Are the changes detectable?

OR

What are the (important, confident, ready-to-solve) gaps in terrestrial observation systems?

OR

Why (and where) we need more data

# In order to detect change, we must

- Anticipate the change
  - Past behavior
  - Recent observations
  - Models
- Have the right data series or measurements

# Why is there uncertainty?

- Unknown or uncertain function
  - “We need more data”
- Misinterpretation (trends ≠ future, nonlinearities)
  - Move from empirical to process-based understanding
- Model or measurement error
  - Model comparison, networks
- Surprises

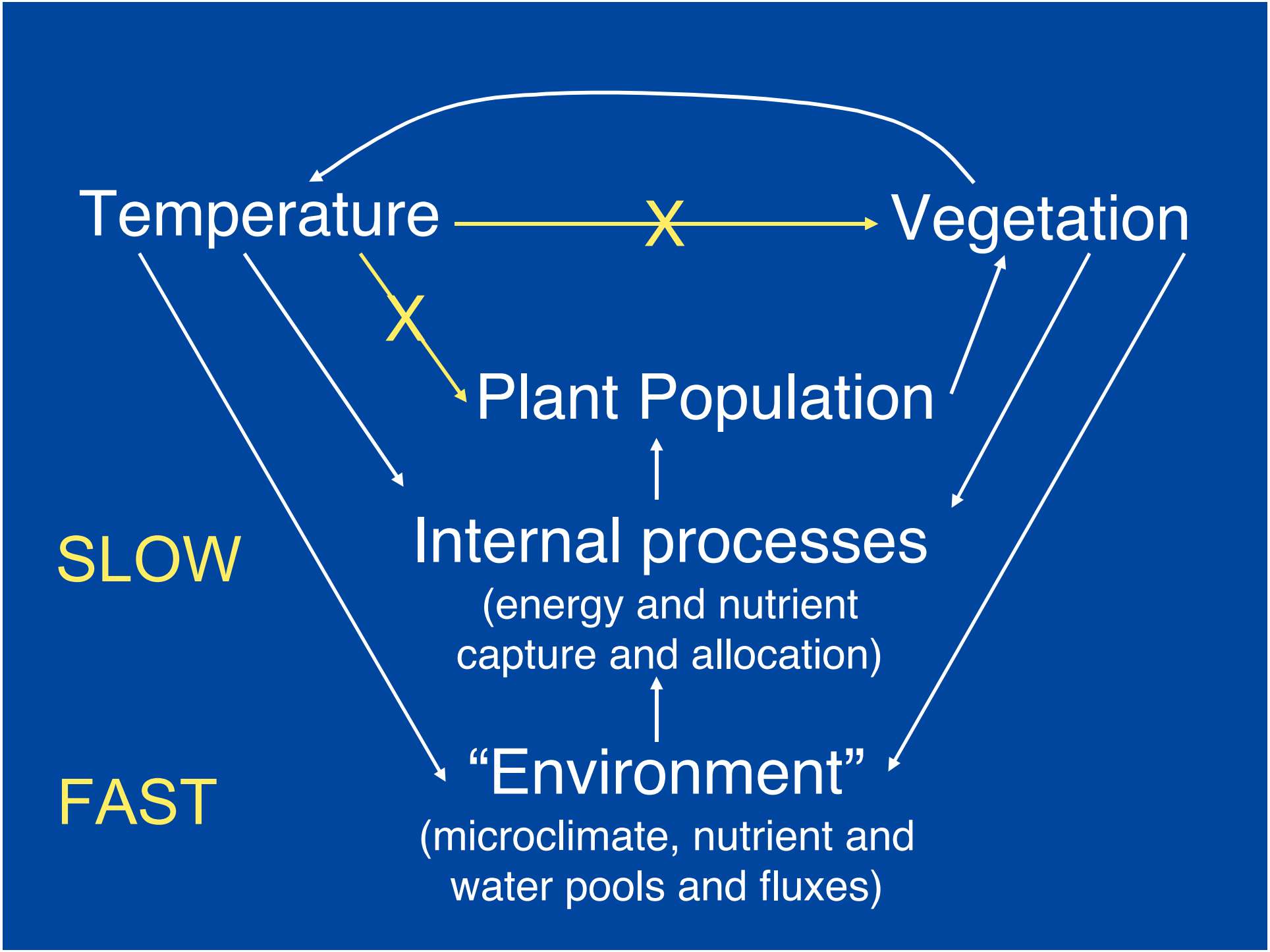
Focus on vegetation as an important ecosystem integrator (as an example)

