Regeneration in Subalpine Coniferous Forests

I. Mosaic Structure and Regeneration Process
in a *Tsuga diversifolia* Forest

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The regeneration process of a subalpine coniferous forest, a mixed forest of *Tsuga diversifolia* (dominant species), *Abies veitchii*, *Abies mariesii*, and *Picea jezoensis* var. *hondoensis*, was studied on the basis of annual ring data. The age class distribution was discontinuous and four age groups occurred in the study plot (30 m x 30 m). The canopy layer was a mosaic of patches (83.8-133.7 m² patch area), which had different mean ages. The recruitment of canopy trees was carried out only by advance regeneration in the plot. The diameter growth of *Abies* and *Picea* exceeded diameter growth of *Tsuga* in the gap. *Abies* lived for 200-300 years and their trunks were susceptible to heart rot. *Picea* lived for 300-400 years and *Tsuga* for more than 400 years. The regeneration process derived from the analysis of the plot consisted of three phases leading to the development of a even-aged patch; (1) the establishment of saplings before a gap opening, (2) the opening of a gap in the canopy and repair of the canopy by advance regenerated saplings dominated by rapid growth species, *Abies* and *Picea*, and (3) the dying off of canopy trees as each species reached the end of its life-span, resulting in pure patches of long-lived *Tsuga*.

Key words : *Abies*—Age structure—Life-span—Mosaic structure—*Picea*—*Tsuga*.

Subalpine coniferous forests in Japan usually consist of several canopy tree species. On the Pacific Ocean side of central Honshu, lower subalpine forests are mixed forests of *Tsuga diversifolia* (Maxim.) Masters, *Abies veitchii* Lindl., *Abies mariesii* Masters, and *Picea jezoensis* (Sieb. et Zucc.) Carr. var. *hondoensis* (Mayer) Rehder. Their successional relationships have been discussed by several researchers on the basis of the monoclimax or polyclimax theory (Kimura, 1963; Tatewaki et al., 1963; Kobayashi and Inoue, 1973). These studies do not agree on the successional relationships between *T. diversifolia* and *Abies* spp.

The mono- and polyclimax theory, however, must be considered for its validity in understanding the heterogenous structure of a mixed forest. The importance of disturbances (fire, windstorm, ice storm, etc.) as environmental factors was stressed by White (1979). He suggested that the climax pattern theory (Whittaker, 1953) is appropriate for understanding the diverse composition and structure of vegetation.

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Abbreviation : ha, hectare (=10000 m²); yr, year.
which is affected by disturbances of various frequency and magnitude. Probably, the
mixed forest of the subalpine zone can be described in terms of a pattern closely
relating to disturbance and recovery from it. This series of studies aims at (1)
clarifying the regeneration processes of subalpine mixed forests of conifers and subor-
dinate broad-leaved trees, (2) clarifying the characteristics of and relationships among
component species in the process, and (3) discussing the dynamics of the mixed forest
in relation to natural disturbances.

Watt (1947) suggested that plant communities are mosaics of patches, which are
phases in the development of the community. The regeneration process starts after a
disturbance opens a canopy gap in the forest. Watt's mosaic theory was shown to be
applicable to various forest types (Bray, 1956; Williamson, 1975; Sprugel, 1976;
Suzuki, 1980; Ohsawa, 1981; Komiyama et al., 1981; Naka, 1982; Nakashizuka and
Numata, 1982; Runkle, 1982) and is a valuable concept for understanding forest
structures. Except for long-term observations of a forest, the most direct and surest
method to clarify the regeneration process is to distinguish the mosaic structure of a
forest and to trace the process on the basis of annual ring data (Oliver and Stephens,
1977; Suzuki, 1980; Ohsawa, 1981; Nakashizuka and Numata, 1982). The paper
aims to clarify the regeneration process of a mixed forest of conifers, which have not
been affected by catastrophic disturbances during the last several centuries, and
determine the species characteristics on the basis of accurate ring data and the mosaic
structure of forest.

Study plot

The study area was on the southern slope of Mt. Tekari, 35°20'N in latitude, 138°
06'E in longitude, and 2591 m in altitude. The area is in the Pacific Ocean Climatic
area, characterized by wet summers and relatively dry winters (Suzuki, 1962). Mean
annual precipitation at the nearest meteorological station, Motokawane (268 m in
altitude and 24 km south of Mt. Tekari), is 3105 mm/yr, and 67% of the precipitation
is recorded from May to October (Japan Meteorological Agency, 1972). The parent
rock of the area is mudstone or sandstone (Kano, 1981).

The area is covered by dense forest and the subalpine coniferous forest occurs from
about 1600 m to 2600 m in altitude and T. diversifolia dominates between 1700 m and
2100 m in altitude (Kanzaki and Numata, 1981). In the study area, there is no
evergreen dwarf bamboo, which strongly affects the regeneration of tree species.

A study plot was made in a well developed T. diversifolia forest on a 30° slope
facing N6°E, at 2100 m in altitude. The plot is quadrat No. 6 (Q-6) in Kanzaki and
Numata (1981). An outline of species composition and size structure of the study plot
is shown below on the basis of the previous paper.

T. diversifolia dominated the plot, making up 70.7% of the basal area at 1.3 m in
height, and A. veitchii, A. mariesii, and P. jezoensis var. hondoensis made up 11.8, 9.2,
and 8.2%, respectively. The maximum DBH in the plot was 52.5 cm, and T.
diversifolia appeared in all the DBH classes. Abies species and P. jezoensis var.