Trends in net biomass production of North American boreal forests

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Permanent Sample Plots

How can we study trends in forest productivity:

- Satellite-based vegetation indices
- Tree-ring measurements
- Atmospheric CO2 measurements
- Forest inventories (permanent sample plots)

Models:
- Statistical models
- Ecophysiological models
Three approaches using PSPs:

- **Comparison between $\Delta B$ and $B$**
  
  e.g. Caspersen et al. 2000; McMahon et al. 2009; Hember et al. 2012

- **Time series analysis**
  
  e.g. Ma et al. 2011; Hember 2011; Hember et al. 2012

- **Statistical model predictions**
  
  e.g. Hember 2011; Hember et al. 2012
Permanent Sample Plots

Plot locations

Climate space

Potential evapotranspiration (mm d⁻¹)

Days with frost

Desert

Forest

PSPs

Arctic
Plot Biomass Dynamics

$$\Delta B = G_s + G_r - M - R$$

$\Delta B =$ net biomass production

$G_s =$ growth of survivors

$G_r =$ growth of recruits

$M =$ loss due to natural mortality

$R =$ loss due to harvesting
ΔB - B Comparison

Boreal Plains Ecozone

White spruce

ΔB (Mg C ha⁻¹ yr⁻¹)

Stand age, years

Percent change in ΔB

P. Silver fir
Douglas-fir
Lodgepole pine
Subalpine fir
Engelmann spruce
White spruce
Aspen
Jack pine

Maritime
Montane
Boreal Plains
Boreal Plains Ecozone

Time Series Analysis

- Growth (survivors)
- Net production
- Growth (recruitment)
- Mortality

Flux (g C m$^{-2}$ yr$^{-1}$)

Time, years


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Time Series Analysis

Boreal Shield Ecozone

![Map of Boreal Shield Ecozone]

![Graph showing Time Series Analysis]

- Growth (survivors)
- Net production
- Growth (recruitment)
- Mortality
- Removals

Flux (g C m\(^{-2}\) yr\(^{-1}\))

Time, years

Statistical Modelling

Solar radiation

Snowmelt

Actual evapotranspiration

Soil water content
Mortality:

- Traditional approach
  \[ M = \mu B, \]
  \[ \mu = \text{constant} \]

- Adjustment to account for water stress
  \[ \mu = b_0 f(ET_p) \]
  or
  \[ \mu = b_0 f(W_S) \]
Growth:

- **Heat**
  - Wheat, redrawn from de Vries et al. (1979)

- **Ambient CO₂**
  - Eldarica pine, redrawn from Idso and Kimball (1994).

- **Hydraulic Resistance**
Statistical Modelling

Boreal Plain Ecozone

Growth (Mg C ha$^{-1}$ yr$^{-1}$)

Mortality (Mg C ha$^{-1}$ yr$^{-1}$)

$\Delta B$ (Mg C ha$^{-1}$ yr$^{-1}$)

Time, years
Conclusions

Trends in net biomass production:

$\Delta B$ – B Comparison:

• Boreal Plain shows 15-25 % enhancement of $\Delta B$

• Boreal Shield not yet reported

Time series analysis:

• Boreal Plain shows a -22 g C m$^2$ trend in $\Delta B$ between 1968-2005

• Boreal Shield shows a 42 g C m$^2$ trend in $\Delta B$ between 1972-2007
Final Thought

Transition from emphasis on calibration of static G&Y models to a stable monitoring programme capable of detecting early signs of environmental change.


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