Modelling of Temporal Variabilities of Forest Above Ground Biomass and Net Biome Productivity in Oyster River and Chibougamau Sites

Z. Wang[a], R. F. Grant[a], A. Arain[b], P. Bernier[c], J. Chen[d], N. Coops[e], A. Govind[d], L. Guindon[c], R. Hember[e], W. A. Kurz[f], G. Stinson[f], J. A. Trofymow[f] and J. Yeluripati[b]

[a]Department of Renewable Resources, University of Alberta, Edmonton, Alta., Canada, T6G 2E3; [b]School of Geography and Geology, McMaster University, Hamilton, Ont., Canada; [c]Canadian Forest Service, Laurentian Forestry Centre, Quebec City, QC, Canada; [d]Department of Geography and Program in Planning, University of Toronto, Toronto, Ont., Canada; [e]Department of Forest Resources Management, University of British Columbia, Vancouver, BC, Canada; [f]Canadian Forest Service, Pacific Forestry Centre, Victoria, BC, Canada

Introduction

The objective of this study is to conduct landscape-level simulations of forest carbon dynamics for Oyster River and Chibougamau (Fig.1) for several decades from the past to the present using historic inventory, disturbance and climate data for the purpose of applying and testing various modelling approaches.

Fig. 1 Location of Oyster River (OR) study site and Chibougamou (CH) site.
(After Fluxnet-Canada website, 2006)

Introduction to Oyster River site (Data provided by Tony Trofymow)

Longitude: -125.351614° ~-125.279924°
Latitude: 49.898963° ~49.852634°
Average elevation: 226.1m
Mean air temperature: 8.3°C
Mean Annual Precipitation: 1461mm
Main soil types: Arrowsmith; Bower; Cassidy; Cullite; Dashwood; Fairbridge; Hawarth; Hiller; Honeymoon; Kye; Piggott; Quimper; Quinsam
Forest types: Douglas Fir; Western Redcedar; Western Hemlock.
Major Disturbance period: 1928-1943; 1997-2005
Main Disturbance type: harvesting, slash burn, human caused burn

Introduction to Chibougamou site (Data provided by Pierre Bernier and Luc Guindon)

Longitude: -74.394184° ~-74.258131°
Latitude: 49.710915° ~49.645523°
Average elevation: 239.9m
Mean air temperature: 0°C
Mean Annual Precipitation: 1461mm
Surface deposit types: Glacier deposit; Fluvio-glacial deposit; Organic deposit
Forest types: Black Spruce; Jack Pine; Trembling Aspen
Major Disturbance period: 1963;
Main Disturbance type: harvesting

Methods

For intercomparison, model CBM-CFS3, Ecosys, C-CLASS and 3PG were used for Oyster River area and model CBM, Ecosys and INTEC were used for Chibougamau site.

The modellings of CBM-CFS3 and 3PG in this project were on the basis of forest and disturbance polygons. The attributes of the combined layers of soil, forest type and disturbance provide input data directly.

The modellings of Ecosys, C-CLASS and INTEC were on the basis of grid cells. The GIS vector data layers of soil, vegetation, harvesting, fire and fertilization were converted to 100m x 100m grids. The attributes for the total 2500 grid cells of Oyster River area and 6275 grid cells of Chibougamau site were extracted from their centroids and grouped into different model runs. Each model run has unique input parameters.

Model Ecosys, C-CLASS and INTEC output the grid-based results of Above Ground Biomass (AGB) and Net Biome Productivity (NBP) from 1920 to 2005 for Oyster River site and from 1928 to 2005 for Chibougamau site. The polygon-based AGB results of model CBM-CFS3 and 3PG during the same period were translated into grid cells.

Results

For Oyster River site, the annual average AGB of the total 2500 grid cells decreased sharply during 1928 to 1943 since the harvesting in 1928, 1929, 1932, 1936, 1937, 1940, 1944, the fire in 1942 and the harvesting with fire in 1930, 1931, 1934, 1938, 1939 and 1943. A recovery of ecosystem carbon stocks followed this high disturbance activity. The AGB loss from 1997 to 2005 results from the harvesting during this recent period (Fig. 2).

For Chibougamau site, the annual average AGB of the total 6275 grid cells decreased sharply in 1963 since 666 grids were disturbed by clearcut, 36 grids by infrastructure and 92 grids by partial cut (Fig.3). A recovery of ecosystem carbon stocks followed this heavy harvesting.

