Controls on Vegetation Distribution and Implications for Climate Change in Interior Alaska

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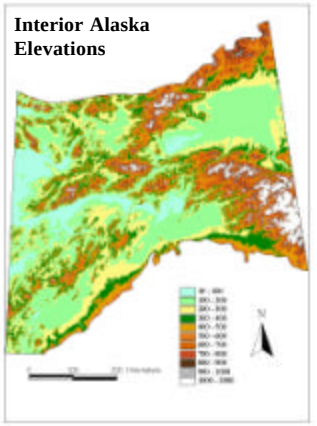
Interior Alaska

Abstract
A hierarchical logistic regression model was developed and applied to determine the controls on vegetation distribution in Interior Alaska. The model was then used to simulate the response of vegetation to several climate change scenarios.

Interior Alaska Elevations



Climate Change Scenarios

- Warming by 1°C, 2°C, 5°C, 10°C
- Precipitation increase & decrease by 10%, 20%, 30%
- Fire interval increase & decrease by 10%, 20%, 30%

Coupled Scenarios:

- Warming with simultaneous precipitation increase & decrease
- Fire interval increase & decrease with simultaneous warming
- Fire interval increase & decrease with simultaneous precipitation increase & decrease

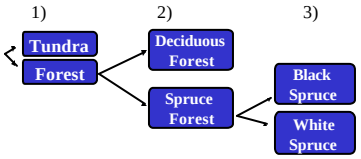
Logistic Regression Model

The logistic regression equation yields a probability value from 0 to 1 that one or another vegetation type may occur. One can then set a threshold value where everything above this threshold is one vegetation type (e.g. tundra) and everything below this threshold is another vegetation type (e.g. forest). Since logistic regression can only predict the probability of two vegetation types, it is run in three hierarchical steps.

Logistic Regression Formula

$$P = \frac{e^{(a_0 + a_1 X_1 + \ldots)}}{1 + e^{(a_0 + a_1 X_1 + \ldots)}}$$

Hierarchical Model



Explanatory variables used for predicting vegetation types

- * Elevation (m)
- * Slope (%)
- * Aspect (S to N and E to W)
- * Drainage (soil moisture)
- * Temperature (average for growing season)
- * Precipitation (total for growing season)
- * Fire return interval

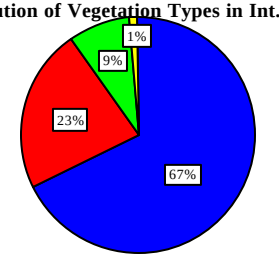
Controls on Vegetation Distribution
(based on standardized coefficient values)

Tundra versus Forest:
1. Elevation
2. Precipitation
3. S-N Aspect
4. Fire Interval

Deciduous Forest versus Spruce:
1. Fire Interval
2. Elevation
3. E-W Aspect
4. Precipitation

Black versus White Spruce:
1. Fire Interval
2. Elevation
3. S-N Aspect
4. Precipitation

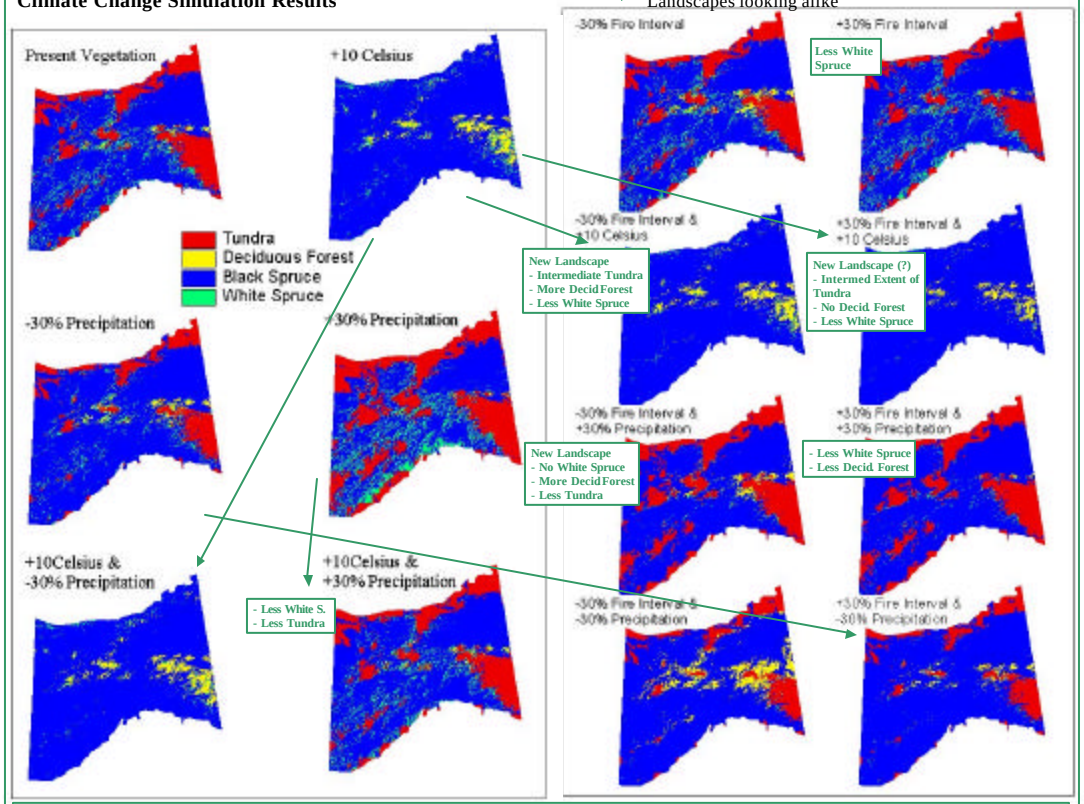
Distribution of Vegetation Types in Int. Alaska



Conclusion

- This is an equilibrium model simulating hypothetical landscapes.
- Response of vegetation to climate change is not linear (e.g. white spruce).
- Coupled environmental change produces landscapes different from individual change scenarios (e.g. fire interval & precipitation).

Climate Change Simulation Results



Climate Change Response Summary

- 10°C warming has a stronger effect than 30% precipitation decrease or 30% fire interval changes.
- 30% precipitation increase has a stronger effect than 10°C warming.
- 30% precipitation & 30% fire interval changes create a new landscape;
- Except 30% precipitation decrease & 30% fire interval increase: in this case precipitation has a stronger effect than fire interval.