NUT SPEICIES MAPPING FOR DETECTING THE HABITAT SUITABILITY AREA OF JAPANESE MACAQUES (*Macaca fuscata*)

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ABSTRACT: Crop damage by wild Japanese macaques is becoming an increasingly serious problem in Japan. The countermeasure of driving monkeys away from farmland to inner forest regions is currently an area of focus. However, when enforcing this measure, the environment where the troop can be established in inner forest regions is indispensable in order to avoid trespass upon farmland again. In this study, the nut species as a food resource were mapped to detect the habitat suitability area of Japanese macaques in inner forest regions. In mapping, after classifying vegetation regions approximately, the lower level classes were prepared in the specific upper level class, and the detailed classification was carried out in the lower level class. In the results, the nut species could be extracted from the remotely sensed data with a Kappa accuracy of 0.649. However, many broad-leaved deciduous forests other than the nut species were contained as an incorrect classification. Moreover, since there are few field survey points, the possibility that deviation arose in accuracy verification is high. It is necessary to acquire accurate training samples and test samples from the whole study area for the improvement in accuracy of the image classification.

INTRODUCTION

Crop damage by wild animals has become serious problem, amounting to 20 billion yen (200 million US dollar). Crop raiding by Japanese macaques (*Macaca fuscata*) which is Japanese endemic species was about 1.6 billion yen (Ministry of Agriculture, Forestry and Fisheries, 2009). As the cause of the damage, large areas of coniferous plantation, prohibited the hunting of monkey, abandonment of fuel-wood forest due to change in human lifestyle, and difficult to drive monkeys away by aging and depopulation (Watanabe, 2000; Mito, 1995). From these reasons, the habitat of the monkeys shifted from upper part of mountain to village, and depended on the crops (Muroyama, 2003). Furthermore, the increase of birthrate and the decrease of the mortality have occurred because nutritional condition improved for the better when it utilized the crops (Ministry of Agriculture, Forestry and Fisheries, 2006). Changes in population parameters would lead to an increase of individual, the distribution have been expanded to the area where was not inhabited by monkeys before. At the forefront of expanding the distribution, severe crop damage was caused further population growth and distribution expansion (Muroyama, 2006).

The main countermeasures for monkey were lethal control with gun and trap, which approximately 10,000 heads were captured for a year. However, the effect of lethal control is not stable and it has not resulted in mitigation of crop damage. (Ministry of Agriculture, Forestry and Fisheries, 2006). Furthermore, the lethal control with gun or trap was not so effective for a method to reduce the damage, and it had possibility that led to eradication of local population (Muroyama, 2006). Therefore, in recent years, not only the lethal control with gun and trap but the comprehensive countermeasures were important for damage management (Izumiyama, 2010).

As the comprehensive countermeasure, the method of driving monkeys away from farmland to inner forest regions was currently focused. In the case study of Enari *et a*l, (2006), it had achieved the movement of the inner forest region of the population and decreased in the crop damage. However, if there were not suitable environment in inner forest regions, the monkeys show high devotion around the farmland. The target inner forest regions should be the suitable environment with rich food resources (Forestry and Forest Products Research Institute, 2008). Before driving monkeys away, detecting the area where the abundant food resources are necessary. As food resource, the monkeys mainly depended on broad-leaved deciduous forest (Forestry and Forest Products Research Institute, 2008). Therefore, verifying the possibility of detecting suitable area with rich food resources is necessary.

The objective of this study was to detect the suitable habitat for Japanese macaques using remotely sensed data. Mapping of monkey's available tree species was conducted in this study. The target tree species was nut species like beech which was nutritious and accounted for about 70% of all feeding time in the fall season (Nakagawa, 1989).

STUDY AREA

The study area was an urban and farmland area near Mt.Kochi (1,024m) and Mt.Akiha (201m) in Shibata city, Niigata prefecture, Japan. An almost study area was mountainous area, and pine (*Pinus densiflora*) and oak (*Quercus serrata*) adjacent to residential area, while beech (*Fagus crenata*) and oak (*Quercus crispula*) developed in upper mountain area. Moreover, Japanese cedar (*Cryptomeria japonica*) plantation was distributed along the road. In study area, various agricultural crops (rice, potato, beans, radish…) encountered damage by Japanese macaques, and it amounted to around 10 million yen every year (Makakudo, LLC, 2010). As the countermeasures, the lethal control with gun and trap performed by hunters, and so nearly 200 heads were captured among one year per an estimated population 800±50 heads (2004 year) around the damaged area. However, though considerable monkeys were captured every year, about 820 heads (2010 year) were living around the damage area now, and the drastic decrease has not been achieved in the amount of damage.

