Phyton (Austria) Special issue: "APGC 2004"	**Vol. 45**	Fasc. 4	(51)-(54)	1.10.2005

Carbon Storage in Larch Ecosystems in Continuous Permafrost Region of Siberia

By

Y. MATSUURA[1)], T. KAJIMOTO[2)], A. OSAWA[3)] & A. P. ABAIMOV[4)]

Key words: Continuous permafrost, Siberia, larch ecosystem, carbon storage.

Summary

MATSUURA Y., KAJIMOTO T., OSAWA A. & ABAIMOV A. P. 2005. Carbon storage in larch ecosystems in continuous permafrost of Siberia. - Phyton (Horn, Austria) 45 (4): (51)-(54).

Deciduous coniferous taiga, larch (genus *Larix*) ecosystem is one of unique biomes in northeastern Eurasian Continent, where vast area of forest exists on continuous permafrost. We selected three representative sites for ecosystem research: 1) a forest near Yakutsk in Yakutian Basin, eastern Siberia (62N-129E), 2) a forest near Tura in central Siberian Plataeu (64N-100E), and 3) a forest tundra transition near Chersky in Kolyma lowland (69N-160E). We estimated C storage in both aboveground and belowground biomass, in forest floor, and in active layer as soil organic C and as carbonate-carbon. Soil organic C in active layer was the largest component in each site. Soils in Yakutsk and Tura showed carbonate-C accumulation in active layer, which might result from extreme continental climate with low annual precipitation. C storage in aboveground and belowground biomass varied among sites, however, ratios of above/belowground biomass C had a relatively narrow range from 1.1 to 1.5. High allocation rate of C to belowground part resulted from a kind of adaptation to effective nutrient acquisition under nutrient limited environment due to low soil temperature.

Introduction

Carbon storage and carbon flux is one of the highlighted ecological issues recently, especially in northern ecosystems where average air temperature rose drastically in those three decades (KASISCHKE & STOCKS 2000). According to

[1)] Soil Resources Evaluation Labo., Department of Forest Site Envirionment, Forestry and Forest Product's Research Institute (FFPRI), Matsunosato 1, Tsukuba, Ibaraki 305-8687 Japan, e-mail: orijoy@ffpri.affrc.go.jp

[2)] Kyushu Research Center, FFPRI, Kurokami 4-11-16, Kumamoto 860-0862 Japan.

[3)] Faculty of International Comunication, Ryukoku University, Yokotani 1-5, Seta-Ohe, Ohtsu 520-2194 Japan.

[4)] V. N. Sukachev Institute of Forest, Russian Academy of Sciences, Akademgorodok, Krasnoyarsk 660036 Russia.

ANDERSON 1992, soil carbon storage in terrestrial ecosystem is 1301 Pg C, of which 30 % organic C is in taiga and tundra ecosystems. Such northern ecosystems are also affected by permafrost distribution that had been almost determined by glacier development in the Pleistocene (VELICHIKO & al. 1984). About 50 % of boreal forest is located on discontinuous permafrost region, and 20 % of boreal forest is on continuous permafrost. Boreal forest ecosystem on continuous permafrost is distributed only in central and eastern Siberia where genus *Larix* (*Larix gmelinii* and *L. cajanderi*) dominates under severe continental climate (ABAIMOV & al. 2000). Since annual precipitation in central and eastern Siberia is from 200 to 350 mm, some soils usually show alkaline pH regime and contain carbonate-C in active layer (MATSUURA & al. 1994).

We estimated carbon storage regime both organic and inorganic in active layer, and above- and belowground biomass C. In this paper, we discuss the peculiar features of C storage in forest ecosystem on continuous permafrost region of Siberia.

Material and Methods

Dataset of tree biomass, forest floor biomass and soil C storage were processed in three representative sites, located on near Yakutsk (62°15'N-129°37'E), in Tura (64°19'N-100°14'E), and in Kolyma lowland (68°41'N-160°16'E), where continuous permafrost is recognized (MATSUURA & ABAIMOV 1998, MATSUURA & al. 1994, 1999). Tree biomass was estimated by destructive sampling and weighing in the field (KANAZAWA & al. 1994, KAJIMOTO & al. 1999), and water content for dry weight conversion were determined by air-dried subsamples in laboratory. Total carbon contents were determined using ground plant tissue samples and 2-mm sieved fine earth fraction, by dry combustion method (NC-800, SUMIGRAPH). Carbonate carbon in soil was determined by volumetric method (ALLISON & MOODIE 1965). We calculated soil organic carbon (SOC) contents by subtracting carbonate-C from total C contents. Storage was estimated by multiplying the contents, bulk density, fine earth ratio, and rock fragment ratio in each horizon of active layer until permafrost table.

