Effect of community vertical structure on light utilization of young white spruce and aspen-white spruce mixtures in western Alberta

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ABSTRACT

Carbon dioxide (CO₂) is one of the green house gases whose atmospheric levels have been dramatically increasing in the last 5 decades (IPCC, 2007). This increment is a primary cause of climate change. This has captured the interest of many scientists and its study and dynamics through the global carbon cycle have become a necessity.

Understory vegetation plays an important and active role in the dynamics of the boreal forest. Young and mature boreal forest stands include trees, shrubs, herbs, graminoids and thallophytes. Each of these strata develops its own leaf area and contributes to the total LAI of the ecosystem to different degrees. While shrubs and herbs have been reported to contribute up to 15% of the LAI of forest ecosystems and it is suggested that understory vegetation may contribute up to 50% of total NPP, there is little information available on this. It is suggested that understory vegetation may contribute to total NPP. According to our results there is a significant difference in total understory biomass more than the composition of pure versus mixed stands.

Light affects forest dynamics mainly beneath the understory, where levels of light are influenced by overstory canopy structure and can limit growth and production. According to Finzi et al. (2001), Finzi and Canham (2000), Liefers and Stadt, 1994; Liefers et al. 2002, Pinne et al, 2001; Strenbog et al, 2004). This is the reason why we observed higher values of LAI and NPP in mixed stands, where trembling aspen is dominating and using most of the light. According to Scarluffo et al (2001) LAI is related to the ability of the lower leaves in the canopy to intercept enough light to sustain a positive carbon balance, if trembling aspen is intercepting most of the light, the understory will not develop as in those treatments where there is no aspen using most of the light. In those plots with no aspen, LAI and NPP are lower but the percentage of understory contribution is much higher.

METHODS

Aboveground overstory biomass was calculated using allometric equations. Trembling aspen aboveground total biomass was calculated considering DBH and heights, using equations provided by Ung et al. (2000) for wood, bark, branches and foliage biomass. White spruce aboveground total biomass was calculated considering diameter at ground level and crown diameter using equations provided by Wagner and Ter-Mikaelian (2000). Carbon content was considered to be a fraction of 0.5 of the biomass. A plant canopy analyzer (LAI-2000) was used to measure light and LAI. To differentiate the contribution of functional group (trees, herbs, shrubs, grasses, and moss), we took readings above the woody vegetation, over the grass cover and at the ground level. LAI-2000 measurements were taken at 4 systematically located points in each plot. Readings were taken in two directions (west and east) at two times of day, with matching open sky readings being taken by a separate sensor place in an open area. These measurements provided us with overstory, understory and total LAI.

RESULTS

Total NPP range from 0.77 to 4.2 tonC/ha•yr⁻¹, being BN treatment (4.2 tonC/ha•yr⁻¹) and BH treatment (4.08 tonC/ha•yr⁻¹) the most productive, followed by BW treatment (1.27 tonC/ha•yr⁻¹) and the less productive BC treatment (0.77 tonC/ha•yr⁻¹). Understory NPP was very variable among treatments, going from 0.06 tonC/ha•yr⁻¹ in BH treatment to 1.1 tonC/ha•yr⁻¹. Overstory NPP was higher than the understory NPP and range from 0.1 tonC/ha•yr⁻¹ in BH treatment to 4.02 tonC/ha•yr⁻¹ in BN treatment. Biomass including herbs, grasses, shrubs, tall, shrubs, deciduous and moss contributed from 1.6% for BH treatments to 91.4% for BW treatment (Figure 3). LAI total ranges from 0.91 m²/m² in BC to 2.57 m²/m² in BN treatment. The overstory LAI accounts for 68.9% of the total LAI in BC treatment, 97.9% in BH, 74.2% in BN and only 14.2% in BW. LAI and NPP seem to be positively correlated (Figure 4). Preliminary regression lines show R² values that go from 0.48 when relating total NPP to total LAI to 0.85 when relating overstory NPP to overstory LAI.

DISCUSSION

Community vertical structure seems to have a significant effect on how the light is utilized by the overstory and the understory, causing considerable differences in how each strata contributes to total aboveground NPP and total LAI. Pure stands are represented by complete control (BC) and woody control (BW) treatments. Mixed stands are represented by herbaceous control (BH) and untreated plots (BN). According to our results there is a significant difference in total understory biomass between all of the treatments. This means that vertical composition is causing a significant difference in total understory biomass more than the composition of pure versus mixed stands.

Light affects forest dynamics mainly beneath the understory, where levels of light are influenced by overstory canopy structure and can limit growth and production (Claveau et al, 2001; Finzi and Canham, 2000; Liefers and Stadt, 1994; Liefers et al, 2002, Pinne et al, 2001; Strenbog et al, 2004). This is the reason why we observed higher values of LAI and NPP in mixed stands, where trembling aspen is dominating and using most of the light. According to Scarluffo et al (2001) LAI is related to the ability of the lower leaves in the canopy to intercept enough light to sustain a positive carbon balance, if trembling aspen is intercepting most of the light, the understory will not develop as in those treatments where there is no aspen using most of the light. In those plots with no aspen, LAI and NPP are lower but the percentage of understory contribution is much higher.

CONCLUSIONS

Management practices, such as herbicide treatments and tending, impact the forest structure and composition and can have profound and long-lasting influences on the carbon cycle due to changes in LAI and therefore in NPP. Understory development is affected by the amount of light reaching the ground, LAI at that level is also influenced and then NPP. Measurements of LAI from 2001 to 2000 provided a good insight, however direct measurements of LAI per functional group would be very useful to further understand the contribution of each group to total NPP and how they are using the light reaching them. LAI and NPP seems to be positively interrelated, however the preliminary low values of R² that we obtained, suggest that further analysis is required to get stronger conclusions.

KEY REFERENCES

Carbon dioxide (CO₂) is one of the green house gases whose atmospheric levels have been dramatically increasing in the last 5 decades (IPCC, 2007). This increment is a primary cause of climate change. This has captured the interest of many scientists and its study and dynamics through the global carbon cycle have become a necessity.

ACKNOWLEDGEMENTS

Special thanks to ForValueNet NSERC strategic network as well as CONACYT (National Council of Science and Technology) for the financial support provided.