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Distribution and conservation of *Grallaria* and *Grallaricula* antpittas (Grallariidae) in Ecuador

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Summary

The current ranges of many tropical species of conservation concern are poorly known, yet this information is critical for assessing their conservation status against the IUCN Red List criteria and implementing species-level management. Antpittas in the genera *Grallaria* and *Grallaricula* are elusive, ground-foraging insectivores, highly susceptible to a range of threats. For these genera, we combine environmental niche modelling with expert knowledge in order to predict species' geographic distributions, and we use current estimates of deforestation to evaluate their conservation status in Ecuador. We use BIOCLIM to generate a first pass geographic prediction, which was further aided by expert knowledge of their natural history. This methodology allowed us to assess the conservation status of each species, revising previous assessments at the national level and making recommendations for revision of global IUCN Red List categories. Based on inferred rates of population decline, derived from estimates of loss of suitable habitat, we suggest ranking three species as 'Endangered' in Ecuador, one as 'Vulnerable', and three as 'Near Threatened'. Predicted national ranges vary in size from 56.05 km² to 112,745 km². Patterns of range loss were different for each Andean slope, with higher deforestation on the western slope. The combination of niche modelling and knowledge of habitat loss can be a powerful tool to aid conservation efforts in the face of a poor understanding of population demographics, as is the case for many Neotropical taxa. We hope the methodology and results provided here will increase our understanding, and focus future attention on the conservation of this poorly known avian group.

Resumen

Existe poco conocimiento sobre los rangos actuales de distribución de muchas especies tropicales amenazadas de extinción, aunque esta información es fundamental para evaluar sus estados de conservación mediante los criterios de Listas Rojas de UICN, y para implementar estrategias de manejo. Los tororois de los géneros *Grallaria* y *Grallaricula* son aves insectívoras terrestres, de hábitos elusivos, altamente vulnerables a la extinción. Evaluamos el estado de conservación en Ecuador de las especies de *Grallaria* y *Grallaricula* empleando modelación de nichos, experticia local y tasas actuales de deforestación, para predecir la distribución geográfica de las especies. Usamos BIOCLIM para generar una primera ronda de predicciones geográficas, la cual fue posteriormente refinada por expertos en la historia natural y distribución de estas especies. Estos métodos nos permitieron estimar de forma más certera el estado de conservación de cada especie y revisar las evaluaciones previas a escala nacional, así como asignar las categorías de conservación de UICN de manera más acertada. Con base en las estimaciones de pérdida de rango, sugerimos categorizar a tres especies como En Peligro, una como Vulnerable y tres especies como Casi Amenazadas en Ecuador. Los rangos de distribución nacionales estimados varían en extensión desde 56,05 km² a 112 745 km². Los patrones de pérdida de rangos fueron distintos entre las dos estribaciones andinas, con mayores tasas de deforestación al occidente. La combinación de modelación de nichos y conocimiento sobre pérdida de hábitats puede constituir una

herramienta eficiente para apoyar los esfuerzos de conservación frente a panoramas de escaso conocimiento de dinámicas poblacionales, como es el caso para la mayoría de aves neotropicales. Esperamos que la metodología y resultados que proveemos aporten a incrementar nuestro conocimiento y a enfocar futuros esfuerzos de conservación hacia este grupo de aves poco conocidas.

Introduction

Information on the distribution of species is crucial to any conservation effort. Nevertheless, the paucity of information about how most Neotropical species are distributed makes this a difficult task. A fairly recent approach which attempts to overcome this lack of information is the simulation of species' distributions based on a model of their ecological niche (Peterson 2001). In this paper we adopt this approach, in conjunction with expert knowledge, to predict the distributions of species in the genera *Grallaria* and *Grallaricula* in Ecuador. We then use the predicted distribution maps, along with each species's natural history and the current and past state of vegetation in Ecuador, to make a national conservation assessment for each species.

Species in the genera *Grallaria* (31 species) and *Grallaricula* (eight species) (Grallariidae, see Remsen *et al.* 2008) are largely terrestrial, understorey, Neotropical insectivores, primarily confined to montane regions of the Andes. Other than a few species above the tree-line, they generally inhabit areas with dense, wet, tangled understorey (Fjeldså and Krabbe 1990, Ridgely and Tudor 1994, Kattan and Beltrán 1999). Both genera reach their peak diversity in the tropical Andes from central Colombia to central Peru (Ridgely and Tudor 1994). Most species of *Grallaria* and *Grallaricula* are fairly restricted both geographically and altitudinally, and are considered habitat specialists (Graves 1988, Kattan and Beltrán 1999, 2002). While several species occur in syntopy, some replace each other altitudinally (Ridgely and Tudor 1994, Kattan and Beltrán 1999). Species of both genera are among the least known of Neotropical birds, due in part to their elusive behaviour and preference for inhabiting thick understorey (Kattan and Beltrán 1999, 2002, Dobbs *et al.* 2001, Greeney *et al.* 2008). This is highlighted by the fact that seven species have been described in the last five decades (Wetmore and Phelps 1956, Lowery and O'Neill 1969, Schulenberg and Williams 1982, Graves *et al.* 1983, Graves 1987, Stiles 1992, Krabbe *et al.* 1999), and very little is known of their breeding biology (Greeney *et al.* 2008).

Six of the 20 species of *Grallaria* and *Grallaricula* occurring in Ecuador are currently ranked as globally threatened or 'Near Threatened' (BirdLife International 2009. At the national level, two additional species are ranked as threatened (Granizo *et al.* 2002). However, we suspect that many more species might be susceptible to extinction than those currently recognised in these works, for two reasons. First, they prefer the understorey of forest habitats and are reluctant to abandon forests. Studies have demonstrated that most *Grallaria* and *Grallaricula* are confined to forests (Kattan and Beltrán 1999, 2002), generally able to briefly occupy neighbouring, more open habitats only under overcast weather conditions (Poulsen 1993). It has also been demonstrated that ground and understorey insectivores are among the first groups of birds that vanish when forests are severely fragmented (Renjifo 2001, Sekercioglu *et al.* 2002). Second, their preferences for specific habitats along narrow altitudinal belts or small geographic regions make them more prone to disappear if those habitats are depleted (Manne *et al.* 1999). Furthermore, taxonomy in the group remains poorly known; species such as *Grallaria gigantea* and *G. nuchalis* are represented by different races in the eastern and western Andes that may actually be specifically distinct, making local declines or extinctions more significant than is recognised under current classifications.

In this paper we evaluate the conservation status of *Grallaria* and *Grallaricula* antpittas in Ecuador using environmental niche modelling based on a compilation of expert knowledge and locality records, primarily from museum specimens and published literature. We then evaluate how their ranges have changed using pre- and post-deforestation vegetation maps (Sierra 1999). With this information, we use IUCN criteria for regional assessments (UICN 2003) to evaluate the national conservation status of each species, with the goal of revising the assessments recently published by Granizo *et al.* (2002) for Ecuadorian birds, and to better understand the threats to these poorly studied species (Freile 2000, Greeney *et al.* 2008). Where data allow, we have indicated species that may warrant reclassifying on the global IUCN Red List.

Methods

Study species and conservation status

Ecuador is home to 20 of the 39 currently recognised species in both genera (Ridgely and Greenfield 2001). In this paper, we consider only 18 species because two – *Grallaria rufocinerea* and *Grallaricula ferrugineipectus* – were only recorded in Ecuador after the data were compiled (Freile 2000, Nilsson *et al.* 2001, P. Coopmans *in litt.* 2001).

