The Role of Land-Cover Change in High Latitude Ecosystems: Implications for Carbon Budgets in Northern North America

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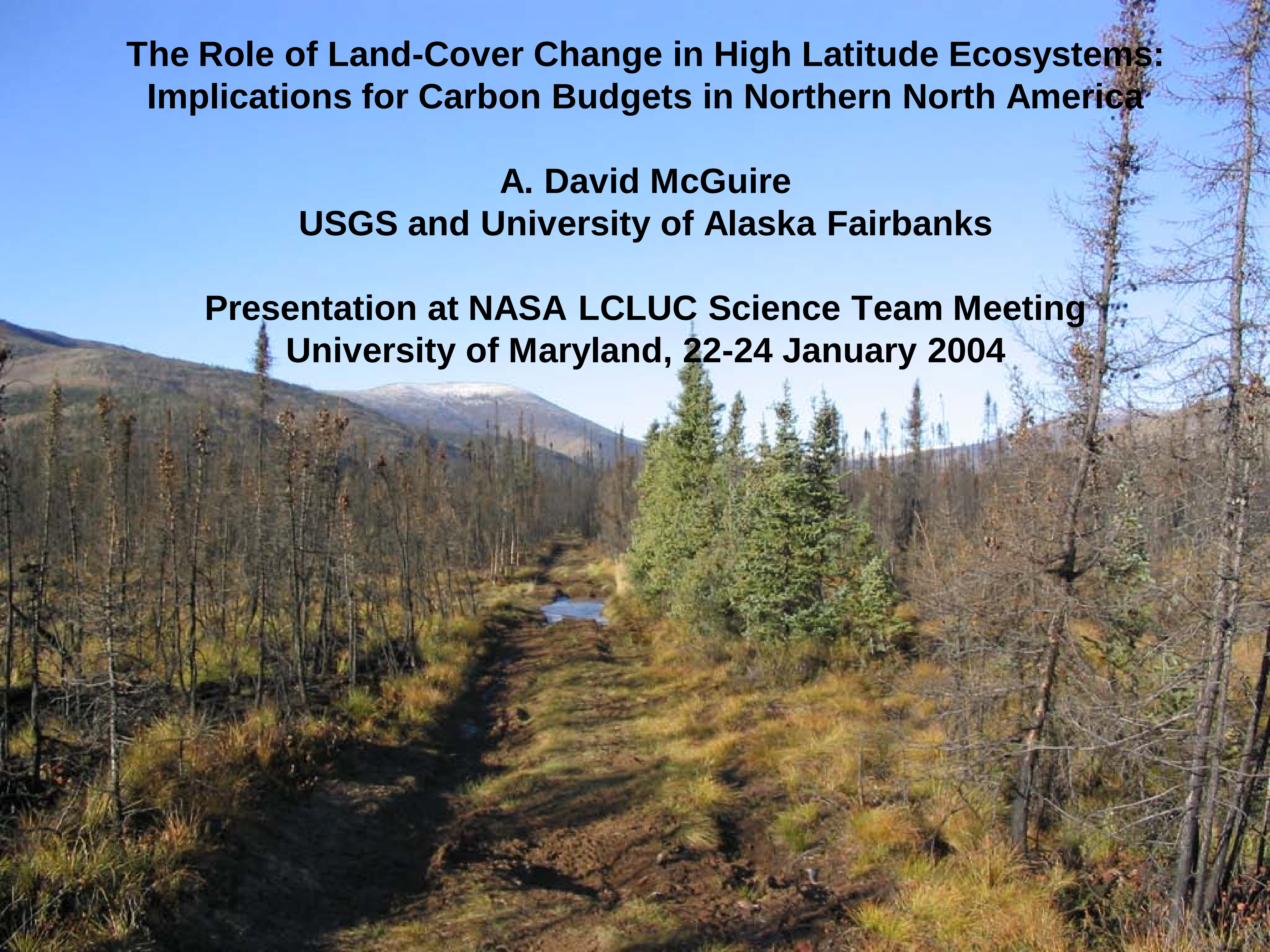

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Questions and Goals

Questions:

(1) Are Lakes and Wetlands Drying Up in Alaska?

(2) What are the Consequences of Land Cover Change in Alaska and Canada for Carbon Storage in the Region?

Goals:

(1) To evaluate the extent to which lakes and wetlands are drying up in the Alaska region between 1950 and present.

(2) To elucidate the relative importance of mechanisms affecting changes in carbon storage of the Alaska-Canada Region in the 20th Century.

Are Lakes and Wetlands Drying Up in Alaska?

Tasks:

- Locate focus areas in Alaska that span variation in temperature and precipitation across Alaska.
- Estimate total gain or loss of water area between 1950 and present in aerial photographs and Landsat imagery.
- Use temperature and precipitation data and estimates of evapotranspiration evaluate whether gain or loss of water can be explained by changes in thermal regimes (i.e., enhanced drainage associated with thawing of permafrost) or negative water balance (i.e., decreased precipitation or enhanced evapotranspiration).

