POTENTIAL NESTING SITE ANALYSIS OF RED-CROWNED CRANES USING GIS

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ABSTRACT:

Red-crowned cranes (*Grus japonesis*), once considered extinct, has been increasing in number in eastern Hokkaido, a northern island of Japan. One of the recent concerns about the cranes has been that the habitat in eastern Hokkaido may not be large enough to accommodate the increasing number of cranes. This study focuses on the breeding areas, especially the nesting areas of the cranes to develop a simple nesting site selection model using GIS so that the model will be used to help find suitable nesting areas in other parts of the island.
Geographic features in 1:25,000 scale maps and existing nest location points were digitized and a nesting site selection model developed for Kushiro Wetland with GIS. Potential nesting areas located by applying this model were small and existed only along the edge of the wetland. The result was consistent with the understanding of experts on the cranes whose breeding environment is becoming undesirable. It is expected that GIS will be also useful for the subsequent analyses required to find new nesting areas other than eastern Hokkaido.

1. INTRODUCTION

Red-crowned cranes (*Grus japonesis*), called Tancho in Japanese, inhabit Hokkaido, a northern island of Japan. They were once considered extinct about 80 years ago, because of overhunting and loss of habitats (Masatomi, 1993). However, in the 1920s, a few cranes were found to exist in Kushiro Wetland located in eastern Hokkaido (Saito, 1926). Since then they have been well protected, designated as a special national natural monument by the Japanese Government, and increasing in number. Especially, local people's effort to feed them during winter greatly helped the cranes survive and increase. The number of cranes has been counted in winter through annual crane census since 1952. Now, about 600 cranes are identified in eastern Hokkaido. Although the crane population is steadily increasing, its habitats, especially, the breeding areas, are decreasing. Agricultural, industrial and residential development have reduced one-third of the Kushiro Wetland, the largest wetland in Japan, during the last 20 years, and the crane population density in the wetland doubled between 1988 and 1992 (Masatomi, 1993).
Surveys on the crane nesting sites have indicated that most of the cranes in Kushiro Wetland select their nesting sites in low moor and use decaying reeds to make their nests. But the cranes are very adaptable in their nesting site selection, and those nesting in other wetlands such as Nemuro and Tokachi areas make their nests in near open marshes, and mud flats. Consequently, it is difficult to tell what environment should be preserved (Masatomi, 1993). Herr and Queen (1993) also indicated the difficulty of modeling the nesting habitat of greater sandhill cranes in northwestern Minnesota using GIS.
Recognizing the steady increase in the number of the cranes and continuing development pressure on their habitats, however, it is practical to assume that the current breeding areas in eastern Hokkaido will someday be oversaturated for the cranes. Masatomi (1993) pointed out that the nesting sites are increasing in peripheral zones of the Kushiro Wetland where the accessibility to predators such as minks and foxes are high. High vulnerability of chicks and juveniles to such predators creates great concern about the future population of the cranes. Experts agree that the current number, about 600, is not enough to maintain the species against diseases and natural disasters and at least over 1,000 cranes are necessary. In that case, new habitat areas other than eastern Hokkaido need to be found for the cranes.
The goal of this research is to find suitable nesting areas for red-crowned cranes in Hokkaido other than eastern part using GIS. To attain this goal, the research was divided into three stages: (1) spatial analysis of existing nesting sites in a study area to develop a simple model on the nesting conditions; (2) same analysis as (1) for whole eastern Hokkaido in which there exist a variety of natural environments from ordinary wetlands to coastal areas including open

marshes; and (3) potential nesting area analysis for the other parts of Hokkaido using the model developed during the first and second stages. This paper summarizes the preliminary results of the stage (1).

2. STUDY AREA AND AVAILABLE DATA SETS

The study area of the first stage encompasses ten 1:25,000 scale topographic map sheets covering most of the Kushiro Wetland (Figure 1). These topographic maps were updated in 1992 and 1993. In addition to the annual crane census conducted in winter, another annual survey has been conducted by the Environment Agency of the Japanese Government for the number and location of nests and breeding pairs during breeding seasons. Identifying cranes and their nests during breeding seasons is very difficult from the ground because of tall reeds and alders in the wetlands. Nests are identified from helicopters or airplanes and their locations plotted on 1:50,000 scale topographic maps. The distribution of the original nest location maps is very limited to protect the habitat from human disturbances. This project employs nest location data re-plotted and provided on 1:200,000 scale maps by the Environment Agency. The positional accuracy of the nest data is not accurately known, but it is roughly estimated not to exceed 100 m on the ground (H. Masatomi, personal communication, 1996). Nest location maps have been compiled every year. In this study, only those compiled for 1994 was used. A total number of 39 nests were identified in the Kushiro Wetland in 1994. The quality and the completeness of the nest location maps may not be uniform every year due to different weather and ground conditions for nest observations.

