 0B1, †Institute of Arctic Biology, University of Alaska Fairbanks, Fairbanks, AK 99775, USA, ‡USDA Forest Service, PNW Research Station, Boreal Ecology Cooperative Research Unit, University of Alaska Fairbanks, Fairbanks, AK 99775, USA, §Department of Botany, University of Florida, Gainesville, FL 32611, USA

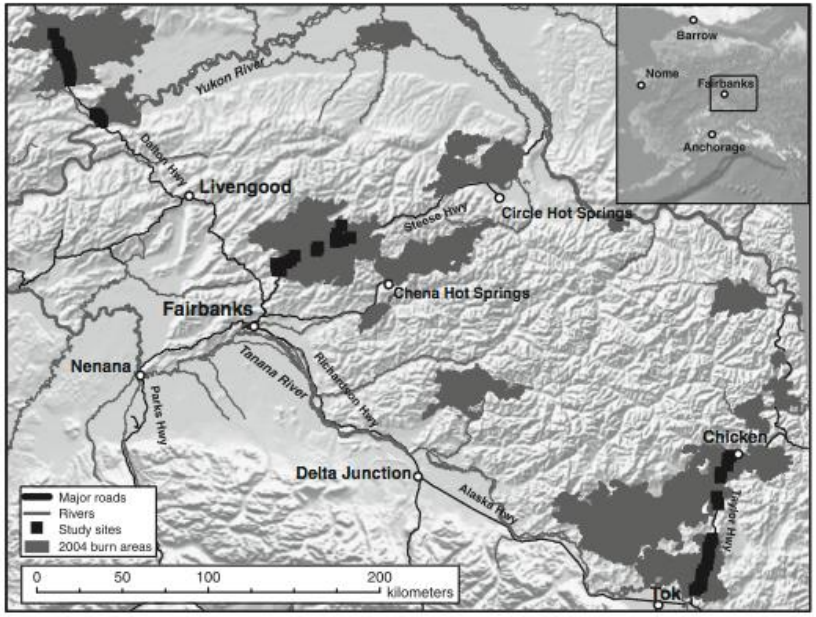
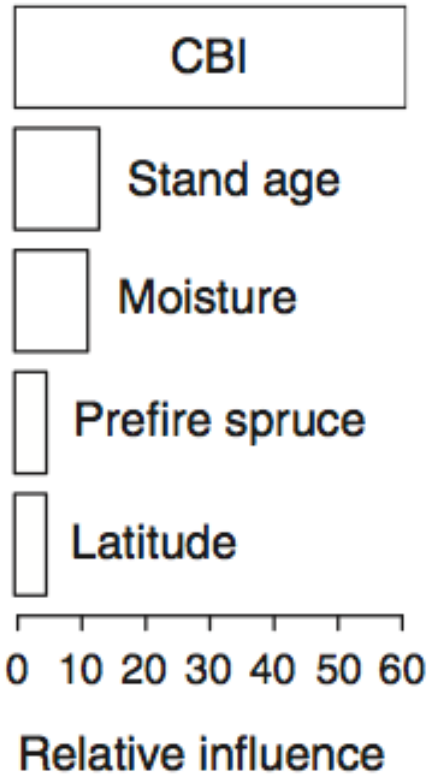


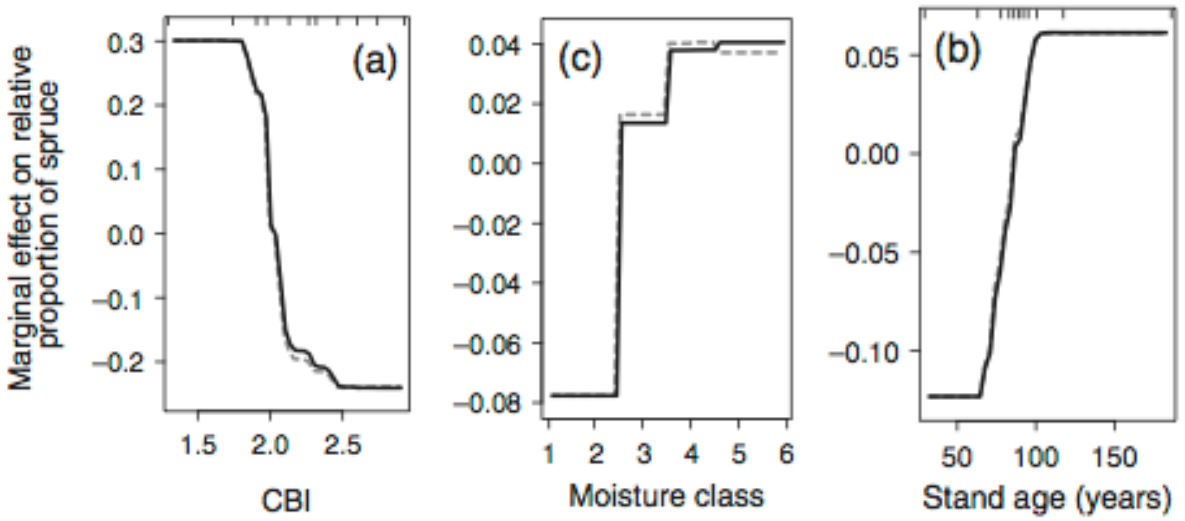
Fig. 1 Map of the study sites in interior Alaska (modified from Johnstone *et al.*, 2009). Solid gray polygons indicate areas that were burned in 2004. Study sites ($n = 90$) are shown as filled black squares in fires that intersected the Dalton, Steese, and Taylor highways. Because of the small scale of the map, symbols overlap for some sites.



