Strategy forest planning based on forest management information system(FMIS)

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Astract: This study purposes to present strategic forest planning that can support the identification of forest resources and the maximum uses of forest functions through FMIS combining GIS, RS and LP. Forest information such as compartment structure and forest road was entered into GIS to construct FMIS. Remotely sensed data were used to land cover classification, and then geographical attributes were identified. New grouping unit, so called "harvest unit", was introduced as the forest management unit. Strategic forest planning based on the "harvest unit" was proposed that considered together the economic, environmental aspect of forest.

Keywords: GIS, Remote Sensing, LP, FMIS

1.Introduction

Harvest plan of forest management should be flexible for meeting the changing social and environmental needs. We need to collect and process the proper forest information, which will enhance the efficiency of working process in the plan. Especially, GIS and RS techniques have been considered to have a benefit in processing the multidimensional information.

The purpose of this study is to present strategic forest planning that can support the identification of forest structures and the maximum uses of forest functions through forest management information system (FMIS) combining GIS, RS, and Linear Programming (LP).

2.Methodology

With the information derived from Orthophoto data and conventional data stored in GIS, forest structure analysis and harvest planning was done. Fig.1 shows the diagram of strategic forest planning based on RS, GIS and LP techniques.

3.Study area and data processing

1) Study area

The subject area of this study is a part of the forests in Takefu city, Fukui prefecture. The most common type of forest stands (97%) is Sugi (*Cryptomeria japonica*).

2) Conventional data and processing

Forest information such as compartment structure and forest road was entered into GIS to construct forest information system (Fig-1). DEM was constructed with basic map of 1/5000 for the geographic analysis. The resolution of DEM was build as 10m*10m.

Aerial photographs and DEMs were used to create orthophotos. Orthophotos were used to classify forest into 3 types, artificial, natural and bare forest. And then geographical attributes of each forest type were identified. Spatial design: Representing the forest in a simplistic grid using extracted Sugi forest area. New grouping unit, so called "harvest unit", was introduced as the forest management unit. Forest plan was construct ed based on new harvest unit.

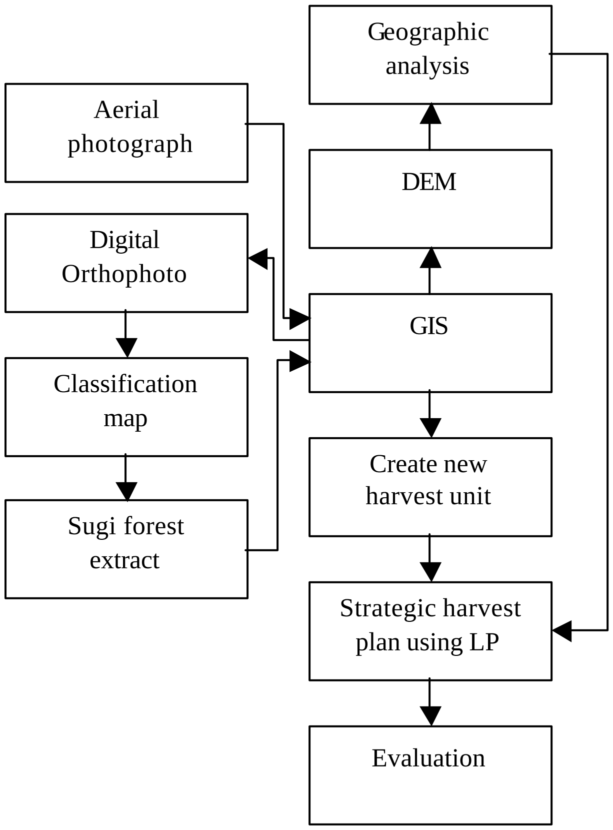

Fig.1 the diagram of strategic forest planning based on RS, GIS and LP techniques.

3) Strategic forest planning model

The goal of the model is to maximize the amount of harvest in the planning. Spatial and environmental constraints were considered together in the linear planning model. Three plans having different conditions were applied to the planning area, and outputs from models were compared and the plan having best result was selected.

Planning horizon was 60 years, each compartment will be entered on a 6-year cutting cycle.

Three conditions were used to decide the order of harvesting in compartments; Volume priority: compartment with high volume has priority,BC priority: Benefit was calculated by multiplying volume and timber price, and cost was the collecting cost depending on the distance to road. Compartments with high B/C ratio have priority, and Distance priority: compartments having shorter average distance between road and compartment have priority.

Constraints: Three scenarios using area and volume control approaches to achieve both economic and ecological goals. Harvest area requires a maximum of 1ha in each period. Harvest flow policy that enables a maximum 20% increase or decrease of harvest volume between successive periods.

This study also included spatial constrains from Probability Proportional to Prediction (P.P.P) method. P.P.P. method depends on an expert estimator's ability to estimate a particular value consistently. After calculating index from dividing the amount of volume by distance to road in an area, if the index were with in predetermined standard threshold, the area is considered to harvest. The index is between 1 and 40. Amount of volume that was used to decide a harvesting area was from 300m^3 to 600m^3, and standard distance was 15m to 300m.

The model was based on the formulation assigned as Model I with the following structure.

