USING AERIAL PHOTOGRAPHS AND GIS FOR CONSERVATION PLANNING IN THE YANGMINGSHAN NATIONAL PARK, TAIWAN

Li-Ta Hsu[1] and Li Lin[2]

[1]Associate Professor, Dept. of Forestry and Nature Conservation, Chinese Culture Univ.,
55 Hwa-kang Rd., Taipei 11114, Taiwan; Tel: +886-2-28610511#31322;
E-mail: lita@faculty.pccu.edu.tw

[2]Undergraduate Student, Dept. of Forestry and Nature Conservation, Chinese Culture Univ.,
55 Hwa-kang Rd., Taipei 11114, Taiwan; Tel: +886-2-28610511#31305;
E-mail: s9623848@msd.pccu.edu.tw

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ABSTRACT: The Yangmingshan National Park in northern Taiwan is located nearby metropolitan areas, and is therefore highly prone to human disturbances. To assist in the conservation planning, this study used land use map derived from aerial photographs, and used GIS to analyze the spatial distribution of land developments in terms of environmental and socioeconomic factors. A binary logit model was used to analyze the relationship between land development and environmental factors. The derived model was then used to identify areas prone to land development and areas suitable for preservation. The results showed that the distribution of land developments was mainly affected by slope and proximity to rivers and roads. The predicted land development probabilities show that some of the edges around the existing protected areas are prone to human disturbances. Based on the predicted development potentials, it is recommended that reshaping the protected areas by excluding areas with high development potential and expanding to areas with low development potential could improve the effectiveness of landscape protection.

1. INTRODUCTION

1.1 Paper Format and Typesetting

Land uses characterize human-nature interactions. Land uses on a location not only reflect human needs from the nature, but also record the changes human imprinted on land (Parker et al., 2003). Therefore, land uses, especially the spatial patterns of land uses, have been a focus in many realms such as geography, politics, socioeconomics, and ecology. Early scholars such as Chapin and Weiss (1962), Alonso (1964), and Barlowe (1978) have devised various theories and viewpoints to elucidate the mechanism and forces behind land uses. Among those complex factors, environmental factors such as topography, hydrology, and locational proximity have always been considered as the determinant influences (Chang, 2005).

Taiwan is a small island compacted with dense population. As a result of population growth and economic prosperity, the surging demand for land forces land development moving towards slope lands. However, slope lands in Taiwan play an important role in terms of resource provision, soil and water conservation, and ecological protection. Unregulated development on slope lands may seriously damages the environment and ecosystem, and may in turn results in disastrous harms to human lives and properties. Therefore, the effectiveness of environmental protection and ecological conservation on slope lands greatly relies on the regulation of slope land development.

Established in 1985, the Yangmingshan National Park is the third national park in Taiwan. Located in northern Taiwan, the Yangmingshan area has been constantly undergone the strong wind from the northeast. The particular climate condition and volcanic terrain generate a very diverse environment, and therefore support a very rich ecosystem. Although protected by the law, the national park still faces development pressure due to its proximity to metropolitan Taipei and large amount of visitors. The current land uses in the park provide clues for possible future land development. The objective of this study was to analyze how environmental and socioeconomic factors have affected the land uses. Base on the analysis, potentials of land development will be evaluated to provide information for the land management and conservation planning of the national park.

2. MATERIALS AND METHODS

2.1 The Study Area

The study area is the Yangmingshan National Park. The boundary of the park spans across Taipei City and New Taipei City, and the size of the park is 11,455 ha (Fig. 1).