Vegetation data of high spatial resolution is considered important to develop a nesting site selection model because of its presumed relation to nesting conditions. But at the beginning of the project, the data was not available, and wetland areas delineated on 1:25,000 topographic maps were used instead.Masatomi, et al. (1990) employed satellite images to analyze the vegetation composition around each existing nest and found large fluctuation between the composite ratios, which suggests the difficulty of modeling the vegetation conditions for nesting.

Protected area maps were also employed to analyze the relationship between existing nesting sites and unprotected areas.

3. GIS DATABASE

The maps described in the previous section were digitized in vector format to make a GIS database for this project. The features digitized from the 1:25,000 topographic maps include road and river networks, buildings and wetland areas. A tablet was employed to digitize the nest location points on 1:200,000 scale topographic maps.

4. ANALYSIS

Since no complete model for nesting site selection has been developed and is difficult to develop, we developed a simple model based on a rule of thumb. Wetland areas and rivers are considered favorable for nesting while roads and buildings should be unfavorable due to possible human interference and intrusion of predators. Each nest must also be spatially separated with each other to avoid mutual interference. Every road and river segment and every building were assumed to have equal influence to cranes and/or nesting conditions. In this preliminary analysis, the wetland area was assumed uniform, even though different vegetation types such as reed, sedge, alder and sphagnum are present. The 39 existing nest location data of 1994 was then used to measure the distance between the nearest ground features and nesting sites, and between adjacent nests. In order to avoid unusual or exceptional cases of nesting sites, 10 % of the nests with extreme values were ignored for each ground feature.

The measurement was done by changing the buffer size of ground features or existing nests. For example, the river network data was buffered to the extent that the buffered areas include 90 % of the existing nests. The resulting buffer size (90 % buffer size) was 265 m. Figures 2 shows the distribution of existing nests and river networks with 265 m buffer. Figure 3-5 show the results of the same analysis for road networks, buildings and adjacent nests with the 90 % buffer size of 104 m, 364 m and 1320 m, respectively. It should be noted for the case of adjacent nests that the 90 % buffer size is half of the distance from an adjacent nest. The relationship between the Kushiro Wetland area and existing nests found in 1994 is shown in Figure 6.

The model for crane nesting thus derived has the following conditions:

(1) Distance from the nearest river network is less than 265 m;

(2) Distance from the nearest road network and the nearest building is larger than 104 m and 364 m, respectively;

(3) Distance from the existing nests is larger than 2640 m; and

(4) Nest is located within the wetland area.

5. RESULT

This model is then employed to find potential nesting sites in the Kushiro Wetland. The result is shown in Figure 7, which indicates the following:

(1) Compared to the area of the Kushiro Wetland shown in Figure 6, potential nesting areas in Figure 7 are small, scattered and separated from with each other; and
(2) Most potential nesting areas are located along the edge of the wetland which is outside of the protected areas.

One exception is found in a circled area of the lower left part of Figure 7. Although this area is part of the Kushiro Wetland, the natural conditions are considered different from the rest of the wetland because the road constructed north of it has changed the water flow pattern and, as the result, made the area inappropriate for nesting sites (Masatomi, H., personal communication, 1996). This difference is clearly shown in Figure 8 in which the locations of all identified nests from 1979 to 1994 except 1981-84 and 1986-89 are plotted. There existed no nest in these years in the same circled area as Figure 7. The model developed in this study was not able to distinguish this area from the rest of the wetland. The land cover data of the wetland derived from satellite images by Masatomi, et al. (1990) does not show any difference associated with the conditions, either.
The areas for potential nesting is only about 5 % of the total Kushiro Wetland, and there is not much space left in the Kushiro Wetland for nesting. In addition, the potential nesting areas are located in the peripheral areas of the wetland where accessibility to predators is high.