Methods:

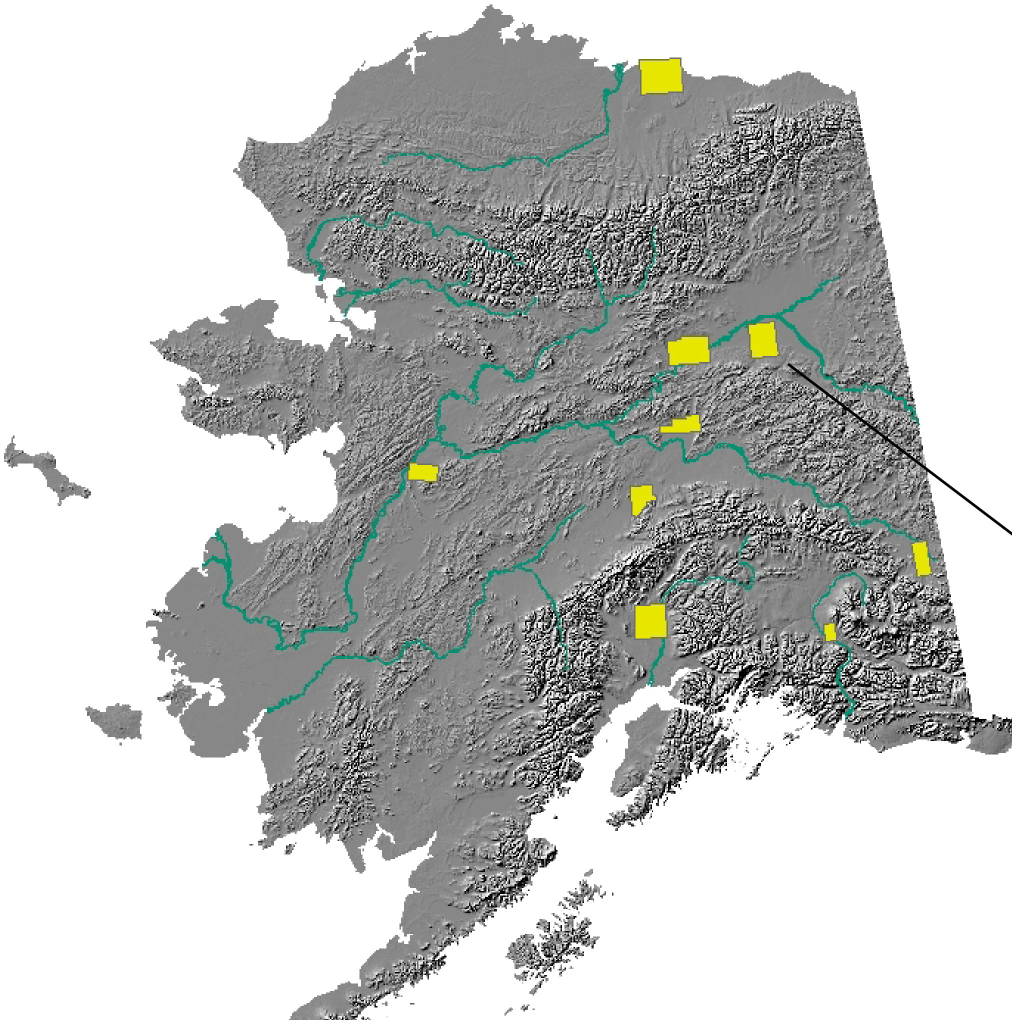
- Use a minimum of 3 time periods for each area
- Obtain cloud free imagery between July 15 and Aug 15 for each time period
- Separate closed-basin water bodies from open-basin water bodies
- Create polygons of water bodies for each time frame
- Calculate acres from polygons

