Conservation of the 'Vulnerable' Beautiful Nuthatch, *Sitta formosa*: A Preliminary Analysis of Species Distribution and Habitat Requirements

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ABSTRACT

The Beautiful Nuthatch, *Sitta formosa*, occurs in high altitude evergreen and semi-evergreen forests throughout the eastern and southeastern extent of the Himalayan Mountains. Populations of *S. formosa* are small, declining, and severely fragmented as a result of habitat degradation and fragmentation. The BirdLife International Red Data Book designates *S. formosa* as a Vulnerable species and recommends its protection throughout its range. Little is known of *S. formosa's* habitat requirements, other than an apparent link with the oldest and largest trees in montane forests and a hypothesized dependence on *Fokienia hodginsii*, a tree species on the IUCN Red List of Threatened Species. We present a distribution map for *S. formosa* based on observed locations reported in surveys and museum specimens and a preliminary habitat suitability model which relates known observations of *S. formosa* to habitats with specific biological and topographic characteristics. We discuss the usefulness of the species distribution map and habitat suitability model in identifying habitat requirements and delineating key areas for the conservation of this species.

INTRODUCTION

Loss of tropical forests constitutes one of the greatest threats to faunal biodiversity and is the primary contributor to species extinction in many developing countries. The beautiful nuthatch, *Sitta formosa*, is a bird species that occurs throughout the eastern and southeastern extent of the Himalayan Mountains, including India, Bhutan, Myanmar, China, Thailand, Laos and northern Vietnam (Fig. 1, BirdLife International, 2001). Little is known of *S. formosa's* habitat requirements, other than an apparent link with the oldest, largest trees in montane forests. Additionally, it has been proposed that S. formosa may be partially or locally ecologically reliant on *Fokienia hodginsii*, a commercially valuable cypress-like conifer that is considered "near-threatened" in the IUCN Red List of Threatened Species (IUCN, 2003). *Sitta formosa*, according to BirdLife International (2001), has a small, declining and severely fragmented population as a result of habitat loss and fragmentation (Fig. 2). For this reason it is classified as "vulnerable", and it is included in the World Checklist of Threatened Birds (Collar *et al*., 1994).

Fig. 1. *Sitta formosa* distribution

Information on species distribution, habitat requirements, and key areas for protection is critical for species conservation. Multivariate, spatially explicit models are used to identify a species' ecological niche and predict its potential distribution. Ecological Niche Factor Analysis (ENFA) (Hirzel *et al.,* 2002) builds on Hutchinson's (1957) definition of an ecological niche, a hyper-volume in the multidimensional space of ecological variables within which a species can maintain a viable population. ENFA differs from many multivariate species distribution models in that analysis requires presence-only data as opposed to presence and absence data. It compares distribution of localities where a species was observed to a reference set of ecological and geographical variables describing the entire study area. A factor analysis, similar to Principal Component Analysis, is used to extract factors that give weights to each independent ecological or geographical variable (independent axes). In ENFA, the first axis accounts for the marginality of the species, i. e. the difference between the mean of the study area and the mean of the species for a particular environmental variable (Fig. 3). The remaining axes generated in ENFA represent the species specialization. Specialization is the ratio between the range of values for a particular environmental variable in the study area compared with the species' range of tolerance. (Hirzel *et al.,* 2002) The objectives of this study are to compare marginality and specialization for two different extents using basic topographic variables.

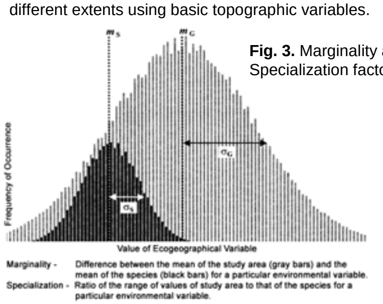


Fig. 3. Marginality and Specialization factors of ENFA.

Fig. 2. Deforestation and fragmentation in the Hoang Lien Mountains, Lao Cai Province, Vietnam. Photo by Jill Witt.