The national conservation status of each species was assessed using the IUCN guidelines for regional assessments (Gärdenfors *et al.* 1999, 2001; UICN 2003). IUCN uses five criteria to determine a category of threat: A. reduction in population size, B. size of geographic range, C. estimated population size, D. small or reduced population, and E. quantified estimate of extinction. The poor knowledge of the ecology of most *Grallaria* and *Grallaricula* antpittas does not allow an accurate evaluation of population sizes and trends, as no current estimates of population densities exist for the vast majority of species (see Kattan and Beltrán 1999, 2002). Therefore, given the information currently available, and the evidence that tropical understorey insectivores, including *Grallaria* and *Grallaricula,* are susceptible to forest fragmentation (Stouffer *et al.* 2006), we consider criterion B1 (extent of occurrence) the most applicable criterion for assessing the conservation status of Ecuadorian *Grallaria* and *Grallaricula*. We also applied criterion A3 (future population reduction) based on current deforestation rates (Stewart and Gibson 1995), an estimation of minimum and maximum deforestation over three generations, and the percentage of species ranges expected to disappear under this deforestation scenario (see species accounts). For data on these estimates, contact the senior author.

Even though we estimated percentage of range loss, criterion A2 (population size reduction) could not be straightforwardly applied as this loss occurred over more than three generations and deforestation rates were not linear. Similarly, criterion B2 was not used as we did not estimate extent of suitable habitat within the range of each species. There was insufficient information to even guess population sizes. Our assessments of conservation status were discussed with local experts and compared with threat categories from Granizo *et al.* (2002) and BirdLife International (2009) for endemics or near-endemics.

Data compilation and data cleaning

In total, 980 Ecuadorian records were compiled from museum specimens, published literature (e.g. Parker and Carr 1992, Poulsen and Krabbe 1998), field work carried out by JFF, and personal contributions from a number of experts on the avifauna of Ecuador.

Museum data were collected through visits to several collections [Museo Ecuatoriano de Ciencias Naturales (MECN), Museo de Zoología del Departamento de Biología de la Escuela Politécnica Nacional (MEPN), Museo de Zoología, Departamento de Ciencias Biológicas, Pontificia Universidad Católica del Ecuador (QCAZ), Museum of Zoology, Louisiana State University (LSUMZ), Museum of Zoology, University of Kansas (KU), and British Museum of Natural History, Tring (BMNH)] and by examining catalogues of the major museum collections in North America known to hold specimens from Ecuador, including: Academy of Natural Sciences of Philadelphia (ANSP), Carnegie Museum of Natural History (CMNH), Field Museum of Natural History (FMNH), Smithsonian Institution (USNM) and Western Foundation of Vertebrate Zoology (WFVZ).

As we were not able to verify the taxonomic identity of all the specimen data gathered, a conservative approach was used to evaluate data accuracy and records located well outside the known distribution range of a given species (e.g. Andean species with a tropical collection site or vice versa) were not included in the analyses. Similarly, records with insufficient information (e.g. eastern Ecuador, Pichincha Province) were not included in the modelling and assessments. The geographic location of most records was verified against topographic and ornithological gazetteers (U.S. Board on Geographic Names 1957, Instituto Geográfico Militar 1978–1982, Paynter and Traylor 1977, Paynter 1993). These three filters left us with a total of 719 points. The number of points per species was highly variable, ranging from four (*Grallaria ridgelyi*) to 178 (*Grallaria quitensis*) (mean 39.9 sites). See Table 1 for number of localities per species.

Table 1. Landscape metrics used for model construction and conservation assessment of *Grallaria* and *Grallaricula* species in Ecuador.

Species	TA	NP	MPS	PSCOV	PSSD	TE	NL
alleni 1	4,788.91	68	7,042.52	374.37	26,365.12	3,439,909.10	9
alleni 2	3,458.76	119	2,906.52	341.55	9,927.26	3,755,688.30	
dignissima 1	59,964.72	4	1,499,118	173.18	2,596,233.25	1,765,638.30	14
dignissima 2	54,215.81	73	74,268.23	792.28	588,411.88	9,216,103.20	
flavotincta 1	1,571.84	39	4,030.36	242.39	9,769.15	1,464,285.60	8
flavotincta 2	1,090.24	59	1,847.86	286.36	5,291.45	1,369,712.20	
gigantea 1	4,297.35	118	3,641.82	536.19	19,527	4,054,636.60	18
gigantea 2	2,921.27	190	1,537.51	416.53	6,404.22	3,993,724.90	
guatimalensis 1	112,744.71	125	90,195.77	1,000.63	902,529.75	10,284,462.70	51
guatimalensis 2	89,907.09	586	15,342.51	1,960.76	300,829.53	29,356,242.10	
haplonota 1	13,567.32	167	8,124.15	583.08	47,370.48	8,388,184.70	16
haplonota 2	9,244.60	372	2,485.11	618.32	15,365.96	9,615,235.20	
hypoleuca 1	9,396.36	81	11,600.44	453.60	52,619.79	5,559,797.20	23
hypoleuca 2	7,149.88	196	3,647.90	491.26	17,920.68	6,623,347.80	
nuchalis 1	9,632.26	181	5,321.69	405	21,552.85	7,816,736.60	41
nuchalis 2	7,230.98	307	2,355.37	441.54	10,399.92	8,191,023.10	
quitensis 1	27,179.77	133	20,435.92	923.77	188,780.66	10,411,094.90	178
quitensis 2	17,229.38	400	4,307.35	634.07	27,311.65	13,172,159	
ridgelyi 1	56.05	28	200.16	104.79	209.75	213.191	4
ridgelyi 2	43.52	29	150.07	86.40	129.66	198,764.60	
ruficapilla 1	33,243.11	183	18,165.63	905.65	164,517.12	17,644,361.40	124
ruficapilla 2	19,362.00	735	2,634.29	679.58	17,902.15	19,835,580.30	
rufula 1	25,605.36	151	16,957.19	576.26	97,716.89	14,661,290.20	87
rufula 2	15,932.31	583	2,732.81	621.70	16,989.86	15,403,451.40	
squamigera 1	32,792.02	160	20,495.01	821.75	168,418.34	16,619,281.30	52
squamigera 2	19,878.61	672	2,958.13	625.25	18,495.75	18,998,845.70	
watkinsi 1	7802.35	18	43,346.41	311.67	135,098.12	2,162,366	36
watkinsi 2	2893.64	301	961.34	549.99	5,287.28	4,987,547.60	
flavirostris 1	11,117.87	97	11,461.72	535.30	61,354.01	5,198,334.20	21
flavirostris 2	5783.92	229	2,525.73	486.22	12,280.48	5,703,260.30	
lineifrons 1	1145.32	37	3,095.45	372.70	11,536.69	1,230,256.40	8
lineifrons 2	813.22	45	1,807.16	318.13	5,749.02	973,786	
nana 1	13,866.82	100	13,866.82	461.47	63,990.61	7,528,207.40	24
nana 2	11,129.91	201	5,537.27	385.90	21,368.49	9,275,412	
peruviana 1	1912.45	147	1,300.99	256.16	3,332.60	2,895,711	5
peruviana 2	1308.80	197	664.36	243.86	1,620.13	2,627,218.60	

1 indicates metrics before deforestation, while 2 indicates metrics after deforestation (see Sierra 1999). All area metrics are in hectares: TA= total area (km^2); NP= number of patches; MPS= mean patch size; PSCOV= patch size coefficient of variation; PSSD= patch size standard deviation; TE= total edge; NL= number of localities. Species are presented in alphabetical order.

In total, 26 field trips were carried out in order to fill gaps in the knowledge of potential distributions. On each field trip, a combination of three methods was used to locate *Grallaria* and *Grallaricula* species: playback transects, dawn chorus recordings, and mist-netting (see Freile 2000 for details). All the information gathered was stored in a Microsoft Access database, and is available on request through the senior author.

Species distribution modelling

We used BIOCLIM (Nix 1986) to create models. BIOCLIM performs well with presence-only data (Parra *et al.* 2004) and was the most straightforward modelling method. This method extracts the values of the environmental data layers at each point locality for a given species and generates a bioclimatic profile that consists of the ranges of all climate variables used (e.g. 95^{th} percentiles). The model matches the bioclimatic profile of each species with climate estimates at other sites on a grid to determine other locations with similar values, thereby producing a map of the predicted potential distribution of a given species. To evaluate models, we split the data into training (80% of points) and testing (20% of points) datasets. We ran BIOCLIM models with the training dataset and then calculated the percentage of withheld (i.e. testing) points that were predicted to be suitable. We only ran evaluation for species where we had 18 or more points. Note that all points were used in final models used in conservation assessment. We also generated models with a machine-learning technique (Maxent; Phillips *et al.* 2006) in order to ensure that the performance of BIOCLIM models was reasonable and similar to that of Maxent. This was done because recent criticisms have been made of BIOCLIM results and machine learning methods have been shown to perform better (Elith *et al.* 2006, Tsoar *et al.* 2007). We found that methods provided similar outputs (see Fig. 1 for a representative sampling of four species).