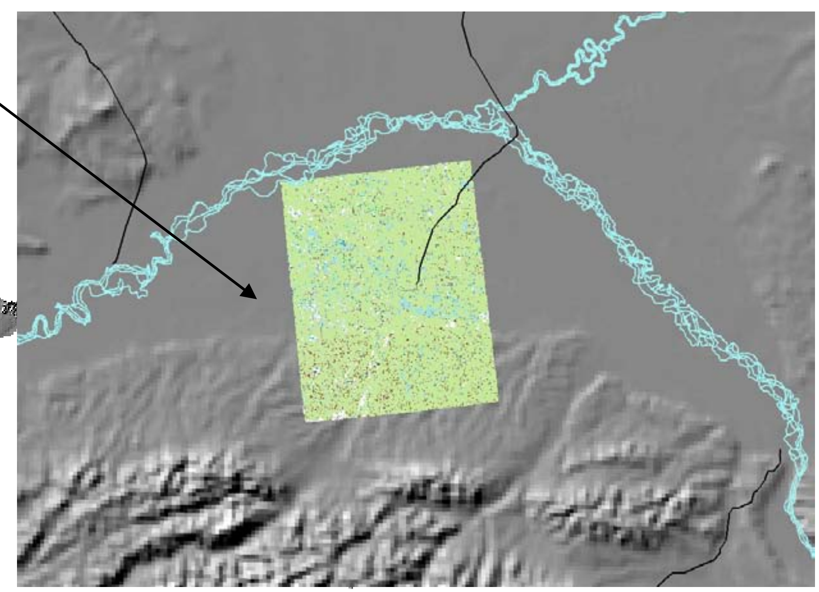
Yukon Flats Region

Lat: 66.30 – 66.00

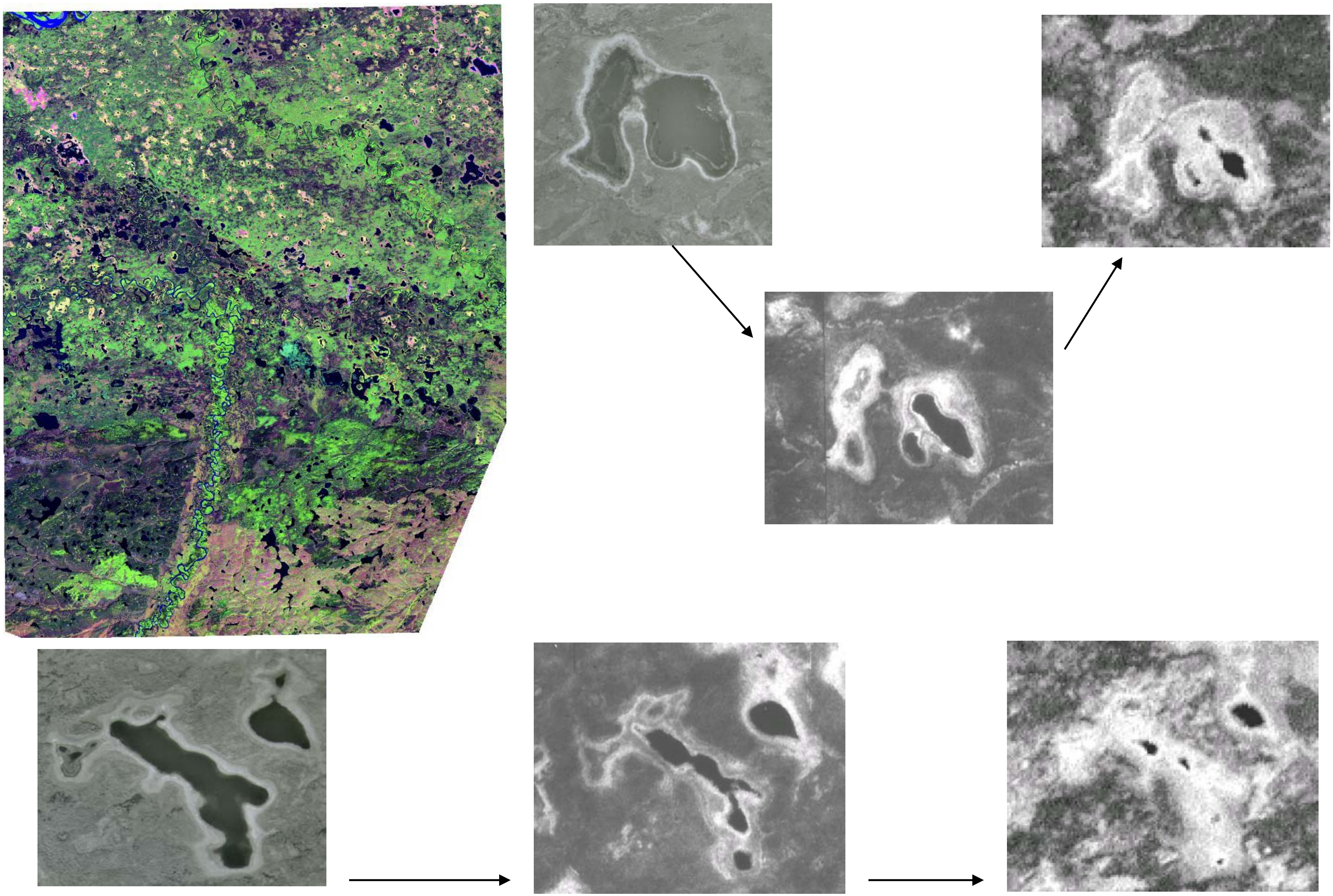
Long: 146.30- 145.30

Acres: 499755.969





Yukon Flats Area



Estimated changes in open water area for 9 focal areaa in Alaska between ~1950 and ~Present

