The usefulness of the umbrella species concept to conserve biodiversity: tests using environmental-valuation and reproductive output of wetland raptors and songbirds

（アンブレラ種を用いた生物多様性保全の有効性：湿地性鳥類と猛禽類の繁殖成功度および環境経済学的視点からの検証）

要約版

北海道大学　大学院農学院

環境資源学専攻　博士後期課程

先崎理之

Summary of this thesis

1. Umbrella species, which are typically large vertebrates (often top predators), play an important role in biodiversity conservation both by representing many other species that share the same ecosystem and by serving as flagship species to raise the environmental awareness of the general public.
2. Two issues relevant to the umbrella species concept are urgently in need of clarifying research: 1) the unknown reproductive outputs of both umbrella species and co-occurring species and 2) the poorly quantified relative economic values of umbrella species with different ecological statuses (e.g., occupancy status or breeding status) compared to other conservation targets such as ecosystem services or habitat metrics.
3. In this thesis, I examined the efficacy of using an umbrella species (the eastern marsh harrier *Circus spilonotus*) to conserve the reproductive outputs of other sympatric bird species in a fragmented wetland landscape. I also quantified the monetary value of another umbrella species (the red-crowned crane *Grus japonensis*) with a different ecological status and that of a principal ecosystem service (establishment of a bird-watching station) and wetland size using a public choice experiment.

4. My results showed that the reproductive output of the eastern marsh harrier could act as a useful indicator of the productive areas of various wetland bird species and that it could be managed by different land-use strategies at different distances from the breeding wetlands (artificial construction and foraging habitats within 2.0 km and 0.5 km of the wetlands, respectively). I also found that the fundraising ability of the red-crowned crane is superior to those of the ecosystem service and wetland sizes, irrespective of its ecological status.
5. This thesis is the first to suggest that the umbrella species concept could be a useful shortcut to conserve the reproductive output of other species. In addition, I suggest that, although using an umbrella species as a conservation flagship might be the best way to raise the economic value of conservation practices, raising awareness of important ecological statuses (such as reproductive outputs) of umbrella species could also be key to making conservation practices ecologically and economically justified.

Chapter 2 --- The usefulness of top predators as biodiversity surrogates indicated by the relationship between the reproductive outputs of raptors and other bird species

Summary

Given the global reduction in biodiversity, conservation actions must occur even with only a partial understanding of the distribution and abundance of species in various locales. The concept of surrogate species, those whose protection affords the protection of other species, is considered a conservation short-cut. Although surrogate species have been used as practical conservation tools, whether they serve as indicators of the reproductive output of other species is still unknown. I hypothesized that the reproductive output of the eastern marsh harrier (*Circus spilonotus*) can serve as a surrogate for both the adult abundance and reproductive output of sympatric birds. In a fragmented wetland landscape (approximately 211 60 km^2), I measured the reproductive output of harriers for 3 years and conducted replicated counts of the adults and juveniles of other wetland bird species in wetland patches that varied in harrier reproductive output. I used playbacks of mobbing calls in replicated counts and accounted for imperfect detection using an *N*-mixture model. I modeled adult and juvenile abundances

for 10 and 7 species, respectively, and showed that the reproduction-based habitat quality of the marsh harrier (cumulative numbers of both years occupying the habitat and chicks produced) was positively associated with adult abundances in four species and with juvenile abundances in five species (Figs 2.1 & 2.2). I suggest that areas with high reproductive output of several sympatric bird species could be selected based on the reproduction-based habitat quality of the marsh harrier. Furthermore, the approach combining the playback of mobbing calls and *N*-mixture models enabled us to estimate juvenile abundances for many bird species on a landscape scale over a short period of time.