6. DISCUSSIONS

Since a perfect model for crane nesting site selection is unknown and will be difficult to develop, the model employed in this study is based on a simple set of rules using available data of geographic features. And there is no other data to evaluate the model and result of this study.
However, even though the maximum crane population of the Kushiro Wetland is unknown, experts believe that many cranes appear to build their nests in less than ideal locations (Masatomi, 1993). In the other parts of eastern Hokkaido, the extent of breeding areas has also been gradually expanding recently, and due to the reduction of breeding areas caused by wetland development, there have been an increasing number of new nesting sites under undesirable conditions (Masatomi, et al., 1994; 1995). This tendency can be explained by the small potential nesting areas scattered along the edge of the Kushiro Wetland which were derived in this study.
The significance of small potential nesting in Figure 7 needs to be assessed with the accuracy of the original map and existing nest location data sets. The horizontal accuracy of ground features digitized from 1:25,000 topographic maps is less than 18.5 m R.M.S.E. based on the fact that the accuracy of original topographic maps is better than 17.5 m R.M.S.E. and the digitization error is estimated at 6.25 m R.M.S.E. (Murakami, 1995). The accuracy of the existing nest location data is estimated at not more than 100 m. If this value covers 95 % (2σ) of the error, the root mean square error can be estimated at 50 m. This error of nest location is not small enough compared to the buffer size derived in this study. Since there are a number of potential nesting areas smaller than 50 m, it would be necessary to incorporate this error component in the model development process for more appropriate interpretation of the result.

7. CONCLUSIONS

GIS technology was applied to analyze nesting sites of red-crowned cranes in the Kushiro Wetland in Hokkaido, Japan. A simple model for crane nesting site selection was developed using existing nest location and geographic features data. Potential nesting areas located by applying this model were small and existed only along the edge of the wetland. The result was consistent with the understanding of experts on the cranes whose breeding environment is becoming undesirable. It is expected that GIS will be also useful for the subsequent analyses required in the second and final stage of this research to find new nesting areas other than eastern Hokkaido.
The GIS approach helped objectively visualize the circumstances of the Kushiro Wetland for the crane breeding areas, which have been pointed out by crane experts in subjective manners.
Since the accuracy of nest location data is not high enough compared to the scale of spatial analysis required to develop a nesting site selection model, an error analysis method needs to be developed and incorporated in the future potential nesting site analyses.

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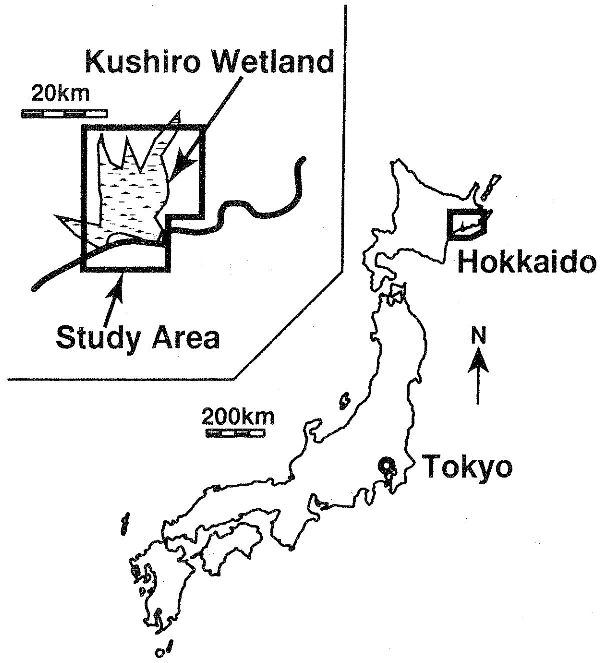

Figure 1. Location of study area.

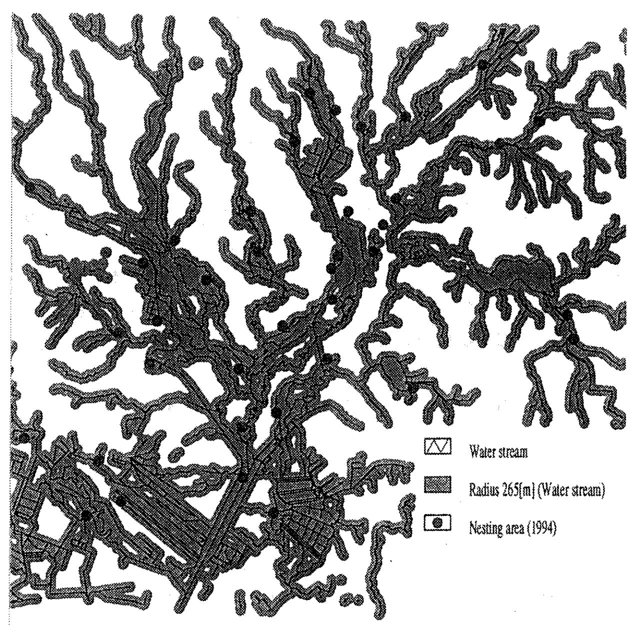

Figure 2. Distribution of existing nests and river networks with 265 m buffer in Kushiro Wetland.