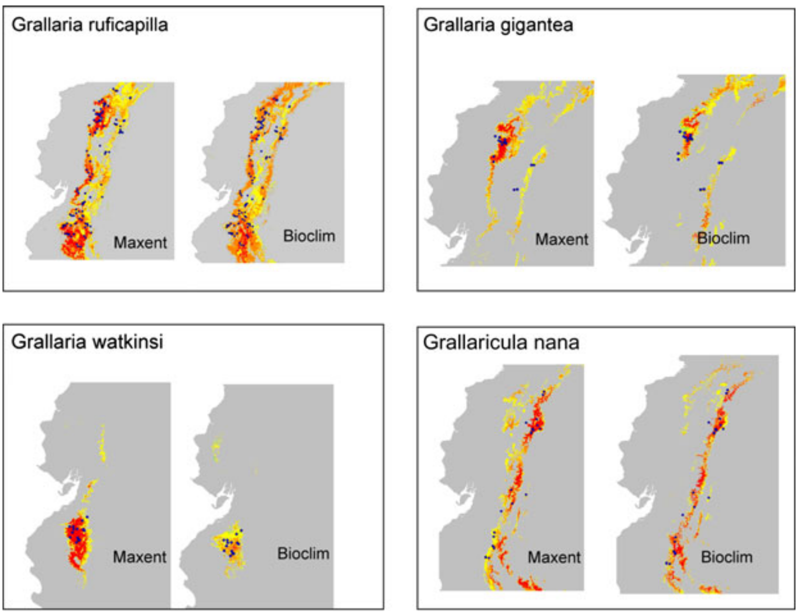

Figure 1. Comparison between BIOCLIM and Maxent models for a representative set of species, three *Grallaria* and one *Grallaricula* species. Note that the main differences (BIOCLIM smaller predicted ranges) are the result of expert knowledge cutting and that our models (Figs. 2–10) present only areas with highest presence probability.

We used the following environmental variables in the model: 1. annual mean monthly temperature, 2. total annual rainfall, 3. coefficient of variation in temperature, 4. coefficient of variation in rainfall, 5. driest consecutive three months of the year and 6. water budget. These variables, recently made available by CHG after a compilation of weather station data for Ecuador, were chosen because, in concert, they should be representative of a major axis of the birds' ecological niche (i.e. factors that might limit *Grallaria* and *Grallaricula* distributions). Assuming we have a representative sample of the range of climatic variables important for a given species, final models will likely represent the potential or historic distribution of the species, as they are based only on climatic parameters and do not reflect recent land-cover changes (deforestation). These predicted geographic distributions were further modified based on expert knowledge (JFF, N. Krabbe, P. Greenfield, R. Ridgely, F. Ortiz-Crespo, P. Coopmans). Major modifications were based on (i) suitability of vegetation, (ii) exclusion by competing species and (iii) elevational limits. To evaluate how recent deforestation might have influenced species' ranges, we identified all deforested areas within each predicted distribution based on a recent map of deforestation of Ecuador (Sierra 1999), removing these areas from the modelled distribution. This resulted in two modelled distributions for each species: one that represents the historic distribution and one that represents the current distribution with deforested areas removed (Figs. 2–10).

Landscape metrics

We calculated a series of landscape metrics for each modelled distribution to quantify how ranges have changed with deforestation. We used the software Fragstats (McGarigal *et al.* 2002) to calculate the following landscape metrics: total area, number of patches, mean patch size (with coefficient of variation and standard deviation), and total edge (Table 1). We performed a two-factor ANOVA to assess the significance of changes along the distribution ranges using SPSS software (SPSS Inc. 2001).

Results and Discussion

General distribution patterns

The predicted range maps are generally consistent with previously known general distributions (Krabbe *et al.* 1998, Ridgely and Greenfield 2001, Ridgely *et al.* 2003) (Figs. 2–10). BIOCLIM generally predicted withheld data well. For the 10 species with 18 locality points or more, 82% (standard deviation 17%) of withheld points were predicted to be suitable. The higher level of detail in our models provides a more accurate depiction of the distribution ranges and differs in some relevant features from broader models, as discussed below (Ridgely and Greenfield 2001, Ridgely *et al.* 2003).

Fifteen species, including all *Grallaricula* species, are confined to the Andes. Two species occur in the Amazonian lowlands: *Grallaria dignissima* is confined to the Amazon, whereas *Grallaria guatimalensis* is rather widespread in the lower portions of both slopes of the Andes and more local in the eastern lowlands (Figs. 2, 4). Another species is restricted to the lowlands, foothills and slopes of the dry south-western lowlands (*G. watkinsi*, Fig. 3).

Among the Andean species, five are confined to the eastern slope, one is confined to the Pacific slope, five occur on both slopes of the Andes, and four are widespread throughout the Ecuadorian Andes including the inter-Andean valleys and slopes. Furthermore, eight species also inhabit isolated Amazonian volcanoes and mountain ranges (Sumaco volcano, Kutukú and del Cóndor cordilleras), and two species (*Grallaria guatimalensis* and *G. watkinsi*) are found in the southern Cordillera de la Costa (Chongón-Colonche region in western provinces of Santa Elena and Manabí); only *Grallaria guatimalensis* is also present in the northern portion of these isolated and discontinuous mountain ranges (Mache-Chindul) (Figs. 2–10).

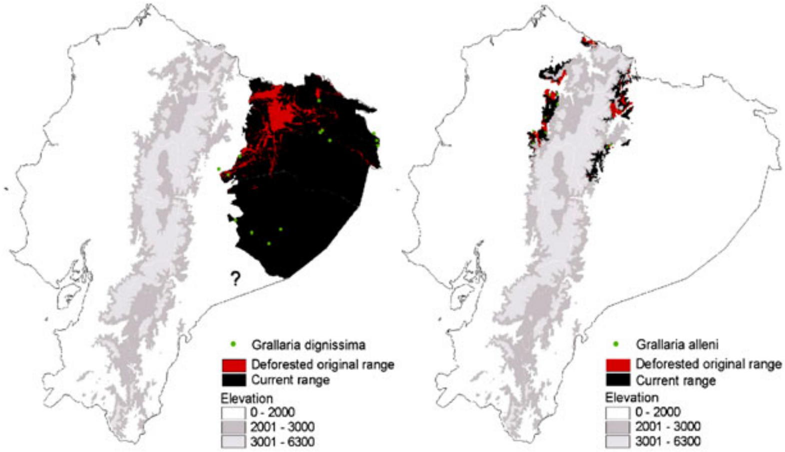

Figure 2. Historical and current distribution ranges of Ochre-striped *Grallaria dignissima* and Moustached *G. alleni* Antpittas in Ecuador. Green dots represent actual locations.