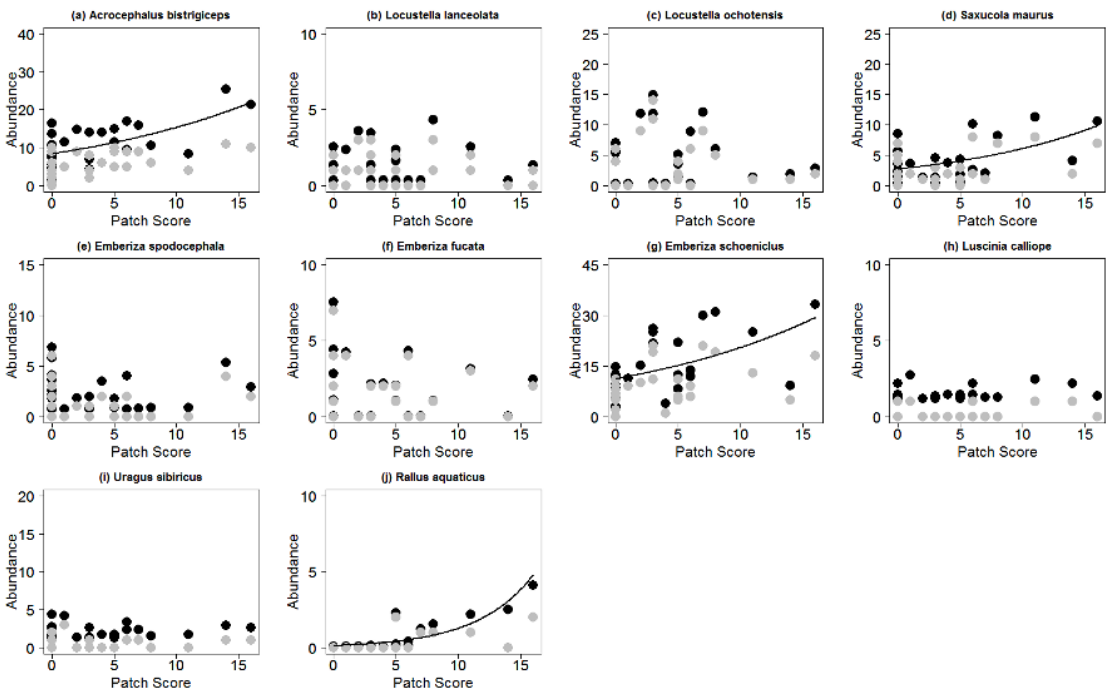

Figure 2.1. Latent abundances (black circles) and the maximum number (gray circles)

of adults of each bird species. Solid lines indicate the significance.

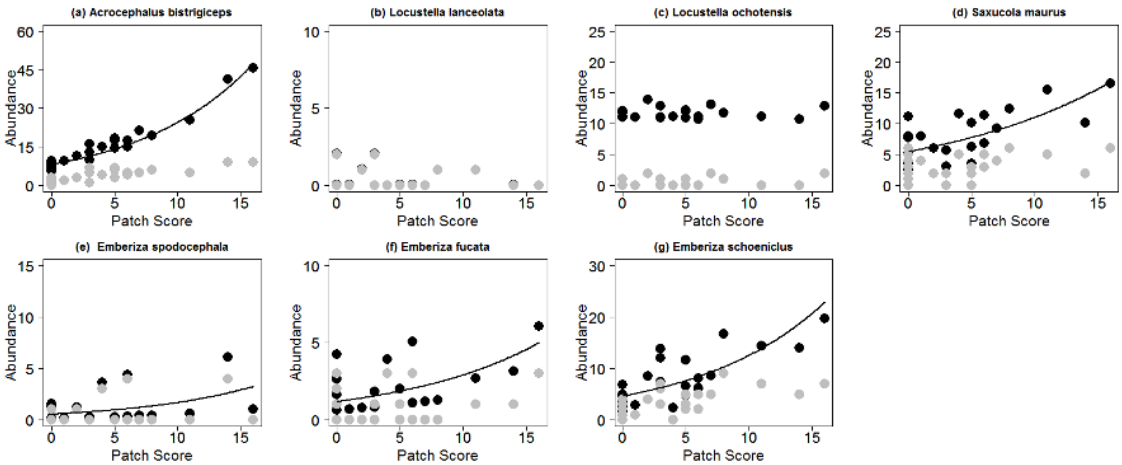

Figure 2.2. Latent abundances (black circles) and the maximum number (gray circles) of juveniles of each bird species. Solid lines indicate the significance.

