An Experiment in Environmental Change: Some Distinguishing Spectral Characteristics of Red Pine and Larch

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1. Introduction

The field survey is an essential means not only of establishing the nature and extent of environmental changes, but also of getting the fundamental information to apply to remote sensing techniques for use in practical analysis. The environmental changes typically have a close relationship to the vitality of trees and this may be used as a unit for measuring quantitative data of environmental behavior.

Using this concept, the authors have started to measure the spectral reflectance for a designated forest trees from tower top of ten meters to establish the relationship between environmental changes and tree vitality. The site chosen was that at where large-scale tunnel construction is now going on. Field work has been continuing there for the test three years using spectrometers, and other methods of investigation.

This paper describes the result of measurement of spectral reflectance over the past three years and discusses these data in relation to the tree vitarity of the environmental unit.

2. Test Site

At present, a tunnel of about six kilometers length is now under construction under the Enrei Mountain area to connect two stations directly, Okaya and Shiojiri, of the Chuo Railway

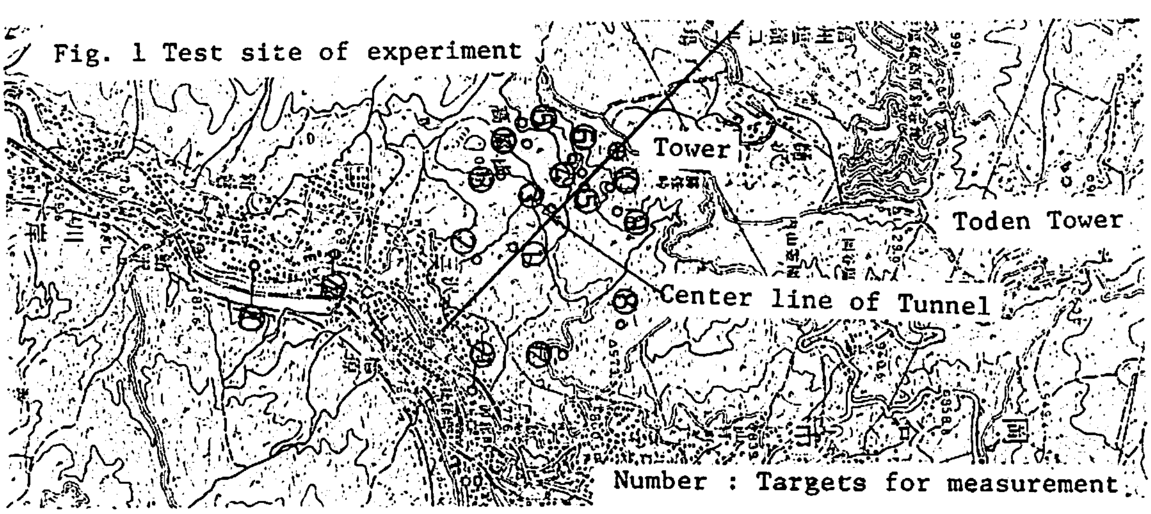

Fig. 1 Test site of experiment

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Line which runs through the central part of Japan. A tower ten meters high was constructed at the top along the range of mountains near the tunnel. Fig. 1 shows the place of tower and positions of the target tree for measurement area. The species studied are red pine, and larch as well as near by buildings.

3. Instrument

The SAM-1 spectrometer, an X-Y recorder, was mainly used with another spectrometers which are small and portable as an auxiliary. The measurements of the SAM-1 are shown in Fig. 2 for a white board (V_w) and the red pine and larch (V_0). We drew a perpendicular normal to the calibrated zero line. This gives the value of the intersection points of the two curves, where L_w and L_0 are the values of measurement by our spectrometer for the trees and white board, respectively.

The formula of the reflectance factor is shown as follows;

Reflectance Factor in percentages $=(L_0 \times V_0) \times (L_w \times V_w) \times 100$

The values measured by the auxiliary spectrometer are transformed on to this graph using the following equation;

Reflectance Factor in percentages $=100 \times 10^{(O^\lambda - W^\lambda)}$

Where W^λ: Reading value of white board

O^λ: Reading value of Target tree

The measurement from the top of the tower was done every month from May to December for three years.