# Things that we know

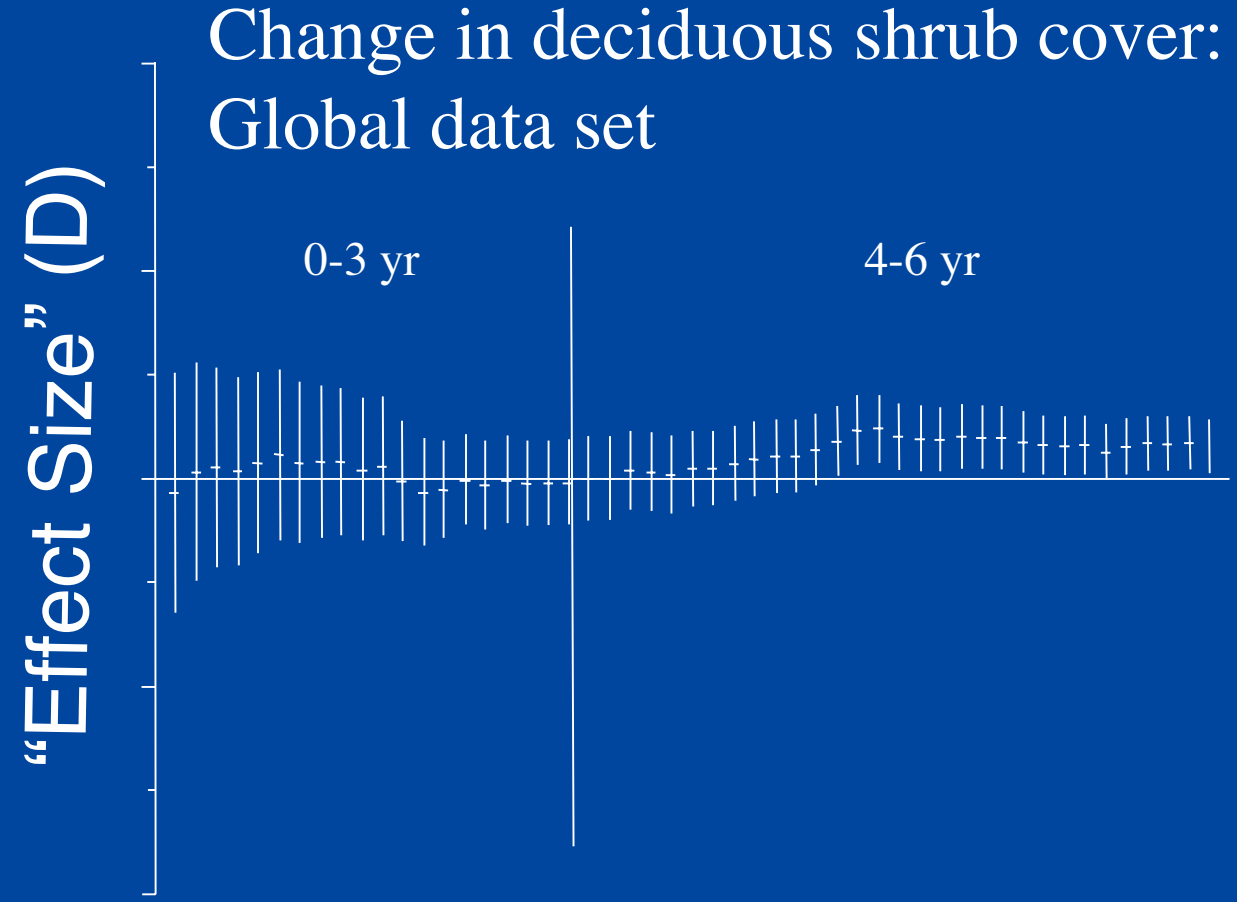
- Vegetation has changed dramatically and rapidly during the Holocene
- Warmer temperatures lead to increased woody vegetation
- Permafrost is linked to both vegetation and temperature
- Reindeer/caribou herds don't do well with lots of birch in their diets (but they like *Salix pulchra)*

# Things that we don't know (not complete)

- Vegetation-hydrology-permafrost-snow interactions
- When, where, and at what rate will vegetation change?
- Both role and pattern of moss cover and composition
- Importance of changes in phenology to both ecosystem processes and ungulates
- Importance of *slow* and *fast* drivers


Temperature
X
Vegetation
X
Plant Population
SLOW
Internal processes
(energy and nutrient
capture and allocation)
FAST
“Environment”
(microclimate, nutrient and
water pools and fluxes)

# Slow change: carbon uptake and allocation



# Fast change (examples)

- Large-scale hydrology and permafrost changes, disappearance of ponds
- Immigration of key species
  - Ex: appearance of black spruce

# RECOMMENDATIONS

- Focus on highly integrative aspects
  - Vegetation
  - Hydrology and permafrost
- Don’t stop high quality time series!
- Use networks and meta-analysis
- Continue to work at (and link) multiple time and space scales
- Improve dynamic vegetation models
- Experiments
  - Sustained and whole watershed