Changes in Vegetation Dynamics in Alaska: Implications for Arctic Herbivores

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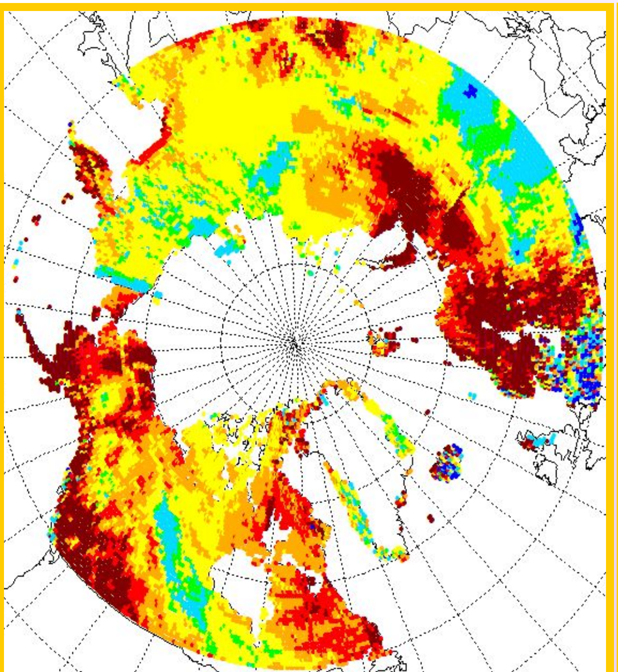
Wildlife Response to Environmental Arctic Change Workshop
Nov. 17 -18, 2008

Pan-Arctic Detection of Recent Land Surface Changes

Change in Snow Cover Duration 1970 - 2000



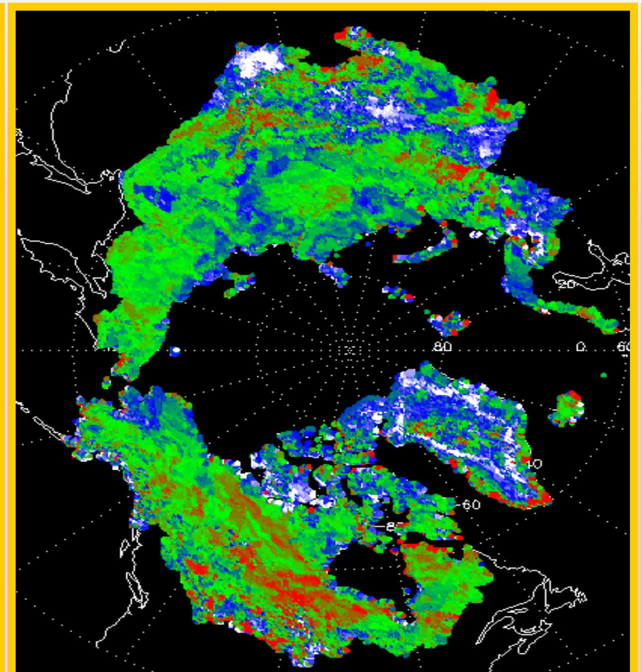
Euskirchen et al., Global Ch. Biol., 2007

- <-0.4
- -0.4
- -0.3
- -0.2
- -0.05
- 0.1
- >0.1

Days shorter yr-1

Days longer yr^{-1}

Growing Season Change 1988 - 2000



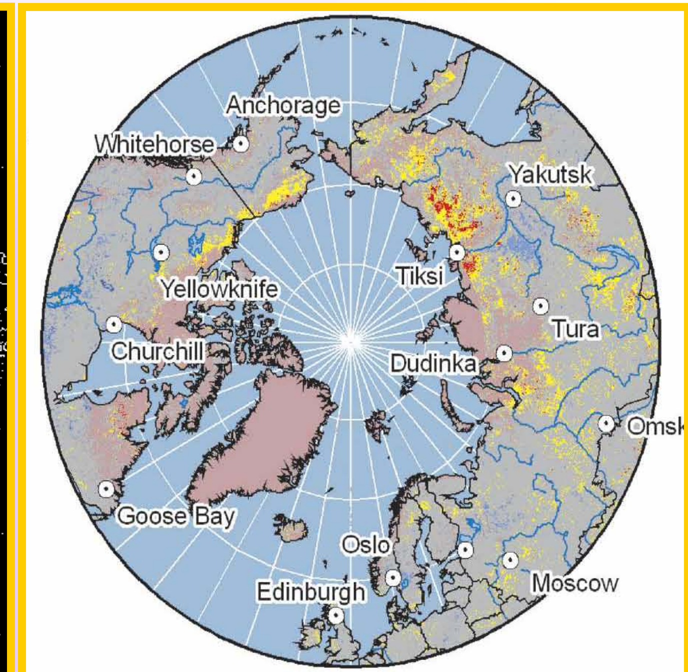
McDonald et al., Earth Interactions, 2004