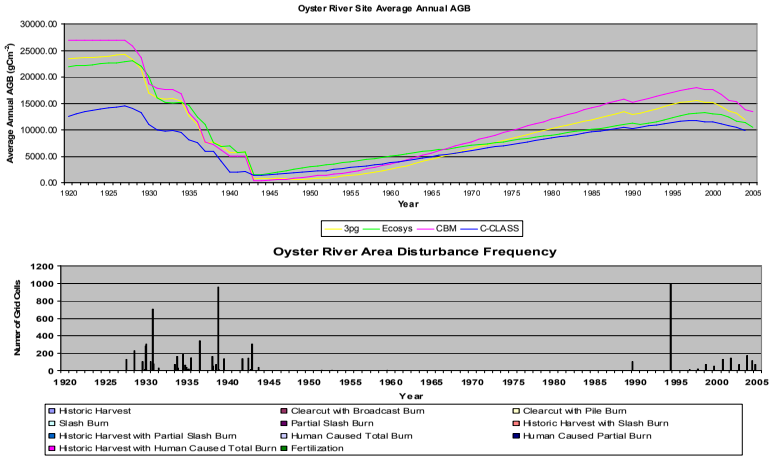

Fig. 2 Oyster River Disturbance Frequency and Annual Total Above Ground Biomass Distribution

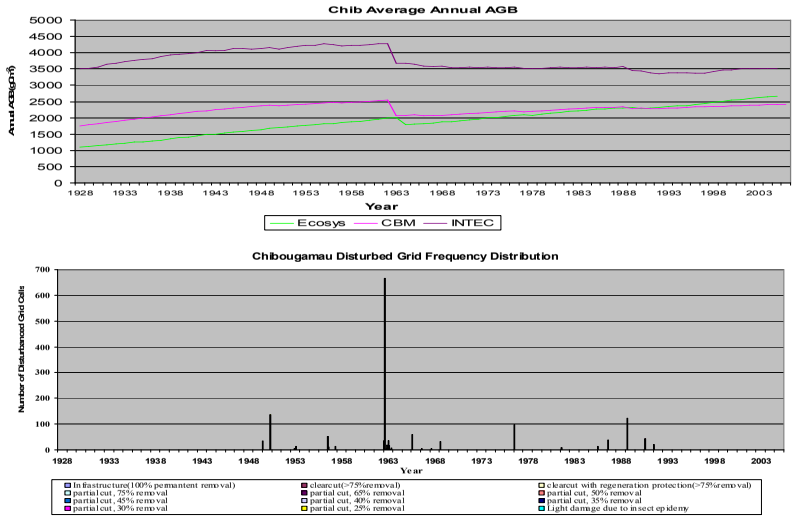

Fig. 3 Chibougamau Disturbance Frequency and Annual Total Above Ground Biomass Distribution

For the Oyster River site, disturbances showed more negative effects on the average annual NBP for model CBM than Ecosys. A gradual recovery of ecosystem C stocks followed the period of high disturbance activity from 1928 to 1943 in model CBM while a rapid regeneration took place in model Ecosys. Ecosys results showed a apparent interannual variability (Fig. 4).

For the Chibougamau site, all the model CBM, Ecosys and INTEC captured the C loss in the disturbances. Following the dominant disturbance in 1963, Ecosys showed a rapid recovery with apparent interannual variability and kept above zero, CBM had a 10 year recovery period with smaller NBP, INTEC showed larger interannual variability with more carbon source periods (Fig. 5).

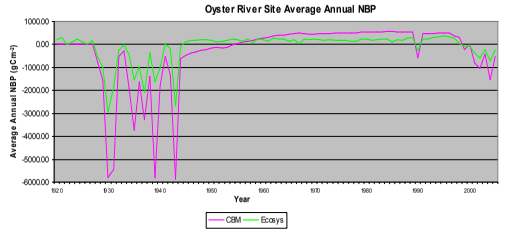

Fig. 4 Oyster River Average Annual NBP of Model CBM-CFS3 and Ecosys

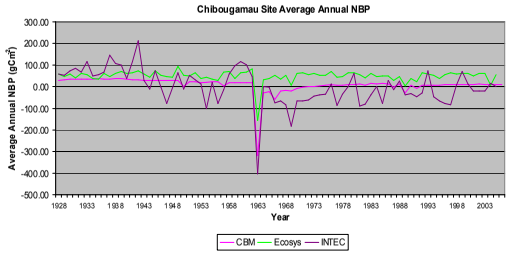

Fig. 5 Chibougamau Average Annual NBP of Model CBM-CFS3, Ecosys and INTEC

Conclusions

The model results showed that the disturbances of harvesting such as clearcut and partial cut and fire such as slash burn and human caused burn had great influence on the total forest above ground biomass and NBP in Oyster River and Chibougamau sites.

All the models agreed to a reasonable level of accuracy at the ecosystem scale. The main differences were attributed to individual model parameterization of disturbance factors on the ecosystem carbon balance.

Acknowledgements

This is partial results of the historic carbon modelling project which is funded by Fluxnet-Canada Research Network. We thank the other members in this modelling group for their help and discussion. We thank TimberWest, Island Timberlands and other forest companies for providing soil, forest and disturbance data.

References

Grant, R.F. 2004. Modelling topographic effects on net ecosystem productivity of boreal black spruce forests. Tree Physiol. 24:1-18.

Grant, R.F. and Nalder I.A. 2000. Climate change effects on net carbon exchange of a boreal aspen-hazelnut forest: estimates from the ecosystem model ecosys. Global Change Biol. 6: 183-200.