The western Andes has 12 species and the eastern Andes 15 species. Distributions in the western Andes show three distinctive patterns (Figs. 2–9). Four species are restricted to the north (south to Cotopaxi province), four species are continuously distributed, and one is confined to the dry southern slopes (Loja province). Meanwhile, two species (*Grallaria haplonota* and *Grallaricula flavirostris*) share a discontinuous distribution, being absent from approximately 1°25′S to 3°30′S (between southern Pichincha and western Azuay provinces; Figs. 4, 9). It has been suggested for other taxa (Krabbe *et al.* 1998, Freile 2004) that poor knowledge of the avifauna of this 'distributional gap' might explain the patterns found and that ranges might be continuous along this slope. Interestingly, our modelled distributions suggest that these areas have a bioclimatic profile different to the areas to the north and south, supporting the idea that the break in distributions might be real. Distributions of species restricted to one side of the Andes are generally not predicted to occur on the other side based on climatic niche modelling,

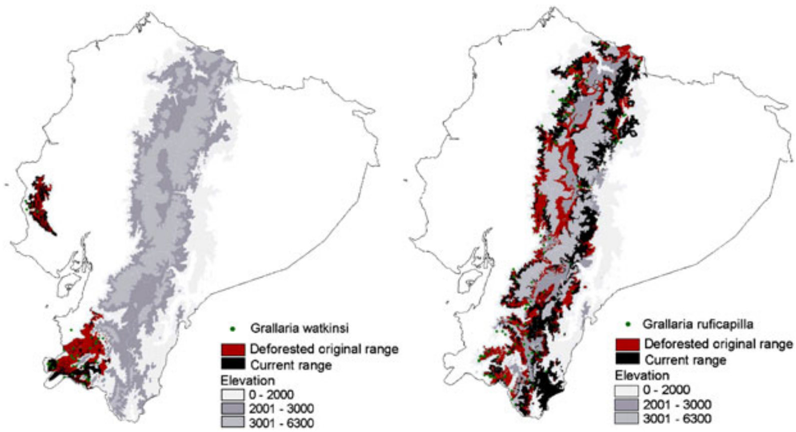

Figure 3. Historical and current distribution ranges of Watkin's *Grallaria watkinsi* and Rufous-crowned *G. ruficapilla* Antpittas in Ecuador. Green dots represent actual locations.

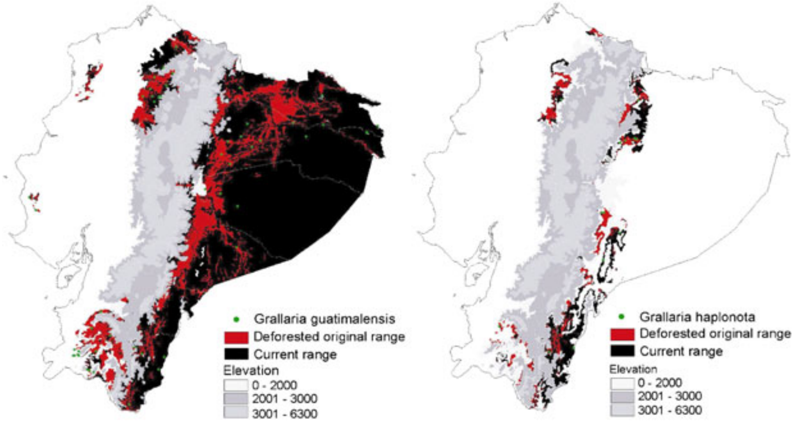

Figure 4. Historical and current distribution ranges of Scaled *Grallaria guatimalensis* and Plain-backed *G. haplonota* Antpittas in Ecuador. Green dots represent actual locations.

suggesting that each slope has a different climatic profile, an observation also made in other studies (Kattan *et al.* 2004). This situation might be mirrored on the western slope, with eco-climatic differences accounting for discontinuous distributions of some species. One additional species (*Grallaria guatimalensis*) appears to have a similar discontinuous range in the western Andes (Fig. 4), but this might only be a result of poor sampling in the central portion (Cotopaxi through northern Azuay) (N. Krabbe pers. comm.) as it apparently tolerates habitat fragmentation and inhabits a range of humid to semi-deciduous forests.

Species' ranges in the eastern Andes tend to be more contiguous: nine species have uninterrupted ranges from the Colombian to the Peruvian border, three occur fairly sparsely along nearly the whole cordillera (*Grallaricula flavirostris*, *G. lineifrons* and *G. peruviana*, Figs. 9-10), while two are restricted to the north. *Grallaria alleni* extends south to the Pastaza river depression and *G. gigantea* probably occurs south to the Paute river depression (Figs. 2, 6). These two fairly deep river depressions, which dissect the eastern Andes, are also considered potential

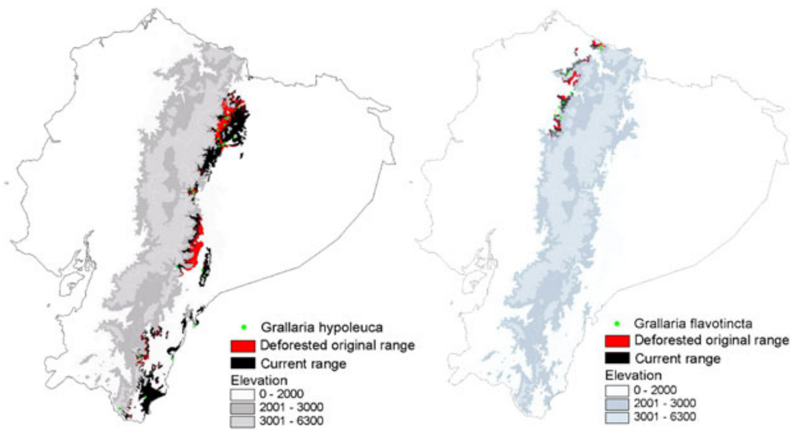

Figure 5. Historical and current distribution ranges of White-bellied *Grallaria hypoleuca* and Yellow-breasted *G. flavotincta* Antpittas in Ecuador. Green dots represent actual locations.

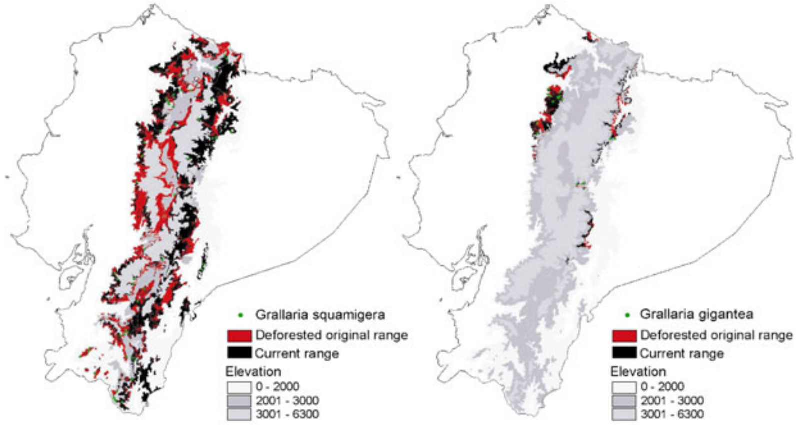

Figure 6. Historical and current distribution ranges of Undulated *Grallaria squamigera* and Giant *G. gigantea* Antpittas in Ecuador. Green dots represent actual locations.

barriers to the distribution of other Andean taxa (Krabbe *et al.* 1998, Krabbe 2008). It should be noted though that widespread species such as *Grallaria squamigera* and *G. ruficapilla*, apparently occur only locally along the eastern Andes (N. Krabbe *in litt.*, *contra* our predicted distributions in Figs. 3 and 6). Recently, the known distribution of *Grallaricula peruviana* changed following a new record nearly 200 km northward (Greeney *et al.* 2004). Bioclimatic profiles were similar along the whole eastern cordillera, supporting the evenness of species' distributions.