- ≤-3.0
- -2.0
- -1.0
- 0.0
- 1.0
- 2.0
- ≥3.0

Days shorter yr-1

Days longer yr^{-1}

Change in Gross Primary Productivity 1982 - 2003

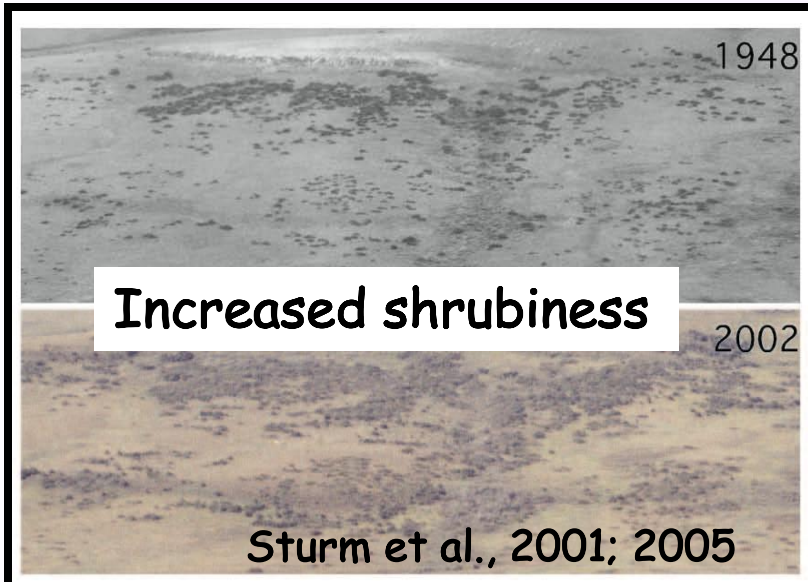


Bunn & Goetz, Earth Interactions, 2006

Slopes

- Strong Negative
- Negative
- Insignificant Slopes
- Positive
- Strong Positive
- Insufficient Data

Studies have also documented changes in plant community composition at high-latitudes



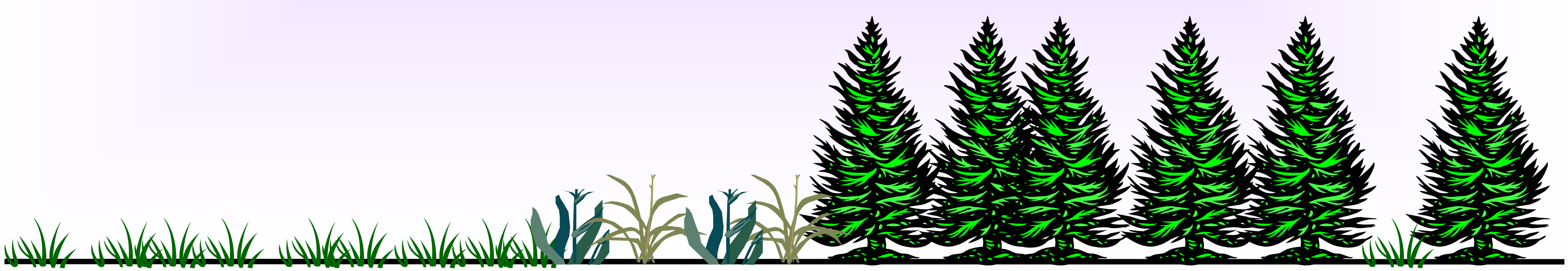
- Changes in the length of the snow & growing seasons impact vegetation.

- How well can we predict these changes in vegetation? (TEM-DVM)

- What is the magnitude of climate-related changes in the productivity of the major ecosystem types (including their dominant plant functional types, PFTs) in northern Alaska?

- How can we use predictions in vegetation changes to gain an understanding of how herbivores may be impacted by predicted changes in vegetation? (TEM-DVM linked to CARMODEL)

- What types of processes / dynamics and habitats do vegetation models need to consider?