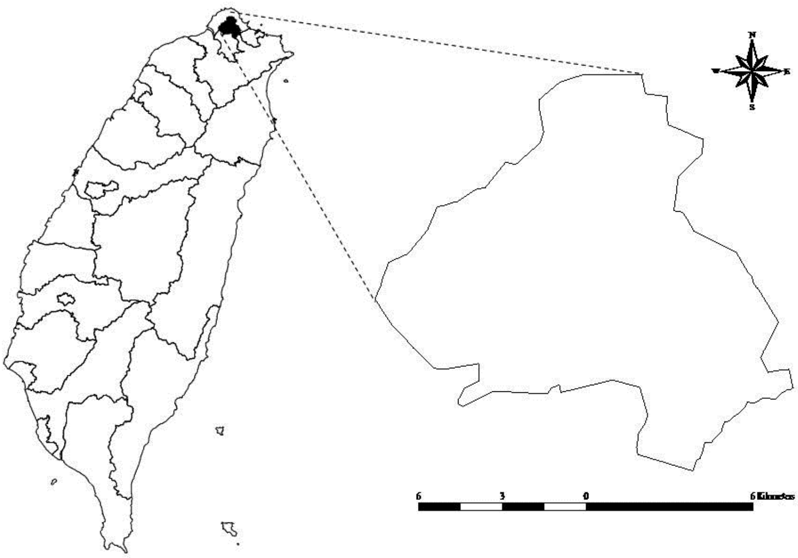

Fig.1. Yangmingshan National Park, the study area.

During the past century, the Yangmingshan area has undergone many kinds of land development activities, including sulfur mining, cattle grazing, and growing of indigo plants, tea trees, rice, fruits, vegetable and flowers (Lee, 1992). The tourism growth during the last few decades also greatly influenced the land uses.

The earliest land use map of the Yangmingshan National Park was published in the book by Huang (1983). The map categorized the park into plantations, natural broadleaf forests, grasslands, rice paddy, and other developed areas. Zhao (1990) classified the park into farmlands, horticulture, orchards, forests, bamboos, grassland, buildings, cemeteries, mining areas, bare lands, and water using base maps. PCCU (2000) used satellite images to classify the area into coniferous forests, mixed coniferous-broadleaf forests, mixed broadleaf forests, bamboos, glebes, Acacia forests, buildings, grasslands, orchards, and rice fields. The land use map used in this study was delineated by Hsu (2008) using colored aerial photographs. The classification includes lowland evergreen broadleaf forests, lower-mountain and lowland broadleaf bushes, lower-mountain and lowland herbs, plantations, bamboos, farmlands, parks, natural bare lands, buildings, and cemeteries (Fig. 2.).

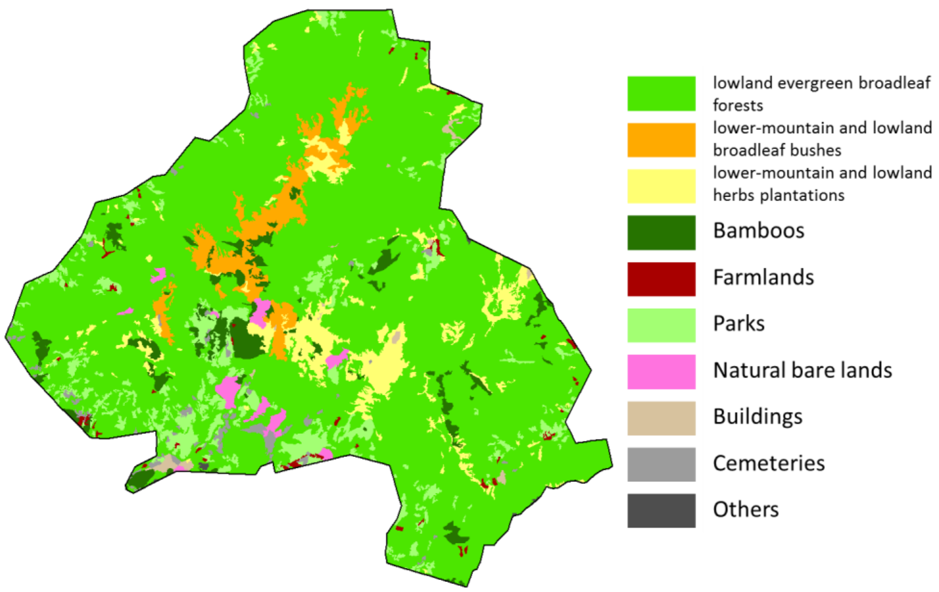

Fig. 2. The latest land cover map of the Yangmingshan National Park (Adapted from Hsu, 2008)

2.2 Data Collection

From Fig. 2., categories including bamboos, farmlands, parks, buildings, and cemeteries were selected to represent human-caused land developments (Fig. 3). Plantations, although planted by human, were excluded from the selection because they are considered beneficial to the environment and ecosystem.