Chapter 3 --- Juvenile outputs of a raptor as a function of the number of pairs and breeding success affected by land-uses at different spatial scales: implications for management of offsite impacts on the Eastern Marsh harrier

Summary

Construction of artificial structures exerts negative impacts on organisms living in the surrounding areas; these effects are termed offsite impacts. To reduce or lessen such impacts, it is critical to determine which biological metrics (e.g., abundance, breeding success) are impacted at which spatial scales. Here, I performed 4-year monitoring of a raptor species (the Eastern Marsh harrier *Circus spilonotus*) breeding in wetland patches and quantified harrier abundance (number of pairs) and breeding output (number of juveniles) in terms of wide ranges among the extents of foraging habitats and artificial construction in the surrounding areas. I developed a hierarchical model allowing us to simultaneously infer the effects of different land uses on the numbers of pairs and juveniles. I found that the extents of the foraging habitat within 0.5 km of breeding patches positively influenced the number of pairs per patch and that the extents of artificial construction within 2.0 km from the patches negatively influenced both the

number of pairs per patch and the number of juveniles per pair (Figs 3.1 & 3.2). The number of juveniles per patch was therefore affected by these two features and was most susceptible to increased artificial construction within 2.0 km from the patches (Figs 3.1 & 3.2). These results can be used to predict the magnitudes of offsite impacts on harriers before any additional development occurs. To effectively manage offsite impacts, I highlight the importance of considering not only species abundance but also the biological processes mediating breeding output that are possibly affected by different land uses.

