Questions relevant to plant allocation

- Allocation is controlled by resource limitation or ontogeny

- How do species differ?

- What factor controls intra-species variation in plant C allocation? (nutrients, moisture)

- How responsive is allocation to changes in environment?

- How genetically “fixed” is allocation
Secondary effects of plant allocation

- Plant species distribution
- Fuel loads
- Ecosystem C distribution
- Ecosystem C balance (respiration and photosynthesis)
Aspen and Spruce C budgets for central Canada

MAT = -3.2°C
Precip = 538 mm
Mature black spruce C budget: Man/Sk Canada

GPP \[\sim 600 \text{ g C m}^{-2} \text{ y}^{-1}\]

- **Foliage NPP**: 6%
- **Wood NPP**: 10%
- **Root NPP**: 18%

**Foliage Respiration**: 20%

**Wood Respiration**: 12%

**Root Respiration**: 35%

Ryan et al. 97, Gower et al. ‘97
Mature (~80 years) aspen annual C budget: Man/Sk Canada

GPP

Foliage NPP

Foliage Respiration

Wood NPP

Wood Respiration

Root NPP

Root Respiration

~800 g C m\(^{-2}\) y\(^{-1}\)

12%

10%

22%

11%

9%

36%

Ryan et al. 97, Gower et al. ‘97
Compare Aspen and Spruce for interior Alaska and central Canada

MAT = -3.2 C
Precip = 267 mm

MAT = -3.2 C
Precip = 538 mm
Black Spruce Foliage vs DBH

Gower/Bond-Canada
Yarie/Kane/Mack-AK

Foliage (g/tree)

DBH (cm)

Aspen and Black spruce

• Apparently less foliage for large diameter black spruce in Alaska than Manitoba

Regional Variation in Allocation

- Boreal Forest by species
- Alaska, Manitoba, and Saskatchewan and Black spruce
Figure 7. Data from review by Gower et al. (2001a), showing the stability of BNPP to ANPP for boreal hardwood and pine species across Russia and North America. There was no relationship between BNPP and ANPP for spruce species across sites, but the relationship appears negative.
Black spruce aboveground growth and root respiration

\[ y = 186.19 e^{-0.0023x} \]

\[ R^2 = 0.88 \]

Aboveground growth (g C m\(^{-2}\) y\(^{-1}\))

Root Respiration (g C m\(^{-2}\) y\(^{-1}\))

Manitoba

Saskatchewan

Alaska

Vogel et al. in prep
Soil respiration in black spruce increases with moisture deficit.

Vogel et al. (2005)
Carbon Cycling (g C m⁻² y⁻¹) dynamics in relation to temperature for Alaska, Manitoba, and Saskatchewan

Vogel et al. in prep
Natural allocation variation with time

- Russian Boreal Forest
- Black spruce forest in Manitoba
Plant allocation responds to moisture deficit in Russia

Acclimation of Russian forests to recent changes in climate

Andrei Lapenis*, Anatoly Shvidenko†, Dmitry Shepachenko‡, On† and Anantha Aiyer*

Global Change Biology (2005) 11, 2090–2102,
Mature (~150 yrs old) black spruce stand in Manitoba

Measured Net Annual Carbon balance (Photosynthesis-Respiration) with eddy-covariance system for 10 years

Photosynthesis unresponsive to climate but ecosystem respiration changes and alters C balance
Manipulations

• Added moisture or nitrogen

• Soil + Air warming
Water and nitrogen manipulations for black and white spruce seedlings

**Fig. 2** Growth (g/plant) of black spruce and white spruce after approximately 16 weeks under various nitrogen and water regimes. Each bar represents the average of about 25 seedlings (±SEM). Species were statistically the same within each treatment. Significantly different ($P<0.05$) treatments within a species are denoted by different letters above the bars.

**Fig. 3** Root-to-shoot ratio, R/S (g/g), of black spruce and white spruce seedlings grown for approximately 16 weeks under various nitrogen and water regimes. Each bar represents the average of about 25 seedlings (±SEM). Species were significantly different in +H$_2$O+N ($P=0.0005$) and +H$_2$O+N treatments, but not in −H$_2$O+N and −H$_2$O+N treatments. Significantly different ($P<0.05$) treatments within a species are denoted by different letters above the bars.

T. B. Patterson · R. D. Guy · Q. L. Dang

Fertilization of boreal forest reduces both autotrophic and heterotrophic soil respiration

PER OLSSON*, SUNE LINDE‡, REINER GIESLER‡ and PETER HÖGBERG*
Manitoba Air + Soil warming
Stith Gower, Univ. of Wisconsin-Madison

Initiated Spring 2004, 20-year old planted black spruce forest

HI  HO  CI  CO
Figure 6. Absolute shoot growth of black spruce trees (n = 3 trees/plot) for all four treatments in 2004 and 2005
2005 Shoot Phenology Absolute Growth

Total growth (cm)

Date

June

July

Aug

CI

CO

HI

HO
Figure 5. Relationship between soil temperature at 10 cm soil depth and soil surface CO$_2$ flux for heated soil inside the chamber (HI), heated soil outside the chamber (HO), control soil inside the chamber (CI) and control soil outside the chamber (CO) (Bronson unpublished data).
Climate Sensitivity Questions

• What really controls allocation in black spruce (moisture/temperature-nutrients)?

• How sensitive are other boreal species to climate?

• How important are these factors to other processes in the boreal forest and to our interpretation of measurements like tree rings?