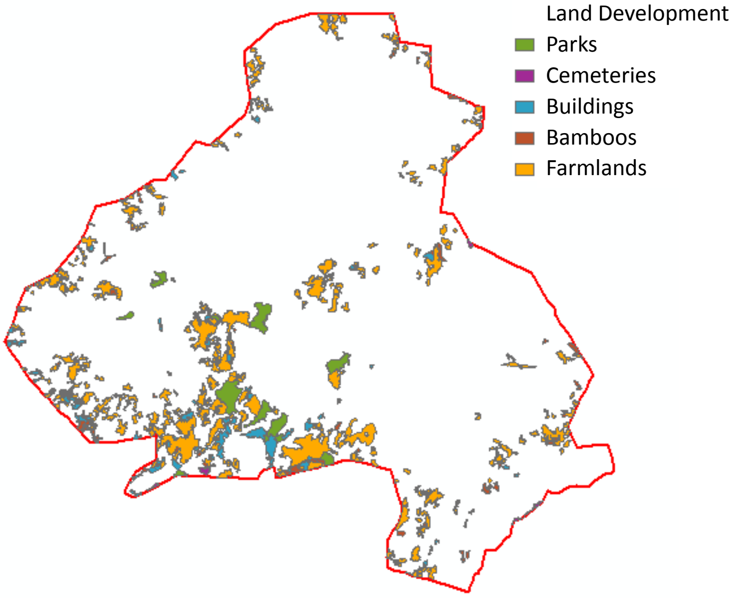

Fig. 3. The observed land development in the study area

Factors potentially affected the observed land developments were classified into environmental factors and socioeconomic factors. Environmental factors include topographic conditions such as elevation, slope, and aspect (Fig. 4). Socioeconomic factors include proximity conditions such as distance to rivers and distance to roads (Fig. 5).