According to our models, the two Amazonian species (*Grallaria guatimalensis* and *G. dignissima*) are widespread across the whole region, but records of both species south of the Pastaza river are sparse (Figs. 2, 4). Further, records of *G. guatimalensis* from the whole Amazonian lowlands are scanty, making thorough field work necessary to corroborate our modelled distribution (Fig. 4). In the humid western lowlands, no *Grallaria* or *Grallaricula* species is known to occur. *Grallaria watkinsi*, the only species in the Pacific lowland region,

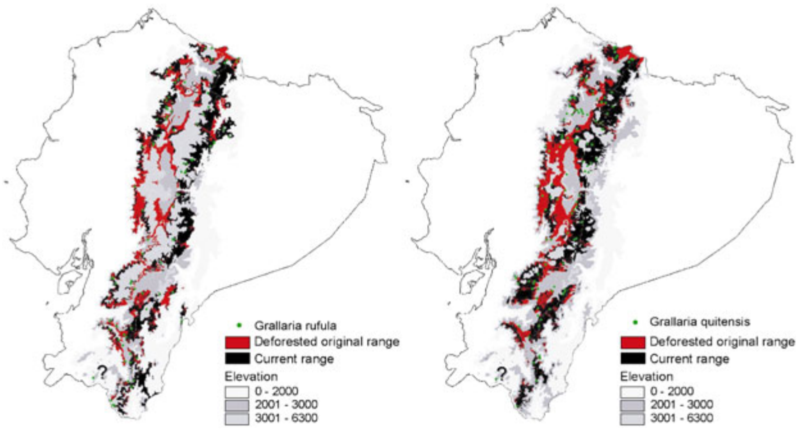

Figure 7. Historical and current distribution ranges of Rufous *Grallaria rufula* and Tawny *G. quitensis* Antpittas in Ecuador. Green dots represent actual locations.

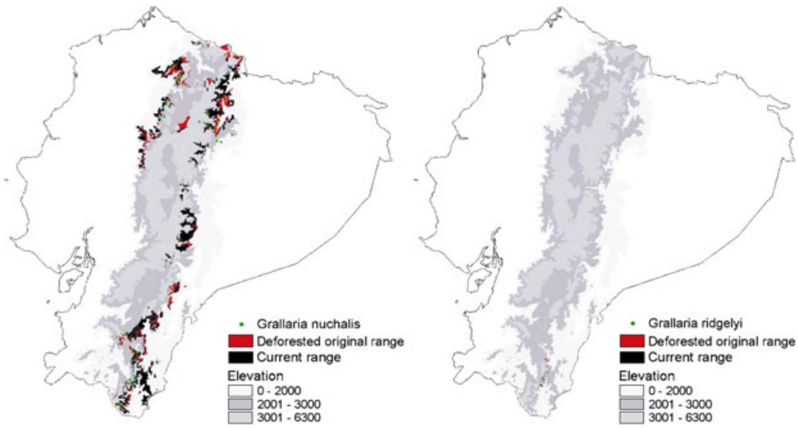

Figure 8. Historical and current distribution ranges of Chestnut-naped *Grallaria nuchalis* and Jocotoco *G. ridgelyi* Antpittas in Ecuador. Green dots represent actual locations.

occurs mostly along the foothills and slopes of the Andes and isolated ranges in semi-deciduous and deciduous forests (see discussion under species account) (Fig. 3).

Estimated historic range sizes in Ecuador vary from 112,745 km^2 for *Grallaria guatimalensis* to 56 km^2 for *Grallaria ridgelyi* (mean range size 20,594 km^2, SD 27,695 km^2) (Figs. 4, 8). Four species have predicted Ecuadorian ranges $< 2{,}000$ km^2, eight species have ranges between 4,000 and 15,000 km^2, and six have ranges $> 20{,}000$ km^2 (Table 1).

Conservation assessments

The amount of habitat loss throughout the country has affected all Ecuadorian *Grallaria* and *Grallaricula* antpittas. A statistical analysis of the degree of range reduction suggests that historic ranges within Ecuador were significantly larger than current ranges as measured by total area (two factor ANOVA; $F = 37.75$, df = 17.00, $P < 0.01$). Range reduction was employed as a measure of range and population decline for the application of IUCN criteria to assess conservation status in Ecuador, as discussed below.

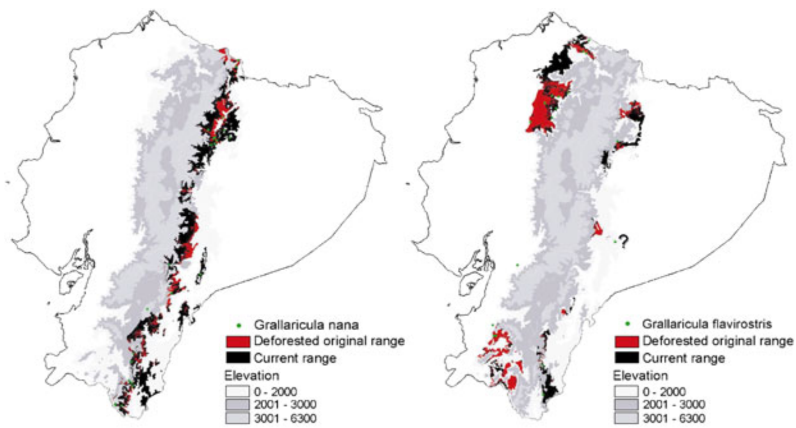

Figure 9. Historical and current distribution ranges of Slate-crowned *Grallaricula nana* and Ochre-breasted *G. flavirostris* Antpittas in Ecuador. Green dots represent actual locations.

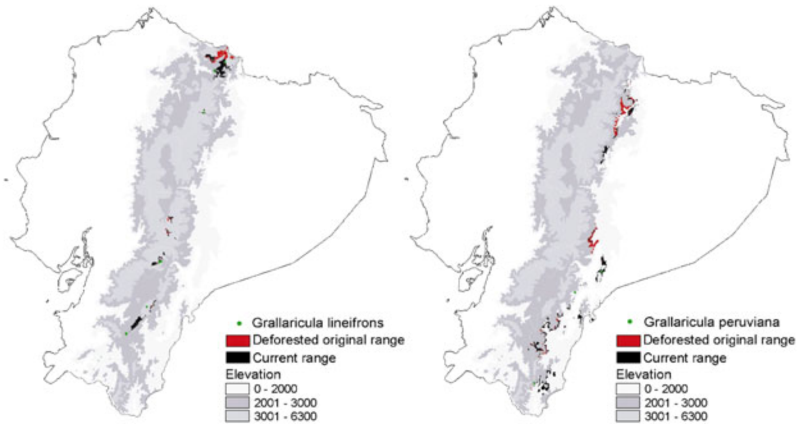

Figure 10. Historical and current distribution ranges of Crescent-faced *Grallaricula lineifrons* and Peruvian *G. peruviana* Antpittas in Ecuador. Green dots represent actual locations.

In our regional assessment, three species were ranked as 'Endangered', one 'Vulnerable' and three as 'Near Threatened' in Ecuador (Table 2). All *Grallaria* and *Grallaricula* species ranked as threatened or 'Near Threatened' (see below) have small distributional ranges and are confined to particular centres of endemism (Long *et al.* 1996). In a previous assessment of the conservation status of Ecuadorian birds (Granizo *et al.* 2002), four species were ranked as 'Endangered', one as 'Vulnerable', and two as 'Near Threatened'. Those species included in Granizo *et al.* (2002) are also considered here as threatened or 'Near Threatened', but four species are included in different categories. These differences in categories assigned to each species at national level arise (i) because of the more precise distributional data and recent historic vegetation maps we used to make more precise distribution maps, and (ii) because we applied the most recent IUCN criteria and guidelines for regional assessments (UICN 2003), whereas Granizo *et al.* (2002) applied an older version for global (rather than regional) assessments (UICN 2001). Further discussions on the categorisation of each species are presented in the species accounts below. Ridgely and Greenfield (2001) also provide a list of threatened species within Ecuador, in which they include two *Grallaria* species as 'Endangered' (one of them, *G. rufocinerea*, not considered in our assessment), two as 'Vulnerable' and one *Grallaricula* as 'Near Threatened'. These differences will also be discussed below.

The remaining 11 species, not considered as threatened in our evaluation, might nevertheless be of conservation concern at different levels. *Grallaria dignissima* is restricted to western Amazonia north of the Marañón river, within the Napo and Pastaza river basins (Napo Endemic Bird Area *fide* Stattersfield *et al.* 1998, Fig. 2). Forest is still extensive in the region, but deforestation, logging, oil extraction, and agricultural expansion are rapidly devastating large tracts of forest in the northern provinces of Orellana and Sucumbíos (Vallejo 2003).

