Effects of and responses to climate change on National Forests: Addressing Climate Change in the Forest Vegetation Simulator

Foresters are responsible for growing trees to provide desirable ecosystem services such as wood products, watershed, wildlife, and carbon sequestration. Climate is the most important driver of potential vegetation. Climate change threatens the ability to manage forests as done in the past. A tool designed to aid in managing climate change is Climate-FVS and is a modification of the Forest Vegetation Simulator.

What is Climate-FVS?

The base Forest Vegetation Simulator (FVS) components predict performance in the absence of climate change and assumes site capacity does not change over time. To accommodate the effects of climate change, Climate-FVS modifies components rather than replacing them with new climate estimators. Thus the primary intrinsic components of FVS and its empirical heritage remain intact. With the introduction of Climate-FVS, there is now the ability to use information regarding climate change to affect site capacity and estimate the effects on tree growth, mortality, and regeneration potential.

How do we compare contemporary climates with future climates?

Contemporary climate surfaces

We used temperature and moisture data from 11,00 weather stations, representing the period 1960-1990.

- ANUSplin model of climate as a function of latitude, longitude, and elevation.
- Three temperature and one precipitation surface for each month.
- Algorithms for 35 derived variables and interactions
- Ability to map these predictions.

Future climate surfaces

We used three General circulation models (GCM) outputs to tell us how current climate will change.

- CGCM3: Canadian Center of Climate modeling and Analysis, green house gas (GHG) scenarios: A1B, A2, and B1.
- HADMC3: Met Office Hadley Centre (UK), scenarios: A2 and B1.
- GFDLCM21: Geophysical Fluid Dynamics Laboratory (Princeton University, NOAA Research). Scenarios: A2 and B2.

Contemporary climate was updated to be consistent with GCM/SRES predictions. Each observed datum used to fit the contemporary climate is updated by adding the projected difference in the climate at the datum's location as predicted by the GCM.
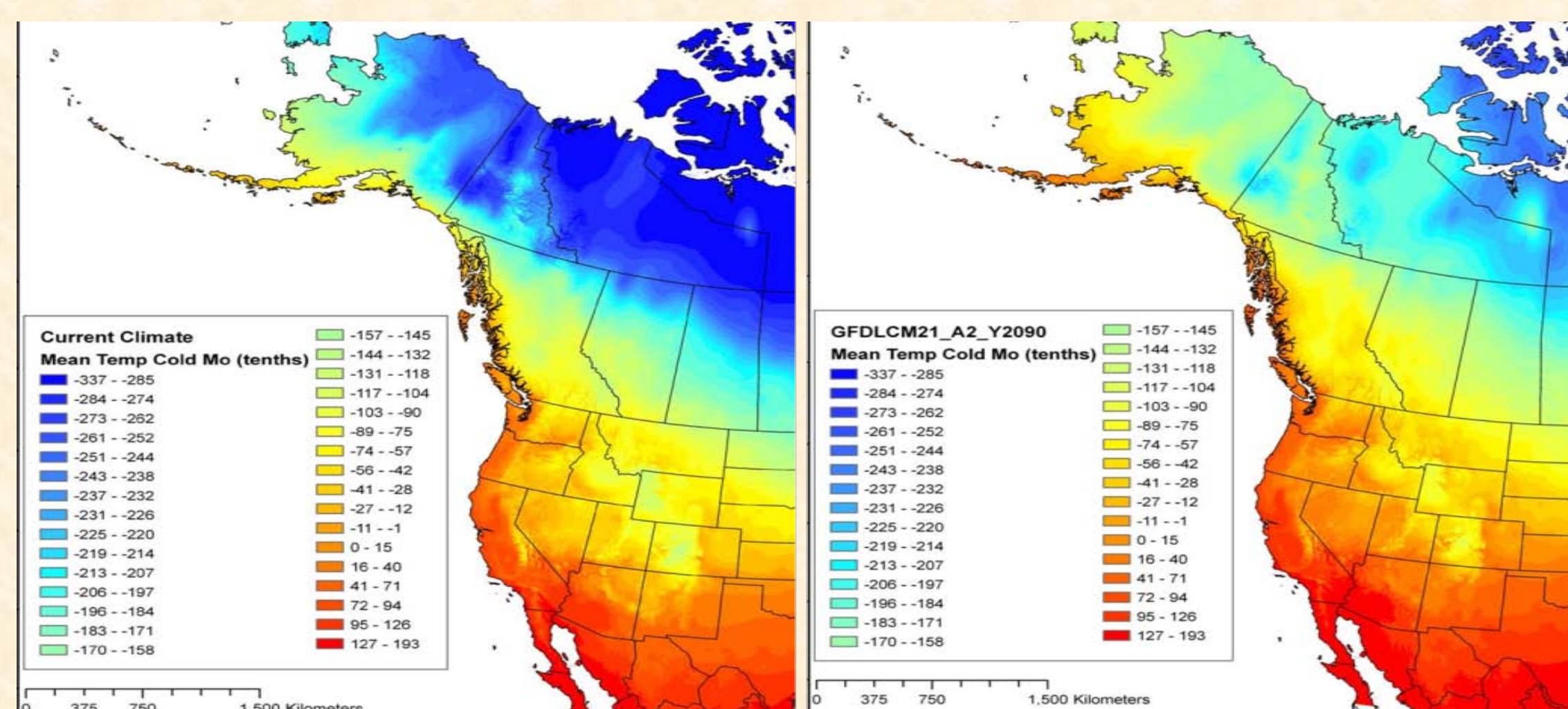