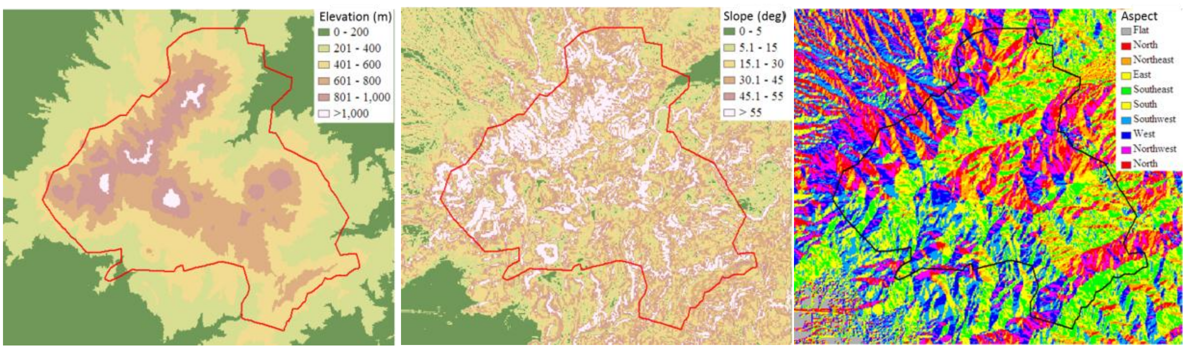

Fig. 4. Elevation, slope and aspect of the study area

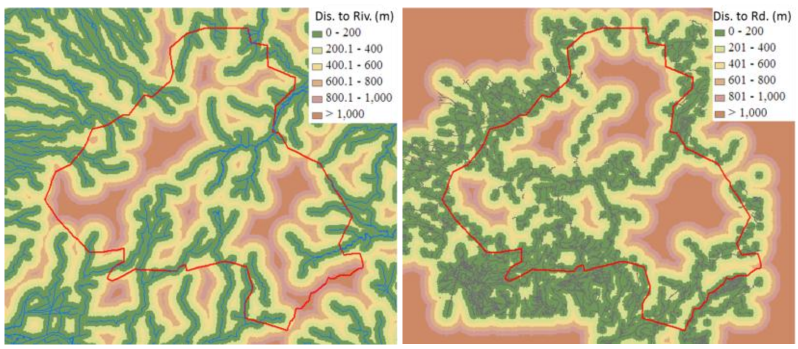

Fig. 5. Distance to rivers and distance to roads of the study area

2.3 Methods

Binary logistic regression, or binary logit model, was used to examine the relationships between land development and the explanatory factors. The binary logit model assumes that decision makers make rational choice between two alternatives based on their utilities, and the utility function can be constructed from some explanatory variables (Ben-Akiva and Lerman, 1985). The concept agrees with the land rent theory in land economics (Brook, 1987), and the model has been widely used in analyzing land use changes. For example, McFadden (1978) and Anas (1978) both used logit model to explore factors contributing to land use changes. McMillen (1989) also used logit model to analyze land uses on the urban fringe. Dale et al. (1993) used similar approach to analyze forest characteristics attracting deforestation.

The binary logit model can be expressed as follows:

$$P = \frac{e^{\beta_0 + \beta_i X_i}}{1 + e^{\beta_0 + \beta_i X_i}} \quad (1)$$

Where P is the probability of land development, X_i represents each explanatory variable, and β_0 and β_i are the constant and the coefficient of each explanatory variable.

In this study, 100 random sample points were drawn from the developed and non-developed areas separately. The elevation, slope, aspect, distance to rivers, and distance to roads of each sample point were extracted using GIS. Maximum likelihood method was used to estimate the coefficients of the model.

3. RESULTS AND DISCUSSIONS

3.1 Results of model estimation

The estimation results were shown in Table 1. Among the five factors examined, slope, logarithmic distance to rivers, and logarithmic distance to roads entered the regression function. Slope appeared to be the most significant variable in determining land development. The significance of Omnibus statistic was less than 0.001, indicating a fairly well goodness of fit. The Cox & Snell R^2 and Nagelkerke R^2 were 0.195 and 0.260, indicating that around 1/5 to 1/4 of the variances can be explained by the entered variables. Moreover, the percentage of sample correctly classified was 71.0%.

Table 1. Estimation results of the binary logit model

Variables	B	SE	Wald	Significance	Exp(B)
Slope	-0.067	0.018	13.561	0.000	0.935
ln(Dist. to rivers)	-0.363	0.136	7.162	0.007	0.695
ln(Dist. to roads)	-0.248	0.129	3.67	0.055	0.78
Constant	4.673	0.962	23.583	0.000	106.97

Omnibus significance: <0.001
Cox & Snell R^2 = 0.195；Nagelkerke R^2=0.260
Sample correctly classified = 71.0%

3.2 Map of predicted land development potentials

Using the estimated binary logit model, a map of predicted land development potentials was created using GIS. Overlain with the observed land development, it can be seen that the developed areas generally have higher predicted probabilities (Fig. 6). Randomly selected another 188 points for validation also suggests a significant positive correlation between observed land development and predicted probabilities (R=0.78, p<0.001).