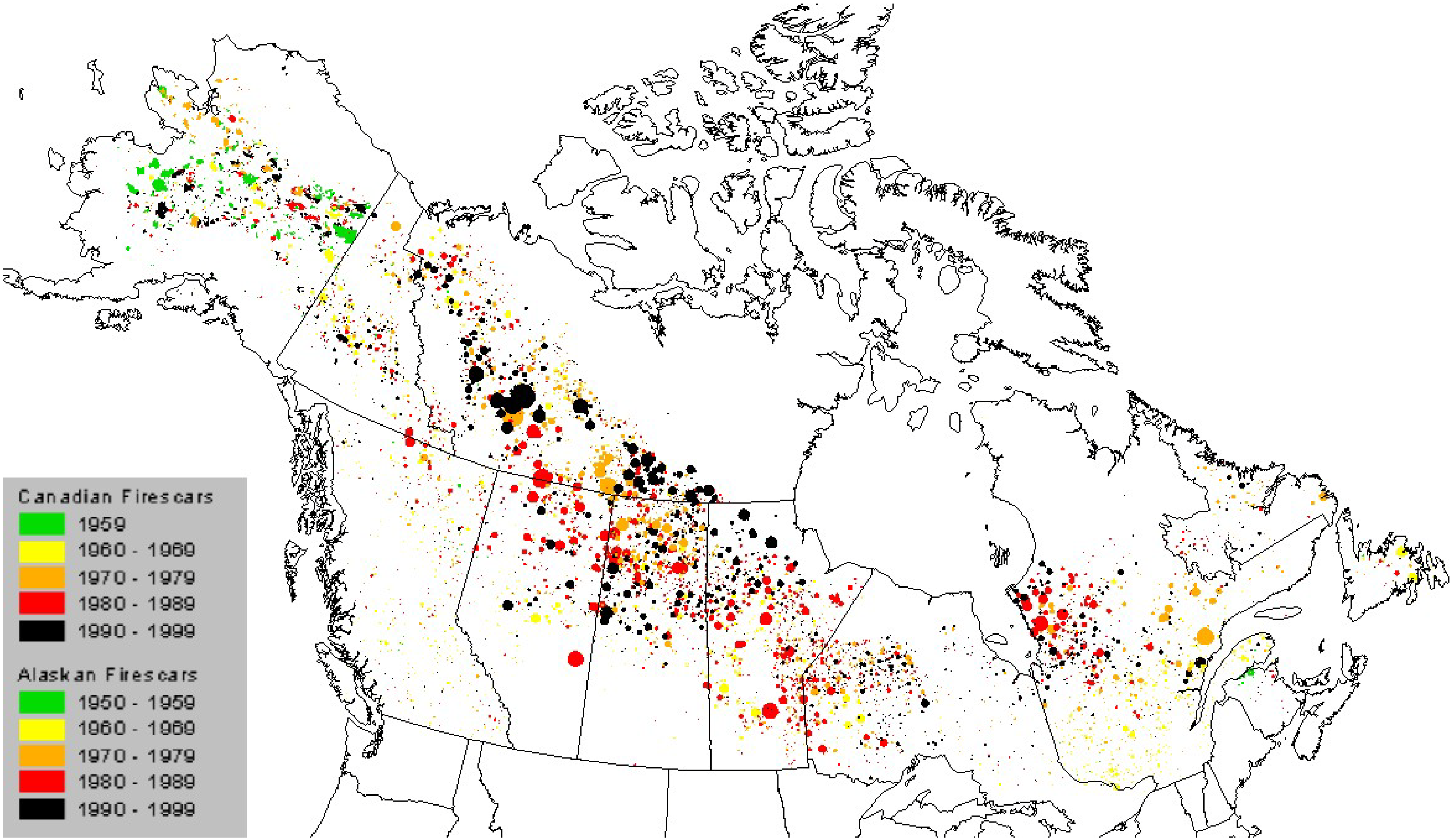
Area	Percent change over 50 years
Innoko Flats	-33
Copper River Basin	-28
Minto Flats	-21
Yukon Flats	-18
Talkeetna	-19
Alma lakes	-15
Stevens Village	-3
Forty Mile Flats	3
North Slope	1

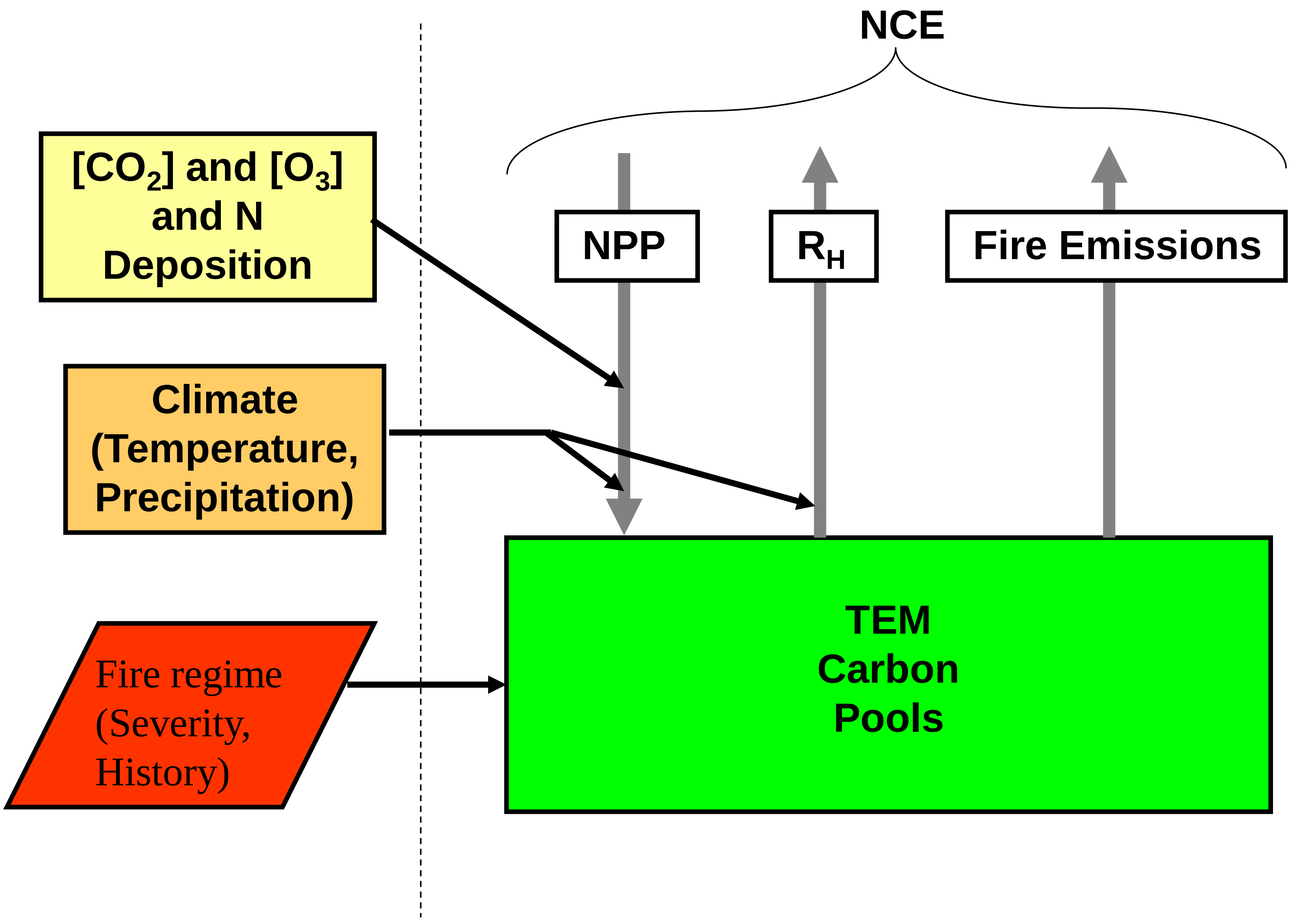
What are the Consequences of Land Cover Change in Alaska and Canada for Carbon Storage in the Region?