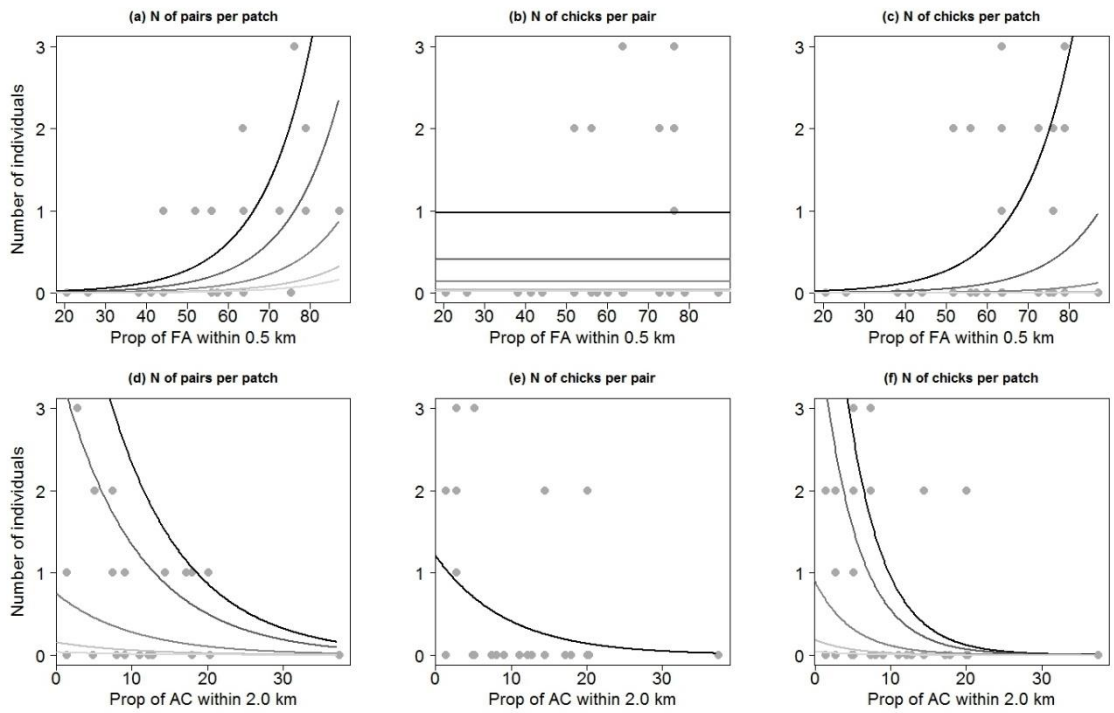

Figure 3.1. The upper three boxes indicate the effects of the proportion of the foraging

area within 0.5 km of the wetland patches (0.5_FA) on (a) the number of harrier pairs per patch; (b) the number of juveniles per pair; and, (c) the number of juveniles per patch. The five lines in each box were derived using the hierarchical model; the various colors indicate differences in 2.0_AC values, in descending order of darkness (2, 10, 20, 30, and 37%). The bottom three boxes indicate the effects of the proportion of the artificial construction within 2.0 km from the wetland patches (2.0_AC) on (d) the number of harrier pairs per patch; (e) the number of juveniles per pair; and, (f) the number of juveniles per patch. All lines were derived using the hierarchical model, and the five different colors employed in boxes (d) and (f) indicate differences in 0.5_FA values, again in descending order of darkness (87, 80, 60, 40, and 21%). The gray circles are actual values from field surveys.

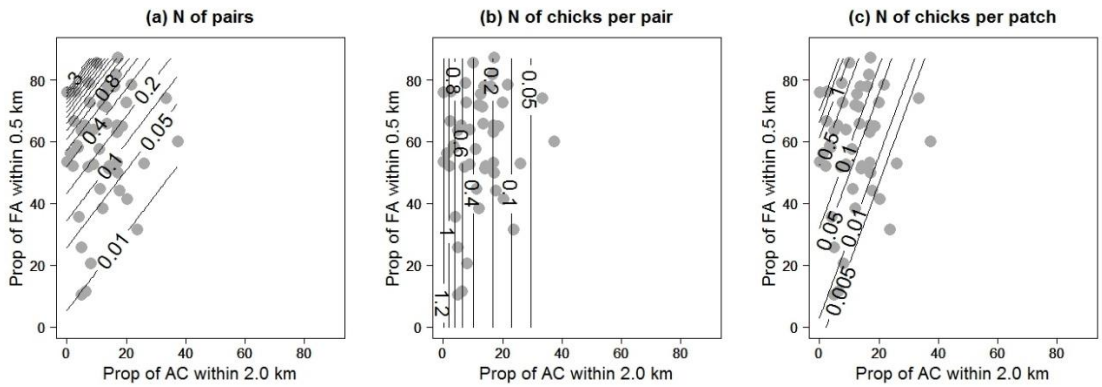

Figure 3.2. (a) The expected numbers of pairs per patch; (b) The number of juveniles per pair; and, (c) the number of juveniles per patch in terms of a combination of the 0.5_FA and the 2.0_AC (solid lines). Only the number of juveniles per pair (b) varied depending on the value of a single factor (2.0_AC). Gray circles indicate all potential breeding wetland patches in the study area (n = 48).

Chapter 4 --- Occupancy and breeding of umbrella-flagship species can elicit greater public economic support for conservation practices than habitat size and ecosystem services

Summary

Assessing the non-market value of biodiversity conservation is crucial to justify it economically. Using a choice experiment on wetland restoration in Hokkaido, northern Japan, I assessed the willingness of citizens to pay for different ecological statuses of an umbrella-flagship species (absence, occasional occupancy, permanent occupancy, and breeding) and other principal conservation targets (establishment of a birdwatching station and wetland sizes). The results showed that the fundraising potential of the umbrella-flagship species surpassed those of other conservation targets, irrespective of its ecological status (Fig 4.1), highlighting the superior publicity generated by charismatic species. I also showed that upgrading ecological status from occupancy to breeding did not result in additional financial support (Fig 4.1). This study emphasizes that, although publicizing ecologically important statuses such as breeding is critical for successful conservation efforts, using umbrella-flagship species may be the best way to increase the economic value of conservation practices if such species are available.