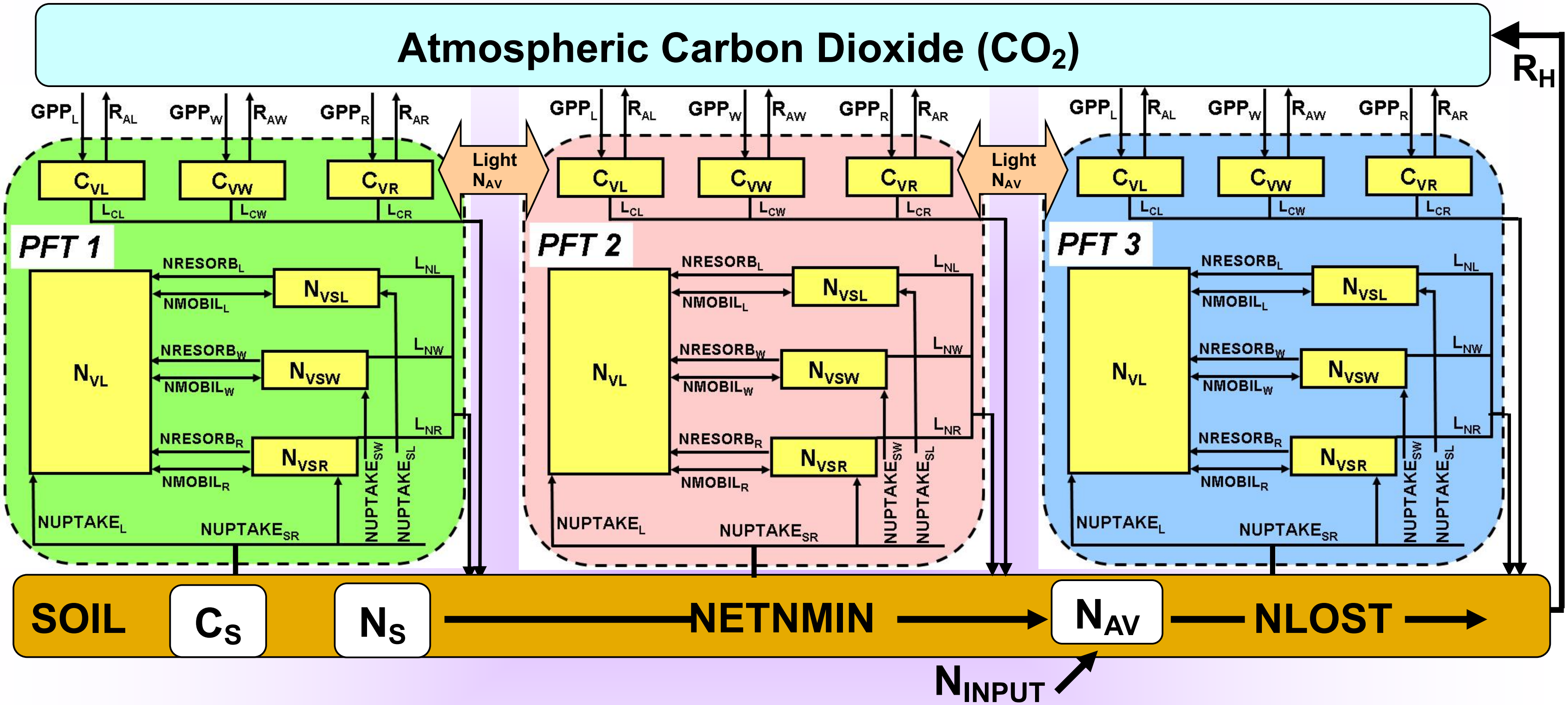


Spruce, *Salix* spp., other deciduous shrubs, evergreen shrubs not including spruce, sedges, forbs, lichens, and feathermoss

Betula spp., other deciduous shrubs, evergreen shrubs, sedges, forbs, lichens, feathermoss and Sphagnum moss

Salix spp., *Betula* spp., other deciduous shrubs evergreen shrubs, sedges, forbs, lichens, & feathermoss

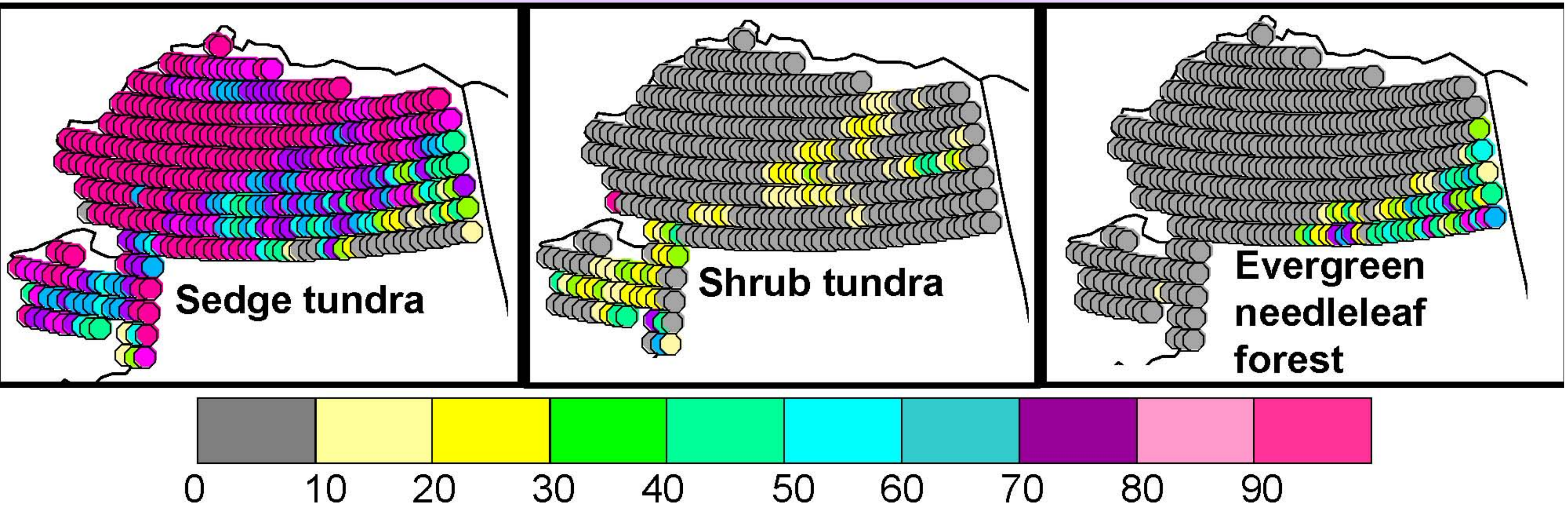
TERRESTRIAL ECOSYSTEM MODEL WITH DYNAMIC VEGETATION AND LEAF, WOOD, AND ROOT COMPONENTS (TEM-DVM)