Results and Discussion

Fig. 1 shows estimated values of C storage in three larch forest ecosystems. Soil organic carbon (SOC) storage in active layer varied much among sites, with range from 83 to 143 Mg C ha^{-1}. The largest SOC storage occurred in Yakutsk site where active layer was the deepest among three sites (1.15 m), on the other hand, the smallest SOC storage was found in Kolyma lowland site with 0.38 m depth of active layer. There was no carbonate-C accumulation in active layer of Kolyma lowland site, where forest tundra transition ecotone distributed on waterlogged soil condition. Soils in Tura and Yakutsk showed carbonate-C accumulation in active layer. The ratio of SOC to carbonate-C in Yakutsk was 11:1, and 52:1 in Tura, respectively. Estimated aboveground biomass C also varied much site to site, ranging from 8.5 to 62 Mg C ha^{-1}. Though values of C stored in above and belowground parts were varied much among sites, three representative sites showed the same allocation pattern, with ratio of aboveground to belowground ranging from 1.1 to 1.5.

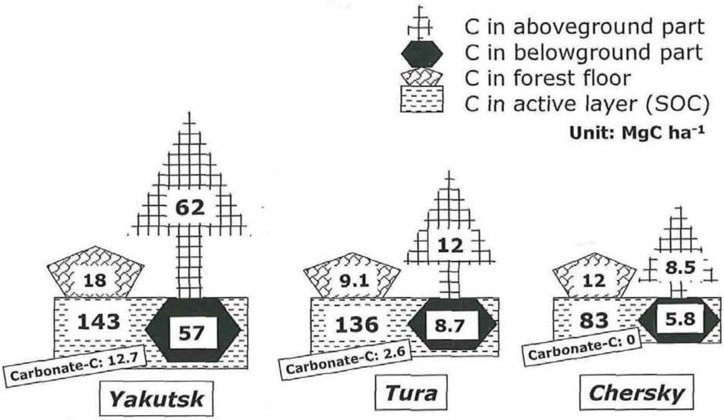

Fig. 1. Carbon storage in three larch ecosystems in continuous permafrost region of Siberia.

The phenomena of carbonate carbon accumulation observed in Yakutsk and Tura is not typical in high latitude boreal forest of other regions, because downward water movement may be dominant by more annual precipitation under other typical moderate continental climate. However, under extreme continental climate in central and eastern Siberia, potential for carbonate-C accumulation may be so high that soil inorganic carbon accumulation is one of a key role of C cycling in high latitude ecosystems under arid climate condition (LAL & KIMBLE 2000).

Biomass C allocation ratio of above/belowground part, ranging from 1.1 to 1.5, was rather low compare with other northern boreal forests (GOWER & al. 2001). MATSUURA & ABAIMOV 2000 suggested that larch forest in continuous permafrost region was under chronic N deficiency because of low N mineralization in mature forest stands. Annual N mineralization rate was less than 4.3 kgN ha^{-1} yr^{-1}, which is equal to the value estimated in arctic tundra studies (MATSUURA & ABAIMOV 2000, NADELHOFFER & al. 1992). Thus, low N availability under such cold soil thermal regime may cause more C allocation to root production for nutrient acquisition.

Forest ecosystems on continuous permafrost, discontinuous permafrost may be subject to nutrient deficiency due to cold climate condition. Permafrost table dynamics may be a critical factor that determines forest structure and function in larch dominant ecosystems in Siberia.

Acknowledgements

This study was conducted as a joint permafrost research between Russia and Japan, financially supported by Ministry of Environment Japan. We greatly appreciated support of V. M.

BORBIKOV in Tura, and cooperative field research of Drs. Y. KANAZAWA and R. TABUCHI. We also express thanks to Drs. T. C. MAXIMOV, A. P. Isaev, D. P. YEFREMOV and R. V. DESYATKIN in Institute of Biological Problems of Cryolithozone (former name Yakutsk Institute of Biology) in Yakutsk, and to Drs. O. A. ZYRYANOVA, S. G. PROKUSHKIN, A. V. VOLOKITINA and M. A. SOFRONOV in V. N. Sukachev Institute of Forest in Krasnoyarsk.