MATERIALS

In this study, IKONOS imagery (5.7km×4.5km) with 1m-pixel resolution was used as high spatial resolution satellite data, taken in 2007/5/4 (Figure 1). The spectral channels of IKONOS were composed from 4 bands; Blue (445～516nm), Green (505～516nm), Red (632～698nm), Near Infrared-Red (757nm～853nm). Moreover, the possibility of the nut species could be detected from this image was high, because photography time of this image was the season that beech and oak leafing was faster than other tree species.

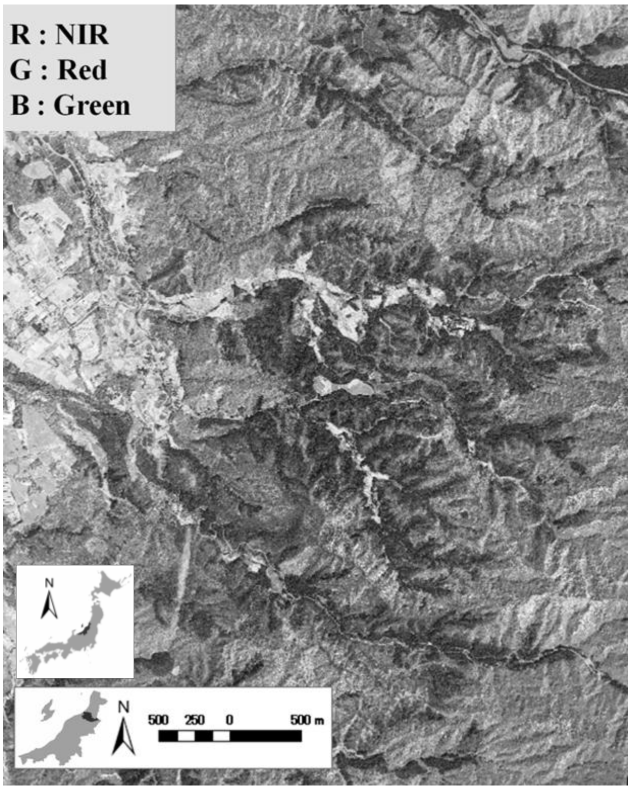

Figure 1 IKONOS satellite imagery of Shibata city, Niigata prefecture, Japan (2007/5/4).

METHODS

In the study area, local investigation was conducted at 2010/10/22 for examining vegetation. As a result, most of tree species that had already finished leafing in the IKONOS imagery was nut species like beech and oak. There was coniferous tree, broad leaved tree except nut species, and nut species that didn't occur leafing for upper elevation yet.

The data were orthorectified with a digital elevation model. All satellite data were geo-coordinated to the Universal Transverse Mercator system. Shade caused by topographic relief can create serious obstacles to analysis of remote sensing data. We used the slope matching method (Nichol *et al*,, 2006). Thereafter, it created a composite image that added NDVI, the feature of IHS and the indices of Tasseled Cap transforms to the image. The synthesis of the image was conducted in order to accuracy improvement of classification, and composite image was compared accuracy with the classification result by IKONOS image (original image).

In mapping, a hierarchical classification was applied. After classifying vegetation regions approximately into the superior 3 classes; nut species, conifer forest and mixed forest by object-based classification, the lower 4 classes; nut species (leafing), nut species (leafing as yet), other broad leaved tree and coniferous tree, were prepared in mixed forest class for the detailed classification. The classification methods of lower class were used pixel-based classification combined non parametric Parallelepiped method and parametric Maximum Likelihood method, and object-based classification of Nearest Neighbor (NN), CART analysis and box plot analysis. The segmentation of superior class and lower class with object-based classification were utilized Definiens Developer7.0 and were shown in Table 1.

In accuracy validation, aerial imagery (spatial resolution: 0.25m) was used as the reference image, but the interpretation of tree species was difficult, because photography acquisition time was summer season and it had finished leafing stage of broad leaved tree except nut species. Therefore, the interpretation of tree species around investigation points were carried out by combining local photograph of the points with aerial imagery and adding defined vegetation area from IKONOS imagery. As a result, training samples were made by 142 points. Moreover, lower classification was carried out 4 classes, but purpose of this study was extracting nut species. So, accuracy validation was carried out 3 classes; nut species combined nut species (leafing) with (leafing as yet), other broad leaved tree and coniferous tree.

RESULTS

From accuracy assessment, the overall accuracy and Kappa coefficient of each classification method was shown by Table 2. In the result, pixel-based classification of original image was the highest accuracy with Kappa coefficient of 0.649 (Figure 2, Table 3). However, the result of composite image was higher accuracy than original in all object-based classification method except pixel-based classification. The pixel-based classification of original image was shown that there was hardly misclassification in coniferous tree class, while nut species class misclassified other broad leaved tree, and there were misclassification of nut species and coniferous tree in other broad leaved tree class (Table 3).

