B-9.1 Evaluation and Prediction of the Global Warming Effects on the Distribution of the Natural Vegetation

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Abstract

For the purpose of evaluation and prediction of the global warming effects on the distribution of the natural vegetation, studies as follows were carried out.

1) The distribution of Japanese natural vegetation was modeled on two spacial levels; "class" level and "order" or "alliance" level, and potential shift of natural vegetation in Japan caused by global warming was estimated by the steady-state correlation approach.

2) The possible changes of phenology (the date of blooming, budding, leaf-color change, leaf-falling) were predicted based on the correlative relationships between the phenological observation data and the monthly meteorological factors.

3) The long-term effect of high temperature condition on the dry matter growth and bud formation of *Pleuropteropyrum weyrichii* var. *alpinum* was clarified through experiments. The leaf-temperature of *Pleuropteropyrum weyrichii* var. *alpinum* growing around 2,600 m of Mt.Fuji, which location is the southern limit of its distribution, was measured.

4) Present situation of the populations and their surrounding habitat at the southern limits and vicinities of numerous temperate species were investigated in the field. Some of the populations were studied taxonomically. These data were prepared in a computer using data-file.

5) An experiment was attempted to examine the impact on the plants under the increased condition of CO_2 and ozone. The result of the experiment shows that the productivity of plants does not necessarily increase in the case of the high ozone concentration even if the CO_2 concentration increases.

Key Words Distributional Shift, Complex Effect, Phenology, Southern Limit, Natural Vegetation

1. Introduction

There is current concern about changes in the distribution of vegetation and possible extinction of plant species caused by global warming. Therefore, it is necessary to conduct studies on prediction of changes and clarification of effect.

2. Research objectives

The objectives were to promote fundamental studies on the relation between phytophysiology and climate, and to evaluate and predict global warming effects on the distribution of the natural vegetation.

3. Results

(1) Prediction on distributional shift of Japanese natural vegetation

1) A statistical model explaining the distribution of four major climatic vegetation zones was established by the analysis of the data of climatic factors and vegetation distribution. Then, by means of the statistical models, prediction of changes in vegetation zones was attempted.

2) Potential shift of natural vegetation in Japan caused by global warming was estimated by the steady-state correlation approach. Two types of vegetation distribution model, fuzzy model and multinominal logit model, were applied to explain the relationship between vegetation classification of remaining natural vegetation and climatic conditions. The logit model indicated a more successful result than the fuzzy model. Then, the effects of increase of mean annual temperature were estimated using the logit model. It was indicated that the percentage of grid-cells in all of Japan which showed different estimated vegetation classifications from the present classifications are approximately 23% for a 1 degree increase, 44% for a 2 degree increase, and 62% for a 3 degree increase.

3) Vegetation investigation sheets were digitized and put into the database system. By utilizing the database system, it is possible to make maps of plant species distribution, grasp the northern and/or southern limit of distribution, and predict potential shift due to global warming.

(2) Prediction on phenological changes

Since The Manual of Phenological Observation was published in 1953, there have been a general standard about the objective methods and the kinds of plant for examine (Japan Meteorological Agency, 1988). By means of "The Phenological Observation Data", the correlative relationships between the blooming date of each plant (*Prunus yedonensis*, *Prunus mume*, *Camellia japonica*, *Taxacum*, *Rhododendron kaempferi*, *Wistaria floribunda*, *Lespedeza bicolor*, *Hydrangea macrophilla*, *Lagorstroemia india*, *Miscanthus sinensis*, etc.) and the monthly meteorological factors were clarified. Then, the phenological changes caused by global warming were predicted using the data of monthly mean temperature.

In overall consequence, however it is depend on the local condition, when the monthly means of temperature rise by 1 ℃, the blooming dates of *Prunus yedoensis* shift 2.7 - 4.8 days earlier, 3.24 days in mean.

The blooming dates of *Prunus mume*, *Taraxacum* were predicted by the same method. When the monthly mean temperature rise 1 ℃, the blooming date of *Prunus mume* shifts 4 - 13 days earlier, 6 days in mean, and the blooming date of *Taraxacum* shifts 3 - 8 days earlier, 5 days in mean.

If the monthly mean temperature of January rises 1 ℃, it was predicted that blooming date of *Camellia japonica* shifts 8 days earlier, and that of *Prunus mume* shifts 6 days earlier.

The global-warming tendency is variable in each region, therefore, the regional variability of phonological change was clarified. For example, the greatest warming were found at Tokyo in Kanto region, Osaka in Kansai region, Fukuoka in Kyusyu region, and Sapporo in Hokkaido. The mean-temperature rise per hundred years among eight observatory stations in Kanto region was 1.21 ℃; the greatest rate was 2.55 ℃ in Tokyo, while the minimum rate was 0.68 ℃ in Choshi.