Additionally, all Andean species are threatened by ongoing deforestation, caused primarily by agricultural expansion. Some species seem to be especially susceptible, even to moderate habitat modification. While some species inhabit open areas (*Grallaria quitensis*), others have fairly limited altitudinal distributions and/or fragmented ranges (Figs. 4, 6, 8, 9) and tend to prefer less disturbed forests (*Grallaria squamigera, G. nuchalis, G. haplonota* and *Grallaricula flavirostris*). Similarly, *Grallaria hypoleuca, G. rufula* and *Grallaricula nana* are linked to somewhat naturally disturbed areas, especially dense secondary growth and bamboos stands, but are still reliant on 'good' forest coverage. On the other hand, *Grallaria ruficapilla* tends to prefer more disturbed areas (though not fully open), which might make it more tolerant of human-induced habitat modification (Figs. 3, 5, 7, 9).

Table 2. Species of *Grallaria* and *Grallaricula* occurring in Ecuador, with their conservation categories in Ecuador and supporting information and criteria.

Species	EOO (km^2)	Range lost (%)[1]	Gen. length[2]	3-gen. pop. trend[3]	Global[4]				Ecuador		
					status	criteria met	Revised status	Revised criteria met	National status[5]	Revised national status[6]	Regional criteria met[6]
Grallaria guatimalensis	112,744.71	20	10.5	stable	LC				LC	LC	
Grallaria dignissima	59,964.72	10	10.5	stable	LC				LC	LC	
Grallaria ruficapilla	33,243.11	42	10.5	stable	LC				LC	LC	
Grallaria squamigera	32,792.02	39	10.5	stable	LC				LC	LC	
Grallaria quitensis	27,179.77	37	10.5	stable	LC				LC	LC	
Grallaria rufula	25,605.36	38	10.5	stable	LC				LC	LC	
Grallaricula nana	13,866.82	20	8.7	stable	LC				LC	LC	
Grallaria haplonota	13,567.32	32	10.5	stable?	LC				LC	LC	
Grallaricula flavirostris	11,117.87	48	8.7	stable?	LC				LC	LC	
Grallaria nuchalis	9,632.26	25	10.5	stable	LC				LC	LC	
Grallaria hypoleuca	9,396.36	24	10.5	stable	LC				LC	LC	
Grallaria watkinsi	7,802.35	63	10.5	decline	LC		NT	B1a+b (i-v)	EN	**NT**	A3c, B1a+b(i-v)
Grallaria alleni	4,788.91	28	10.5	stable?	VU	B1a+b(i-iii)			EN	**EN**	B1a+b(i-v)
Grallaria gigantea	4,297.35	32	10.5	decline?	VU	B1a+b(i-iii); C2a(i)	EN	B1a+biii	VU	**EN**	B1a+b(iii)
Grallaricula peruviana	1,912.45	32	8.7	decline?	NT	A2c; A3c; A4c; B1a+b(i-iii,v)			NT	**NT**	B1a+b(i-v)
Grallaria flavotincta	1,571.84	31	10.5	decline?	LC		NT?	B1a+b (i-v)	EN	**VU**	B1a+b(i-v)
Grallaricula lineifrons	1,145.32	29	8.7	decline?	NT	B1a+b(i-iii,v)			VU	**NT**	B1a+b(i-v)
Grallaria ridgelyi	56.05	22	10.5	stable?	EN	B1a+b(i-iii,v); C2a(i)			EN	**EN**	B1a+b(iii-iv) D1

Species are organised according to range extent (EOO) within Ecuador, as estimated in the software Fragstats (McGarigal *et al.* 2002). Range loss and fragmentation were also calculated using this software. Proportion of range loss[1] occurred over a long time frame since species original historic range extent to present time. Generation length[2] and IUCN Global Red List status and criteria[4] from BirdLife International (2009). National status in Ecuador[5] assessed by Granizo *et al.* (2002). Population trend[3] extrapolated from total forest loss within species ranges over a long undetermined time frame. Revised national status[6] from this study. *Grallaria rufocinerea* and *Grallaricula ferrugineipectus* were not included in this analysis as both were discovered in Ecuador after data compilation for this study was finished.

Of the species studied here, *Grallaria quitensis* is probably the most tolerant of moderate disturbance. The only *paramo* species in Ecuador can survive in fairly degraded *paramos*, even in the vicinity of small agricultural towns, exotic tree plantations, and agricultural fields. It should be noted that, even though it tolerates a certain level of habitat modification, it is one of the Andean species with the highest overall amount of range loss (*c.* 37%; Fig. 7). Finally, *Grallaria guatimalensis*, the most widespread species in Ecuador, is not currently considered threatened due to its large extent of occurrence. *Grallaria guatimalensis* inhabits several different ecosystems (from Amazonian *terra firme* forest through humid cloud forest on Andean slopes). Forests in some areas within its range are extensively fragmented (e.g. south-western Andes in Loja and El Oro provinces). Even though this species regularly occurs in fragmented habitats (N. Krabbe, pers. comm.) ongoing fragmentation might adversely affect population dynamics and breeding success (Tewksbury *et al.* 2006).

There are notable differences in the conservation status of populations on the western and eastern Andean slopes. The populations of three species not considered as threatened (*Grallaria nuchalis*, *G. haplonota*, and *Grallaricula flavirostris*) and two ranked as 'Endangered' (*Grallaria alleni* and *G. gigantea*) occurring in the Cordillera Occidental are likely to be facing severe declines due to deforestation and habitat fragmentation. In fact, *Grallaria nuchalis*, *G. haplonota* and *Grallaricula flavirostris* nearly met the quantitative threshold for listing nationally as 'Vulnerable' under criterion B (i.e. estimated EOO $< 20{,}000$ km^2 within which it occurs at no more than ten locations or habitat is severely fragmented), particularly for their western populations. It is important to highlight that, except for *G. alleni*, all these species have different subspecies on the eastern and western slopes (*Grallaricula flavirostris* has two races in the west and one in the east). From an evolutionary standpoint, differences in the conservation status of these subspecies may be critical (Moritz 2002). Studies have shown that within a single species, eastern and western subspecies are genetically divergent (Chaves *et al.* 2007). It has even been suggested that the *hylodroma* (western) race of *G. gigantea* is a valid species (Ridgely and Greenfield 2001). If this is confirmed, the conservation status of *G. hylodroma*, both at national and global levels, will need careful evaluation, as it would likely qualify as 'Critically Endangered'.

Species accounts

Giant Antpitta *Grallaria gigantea* - Revised national status: EN

The national conservation status of the two subspecies of *G. gigantea* occurring in northern Ecuador differ. In eastern Ecuador, *G. gigantea* has only been recorded at a few sites (only two of them recent), but forests are still extensive along its predicted range, and there is a high level of protection in most of its range (Fig. 6). There are two Ecological Reserves (Cayambe-Coca and Antisana) and three National Parks (Sumaco-Napo Galeras, Llanganates and Sangay), covering *c.* 60% of the species's range in Ecuador (Freile 2000). On the other hand, the western race (*hylodroma*) has been recorded from several localities in Ecuador, most of them confined to the western slopes of Volcán Pichincha. While there are no records from the large Cotacachi-Cayapas Ecological Reserve, north of Pichincha, and only two recent records from the surrounding areas of Illinizas Ecological Reserve, our model (Fig. 6) predicts its presence in both protected areas. These differences in the protection status, the number of known localities, and the degree of forest fragmentation between the ranges of the eastern and western subspecies of *G. gigantea* complicate an assessment of its national conservation status. This can only be assessed by combining the two ranges, populations, and trends, to conduct a pooled but not necessarily accurate evaluation. Granizo *et al.* (2002) and BirdLife International (2009) found that *G. gigantea* qualifies as 'Vulnerable' owing to its small and declining range size. Our modelled distribution of its current range suggests it is 'Endangered' (EOO $< 5{,}000$ km^2 and habitat is severely fragmented) at national scale. Neighbouring Colombian populations might not represent a potential source for immigration (see IUCN 2003 guidelines for regional assessments) as it is also threatened in Colombia (EN), where its range is minute, and no populations are known near the Colombia-Ecuador boundary to act as a source of immigrants (Renjifo *et al.* 2002). Given the small global range of *G. gigantea* and the critical situation of Colombian subspecies *lehmanni* (Renjifo *et al.* 2002) we suggest it is uplisted globally to 'Endangered' (meeting criterion B1a+biii).