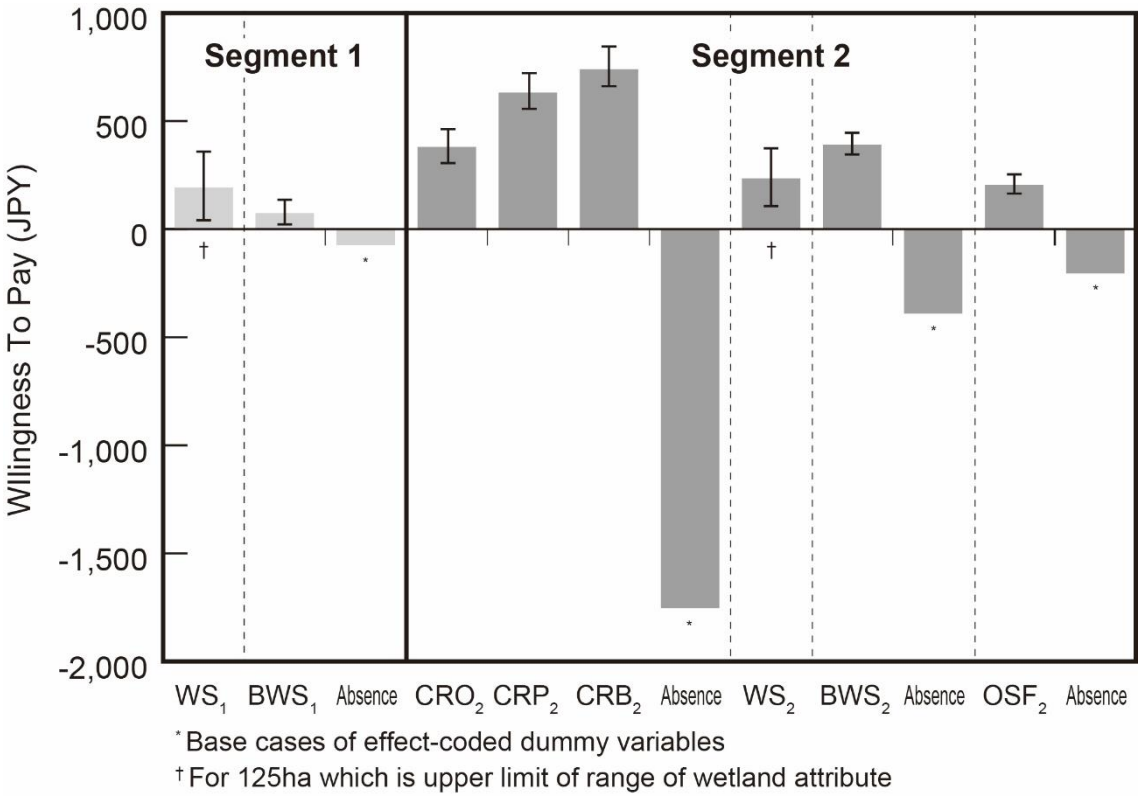

Figure 4.1. Willingness to pay (WTP) for choice experiment attributes derived from the latent class model. Error bars in the upper panel are 95% confidence intervals calculated from the coefficients and variance terms of the latent class model. "CRO," "CRP," "CRB," "WS," "BWS," and "OSF" indicate "occasional occupancy of the crane", "persistent occupancy of the crane", "breeding of the crane", "wetland size", "bird-watching station", and "option to suspend the flood control function," respectively.