Object function:

$$MAX\sum_{i=1}^{m}\sum_{j=1}^{p} TOHAV$$

$$i = 1,2,\ldots\ldots\ldots, m$$

$$j = 1,2,\ldots\ldots\ldots, p$$

Constraints:

$$\sum_{i=1}^{m} THAR_i = TOHAV$$

$$\sum_{i=1}^{m} THAR_i - 1.2\sum_{i=1}^{m} THAR_{i-1} \le 0$$

$$\sum_{i=1}^{m} THAR_i - 0.8\sum_{i=1}^{m} THAR_{i-1} \ge 0$$

$$\sum_{i=j}^{k} H_j = THAR_{k/6}$$

$$j = 1,7,13,\ldots.., 55$$

$$k = j + 5$$

$$AC_i \le 1$$

$$X_{i,j,k} = 0$$

$$k = 0,\ldots\ldots, 7$$

$X_{i,j,k}$: *uncut from site i, class age k at period j*

TOHAV: Total Harvest

$THAR_i$: Volume harvested cutting at period i

H_j: Volume harvested cutting at period

AC_i: Cutting area from site i

4.Result

It is found that volume priority scenario had largest amount of volume. Distance priority option has worst output.

Volume-priority scenario and BC-priority scenario did not show big difference in total amount of return. But Distance-priority scenario produced only small returns (Fig-2). It will be explained by the existence of immature stand in compartment with high road density. Young stands harvested in earlier periods will result in the reduction of outputs.

Study results indicated that along with volume constraints, a harvest increased with the progress of cycle. After 7 cycles, a harvest increased rapidly. Compared to the first period, the harvest in last period is almost doubled (Fig-3).

The scatter index (S.I.) was increased in each successive period. Harvesting areas are not clustered, but spread over the areas (Fig-4).

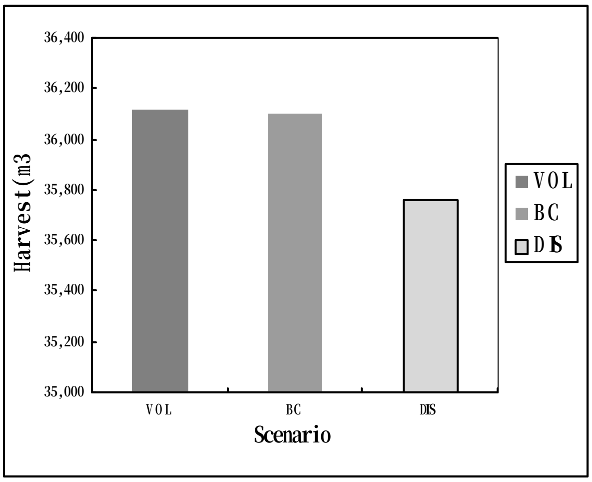

Fig.2 Timber harvest volumes for three scenarios.

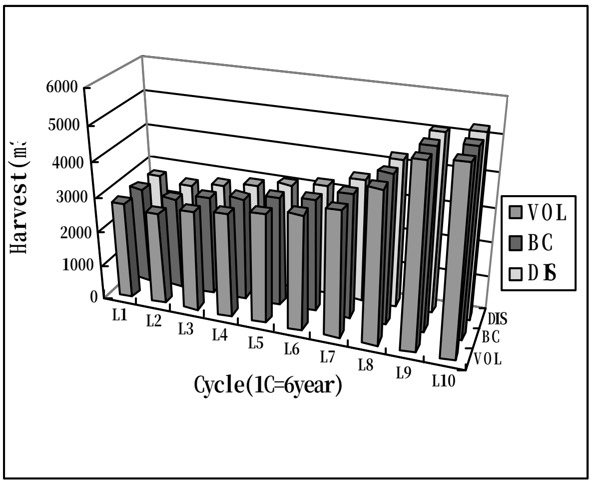

Fig 3. Timber harvest flow by three scenarios

Integrated LP, GIS and RS method was used to test strategic forest planning.

In this study, a new approach for integrated forest planning was presented. The method uses RS, GIS to produce a harvest unit, and LP was used to analyses alternative forest management plans.

This approach enables us to compare the results quantitatively and select the most desirable one. The combined use of three methodologies will have a benefit to consider together the time serial and spatial data in an analysis. This approach also has an advantage to consider the spatial allocation of forest while limiting the environmental damage.

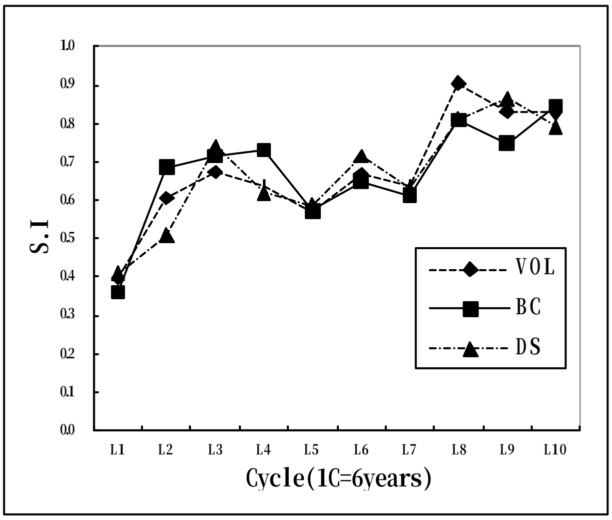

Fig 4. Harvest form for three scenarios

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