Linked to other submodels including a soil thermal model (permafrost dynamics; Zhuang et al., 2001) and hydrology model (snow dynamics; Euskirchen et al., 2007)

Euskirchen et al., in press, Ecol. Applications

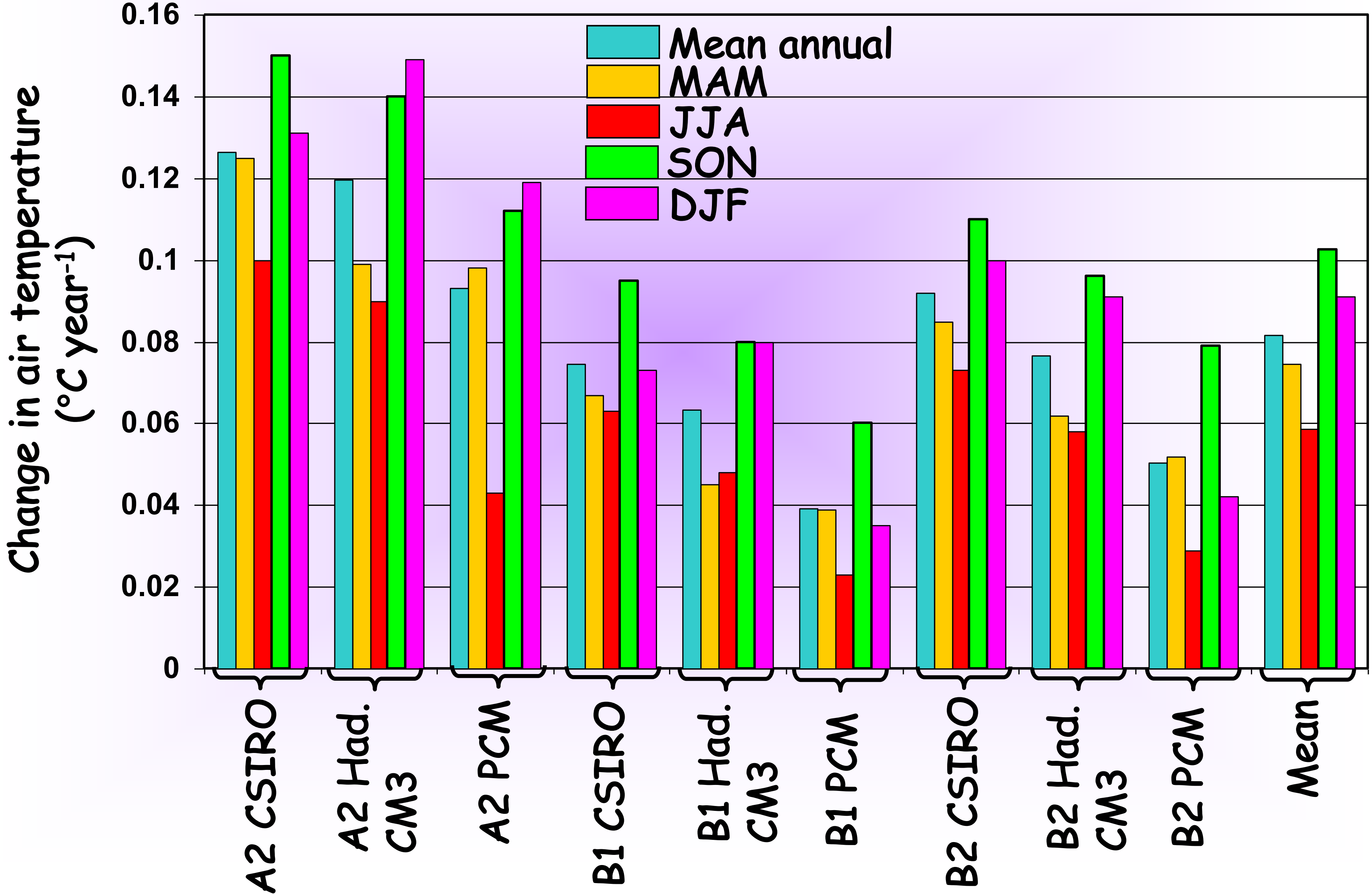
- The study region in northern Alaska is classified as 77% sedge tundra, 13% shrub tundra, and 8% evergreen needleleaf forest, with each of these ecosystems comprised of 8 or 9 PFTs.
- The model is parameterized based on field data collected in the study region.