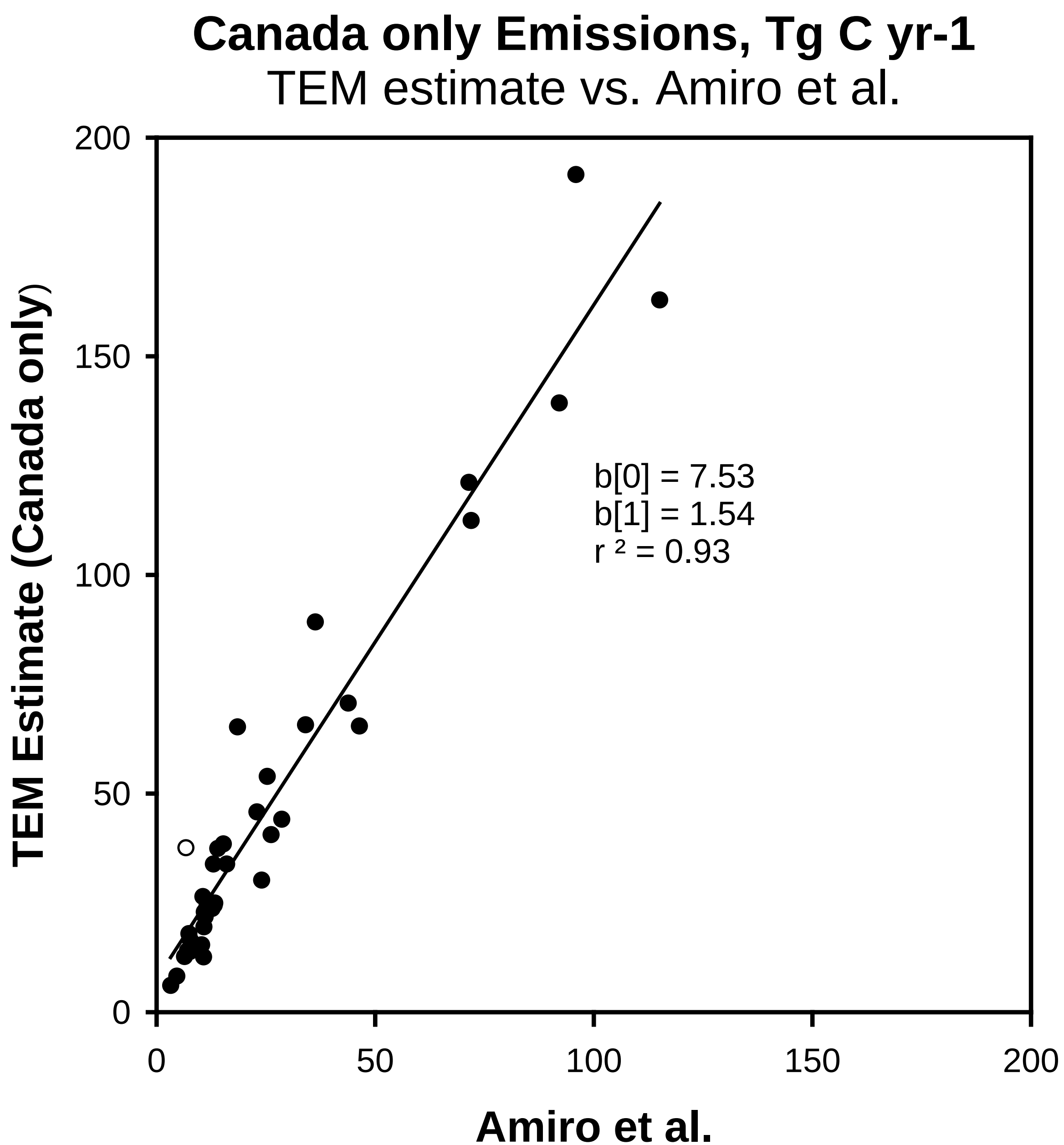
Tasks:

- To finalize a version of the Terrestrial Ecosystem Model TEM) that considers multiple disturbances (fire, insect disturbance, logging, and cropland establishment and abandonment), effects of changes in tropospheric atmospheric chemistry (CO_2, O_3, and N deposition), and climate (including representation of responses of freeze-thaw and permafrost dynamics).
- To conduct simulations of changes in 20th Century carbon storage for the Alaska-Canada region with the new version of model with data sets that we have already organized,
- To develop and organize the spatially explicit data sets required by the modeling framework for simulating how the full array of disturbances and other factors influence carbon storage in the Alaska-Canada region,
- To evaluate the simulation results in the context of inversions of the exchange of CO_2 between the atmosphere and terrestrial ecosystems of the Alaska-Canada region.

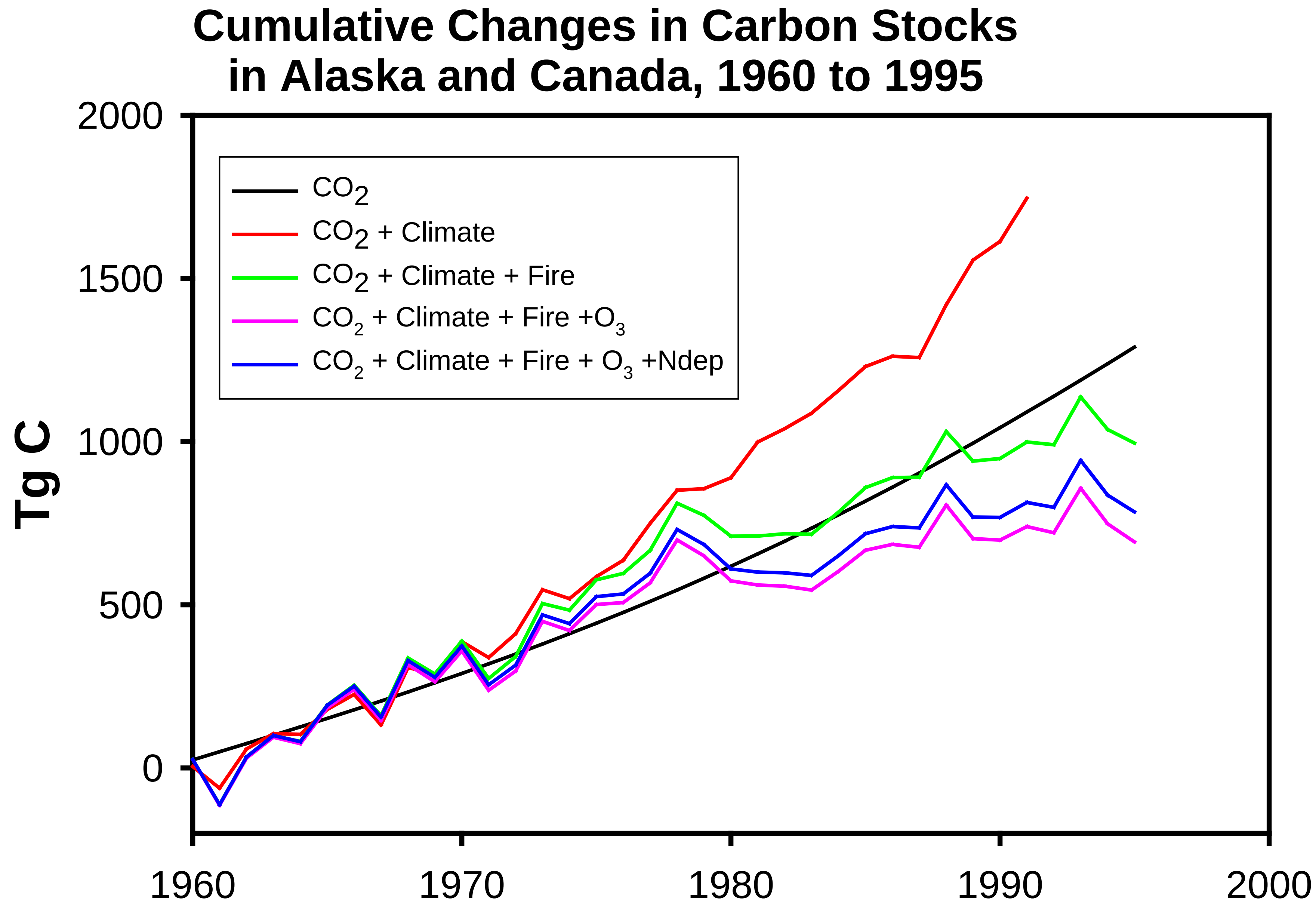
Fire Locations In Alaska (1950-2000) and Canada (1959-2000)