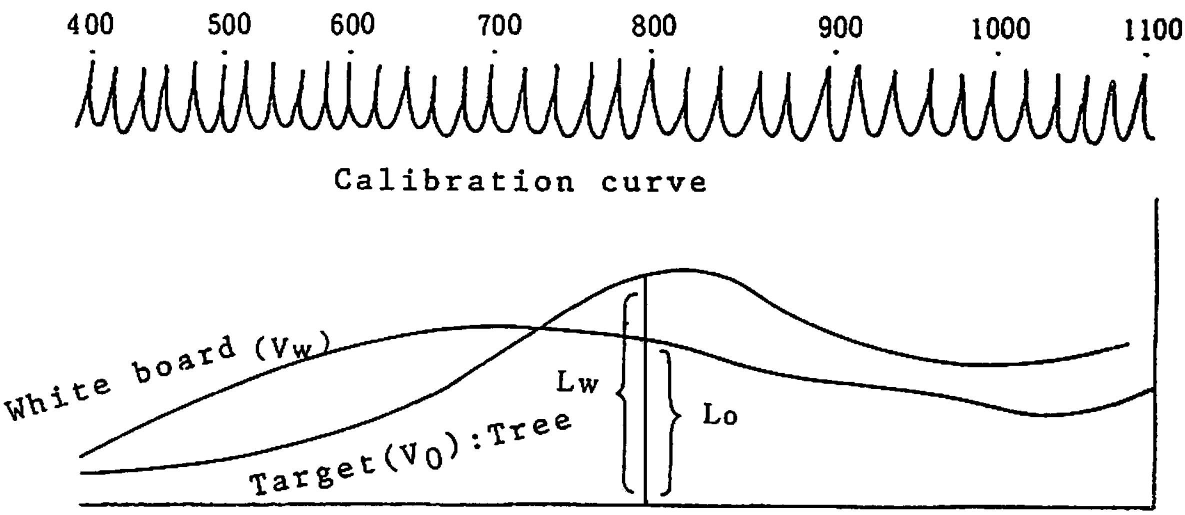

Fig. 2 Data of measurement & Correction pulse

4. Results and Discussions

4.1 Reflectance at different distances

The reflectance of targets at various distances from the tower show differences owing to scattering and the absorption behavior of the atmosphere. Fig. 3 shows reflectance measured for the red pine tree, target No. 9 (at 413 m) and target No. 12 (at 1375 m). The figure shows clearly that the reflectance of distant objects is higher in the range of visible light than that of close objects, but in the range of nearinfrared the opposite occurs. Therefore, it is essential to measure the atmospheric absorption of the air. The reason why such above mentioned happens is simply, because of absorption in the air, but in the range of visible light, scattering increases apparent reflectance, but in the range of nearinfrared, it decreases the apparent reflectance.

Accordingly, it is necessary to measure and correct for the absorption of the air and arrive at a constant reflectance which is not effected by different distances of measurement. This year, the authors used a long focal length lens ($f=500$ mm) and measured the quantity of absorp-

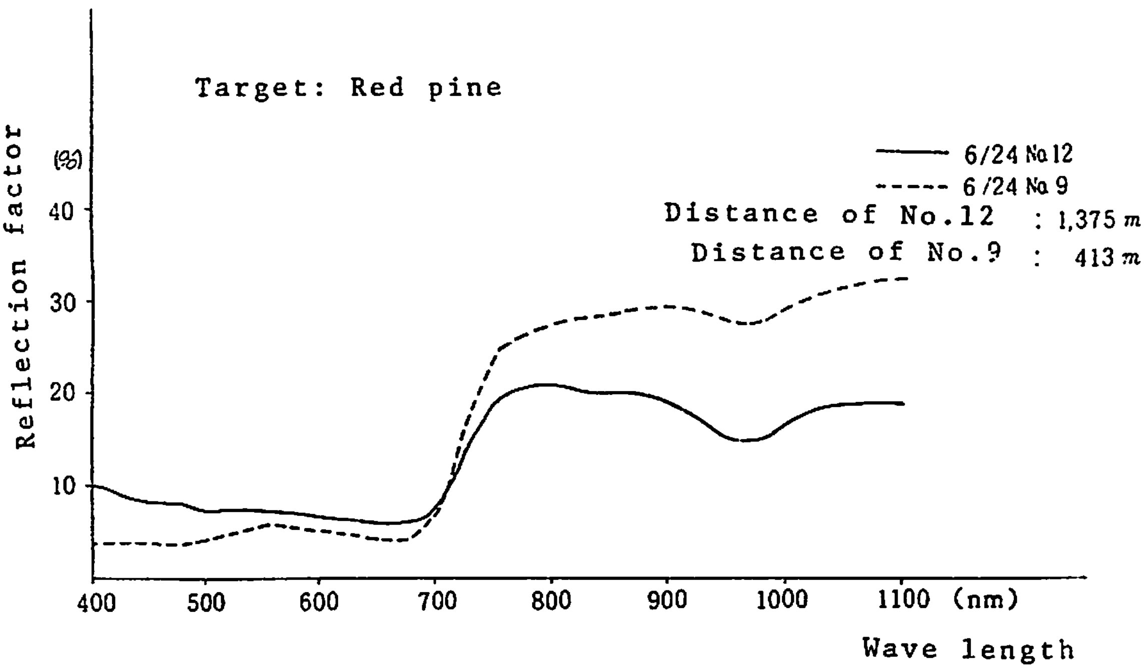

Fig. 3 Reflection factor of Red pine.