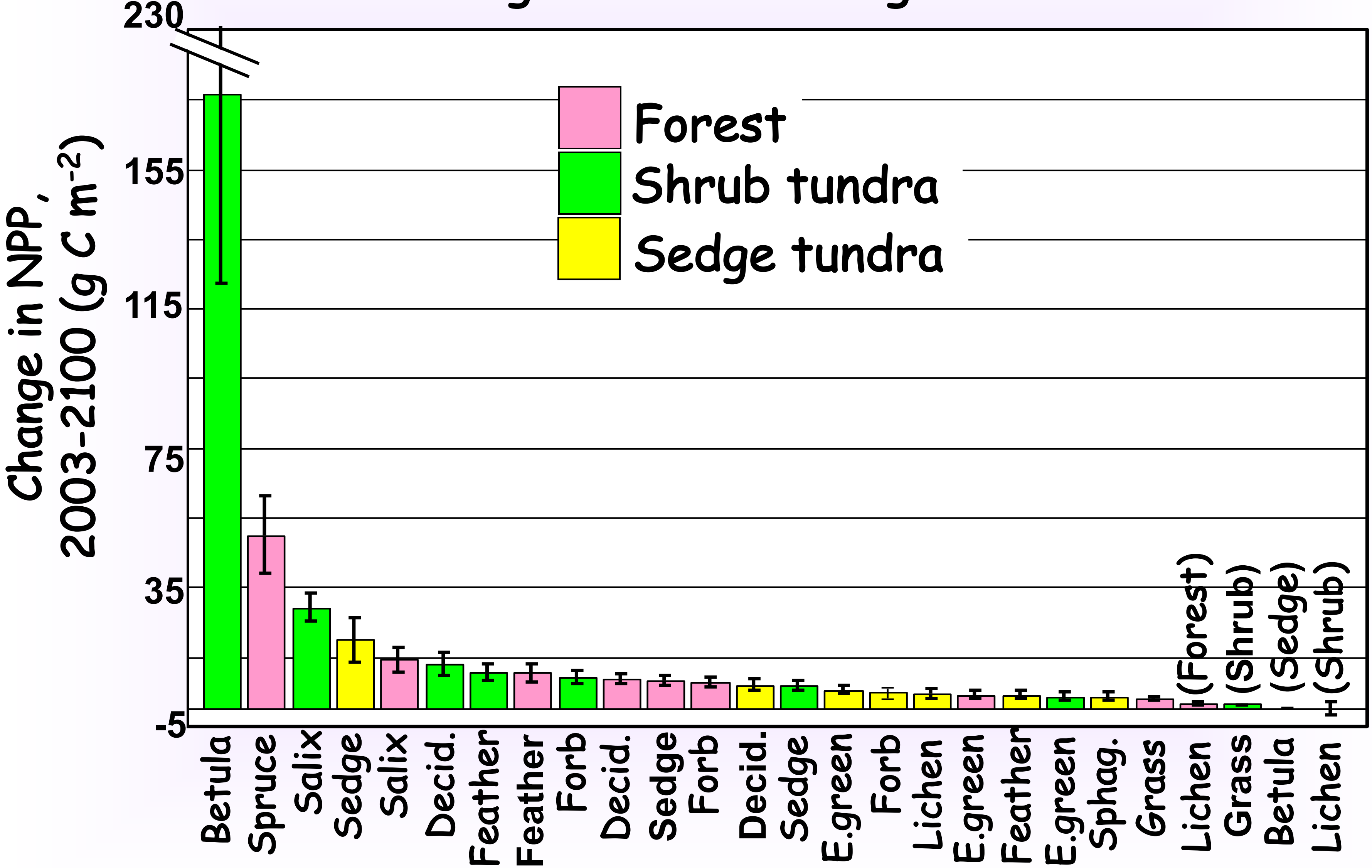
Percent of vegetation type in each half-degree (latitude by longitude) grid cell

Small percentages of ice, rock, lakes, and broadleaf deciduous not shown.