NCE
$[CO_2]$ and $[O_3]$ and N Deposition
NPP
R_H
Fire Emissions
Climate (Temperature, Precipitation)
Fire regime (Severity, History)
TEM Carbon Pools

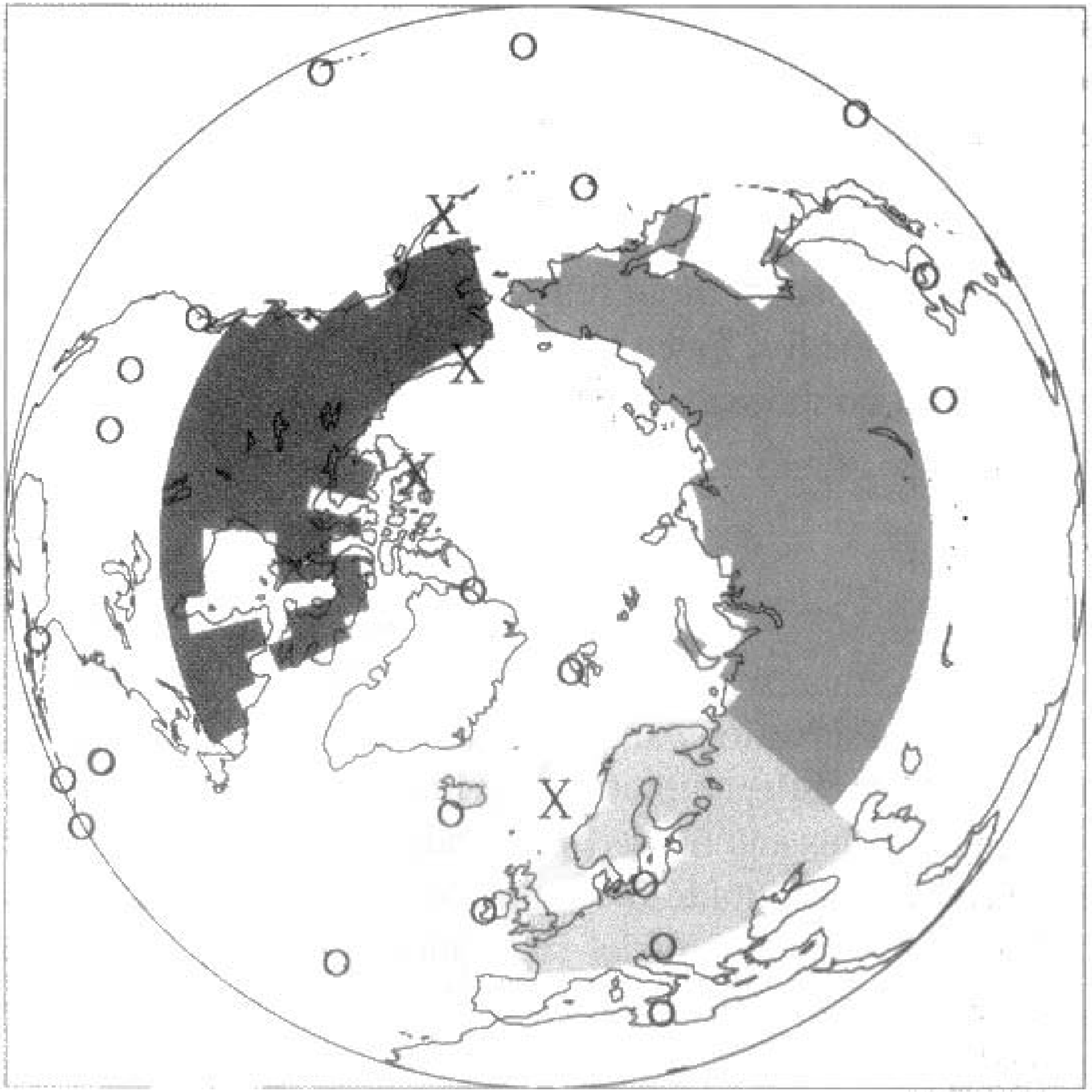

Canada only Emissions, Tg C yr-1
TEM estimate vs. Amiro et al.
TEM Estimate (Canada only)
Amiro et al.
0
50
100
150
200
0
50
100
150
200
b[0] = 7.53
b[1] = 1.54
r ² = 0.93

