Larch Stand Regeneration and its Estimation with Satellite Images in Central Yakutia, Russia (Extended Abstract)

著者	Takao G., Kushida K., Maximov T. C., Fedorov A. N.
雑誌名	The science reports of the Tohoku University. Fifth series, Tohoku geophysical journal
巻	36
号	4
ページ	475-478
発行年	2003-05
URL	http://hdl.handle.net/10097/45429

Tôhoku Geophys. Journ. (Sci. Rep. Tôhoku Univ., Ser. 5), Vol. 36, No. 4, pp. 475-478, 2003

Larch Stand Regeneration and its Estimation with Satellite Images in Central Yakutia, Russia (Extended Abstract)

TAKAO, G.[1], KUSHIDA, K.[2], MAXIMOV, T.C.[3], FEDOROV, A.N.[4]

[1]Hokkaido Research Center, FFPRI, 7 Hitsujigaoka, Sapporo 062-8516, Japan
[2]Inst. Low Temperature Science, Hokkaido Univ., Japan
[3]IBPC, SB-RAS, Russia
[4]Permafrost Inst., SB-RAS, Russia

(Received December 30, 2002)

1. Introduction

Larch (*Larix cajanderi*) dominates major part of the taiga forest near Yakutsk, Russia, where forest fires occur frequently. Many studies showed the biomass of the larch forests on the permafrost saturated at a stage of succession (Schulze *et al.*, (1995), Tsuno *et al.*, (2001)) and suggested they followed a different rule of self-thining than the vegetation in other places (Schulze *et al.*, (1995), Osawa *et al.*, (2000)). That is, as larch trees of a stand grow, the biomass saturates while the tree density becomes sparser and sparser.

In sparse stands a satellite observes from above the mixture of tree crowns and floor vegetation. During winter snow hide forest floors, complex mixtures of soil and vegetation, but high trees.

In a unique forest ecosystem frequently disturbed by forest fires, we aim to map the different stages of forest regeneration and succession, and set the objectives of this study as follows ;

—Describe the trees and stand structure of varied forest stands
—Find detectable parameters of larch stands on winter satellite images

Study site

The study area is a rectangular of 60 km by 75 km covering City of Yakutsk and both sides of Lena River. The terrain is characterized by flat river terraces separated by gentle slopes or steep cliffs. The climate is severe ; the minimum temperature reaches −55-60 C in January while maximum +30-35 C in July, and an annual precipitation is around 200 mm (Isaev (2001)).

Other than the city and towns, open grasslands and riparian deciduous bushes dominate on the lower terraces along Lena. On the higher terraces, Larch (Larix cajanderi) dominates in almost pure stands. Pine (*Pinus sylvestris*) can be found on dry slopes on sandy soil. Birch (*Betula platyphylla*) is also found in mixed stands with larch

(Isaev (2001)). Pine is, thus, the only evergreen high tree species in the study area.

Method

The satellite image used in this study is a LANDSAT7 ETM+ image acquired on 30 Oct. 1999 (Path/Row=122/016). At the moment of image acquisition, the entire water surface but a small part of Lena River frozen, and almost all the open ground surface and the frozen water were covered by snow. A summer ETM+ image on 28 Aug. 1999 (same Path/Row) is combined with the winter image for the classification and the comparison.

The image is georeferenced to the topological maps of the scale of 1 : 200,000. Dark object retrieval (Chevaz *et al.*, (1994)) is applied to remove the atmospheric effect in dark portion of the image. There are thin clouds overcastting shadows on the ground. To adjust the income radiation from the sun, local snow reflections from open lands are used with an assumption that the snow reflectance at that time is constant over the study area. The forests on the image are stratified using unsupervised classification so that the ground survey plots are efficiently selected.

Among six reflection bands of the LANDSAT7 ETM+ image, Band 2 and Band 5 are used for the analyses. Mean DN of 3×3 pixels for the two bands around each plot location are assigned as the image values of the plot.

Forests are measured in June and July, 2000, at 58 plots selected from the stratified image. Trees are counted using plotless sampling (Bitterlich method), and the species and DBH for each counted tree is recorded. The heights of a few trees among counted are also measured, from which the diameter-height curve is estimated for each species. Number of trees, mean DBH, basal area, height density, and volume as the product of mean height and basal area are calculated.

Height density is an Expected number of trees counted when they are observed higher than an elevation angle θ from a point on the forest floor.

$$HD=\sum_{D,S}\pi\left(\frac{H_S(D)}{\tan\theta}\right)^2 N_S(D)$$

$$\theta=45^{\circ}\rightarrow HD=\pi\sum_{D,S}H_S(D)^2N_S(D)$$

Where D : DBH, S : Species, $H_S(D)$: Height Distribution. It is introduced as an indicator of density or congestion of forest crown observed from beneath.

Result

Among the 58 plots, 22 larch stands on flat terrain are selected for the analyses. Each tree height is estimated with a D-H curve, then a stem biomass is estimated by an allometric relationship (Tsuno, personal communication). 3 of the 22 plots are relatively new burnt stands with small seedlings.

There are strong correlations among tree density, mean DBH and stem biomass.