(3) Clarification of effects of high temperature on plants with the southern limit of distribution

Polygonum cuspidatum grows below about 2600 m on Mt. Fuji. On the other hand, *P. weyrichii* var. *alpinum* grows above there. The long-term effects of high temperature on dry matter growth were studied in these two species grown at mean temperature of 17.9, 22.9 or 27.9 ℃. Growth of *P. weyrichii* decreased at 27 ℃ . In all temperature treatments, that of *P. cuspidatum* was not affected.

It was found that the leaf-temperature of *Pheuropteropyrum weyrichii* var. *alpinum* growing around 2,600 m of Mt. Fuji, which location is the southern limit of its distribution, temporary rises up to around 30℃, and that the growth-rate gets smaller when the temperature was controlled at 30℃ and 25℃. The bud formation was found during the growth under the temperature between 25℃ and 20℃, however, there was no bud-formation between 20℃ and 15℃, so that the *Pleuropteropyrum weyrichii* var. *alpinum* around 2,600 m of Mt. Fuji is exposed to such high temperature as the bud-formation is temporary disturbed.

(4) Field survey at distributional limits of natural vegetation (Tokyo University)

Vegetation consists of species which can survive locally under different physical environment and selection through history. Affection of global warming to natural vegetation can be prospected through real change of temperate (also arctic) species distribution, especially on the southern limits and vicinities. This work was carried out the following items.

1) Field surveys on present situation of populations, reproduction, habitat condition at the southern limit and vicinities of distribution in some temperate species; 2) Taxonomic studies of some populations of the southern limits and vicinities; 3) Preparation of a data-file of southern limit and vicinities of temperate species found in Japan.

Result.

1) Field surveys were undertaken in central Honshu (Chubu and Kinki districts), Kyushu and particularly the Nansei Islands south from Yakushima. Physical conditions of previously known southern limit localities have been changed in many species, e.g. *Pieris liukiuensis*, *Hydrangea liukiuensis*. The populations of the southern limits are very fragile in many species, e.g. *Eriocaulon hananoegoense*, *Cardiandra amamiohsimensis*, *Deutzia yaeyamensis*. Some species are vigorous but limited the localities, e.g. *Deutzia naseana*. These distribution and condition were recorded in personal computer for the preparation of a data-file.

2) a) In the case of specific differentiation: Several Hydrangeaceous species were mainly studied. In *Deutzia*, *D. naseana* and *D. yaeyamensis* were considered as distinct species. *Deutzia naseana*, known from Amami-oshima, Tokunoshima, Kikaigashima is tetraploid and vigorous, while *D. yaeyamensis*, limited in some peculiar environment in Iriomotejima, is diploid and vulnerable. In *Hydrangea*, *H. yayeyamensis* closes to *H. chinensis* ranging Taiwan to S. E. China. *Hydrangea liukiuensis* is related to a temperate species, *H. luteo-venosa*, and vigorous. *Hydrangea yayeyamensis* has both octaploid and decaploid and *H. liukiuensis* has both diploid and tetraploid. The species has both diploid and tetraploid. *H. kawagoeana* ranging from Tokunoshima to Yakushima through Tokara Islands is related to temperate species, *H. scandens* and also vigorous. *Hydrangea involucrata*, a temperate species ranging from Gifu Prefecture to Fukushima Prefecture, was found in Suwanoseshima. *Cardiandra amamiohsimensis* was morphologically

considered as the ancestor of other two present species and temperate origin. The present condition of the species is vulnerable known from only several places in Amami-oshima.

b) In the cases of infraspecific differentiation; *Saxifraga nelsoniana* was found disjunctively in central Honshu. The population differs from those of the main distribution area north from Hokkaido, and was regarded as a local variety. *Anemone pseudo-altaica* is known to have wide variation. The population in Yamagata Prefecture differs from typical ones and regarded as a variety. *Heracleum sphondylium* has wide distribution range in northern hemisphere. Two subspecies and local varieties and forms are distinguished in Japan.

3) The distribution range of *Rhodiola rosea* was intensively surveyed. The distribution and condition of other species were recorded.

(5) Clarification of complex effects of the increase of CO_2 and ozone concentration

As a result of recent studies on global warming, it is said that the concentration of ozone within the convection layer would possibly increase with the air temperature rise. An experiment was attempted to examine the impact on the plants under the increased condition of CO_2 and ozone. The result of the experiment shows that the productivity of plants does not necessarily increase in case of the high ozone concentration even if the CO_2 concentration increases.