## Where will species be in future climates?

Species climate profile models

Species presence/absence were modeled as functions of contemporary climate. The presence/absence data from the western United States Forest Inventory and Analysis were used. Future climates were used to predict where the species climate profiles will occur. The species viability for the future climates was predicted and mapped for three future points in time: 2030, 2060, and 2090.

Douglas-fir climate profile location change
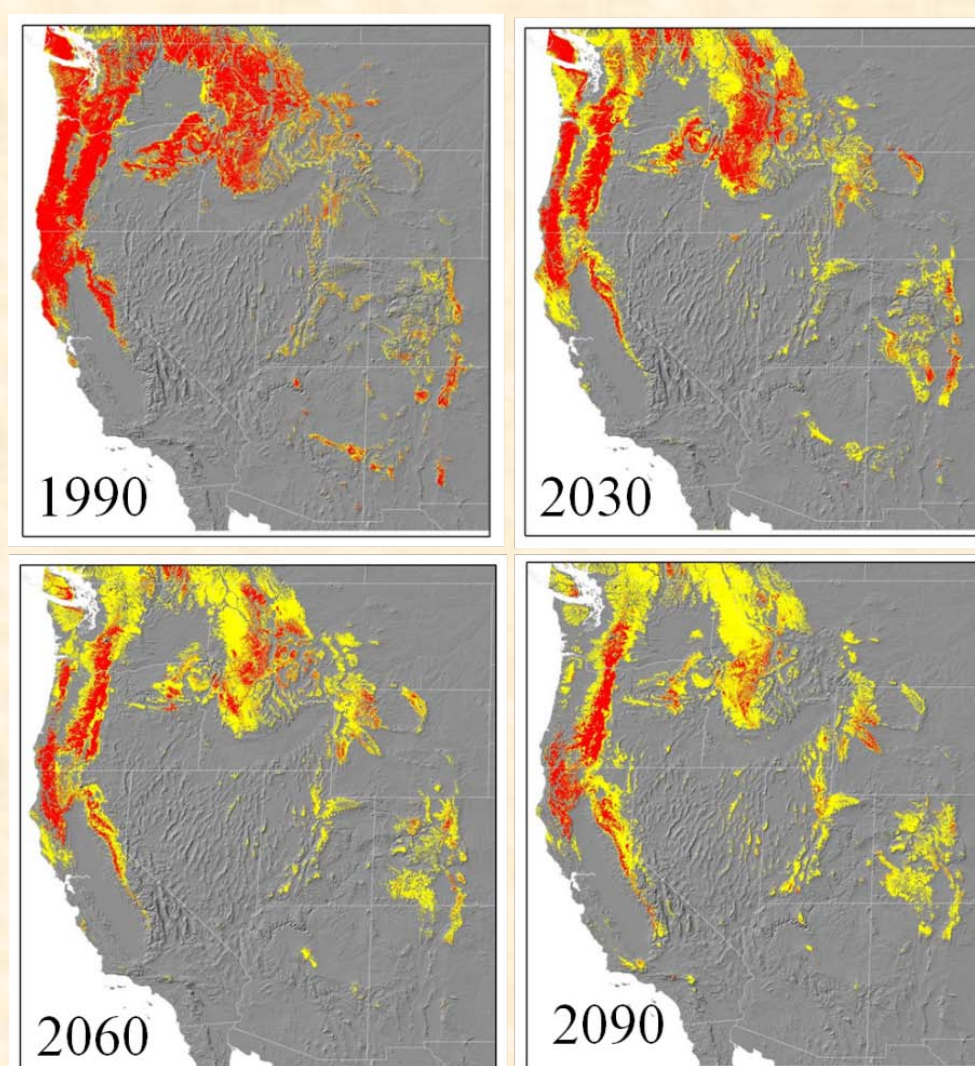
Douglas-fir change by 2060