We used a wide range of future climate scenarios, based on the IPCC SRES scenarios and three global climate models (GCMs). Shown below is input air temperature data.

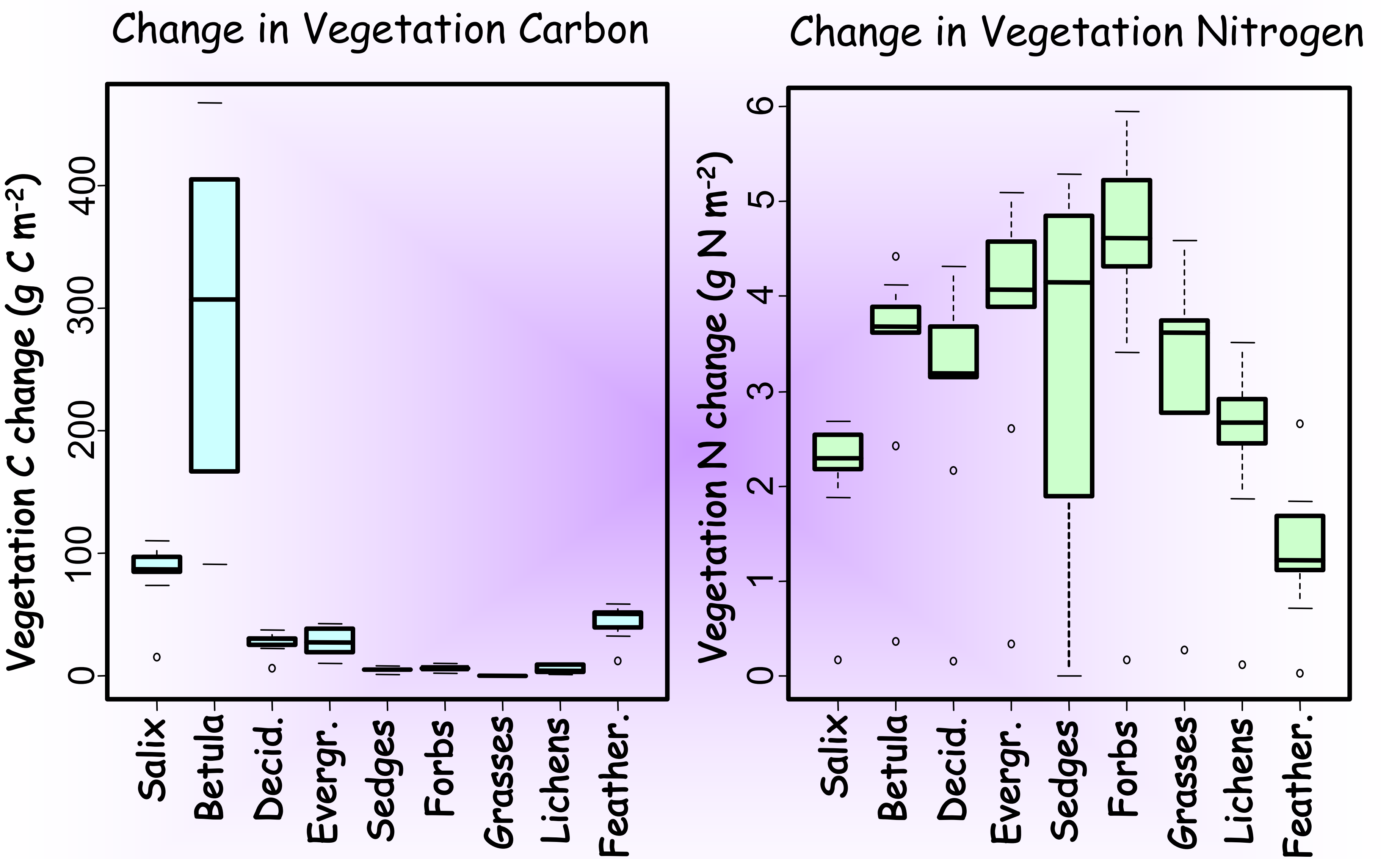


Change in NPP (2003 – 2100) across all ecosystem types and PFTs, arranged in descending order.