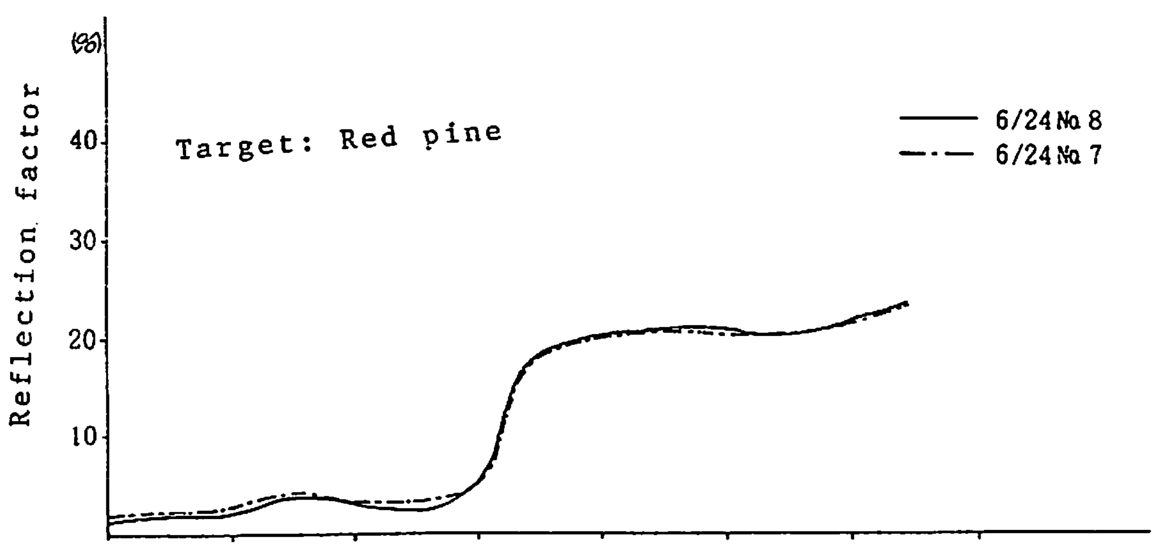

Fig. 4 Reflection factor of Red pine.

tion and scattering for a test target (a building wall) for which reflectance is not affected, but due to the focal lengths being less than desired other objects, besides these building came into the field of the camera and as a result, we were unable to measure the air scattering for the building alone. Fig. 4 shows the spectral reflection factor of larch in which objects within about 20 meters. The result shows to be consistent in both distant and near distance.

4.2 Seasonal variation of spectral reflection factor

The seasonal change pattern is shown in relation to the vitality of tree foliage, that is the quantity of chrolophyll and reflectance characteristic in the range of infrared. Fig.5 and Fig. 6 show the seasonal changes of tree vitality of red pine and larch through whole year which are closely dependent upon chrolophyll quantity. Fig. 7 tells us how atmospheric and sun angle affects reflectance from the test building in different seasons.