Lost
Stays
Added
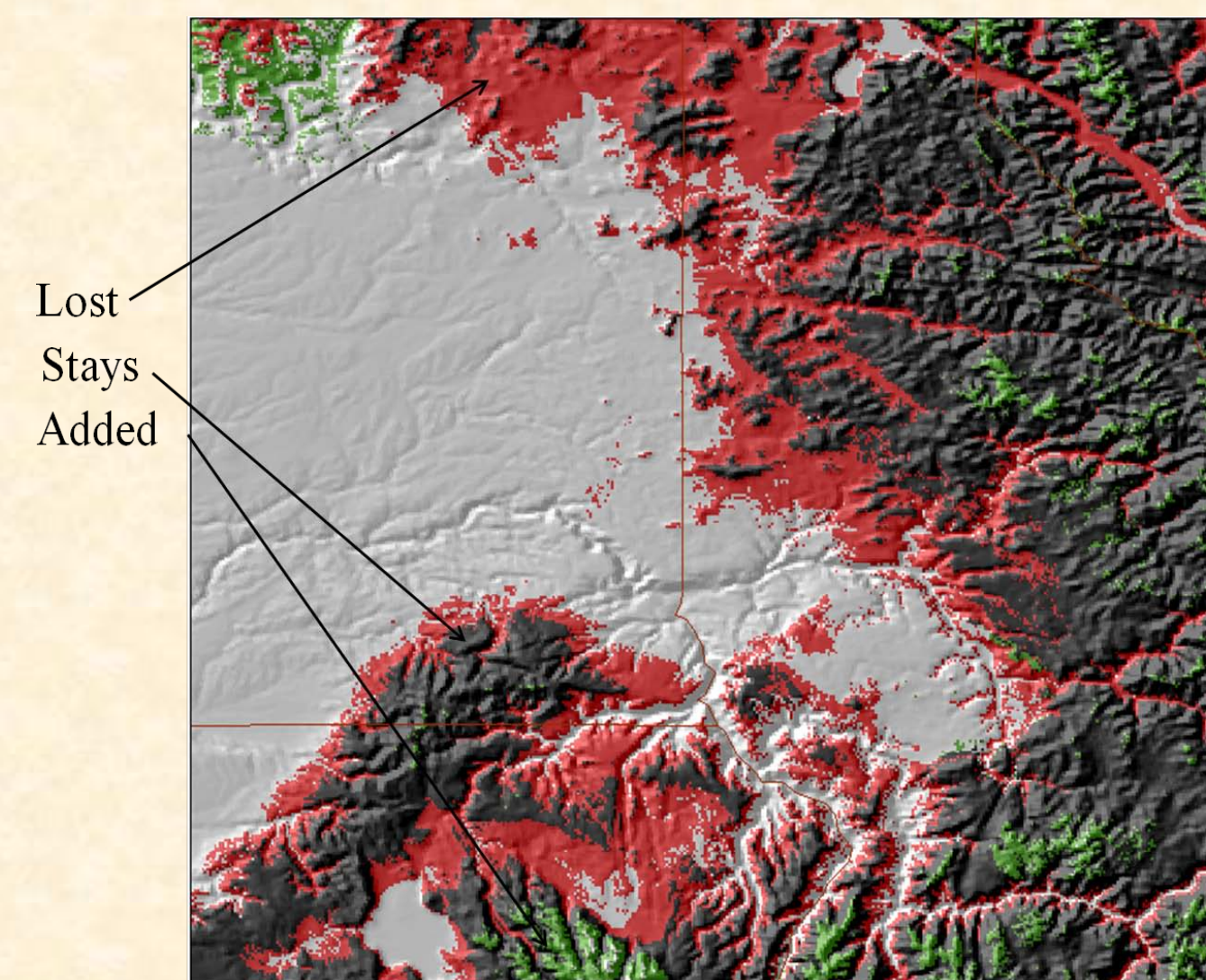
How does Climate-FVS work?

The core tree growth, mortality, and regeneration components in FVS are modeled as functions of site capacity, tree size, and competition. The measures of site capacity rely on direct observations of biological indicators such as site index.

### How species composition changes in future climates:

- Mortality rates increase when the viability score falls below 0.50. This threshold gives species the benefit of doubt: there is virtually no evidence that species grow in the climates with such low viability scores.
- Establishment
  - Triggered by low stocking.
  - Add the most viable species, and add more trees per acre of the most viable species.
  - Does not represent migration, it is intended to provide a suggested set of species to consider.

How tree growth changes in future climates:

- Site index was modeled as a function of climate for the western US.
- A proportionate change in site index results in corresponding change in growth.
- This component assumes the growing stock is reasonably adapted to the site.
- It represents the *environmental* effect on growth.