Fire severity

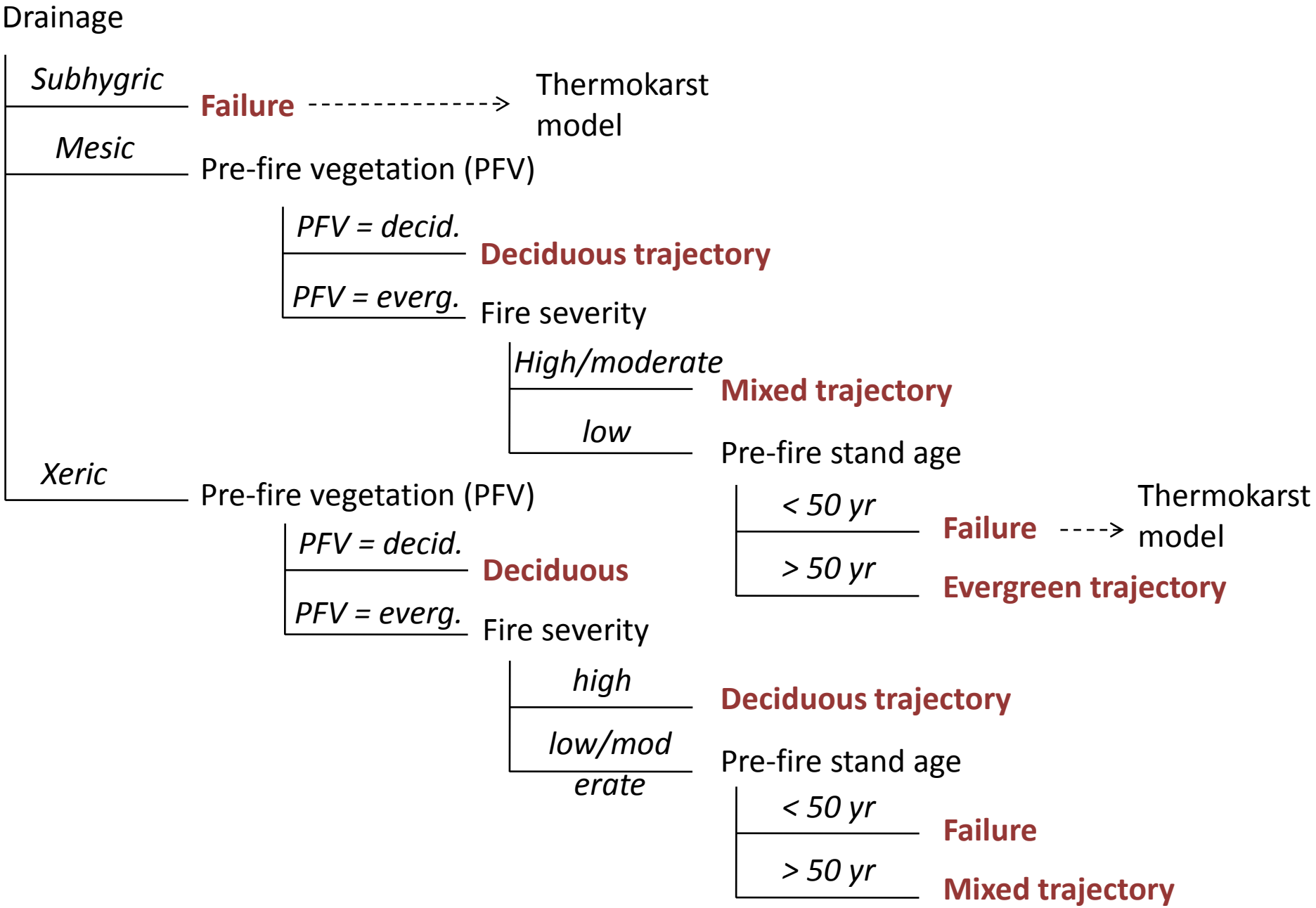
Drainage

Stand age



Relative influence and partial dependency plots for variables in a boosted regression tree predicting relative spruce dominance

Post-fire succession model in development



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Thank you

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Patrick Endres, AK photographics