Table 1 Segmentation parameters of each class.

	Scale Parameter	shape	compactness
Upper class	500	0.2	0.5
Lower class	10	0.3	0.5

Table 2 Overall accuracy and Kappa coefficient of each classification methods.

	Original image		Composite image	
	Overall	Kappa	Overall	Kappa
Pixel-based	0.768	0.649	0.754	0.628
NN	0.662	0.487	0.690	0.531
CART	0.641	0.445	0.697	0.528
Box plot	0.732	0.591	0.754	0.626

Table 3 Result of pixel-based classification of original image.

	Reference			Total	User
Classification	Nut	Other	Conifer		
Nut species	35	6	1	42	0.833
Other broad leaved	14	25	0	39	0.641
Coniferous	6	6	49	61	0.803
Total	55	37	50	142	
Producer	0.636	0.676	0.98		
				Overall	0.768
				Kappa	0.649

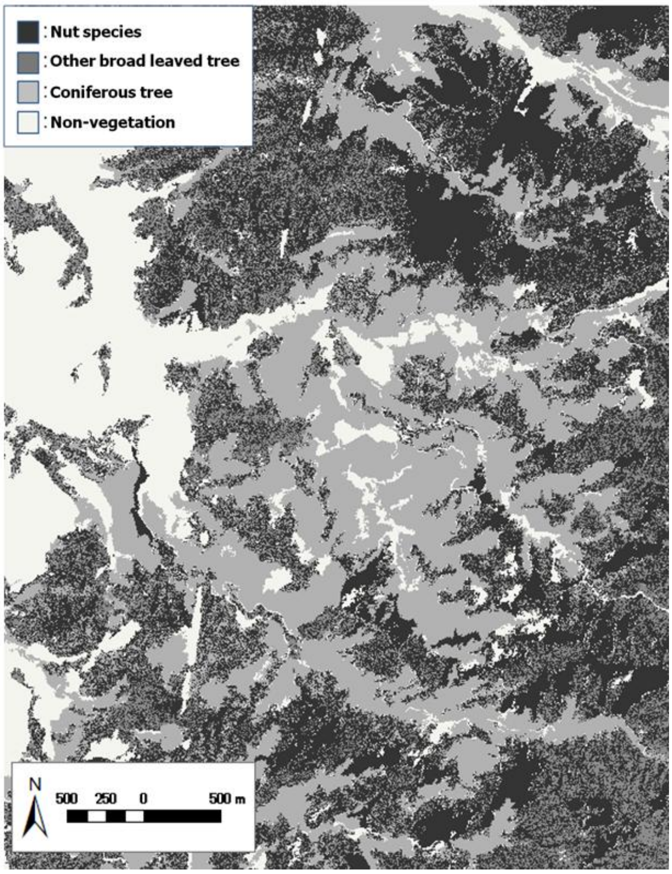

Figure 2 Classification image of pixel-based classification (original image).

DISCUSSION

All object-based classifications were lower accuracy than pixel-based classification. The classification accuracy had decreased because the precise segmentation could not performed in the area of thin single tree and trees overlapped even IKONOS imagery of 1-m resolution. However, the classification results of composite image were higher accuracy of overall accuracy and Kappa coefficient than original image in the all object-based classification methods. A case of composite image, it was considered that it had abundant features by adding plural index data, and so more appropriate threshold was able to be selected in the lower classification. In case of pixel-based classification, the result of composite image was lower accuracy than original image, but the difference of both hardly existed only by the coniferous tree class slightly having many misclassifications in composite image.

In the highest accuracy classification, pixel-based classification of original image, nut species class contained many other broad leaved trees. It was considered that nut species with early leafing was classified into other broad leaved tree class. On the other hand, other broad leaved tree class was misclassified into nut species and coniferous tree. As the cause, it was considered the classification threshold of this class was spread; the various vegetations became target in other broad leaved tree class, while clear classification subjects were determined in nut species and coniferous tree class.

As a cause of many misclassifications between nut species and other broad leaved tree class, other broad leaved tree class hadn't been acquired more suitable training samples than other classes. Therefore, it was important to make difference of nut species and other broad leaved tree class clear by acquiring training sample of other broad leaved tree from the entire satellite imagery to improve distribution accuracy of nut species in this investigation area. About the accuracy validation, the problem with high possibility that there was bias in the test sample remained for using IKONOS imagery because of the tree species interpretation only by the aerial image was difficult, and acquiring few local investigation points per entire investigation area.

In the study, nut species were able to be extracted successfully using high spatial resolution satellite imagery. However, it was difficult to catch the accuracy of the entire image in this accuracy interpretation result, considering the above-mentioned problems. To acquire the training sample and the test sample of high accuracy for the entire satellite imagery is necessary for the accuracy improvement.

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