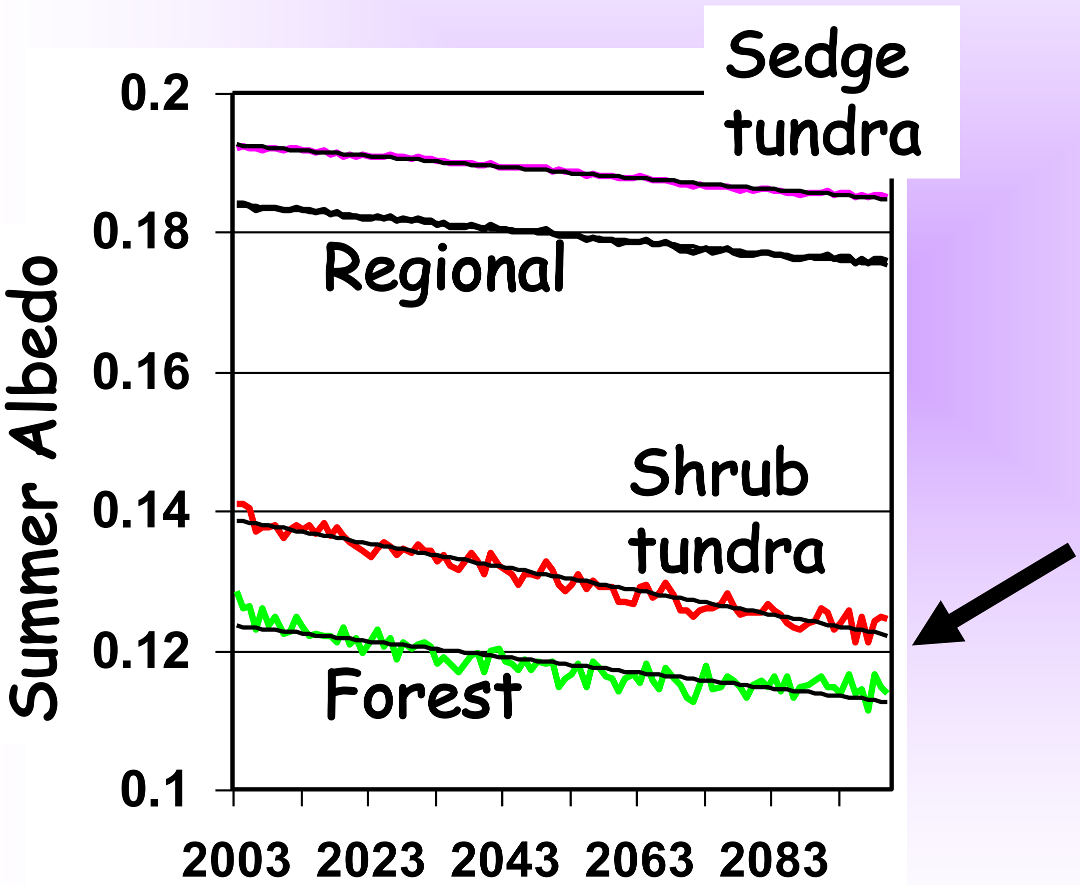


Euskirchen et al., in press, Ecol. Applications

Shrub Tundra 2003 - 2100



Increases in NPP resulted in increases in biomass, and consequently, decreases in summer albedo.