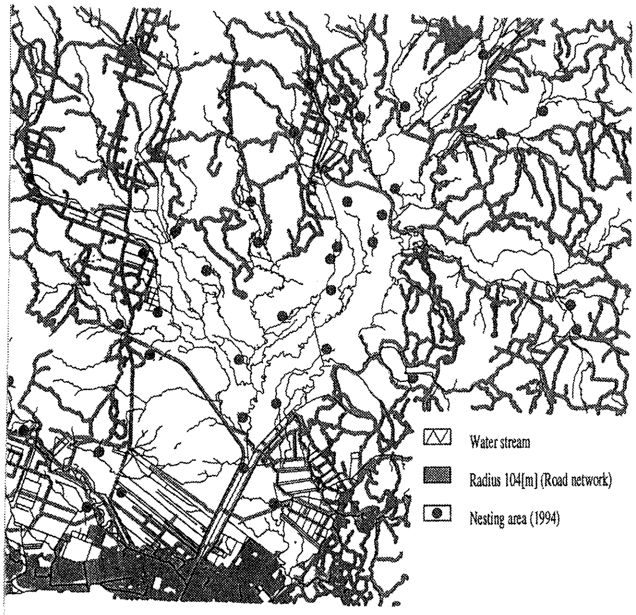

Figure 3. Distribution of existing nests and road networks with 104 m buffer in Kushiro Wetland.

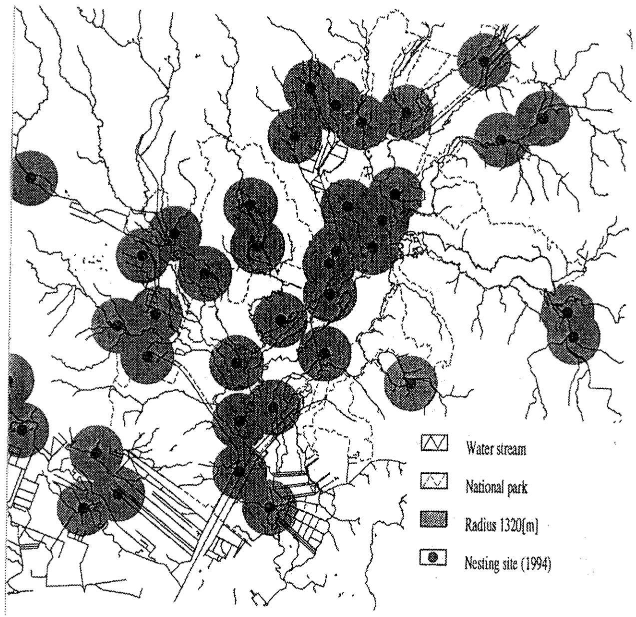

Figure 5. Distribution of existing nests with 1320 m buffer in Kushiro Wetland.

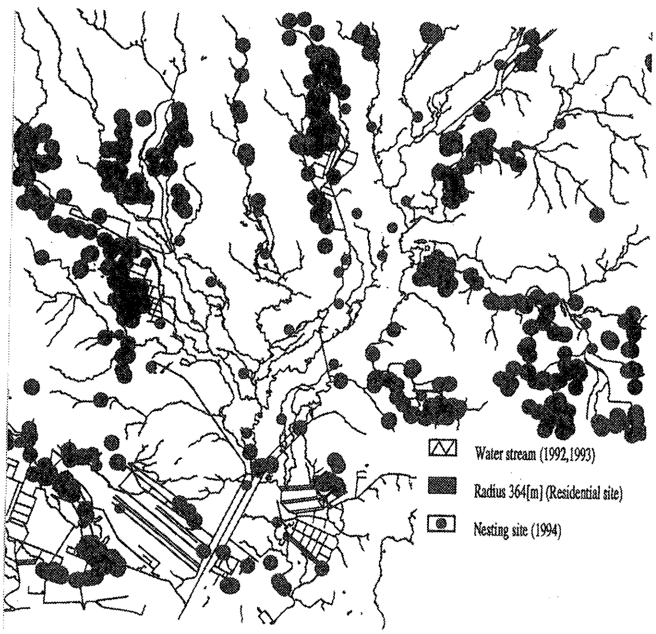

Figure 4. Distribution of existing nests and buildings with 364 m buffer in Kushiro Wetland.