JSC 1/16/04

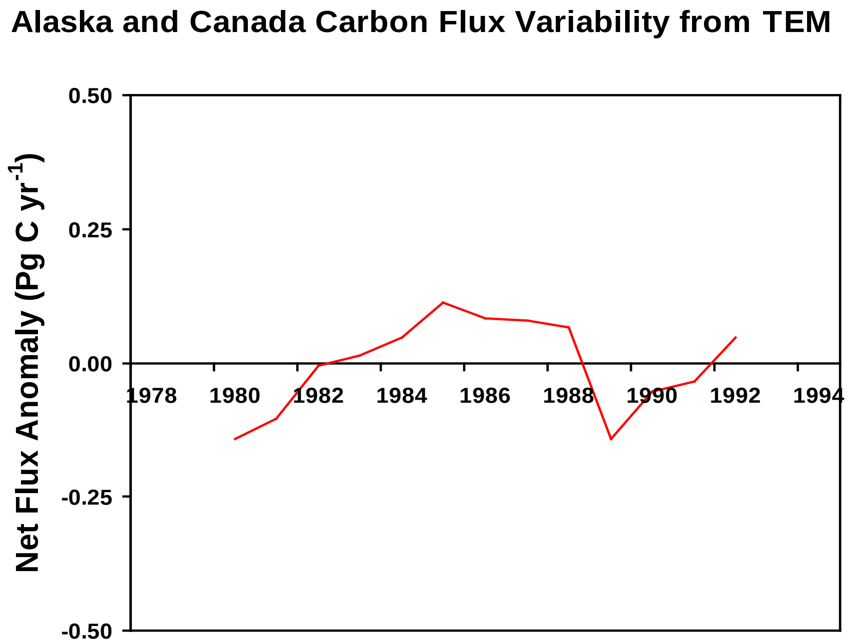


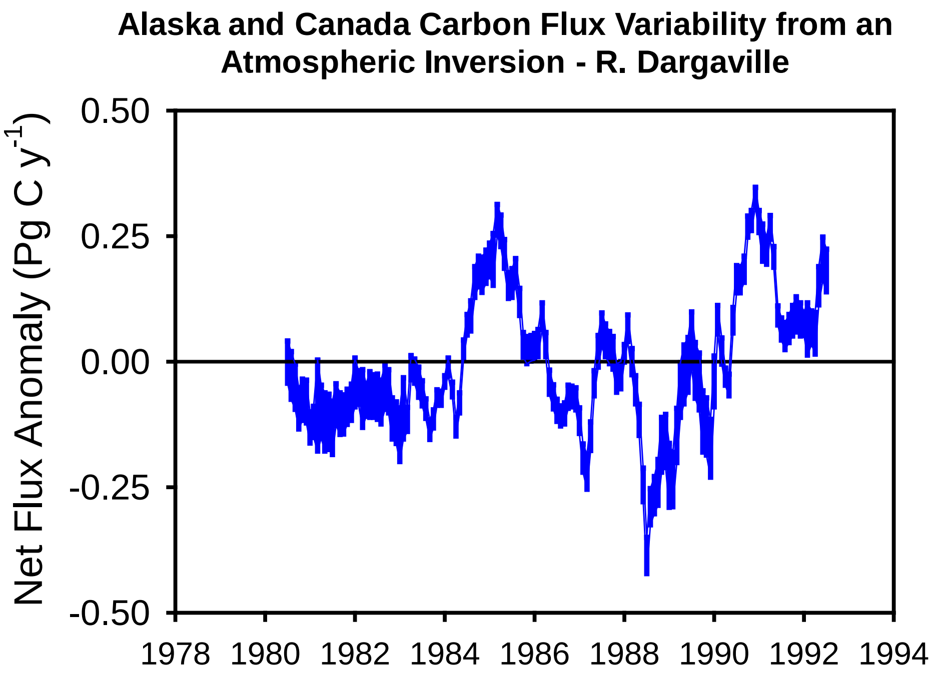
Cumulative Changes in Carbon Stocks
in Alaska and Canada, 1960 to 1995
Tg C
2000
1500
1000
500
0
1960
1970
1980
1990
2000
CO_2
CO_2 + Climate
CO_2 + Climate + Fire
CO_2 + Climate + Fire +O_3
CO_2 + Climate + Fire + O_3 +Ndep

Stations used to constrain atmospheric inversions of high latitudes



Comparison of process-based and atmospheric approaches for Alaska-Canada after consideration of fire by the process-based approach





Summary of Results

Are Lakes and Wetlands Drying Up in Alaska?

- In general, the area of open water of closed drainage in Alaska seems to be declining over the last several decades, with losses up to 33% in some wetland complexes.
- Analyses are being conducted to evaluate the “thermal” vs. “water balance” hypotheses of water loss.
- How inter-annual variability influences our results is a major concern, and needs further evaluation.

What are the Consequences of Land Cover Change in Alaska and Canada for Carbon Storage in the Region?

- Both increases in CO_2 and fire appear to have large effects on carbon storage, but the magnitude of these effects appear to have approximately balance each other since about 1970 when the fire frequency in Canada doubled.
- Climate, N deposition and O_3 have had smaller effects on carbon storage, with climate and N deposition tending to increase carbon storage, while O_3 tends to decrease carbon storage.
- Simulations conducted to date required the addition of fire to simulate patterns of inter-annual variability that are similar to those estimated by atmospheric inversions.
- A major challenge in integrating multiple data sets of disturbance into the modeling framework include harmonizing the stand-age distributions in the data sets developed for driving the model framework with data from forest inventory analyses on stand-age distributions.

Major Conclusions

- The area of open water bodies in Alaska has been declining over the last several decades, with losses up to 33% in some wetland complexes.

- Comparisons of simulations with atmospheric inversions suggests that fire drives the inter-annual pattern of carbon exchange with the atmosphere in the Alaska-Canada region.

- Fire disturbance in the Alaska-Canada region is sensitive to climate warming and has doubled in frequency since 1970. It appears that the increased fire frequency may be offsetting carbon sequestration from other factors (increases in atmospheric CO_2, climate warming, and N deposition).

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