Moustached Antpitta *Grallaria alleni* - Revised national status: EN

The distribution and status of this species is similar to *G. gigantea* (Fig. 2). While in the east, forests are still extensive, with large areas almost inaccessible and protected (e.g. Sumaco National Park), in the western Andes forests are more fragmented. Similarly, protection in the west is deficient; there are no records from Cotacachi-Cayapas Ecological Reserve and only two records from the vicinity of Illinizas Ecological Reserve. Several private preserves hold populations of *G. alleni*, and while it seems to be fairly common in adequate, forested habitat (e.g., Maquipucuna and Otonga Reserves), few of these are large enough for long-term conservation. The occurrence of *G. alleni* in Ecuador was only recently confirmed (Krabbe and Coopmans 2000) because its vocalisations were previously unknown. Since tape-recordings became available, several new localities have been discovered and its natural history has become better understood (Freile and Renjifo 2003, Greeney and Gelis 2006). Quantitative data suggest that 'Endangered' status in Ecuador is appropriate (Table 2, see also Granizo *et al.* 2002). This category might be overestimating its actual conservation status in Ecuador, particularly in the eastern Andes, but is the result of a conservative application of IUCN criteria. Potential immigration from Colombian populations is rather unlikely as it has also been ranked as EN in that country (Renjifo *et al.* 2002).

Watkin's Antpitta *Grallaria watkinsi* - Revised national status: NT

The Tumbes endemic *G. watkinsi* is not currently considered globally threatened despite its small range, rather specific habitat requirements, and the extent of habitat loss throughout its range. Nonetheless, early evaluations included it in lists of candidate species for the Red Data Book of the Americas (Best *et al.* 1993). This species is primarily restricted to foothill forests and scrub in the Andean slopes of south-western Ecuador (Loja and El Oro provinces), as well as in the low coastal ranges of Guayas, Santa Elena, and Manabí provinces (Fig. 3). There is a gap in the distribution of *G. watkinsi* between the Andean slopes of El Oro-Loja and the coastal cordillera of Guayas-Santa Elena-Manabí. It is not clear if this distributional gap is natural or is a consequence of the high level of habitat alteration that exists in the intervening area. Bioclimatic differences shown in our model suggest that this may be a real discontinuity. *Grallaria watkinsi* has the highest percentage of range loss (63%) of all the studied species, reflecting the current status of deciduous and semi-deciduous forests, and even scrub, in the Pacific lowlands of southern Ecuador (Sierra 1999). This author demonstrated that most forest types in the region (eight) are facing critical rates of deforestation. Even though, *G. watkinsi* ranges from forest understorey to dense regenerating scrub, the critical degree of habitat degradation throughout its range over the last decades has wholly devastated all vegetation cover from large areas, particularly in Manabí, Guayas, Santa Elena, and El Oro lowlands, and in El Oro and Loja lower slopes (Sierra 1999).

Remnant forests in western Ecuador (*c.* 10% of original cover) are generally small and fragmented. Moreover, land protection is low. There are three fairly small protected areas in the region (Machalilla National Park, Manglares-Churute and Arenillas Ecological Reserves), but there are no confirmed records from Manglares-Churute. A few scattered, privately protected reserves, much smaller than these national reserves, also exist. Their limited extension, combined with habitat destruction in surrounding areas, makes long term conservation seem dubious.

Grallaria watkinsi appears to tolerate a moderate to high degree of habitat alteration, inhabiting dense regenerating scrub and secondary forest edges, but being absent from completely modified areas or from forest patches where domestic animals (e.g. goats, pigs) forage and trample all understorey vegetation (an important threat to Tumbesian dry forests) (Bonaccorso *et al.* 2007). The critical level of range loss, as well as loss of suitable habitat within current extent of occurrence, suggest that its conservation status has been underestimated. However, the degree of tolerance to habitat alteration of this species precluded a threatened category even though it might fit quantitative thresholds for 'Vulnerable' in the country under criteria B1 and A3 (Table 2). We estimate a 10–30% reduction in population size over the next three generations (10.5 years) based on an educated guess of 288.9–866.7 km^2 lost in this span of time, as a result of a national deforestation rate calculated in 1,000–3,000 km^2 annually (Stewart and Gibson 1995). For further data on these estimates, contact the senior author.

We suggest, therefore, the 'Near Threatened' category for *G. watkinsi* in Ecuador (*contra* Granizo *et al.* 2002). As *G. watkinsi* is near-endemic to Ecuador, we recommend re-assessing the global species status as 'Near Threatened' (with a small range $< 20{,}000$ km^2 but found at more than 10 locations, being fairly tolerant to habitat disturbance and fragmentation).

Yellow-breasted Antpitta *Grallaria flavotincta* - Revised national status: VU

This species is not considered as globally threatened (BirdLife International 2009), but was also a candidate species for the Red Data Book of the Americas (Collar *et al.* 1992; N. Krabbe, pers. comm. 2000). In Ecuador it was accorded 'Endangered' status by Granizo *et al.* (2002). It is confined to very wet, steep slopes and ravines along the Pacific slope of Colombia and north-western Ecuador (Ridgely and Tudor 1994) (Fig. 5). Its range is small, and its area of occupancy (i.e. areas within its distributional range where the species actually occurs = potential niche) might be even more limited considering microhabitat preferences. Within the Ecuadorian part of its range, *G. flavotincta* is fairly uncommon and local, and has not been recorded continuously from the Colombian border to the southern end of its range in western Pichincha province, as shown in map in Ridgely and Greenfield (2001). It shares a similar distributional pattern with other forest-confined Chocó endemics, which are currently ranked as threatened or 'Near Threatened' in Ecuador (e.g. Star-chested Treerunner *Margarornis stellatus* VU, Tanager-Finch *Oreothraupis arremonops* VU; Granizo *et al.* 2002) and consequently might also be facing similar threats. The status of *G. flavotincta* in Colombia is apparently less critical than in Ecuador, in part due to a larger amount of continuous forest (not included in Renjifo *et al.* 2002). However, based on the deforestation map of Sierra (1999) we estimate that less than 50% of the original cover of Andean forests in western Ecuador remains (Sierra 1999). There are two officially protected areas along the Ecuadorian range of *G. flavotincta* (Cotacachi-Cayapas Ecological Reserve and Pululahua Geobotanic Reserve), but the species has not yet been recorded in either, though our model predicts its occurrence in both. We feel confident that the category we assigned to *G. flavotincta* reflects the actual status of this species in Ecuador, and that previous assessments (Ridgely and Greenfield 2001) failed to acknowledge the significant habitat loss and fragmentation which may affect this species. Further, we suggest that its global status needs to be reassessed, taking into account the categorisation of other species with similar distributions and habitat preferences. Even though the species approaches the threshold for EN in Ecuador under criterion B1a+b(i-v), Colombian populations might represent a source of immigrants for declining populations in Ecuador, making the VU category more likely.