The gradient of the stem biomass against the tree density is much shallower than -1.5, which supports the previous studies (Schulze *et al.*, (1995), Osawa *et al.*, (2000)). Height density (HD) has a negative correlation with DBH and a positive correlation with the density. These relationships are opposite to what is expected in other temperate and boreal forests. Basal area (BA) seems saturated at 25-30 cm^2/ha.

Of the satellite image, only single bands comparison against the larch stand parameters are examined. Since the terrain over the site is relatively flat, we do not consider the terrain effects on the images. The uneven atmospheric effect could not be removed completely by the preprocessing, especially in Band 5, so some plots in a small region are not used for the regressions to Band 5.

There is a correlation between Band 2 and the basal area. Since the basal area becomes constant quickly as trees grow, Band 2 would represent an early stage of succession. There are no significant correlations between Band 2 and other stand parameters.

There are correlations between Band 5 and HD and between Band5 and mean DBH when the burnt stands are excluded.

Discussion

Our observations show that from a certain stage of regeneration the larch stands' crown become sparser as the trees grow. The opportunity for satellites to see through the crown, thus, become bigger. On the winter satellite images, the visible band 2 represents BA well until it saturated, while the mid-infrared band 5 represents HD after it starts to reduce.

Rosema (1992) modeled the reflectance of forest crowns by the 3D combination of forest floor, crown and its shadow on the floor, and plotted the various forest conditions

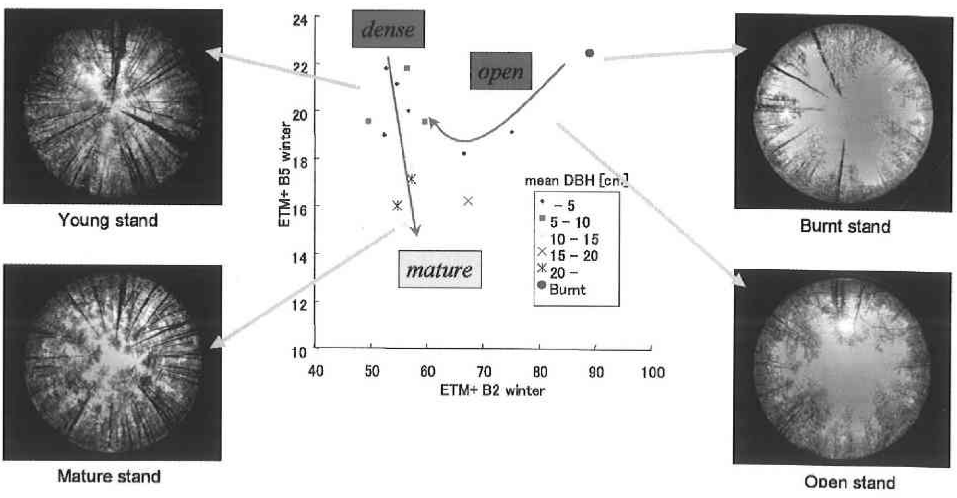

Fig. 1. Succession Trajectory of Larch Stands on Images

on the space of different LANDSAT bands. With the combination of the snow-covered floor, leafless crowns and their shadow, the larch stands on winter images would be plotted following the model (Fig. 1), but the trajectory of succession would have a backtracking due to the HD reduction after BA saturated (the red arrows in Fig. 1).

Conclusion

We represent unique allometric regeneration relationships of the larch stands in Central Yakutia and some indicators of regeneration which can be measured on the winter satellite images. The forest structure estimation using winter satellite imagery can be used to any boreal forests. More detailed analyses would be needed to describe the regeneration quantitatively.

References

Chavez, P.S., Jr, MacKinnon, D.J., 1994 : Automatic detection of vegetation changes in the southwestern United States using remotely sensed images. *Photogrammetric Engineering & Remote Sensing*, **60**(5), 571-583.

Isaev, A.P., 2001 : Post-fire Dynamic of larch Forest in North=East Siberia (Yakutia). Proc. 9th Symposium Joint Siberian Permafrost Studies Between Japan and Russia in 2000, 3-9.

Osawa, A., Abaimov, A.P., Zyryanova, O.A., 2000 : Tree size-density relationship and size-dependent mortality in Larix gmelinii stands. Proc. 8th Symposium Joint Siberian Permafrost Studies Between Japan and Russia in 1999, 36-41.

Rosema, A. *et al.*, 1992 : A new forest light interaction model in support of forest monitoring. *Remote Sensing of Environment*, 42, 23-41.

Schulze, E.-D. *et al.*, 1995 : Aboveground biomass and nitrogen nutrition in a chronosequence of pristine Dahurian Larix stands in eastern Siberia. *Canadian Journal of Forest Research* **25**, 943-960.

Takao, G. *et al.*, 2001 : Biomass Estimation of Taiga Forests in Yakutsk with Winter LANDSAT7 ETM+Image. Proc. 9th Symposium Joint Siberian Permafrost Studies Between Japan and Russia in 2000, 247-253.

Tsuno, Y. *et al.*, 2001 : Aboveground biomass, nitrogen and carbon contents in Larix stands in eastern Siberia. Proc. 9th Symposium Joint Siberian Permafrost Studies Between Japan and Russia in 2000, 68-74.