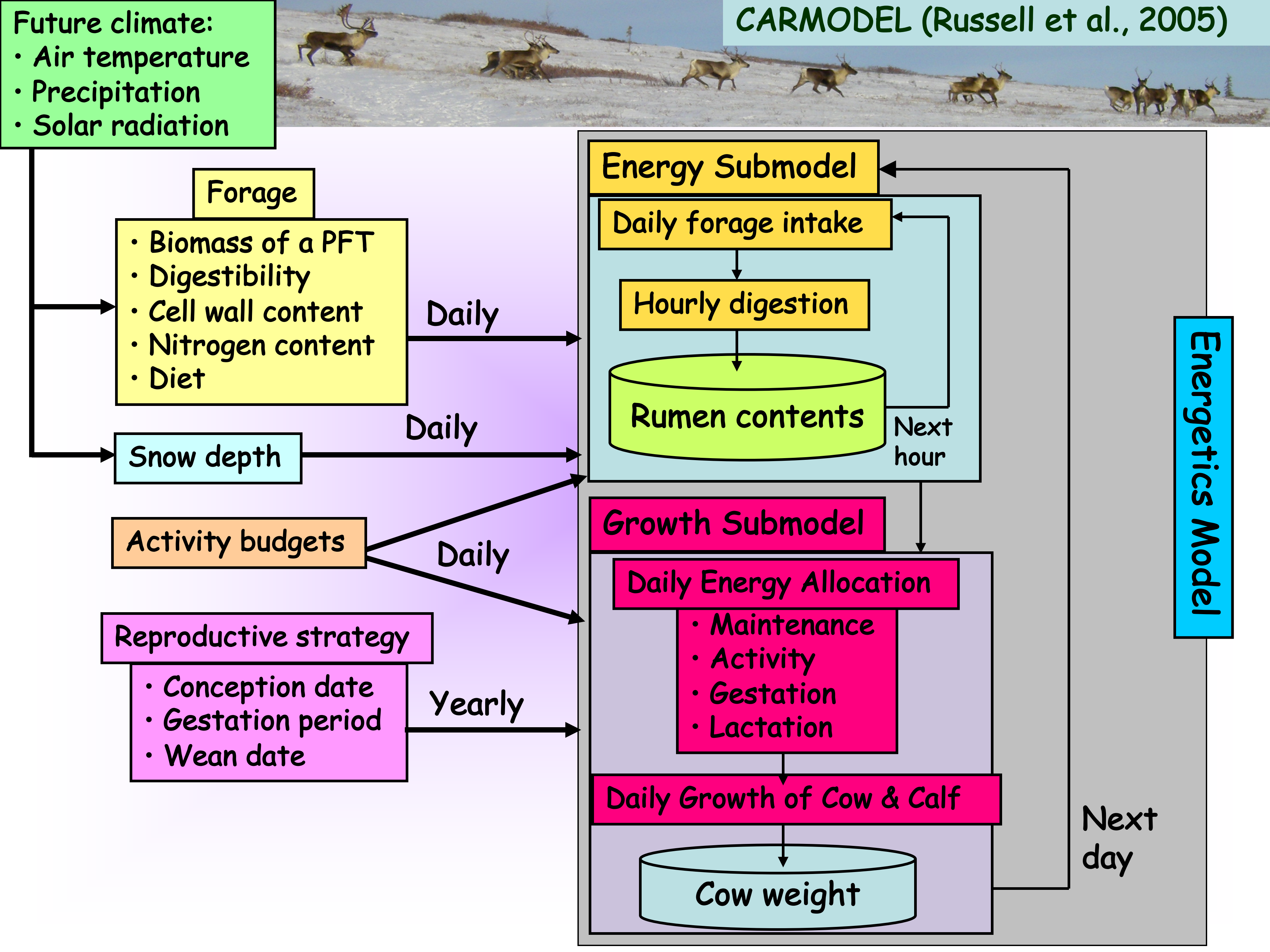


The albedo of the shrub tundra is approaching that of the forest at the end of the simulation. Can the shrub tundra ecosystem still be a considered shrub tundra ecosystem?

How can TEM-DVM be used to relate vegetation changes to herbivores?

- Arctic calving caribou provide an example of a species that is likely to be affected by climate change, but with long annual migrations and a circumpolar distribution the effects on populations will not be uniform.

- An explicit energetics model (CARMODEL) is available that allows assessment of projected climate induced changes in potential forage intake on fat and protein dynamics.


CARMODEL (Russell et al., 2005)
Future climate:
• Air temperature
• Precipitation
• Solar radiation
Forage
• Biomass of a PFT
• Digestibility
• Cell wall content
• Nitrogen content
• Diet
Daily
Snow depth
Daily
Activity budgets
Daily
Reproductive strategy
• Conception date
• Gestation period
• Wean date
Yearly
Energy Submodel
Daily forage intake
Hourly digestion
Rumen contents
Next hour
Growth Submodel
Daily Energy Allocation
• Maintenance
• Activity
• Gestation
• Lactation
Daily Growth of Cow & Calf
Cow weight
Next day
Energetics Model

• Compare and contrast the implications of climate induced changes in forage biomass and quality on fat and protein dynamics in two groups of caribou with characteristically different diets at calving: a) caribou that calve in the wetter portions of the coastal plain (Central Arctic, Teshekpuk), and b) caribou that calve in uplands and drier portions of the coastal plain (Western Arctic, Porcupine).

• Analyses based on a range of climate scenarios will allow managers and subsistence users to more effectively understand the range of possible future conditions and to plan adaptation strategies.

Integration of the model presented here (TEM-DVM) with other land cover maps / habitat classification schemes:

• Finer scale representation of the ecosystem types within a landscape or region is possible.

• It is also possible to incorporate other ecosystem/habitat types than the three presented earlier.

• Some parameterization data for PFTs in a given habitat type is necessary.

• One recent model development is a dynamic soil layer module (Yi et al., manuscript in prep.) that incorporates different types of soil layers (e.g., live moss, humic, fibric) and drainage classes (e.g., moderately well-drained, poorly drained).

Future Work & Challenges:

- Incorporating shifts from one ecosystem type to another

- Incorporating changes in vegetation (at the ecosystem & PFT level) under changes in the fire regime and insect outbreaks

- Understanding how the phenology of the various PFTs responds to changes in growing season length in terms of both budburst in the spring and leaf senescence in the fall

- Incorporating water competition among the PFTs

- Increased levels of herbivory may lead to increases in productivity of ecosystems under climate change. How then does this increased herbivory feed back on the ecosystem? Field experiments suggest that the increased herbivory will ultimately modulate this increased productivity (e.g., Sjögersten et al., 2008).