Jocotoco Antpitta *Grallaria ridgelyi* - Revised national status: EN

This recently described species (Krabbe *et al.* 1999) is the only *Grallaria* almost endemic to Ecuador (recently found in extreme northern Peru, T. S. Schulenberg *in litt.* 2007). The very limited distributional range of *G. ridgelyi* is unique among Andean birds in Ecuador, being confined to steep slopes in a very narrow elevational range of the Cordillera de Lagunillas region of the extreme southern portion of the eastern Andes (Fig. 8). It is apparently replaced by one of its hypothesised close relatives (*G. carrikeri*) south of the Marañón river depression. Another close relative (*G. nuchalis*) occurs in sympatry with *G. ridgelyi* (Krabbe *et al.* 1999), with territories regularly found in close proximity (JFF unpubl. data). Its known global extent of occurrence encompasses less than 60 km^2 (Table 2), but a recent record (Heinz *et al.* 2005) suggests that it might cover at least 180 km^2. Its area of occupancy is even smaller as it is known to range only locally along this tiny global range (possibly around 25–36 km^2). Recent efforts to locate new populations further north, south and east of the few currently known localities resulted in only one new site out of several areas visited (Heinz *et al.* 2005). Additionally, N. Krabbe (*in litt.* 2008) recently found it in San Luis, 20 km south of Tapichalaca, in an area about to be deforested. So far, this species seems to be genuinely rare, and as such, its vulnerability to extinction even under natural (not human-induced) catastrophes is very high (Lande 1998). Forests are still fairly continuous along the limited range of *G. ridgelyi*, and deforestation is similarly restricted (Sierra 1999). Further, two of its four known localities in Ecuador are currently under protection within Tapichalaca Private Reserve and Podocarpus National Park, and new sites might be discovered within Podocarpus and neighbouring Colambo-Yacuri Protected Forest (Freile and Santander 2005). Changes in the conservation status of forests, in the face of new mining concessions and ongoing deforestation, even in protected areas (López *et al.* 2003) might severely affect the small range where *G. ridgelyi* occurs. Currently available data might even justify ranking *G. ridgelyi* as 'Critically Endangered' (under B1a+b(iii) with an EOO < 100 km^2, severely fragmented and declining) both at national and global scales. However, as its global range may be larger than 100 km^2, it occurs at more than one location, and because Podocarpus National Park and Tapichalaca Reserve might effectively protect the majority of the global population, fragmentation is unlikely to be severe and, hence the species should be listed as 'Endangered' EN B1a+b(iii,iv) (Granizo *et al.* 2002, BirdLife International 2009).

Peruvian Antpitta *Grallaricula peruviana* - Revised national status: NT

Grallaricula peruviana has a small geographic range and a limited altitudinal distribution, being endemic of the Amazonian Andean slope and isolated mountain ranges of eastern Ecuador and extreme northern Peru (Ridgely and Tudor 1994) (Fig. 10). Until recently, it was only known from a handful of sites in southern Ecuador, and nothing was known about its natural history (even its vocalisations were unknown). Greeney *et al.* (2004) described the nest and vocalisations of this species and provided a notable range extension that increased its very limited distribution. Its range is potentially continuous at least from the northernmost site (Cordillera de Guacamayos area, Napo province) south to northern Peru. Within this range, several protected areas exist (Antisana Ecological Reserve, Sumaco-Napo Galeras, Llanganates, Sangay and Podocarpus National Parks), but *G. peruviana* has only been certainly recorded from Podocarpus NP. Foothill forests where the species occurs are fairly extensive, particularly in Llanganates and Sangay National Parks, and in the Cordilleras de Kutukú and del Cóndor (Sierra 1999). It seems plausible that the lack of records in the area between the northern and southern localities is a result of insufficient ornithological research in this region (Sangay National Park is one of the least known protected areas of Ecuador). *Grallaricula peruviana* approaches the threshold for listing as EN within Ecuador under criteria B1 and B2 based on its restricted distribution but it does not meet the subpopulation qualifiers (severe fragmentation and ongoing population declines). It qualifies as 'Near Threatened' in Ecuador, in accordance with previous national and global assessments (Granizo *et al.* 2002, BirdLife International 2009). Recent surveys suggest that the species has disappeared from the Cordillera de Guacamayos region (San Isidro Reserve) (N. Krabbe pers. comm.).

Crescent-faced Antpitta *Grallaricula lineifrons* - Revised national status: NT

The altitudinal range of this species is very restricted, as is its overall distribution (Ridgely and Tudor 1994) (Fig. 10). Until recently, it was known from a few sites in northern (Napo and Carchi

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provinces) and southern Ecuador (Loja province), but recent records in the intervening area suggest a continuous distribution (Ridgely and Greenfield 2001). It occurs in the Amazonian and inter-Andean slopes of the Cordillera Oriental, but inter-Andean forests are almost completely gone because of agricultural expansion (Sierra 1999). Ridgely and Greenfield (2001) suggest that *G. lineifrons* is not currently at risk of extinction due to its capability to inhabit naturally altered areas like bamboo stands and secondary growth. However, the species is absent from highly degraded areas, and some areas of its range are threatened by agricultural expansion, burning and timber extraction for charcoal (Freile and Santander 2005). In a study carried out at Guandera Biological Station, Cresswell *et al.* (1999) found *G. lineifrons* to be seemingly rare in secondary forest patches with re-grown canopy (but records were too scarce to allow abundance quantification). The species qualifies as NT in Ecuador (*contra* Granizo *et al.* 2002 but in line with its global status categorised by BirdLife International 2009), but approaching the thresholds for listing as VU under criterion B1.

Concluding remarks

In general, rates of habitat loss and fragmentation are likely to have impacted all species of *Grallaria* and *Grallaricula* antpittas in Ecuador, with some species more severely affected due to their limited distributions in areas with high levels of human-induced habitat degradation. The conservation status of the species studied here was primarily assessed on the basis of distributional data, predicted range distributions based on these data, expert knowledge on the distribution and ecology of the species, and patterns of deforestation and extent and location of protected areas. However, IUCN criteria also take account of population size and population trends, information that is scarce for all *Grallaria* and *Grallaricula* species in Ecuador (Ridgely and Tudor 1994), and that might only be inferred. The IUCN guidelines (UICN 2003) suggest that inferences and projections can be used to evaluate the conservation status of species, but the application of the IUCN criteria is subject to the availability of information, biasing species' status assessments to certain types of information which are more easily attained.

We reinforce the fact that the integration of environmental niche modelling, expert knowledge and knowledge of habitat degradation is a useful means of assessing the conservation status of a species (Renjifo *et al.* 2002, Graham *et al.* 2004, Gelfand *et al.* 2005). Although models are influenced by the quantity and quality of both locality and environmental information, and their performance varies with the technique used (e.g., Loiselle *et al.* 2003, Elith *et al.* 2006, Graham *et al.* 2006, Hernández *et al.* 2006), models can provide useful predictors of species' ranges, especially for poorly known tropical species.

Serious recent criticisms have been made of the performance of BIOCLIM to generate predictive models (e.g. Tsoar *et al.* 2007). Nonetheless, after rerunning models for four species (Fig. 1) using Maxent, a highly recommended technique (Elith *et al.* 2006), we found that while slight improvements might be possible in our models, differences among methods is qualitative and our interpretation of species declines (i.e. deforestation trends, threat level) will not change. Strong climatic and precipitation gradients in the Andes, to which species tend to respond, make it relatively straightforward to capture reasonable species-environment relationships even with simple models such as BIOCLIM (Parra *et al.* 2004). Further, much of our interpretation of ranges (and range changes) was a function of bioclimatic modelling plus expert cutting and a deforestation map, which are not influenced by the original modelling method used. Given that this post-processing of each model influenced our results more than the relatively small differences expected based on what particular method was used, we are confident that our results would be qualitatively similar regardless of the original model choice.

Further information on population sizes, responses to habitat alteration, and the general ecology of antpittas is clearly needed to accurately assess their conservation status. Recently, knowledge about the natural history of both genera has notably increased (Robbins *et al.* 1994, Dobbs *et al.* 2001, Price 2003, Freile and Renjifo 2003, Dobbs *et al.* 2003, Greeney *et al.* 2004, 2008, Martin and Dobbs 2004, Geeney and Martin 2005, Greeney and Sornoza 2005), but information is still mostly anecdotal. Aside from a single study (Heinz 2002), nothing is known of the population dynamics of *Grallaria* and *Grallaricula* species in Ecuador. Research on habitat preferences and population trends are needed, parallel to those recently carried out in Colombia (Kattan and Beltrán 1999, 2002). Further, current assessment methods, including ours, do not include subspecies, and the conservation of eastern and western Andean subspecies is a critical component which should be factored into future models. It is particularly important for isolated races (e.g. *G. nuchalis obsoleta, G. gigantea hylodroma, G. haplonota parambae, G. flavirostris zarumae*), which likely represent significant evolutionary units (Moritz 2002).

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