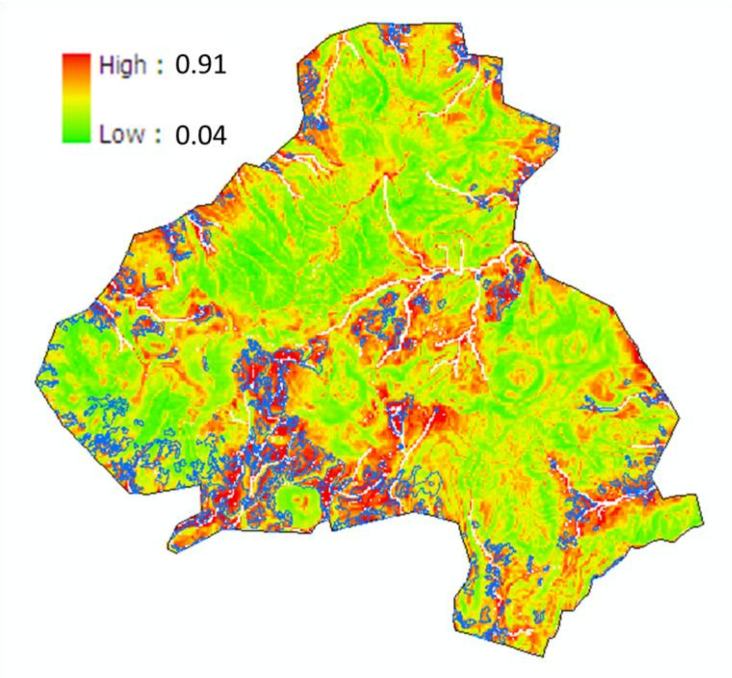

Fig. 6. Predicted land development potentials overlain with existing development

4. CONSERVATION APPLICATIONS AND CONCLUSIONS

There are two protected areas in the Yangmingshan National Park, namely, Lujiaokeng Ecological Protected Area and Mt. Huangzui Ecological Protected Area. Using upper and lower quartiles (0.25 and 0.75) to identify areas with relatively high and relatively low development probabilities, the map of land development potentials overlain with existing protected areas is shown in Fig.7. From the figure, it can be seen that the Mt. Huangzui Ecological Protected Area is located largely at areas with low development probabilities and undeveloped. On the other hand, the southeastern part of the Lujiaokeng Ecological Protected Area contains some developed areas and areas with high development probabilities.

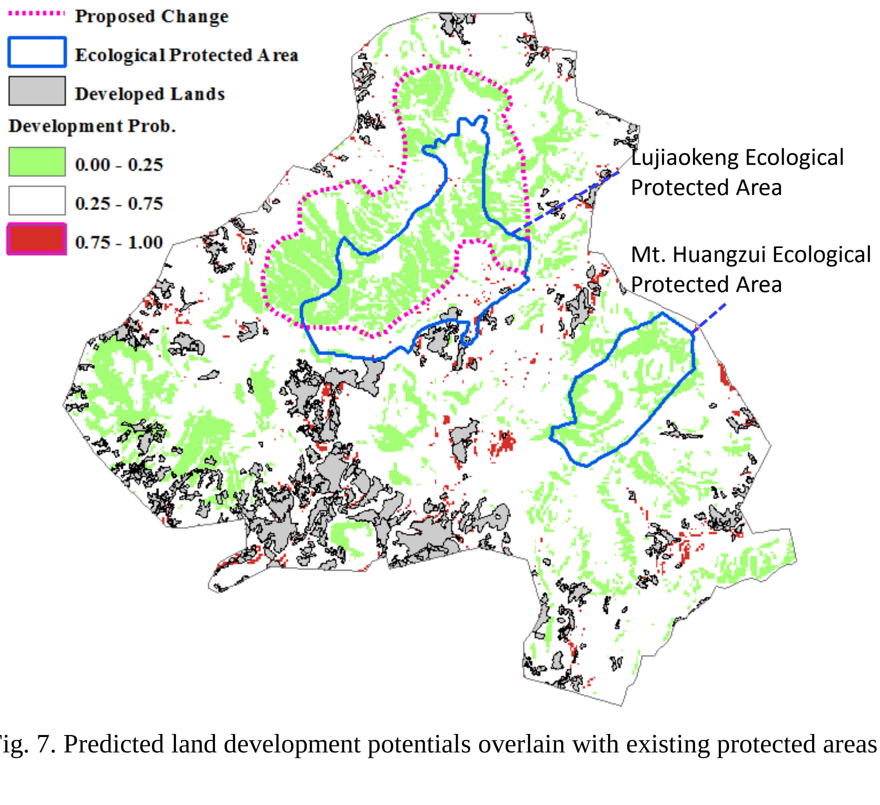

Fig. 7. Predicted land development potentials overlain with existing protected areas

Around the protected areas, the existing developed areas and undeveloped areas with high development probabilities can be identified from Fig. 7 as the "hot zones" for land use monitoring. It is also recommended that by reshaping the protected areas by excluding areas with high development potential, and expanding to areas with low development potential, might improve the effectiveness of landscape protection.

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