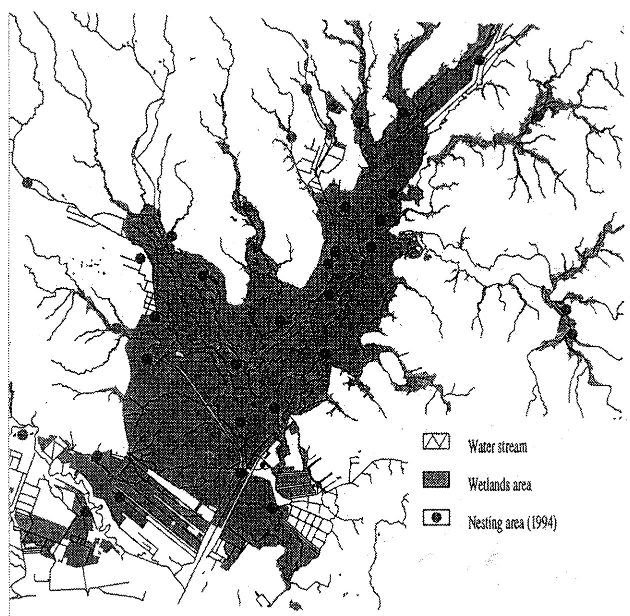

Figure 6. Distribution of existing nests and the Kushiro Wetland area.

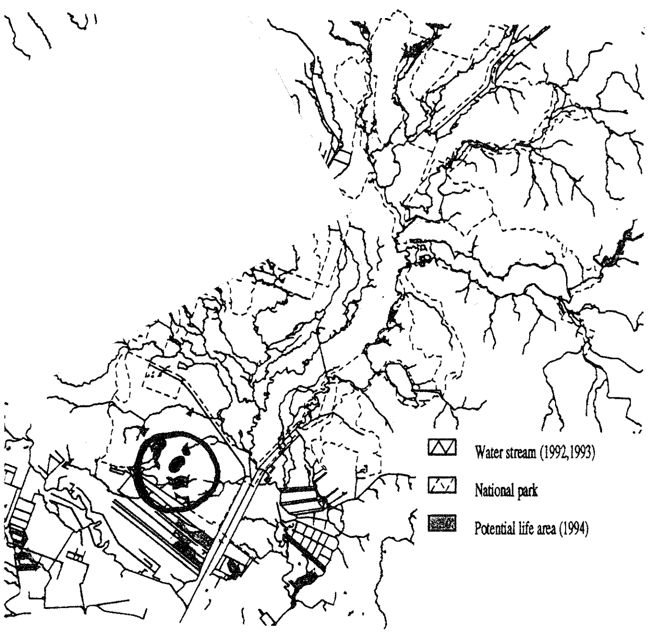

Figure 7. Distribution of potential nesting areas extracted in Kushiro Wetland using GIS.

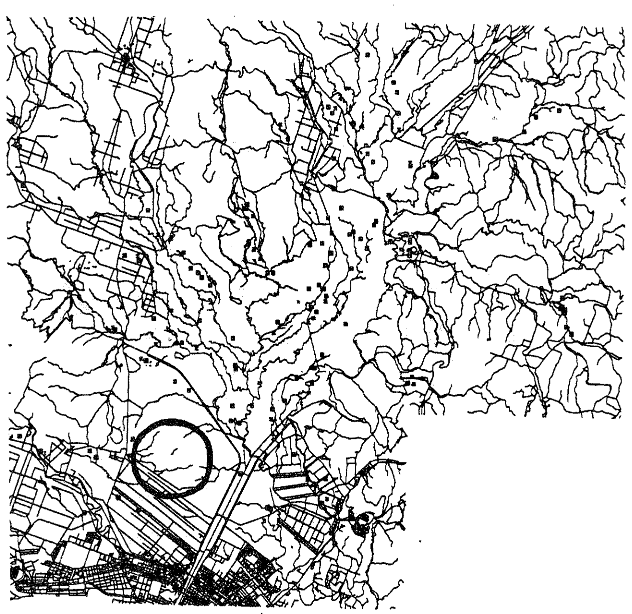

Figure 8. Distribution of existing nests from 1979 to 1994 except 1981-84 and 1986-89 in Kushiro Wetland.