METHODS

We used ENFA to create a preliminary habitat suitability model for *Sitta formosa* (Fig. 4). Biomapper (Hirzel, 2004) is the GIS and statistical tool kit designed to build the habitat suitability model and maps. Topographical variables used for this initial ENFA analysis were elevation, slope and aspect from the Asia HYDRO1k data set (U. S. Geological Survey). The *S. formosa* species presence map contained 39 known locations taken from field observations, biodiversity surveys, and museum specimens. At this time due to the low number of presence locations, we did not separate the dataset into calibration and validation datasets. The two study areas selected for comparison were all of Asia and the Sino-Himalayan mountains (Fig. 5).

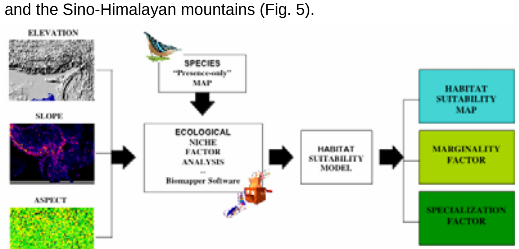
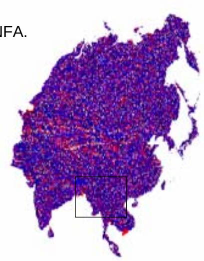


Fig. 4. Flow chart for ENFA model.



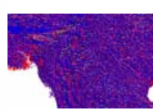


Fig. 5. All-Asia Study Area (left). Sino-Himalayan Study Area (above) - limited to extent of *S. formosa* distribution outlined with black box in the larger study area.

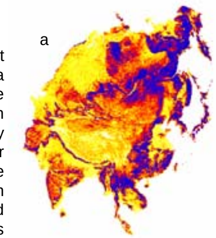
ACKNOWLEDGEMENTS

This research was supported by a Student Summer Scholars Grant from GVSU. We are grateful to the following people for their support at various stages of this research: M. Lombardo, L. Thomasma, J. Peters, and K. Thompson of GVSU, J. Tordoff of BirdLife International, S. Swan and S. O'Reilly of Flora and Fauna International, and A. Hirzel, University of Bern.

RESULTS AND DISCUSSION

The model generated habitat suitability maps for each study area (Fig. 6). Marginality and tolerance (specialization) values depend on the geographic extent of the study area. A species may appear extremely marginalized on the scale of a continent but less so in the context of a more restricted extent. High marginality values (close to 1) indicate a tendency to inhabit extreme conditions and low values (close to 0) indicate a tendency to inhabit conditions average to the study area. As expected, the marginality value for the All-Asia study area (0.6) was larger than that for the Sino-Himalayan study area (0.2). Tolerance values are the inverse of specialization. Low tolerance values (close to 0) indicates that the species has a narrow niche relative to the conditions in the study area. However, tolerance values were similar for the two study areas (0.6 and 0.7, respectively).

a



b

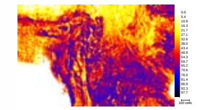


Fig. 6. Habitat Suitability maps for All-Asia study area (a) and Sino-Himalayan Study Area (b). Larger values on the scale (darker colors) indicate more suitable habitat.

Table 1. Variance explained by three ecogeographical factors and coefficient values for All-Asia Study Area (a) and Sino-Himalayan Study Area (b).

Ecogeographical Variable	Marginality (21%)	Specialization 1 (64%)	Specialization 2 (16%)
Slope	0.975	0.052	-0.219
Aspect	0.220	-0.180	0.973
Elevation	0.011	-0.982	-0.076

Ecogeographical Variable	Marginality (43%)	Specialization 1 (41%)	Specialization 2 (15%)
Slope	0.804	-0.167	0.516
Aspect	0.463	-0.428	-0.855
Elevation	-0.374	-0.888	0.049

Ecogeographical variables (Table 1) are sorted by decreasing order of absolute value of coefficient on the marginality factor. Positive values on the marginality factor indicate that *S. formosa* prefers locations with higher values on the corresponding EGV than the mean of the study area. The amount of specialization accounted for with each EGV is indicated in parentheses in each column heading. In both extents, slope was the most important topographic variable determining habitat suitability for *S. formosa*. In future iterations of habitat suitability modeling, we plan to add the following EGVs: vegetation types, landscape heterogeneity, temperature, and precipitation. Additionally, we will continue to expand the species presence data set and divide it into two sets for model calibration and validation, respectively. We plan to also generate habitat suitability models for *Fokienia hodginsii* in order to test the hypothesis that *S. formosa* is ecologically reliant on this threatened tree species.

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