Topographic factors controlling vegetation in the timberline ecotone, Kiso Range, central Japan

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High varieties of plant habitats around the main ridges of Japanese high mountains reflect microclimate and soil conditions varying within in a narrow area. Such complex distributions of vegetation have been studied qualitatively through comparisons between the distributions and other environmental factors. The compared factors were usually derived from narrow areas in previous studies. In contrast, this study examined topographical thresholds of physiognomy through a statistical analysis of the vegetation and topographical parameters calculated from a digital elevation model (DEM), covering the whole alpine zone and the part of the subalpine zone in the Kiso Range.
Bare ground, dwarf pine (*Pinus pumila*) area, alpine meadow, birch (*Betula ermanii*) forest, and subalpine conifer forest were digitally mapped using orthophotographs of the whole area above 2200m a.s.l. Elevation, slope direction, gradient, ridge-valley index (RVI) and vertical distance from the main ridge (VDMR) in same area were calculated from the 10-m-grid DEM. RVI values are based on the lines of sight at each point, the high and low values of which correspond to a ridge and a valley, respectively. Then the vegetation of each grid was linked to the topographical parameters of the grid.
Frequency distributions of altitudes of three vegetations indicate a vertical zonation; in ascending order, coniferous forest, birch forest and dwarf pine area. Each vegetation also has different trends in slope direction, RVI and VDMR from the others. Those trends seem to reflect spatially different snow thickness which is originated from snow redistribution by topographical modulation of winds.
RVI and East-west component of the direction were combined to make a topographical variable of snow redistribution, which is independent from elevation. The combined variable increases when the position is located in more wind-leeward areas, thus the variable is called wind-leeward (WL) index hereafter. We confirmed that 0.68 is the correlation coefficient between the WL indices and snow depths measured around the timberline of the northernmost part of study area.
Boundaries of dominant vegetation are linear in the diagram of altitudes and WL indices (Fig.1). The boundary between dwarf pine and tall tree forests, namely timberline, is roughly constant at 2500 m a.s.l. between dwarf pines and conifers, if WL indices are less than -2. In the area having a WL index larger than -2, the boundary consisting of birches increases linearly with WL indices. An increase of WL index probably relaxes the stresses inhibiting the growth of forest, such as strong wind and icing, which favors the growth of birches resistant to snow pressure. This figure also shows no altitudinal zone for bare ground and alpine meadows. These distributions are controlled not by the altitudes but by the shape of ground surface.
The physiognomy in the timberline ecotone of the Kiso Range was roughly described by two indices indirectly expressing temperature (altitude) and snow thickness (WL index). Thus, this approach can be a range-scale quantification of dominant factors controlling the physiognomy.

Keywords: Vertical distribution, Timberline, Alpine vegetation, Geoecology, GIS, Kiso Range

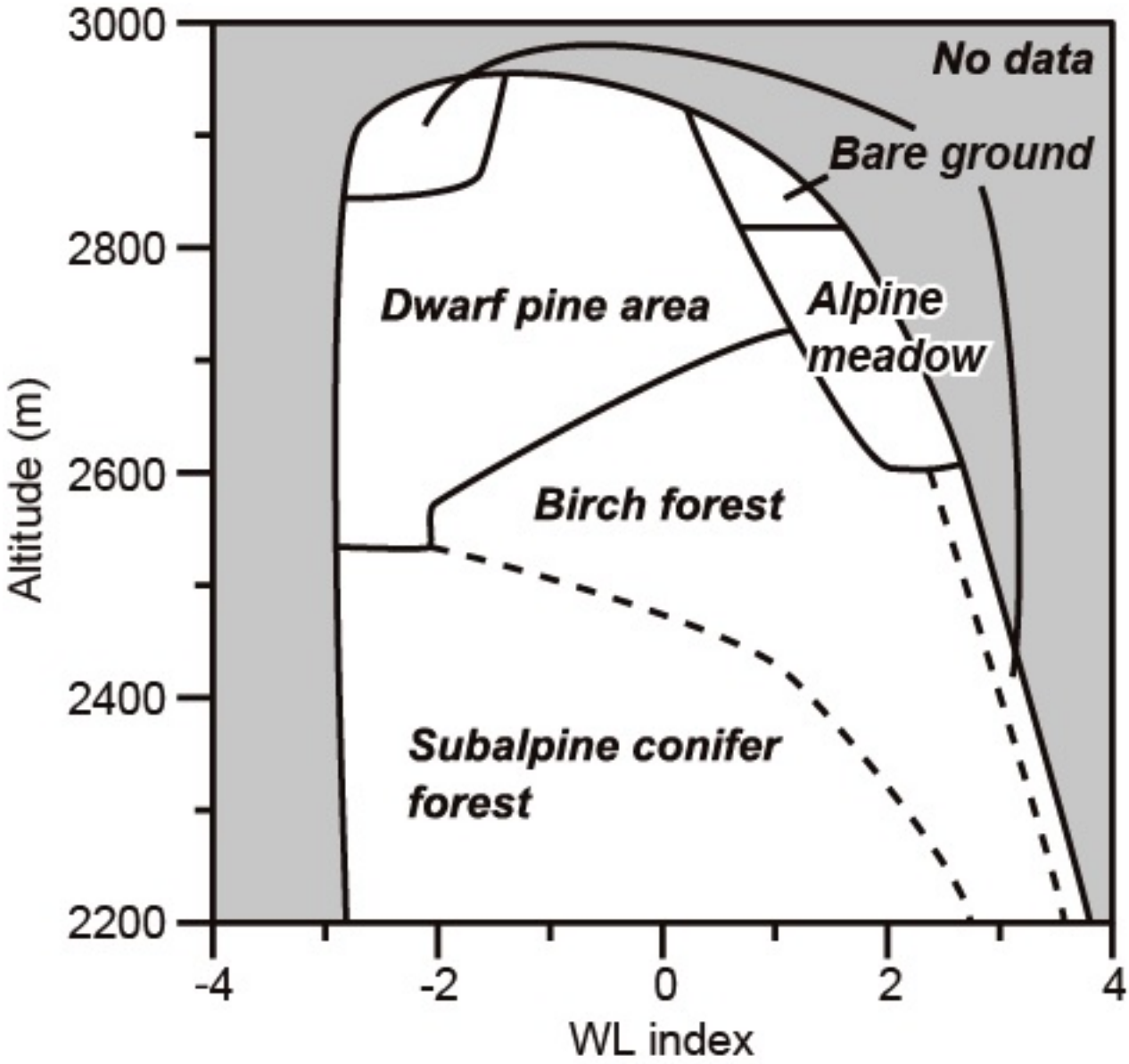

Fig.1: Altitude and the wind-leeward (WL) index in the Kiso Range classified by the dominant vegetation.