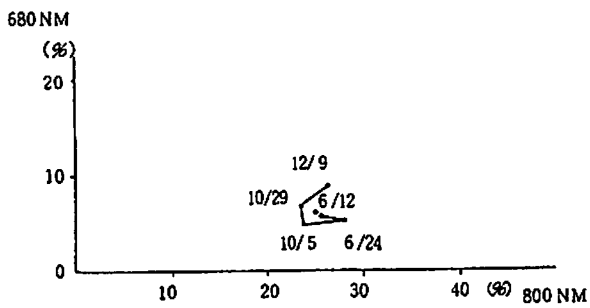

Fig. 5 Seasonal vitality change of Red pine

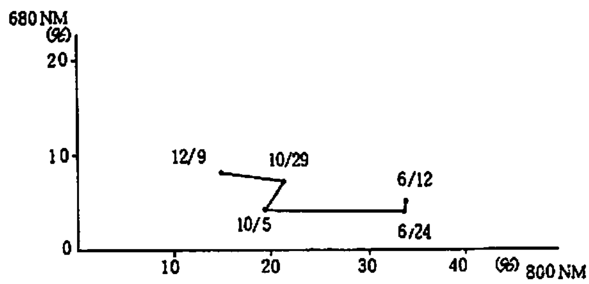

Fig. 6 Seasonal vitality change of Larch

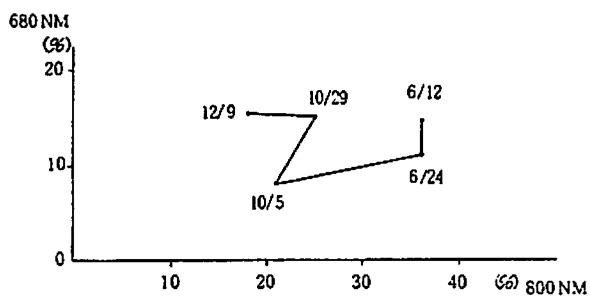

Fig. 7 Seasonal vitality change of Building

4.3 Year-to-year change of tree vitarity

Fig. 8 and Fig. 9 show the pattern of year-to-year change of bi-band ratio for red pine and larch from 1978 to 1980. Although the above mentioned quantity measurement does not always have high accuracy, the graphs show the tendency which are slightly less in 1980 compared to the previous years.

4.4 Indoor experiments of spectral reflection factor

The appropriate time for measurement of spectral reflectance is closely related to the direction of sun, spectrometer and the surface of the objects and appropriate time of measurement from 10 a.m. to 2 p.m.. But there are no definite results on this problem. The authors did the

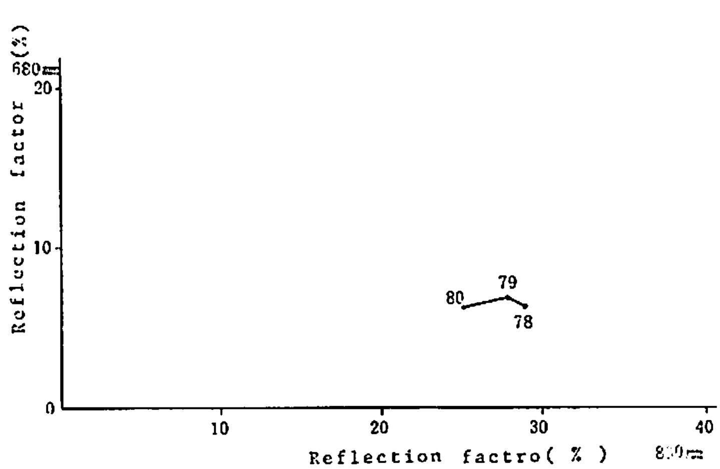

Fig. 8 Year-to-year change of bi-band ratio.

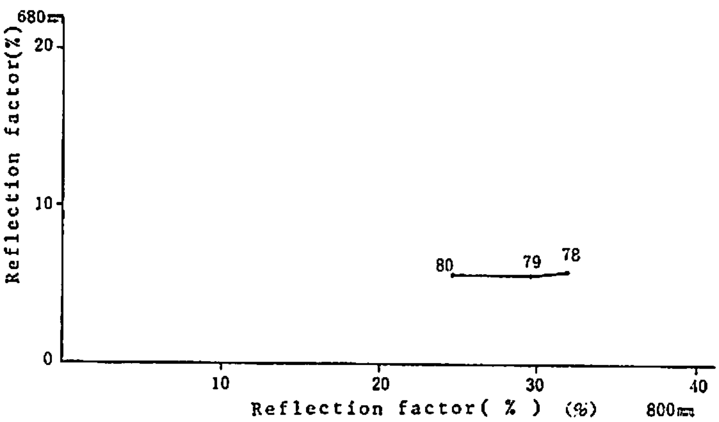

Fig. 9 Year-to-year change of bi-band ratio for Larch.

indoor experiments using the installation system which can reconstruct the actual relative placement of field conditions. These various field conditions include the geographical position of objects, and its inclination, solar illuminating angle and direction of reflector. We did obtain some fundamental information to select the appropriate time of day and season for reflectance measurement in the field. The experiments are now going on and not yet completed. We hope to discuss the interim results of these experiments in the future.

4.5 Conclusion

The spectral signature in forestry has played an important role for environmental evaluation. But there are various problems which must be solved, if this method is to be applicable systematically through the final stage of judgement using multispectral data. Since only a fundamental example is shown in this paper, we must perform more research in order to find the integrated practical data to be used under various conditions.

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