Example

Example from the Clearwater National Forest: Hadley model for A2 and B2 scenarios exhibit the greatest impact.
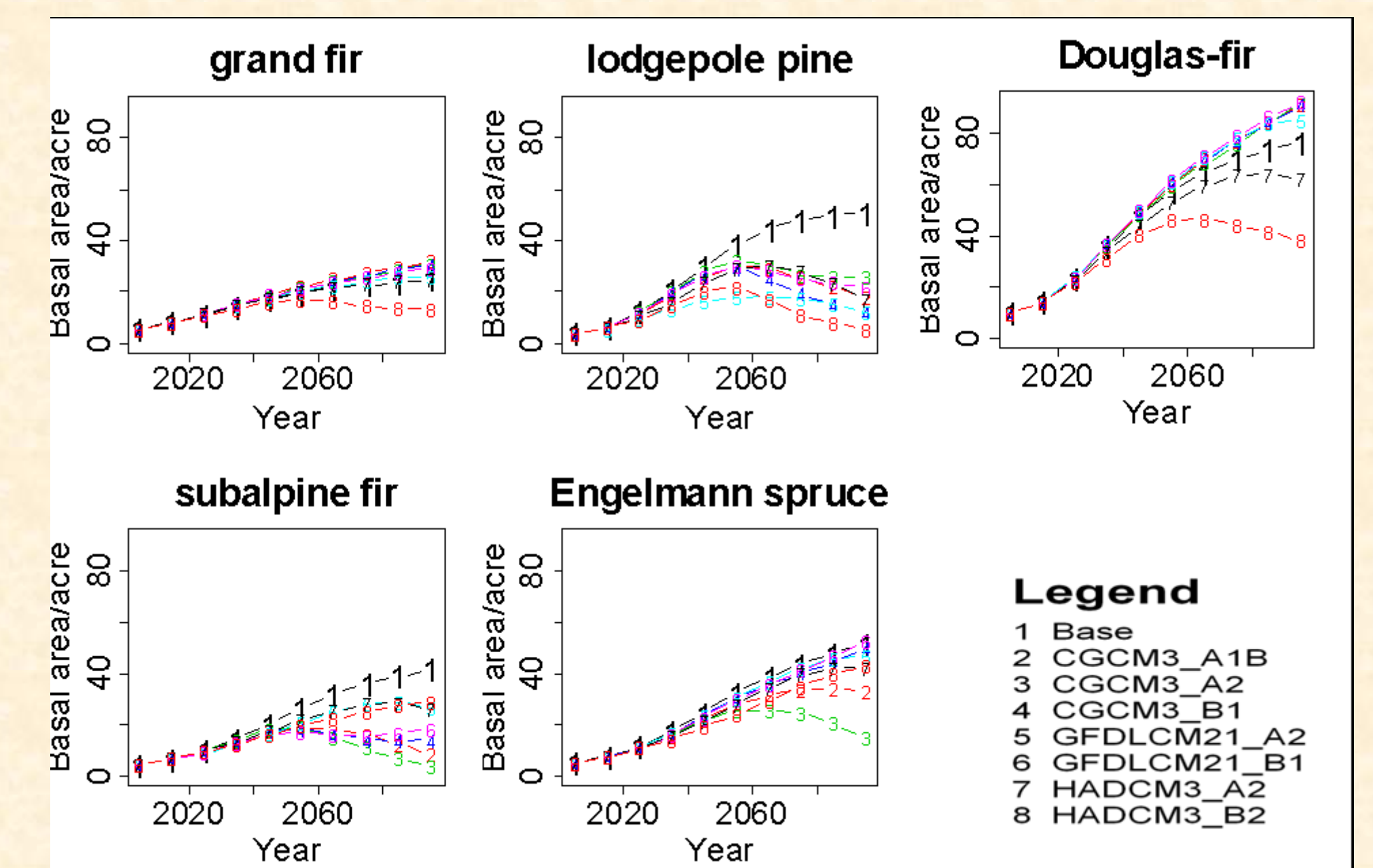
Discussion

- The magnitude of predicted climate change during the expected lifetime of existing trees is large enough that it requires consideration.
- The effects on these changes must be accounted for at the species level and for some species at the population level.
- The species climate profile models do not take into account how *competition* has influenced range (realize verses potential niche).
- Climate-FVS is only available for the western U.S. (excluding Alaska). Climate-FVS for the eastern U.S. is under development and will be available in 2012.

References

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Rehfeldt, Gerald E.; Crookston, Nicholas L.; Warwell, Marcus V.; Evans, Jeffrey S. 2006. Empirical Analyses of Plant-Climate Relationships for the Western United States. International Journal of Plant Sciences. 167(6):1123-1150.

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The Forest Vegetation Simulator is available from the following website:

http://www.fs.fed.us/fmsc/fvs

Our climate web site has supporting information and access to custom climate predictions:

http://forest.moscowfsl.wsu.edu/climate