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学 位 論 文 要 旨

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題目： Research on Responses from Some Landscape Trees to T0613 and Summer Drought with Digital Image and Spectral Analysis

（デジタル画像とスペクトル分析法を用いた台風 0613 号と夏季干ばつに対する緑化樹からの反応に関する研究）

Morphological expression of landscape trees is usually the equilibrium between endogenous metabolic processes and exogenous metamorphic actions exerted by environment. Landscape trees grow in the unremittingly altering environment and respond it at any time and in varied patterns. Under the favorable conditions they make a response with the characteristic of rapid growth. However, the extremely unfavorable or catastrophic environments occasionally appeared in field. In recent years, many reports indicate that the unfavorable meteorological extreme events have increased as the large-scale climate changed in some area. They often induce many landscape trees into protective response or directly damage to them. Aimed at studying about the meteorological extreme events and responses from landscape trees and by using the methods of image and spectral analysis, the damaged status of some landscape tree species have been researched.

From 2004 to 2008 it appeared a significantly varied and strongly contrasted climate in Yamaguchi, Japan. During this period a lot of meteorological extreme events happened, particularly the exceptional typhoon 0613 (T0613) characterized with strong wind (gust wind speed 42.4m/s) and less rainfall (daily precipitation 24mm), and the summer drought in 2007 (SD2007) with the precipitation during the first nine months only 60.1% of the normal. Both are the main study content of this thesis.

Among these extremes, the summer hot wave and the strong typhoon associated with elongated less rainfall often trigger significantly visible injuries to them. The leaf color premature change of sweet gum tree during the summer drought period in 2007 and 2008 is one of them. Both high temperature and strong wind, associated with less rainfall, easily result in landscape trees into serious water imbalance even desiccation. The combination of them evidently decreases the threshold of landscape tree responses to the extreme stresses. Under this kind of extreme water stress conditions, many of them can save their lives from lethal desiccation status at expense of partial tissues or organs, which comprise the major parts of transpiration surface reduction or damage character. It directly results in leaf abscission, necrosis, branch/twig dieback, crown discoloration and canopy gap formation and so on. In fact, these terminal parts are the sensitive or frail points in their hydraulic architecture. The characteristics landscape tree responses to these kinds of extreme events usually show genetic specific diversity and stability. The structure of leaf, branch and cuticle characteristic and so on in a large extent manifest the adaptation pattern of them to severe desiccation. The sensitive landscape tree species often appeared severe injury symptoms after hit by meteorological extremes.

Since the big body of landscape trees, the conventional approach in observing damage characters of them in field is visual scale method. To some extent, it is characterized by observer specific, and probably affected by subjective judgment. As the information technology development, there is a tendency of transformation to objective methods for determining damage by typhoons and other disasters, especially using imagery analysis nowadays. During the study, it is found that the apparent characteristic of responses from landscape trees is the separation of partial tissues or organs from main body of them. The separated parts usually appear special leaf color, spectrum and temperature character for their special structure and substance content. It becomes the foundation of estimation or

evaluation with image and spectral measurement. The apparent symptoms of ginkgo leaves hit by the meteorological extreme event of T0613 were estimated by using the spectral reflectance at red edge under the controlled environment. By using the handhold radiometer of EKOMS720, the optimum wavelength for the calculation of NDVI for necrotic ginkgo leaves is at 679 and 755 nm. The close inverse relationship between $NDVI_{755nm/679nm}$ and LNAP of ginkgo leaves and dogwood leaves indicates that it has potential to evaluate the damaged status and to be an alternative tool to measure the leaf necrosis induced by typhoons like T0613 or SD2007, especially by using the NDVIR value.

Based on the RGB image analysis of both leaves and crowns, the G/L value of bamboo leaves shows lower variance and higher relation to SPAD value comparing to the G/R value at the situation of larger difference of image luminance. Especially, by using the relative G/L value of same leaf/crown in same image, the variance can be significantly lowed so as to make a statistical comparable measurement.

The construction of logistic threshold responsive curves of ginkgo crown discoloration gives a special example of the use of these relative G/L values. By using this kind of logistic threshold curves, the asymmetrically discolored crown of ginkgo hit by T0613 and the evenly distributed leaf necrosis on crown of dogwood under the serious impact by SD2007 can be clearly distinguished from each other. Therefore, they may be the alternative ways to quantitatively estimate the damage or hurt by these meteorological extreme events.

With ground-based digital image, the vigor status of ginkgo damaged by T0613 had been evaluated buy using the characters of defoliation, discoloration and crown symmetry. It is observed that landscape trees seem hit by the environmental extremes one after another, especially the individuals at constricted site condition that are in the situation of high sensitive to the environmental extremes. It is more common that before they perfectly recover from an extreme shock another hit has occurred. Some of them grown at poor site condition are even in the cycle of branch sprout and dieback, and remain a small, narrow or stem alone crown. These kinds of continual damages result in these trees impossible to put up an all-round effective defense against biotic and abiotic intrusion, and induce low vigorousness or abnormal form of them even accelerate the senescence or death. The persistent hit to one direction or part and the self-shelter one part by another as well as the asymmetrical growth during the restoring period often cause asymmetry of some landscape trees. It should affect the vigor status to respond the further meteorological extreme events like Typhoon 0613.

According to image analysis water content measurement, it is observed a tendency that as stress become serious the desiccation of landscape trees often starts from the terminal part of them such as the leaf or branch tip and crown top and the dogwood leaf necrosis and branch dieback showed a special example. During hit by SD2007, about 40% leaf area had been reduced from investigated Kousa dogwood trees. The common result is the defense response of them to separate terminal part from main body to reduce the transpiring surface, although the position of the separation varies with landscape tree species with different properties of water conservation and adaptation to extreme drought conditions. It results in some of them into leaf abscission and necrosis, branch dieback/shedding and son on.

The different variation character of water content and image temperature of separated parts of leaves and branches of dogwood made the thermographic detection of them possible. It manifests the possibility of identification to the reduced parts by amplified variation of imaging temperature, especially for Kousa dogwood.

The visible symptoms of responses from landscape trees often show temporal delay, which manifest the characteristic of the interaction between extreme environment and the response of them. It is the response characteristics of symptoms to these meteorological extreme events that make more complex to distinguish the impact of external factors. The delay of the landscape tree responses to one extreme hit also increases the possibility of further hit by other extremes. It is found that the strong dry typhoons often accompany with a period of no or less rain anticyclone weather. The sudden temperature ascent after strong dry typhoon's hit may be one of this kind of secondary hit and induce severe response from landscape trees just like the situations during the T0613's hit. In field condition, many stress factors usually work together, such as dry and hot wind without rain association and merge with unfavorable site condition, root growing limitation and the improper root/shoot ratio etc., which are lethal environments to landscape trees.