References

ABAIMOV A. P., ZYRYANOVA O. A., PROKUSHKIN S. G., KOIKE T. & MATSUURA Y. 2000. Forest ecosystems of the cryolithic zone of Siberia; regional features, mechanisms of stability and pyrogenic changes. - Eurasian Journal of Forest Research 1:1-10.

ALLISON L.E. & MOODIE C.D. 1965. Carbonate. - In: BLACK A.E. (Ed.), Methods of soil analysis, Part 2: chemical and microbiological properties", 1379-1396. - American Society of Agronomy, Inc., Publisher, Madison, USA.

ANDERSON J.M. 1992. Responses of soils to climate change. - Advances in Ecological Research 22:163-210.

GOWER S.T., KRANKINA O., OLSON R.J., APPS M., LINDER S. & WANG C. 2001. Net primary production and carbon allocation patterns of boreal forest ecosystems. - Ecological Applications 11: 1395-1411.

KAJIMOTO T., MATSUURA Y., SOFRONOV M.A., VOLOKITINA A.V., MORI S., OSAWA A. & ABAIMOV A.P. 1999. Above- and belowground biomass and net primary productivity of a *Larix gmelinii* stand near Tura, central Siberia. - Tree Physiology 19: 815-822.

KANAZAWA Y., OSAWA A., IVANOV B.I. & MAXIMOV T.C. 1994. Biomass of a *Larix gmelinii* (Rupr.) stand in Spaskayapad, Yakutsk. . In: INOUE G. (Ed), Proceedings of the 2nd symposium on the joint Siberian permafrost studies, pp.153-163 - Tsukuba, Japan.

KASISCHKE E. S. & STOCKS B. J. 2000. Fire, climate change, and carbon cycling in the boreal forest. - Ecological Studies 138: 461. – Springer Verlag, New York.

LAL R. & KIMBLE J. M. 2000. Soil C pool and dynamics in cold ecoregions. – In: LAL & al. (Eds., Global climate change and cold region ecosystems, pp.1-28. - Lewis Publishers, Florida.

MATSUURA Y. & ABAIMOV A. P. 1998. Changes in soil carbon and nitrogen storage after forest fire of larch taiga forests in Tura, central Siberia. In:MORI S., KANAZAWA Y., MATSUURA Y. & INOUE G. (Eds.), Proceedings of the 6th symposium on the joint Siberian permafrost studies, pp.130-135 - Tsukuba, Japan.

— & — 2000. Nitrogen mineralization in larch forest soils of continuous permafrost region, central Siberia. An implication for nitrogen economy of a larch stand. - In: INOUE G. & TAKENAKA A. (Eds.), Proceedings of the 8th symposium on the joint Siberian permafrost studies, pp.129-134. - Tsukuba, Japan.

—, ISAEV A. P. & YEFREMOV D. P. 1999. Carbon and nitrogen storage of soils in Plaxino site, Kolyma lowland. - In: FUKUDA M. (Ed.), Proceedings of the 4th symposium on the joint Siberian permafrost studies, pp.141-148. - Sapporo, Japan.

—, SANADA M., OHTA S. & DESYATKIN R. V. 1994. Carbon and nitrogen storage in soils developed on two different toposequence of the Lena River terrain. – In: INOUE G. (Ed.), Proceedings of the 2nd symposium on the joint Siberian permafrost studies, pp.177-182. - Tsukuba, Japan.

NADELHOFFER K. J., GIBLIN A. E., SHAVER G. R. & LINKINS A. E. 1992. Microbial processes and plant nutrient availability in arctic soils. - In: CHAPIN F. S. III & al. (Eds.), Arctic ecosystems in a changing climate, pp.281-300. - Academic Press, San Diego.

VELICHIKO A. A., ISAYEVA L. L., MAKEYEV V. M., MATISHOV G.G. & FAUSTOVA M.A. 1984. Late Pleistocene gleciation of the arctic shelf, and the reconstruction of Eurasian ice sheets. – In: VELICHIKO A. A., WRIGHT H.E. Jr. & BARNOSKY C. W. (Eds.), Late quaternary environments of the Soviet Union, pp. 35-41. - University of Minnesota Press, Minneapolis.

Zeitschrift/Journal: Phyton, Annales Rei Botanicae, Horn

Jahr/Year: 2005

Band/Volume: 45_4

Autor(en)/Author(s): Matsuura Y., Kajimoto T., Osawa A., Abaimov A. P.

Artikel/Article: Carbon Storage in Larch Ecosystems in Continuous Permafrost Region of Siberia. 51-54