Species Status Assessment for the Sira Curassow and Southern Helmeted Curassow

Sira curassow (*Pauxi koepckeae*)

Southern helmeted curassow (*Pauxi unicornis*)
© Asociación Armonía 2021

May 2023
Branch of Delisting and Foreign Species
Division of Conservation and Classification
U.S. Fish and Wildlife Service

Table of Contents

Introduction

We received a petition from the International Council for Bird Preservation (ICBP) on November 24, 1980, requesting to add 79 birds to the list of Endangered and Threatened Wildlife, which included foreign and domestic bird species. Subsequently, another petition received from ICBP on May 6, 1991, they requested to add another 53 foreign birds to the list, including the southern helmeted curassow (*Pauxi unicornis*), as endangered or threatened species under the Act. On March 28, 1994 (59 FR 14496), we determined that petitions submitted in 1980 and supplemented in 1991 to add the southern helmeted curassow was warranted but precluded by other listing actions. Thereby the southern helmeted curassow became a candidate species for listing under the Endangered Species Act (Act). At the time we received the petition, the southern helmeted curassow and Sira curassow were considered subspecies of *Pauxi unicornis*. However, in 2014, the Sira curassow (*Pauxi koepckeae*) was recognized as a full species and subsequently became a candidate species. Even though the Sira curassow occurs in Peru and the southern helmeted curassow occurs in Bolivia, the two species are in the same genus, are very similar in life history, and face similar threats. Therefore, we are assessing the status of both these foreign candidate species in this report.

The species status assessment (SSA) framework provides an in-depth review of a species' biology and threats, an evaluation of its biological status, and an assessment of the conditions needed to maintain long-term viability. This report does not result in a decision by the Service on whether the Sira curassow and southern helmeted curassow should be proposed for listing as a threatened or endangered species under the Act, but instead provides a review of the available information strictly related to the biological status of the species. The Service will make a decision after reviewing this document and all relevant laws, regulations, and policies. We will publish any proposed listing decision in the *Federal Register* with opportunities for public input.

Using the SSA framework (Figure 1), we considered what the species requires for viability by characterizing the status of the species in terms of 3Rs: Resiliency, Redundancy, and Representation (Service 2016, entire; Smith *et al*. 2018, entire). For this report, we generally define viability as the ability of species to sustain populations in the wild over time.

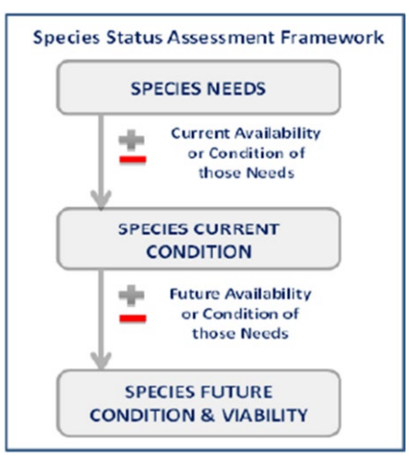


Figure 1. Species Status Assessment Framework

Resiliency describes the ability of populations to withstand and adapt to stochastic events (i.e., those that arise from random factors). For example, we can measure resiliency based on metrics of population health, birth rate versus death rate, or population size. Highly resilient populations are better able to withstand and adapt to environmental variability and/or the effects of anthropogenic activities.

Redundancy describes the ability of a species to withstand catastrophic events. Measured by the number of populations, their resiliency, and their distribution and connectivity, redundancy gauges the probability that the species has a margin of safety to withstand or bounce back from catastrophic events that may involve many populations.

Representation (i.e., diversity) affects the ability of a species to adapt to changing environmental conditions. We measure representation by the breadth of genetic or environmental diversity within and among populations. Representation gauges the probability that a species is able to adapt to environmental changes. The more representation a species has, the more likely it is to adapt to natural or human-caused changes in its environment. In the absence of species-specific genetic and ecological diversity information, we may evaluate representation based on the extent and variability of habitat characteristics across the geographical range.

This report provides a thorough assessment of the biology and natural history of the Sira curassow and southern helmeted curassow, the resources the species requires, and assesses demographic risks, stressors, and limiting factors in the context of determining viability and risk of extinction for the species. To evaluate the biological status of the species into the future, we assessed plausible scenarios based on the species life history, habitat availability, and historical threats within the range of the species to allow us to consider the species' resiliency, redundancy, and representation.

This report includes an introduction, a section describing the ecology of the species; factors influencing the viability of the species; the current condition of the species; and the species' projected future condition, including a description of viability in terms of resiliency, redundancy, representation, and uncertainties with future projections. This report represents a compilation of the best available scientific and commercial information and a description of the present and plausible future risk factors to the Sira curassow and southern helmeted curassow.

Ecology of the Species

Taxonomy

Curassows are gallinaceous birds (relating to the order Galliformes of heavy-bodied largely terrestrial birds in the Cracidae family (subfamily Cracinae)) and are endemic to the Neotropics (del Hoyo 1994, in Hosner et al. 2016, p. 6; del Hoyo et al. 2020a, unpaginated). The Sira curassow (*Pauxi koepckeae*) and southern helmeted curassow (or horned curassow; *Pauxi unicornis*) are very similar in appearance and life history. Both species are large (83–94 centimeters in length) and relatively heavy-bodied (about 3.6 kilograms) with bright red bills and a pale blue "helmet" (casque) atop their heads (del Hoyo et al. 2020b, unpaginated). Casque shape and size are a distinguishing feature between the two species; the casque of the southern helmeted curassow is upright and cone-shaped while that of the Sira curassow is shorter, rounder, and flattened against the head (del Hoyo et al. 2020a, 2020b, unpaginated; Gastañaga *et al.* 2011, p. 271). Additionally, both species have a thin white tip on the tail; the Sira curassow has less white on its tail (Gastañaga *et al.* 2011, p. 271). They were considered two subspecies of *Pauxi unicornis*; however, in 2014 the Sira curassow was elevated to a full species (del Hoyo 2018a, del Hoyo 2018b, unpaginated; Tobias et al. 2010, pp. 6–14).

Range and Distribution

Both curassow species occur on the eastern side of the Andes Mountains of South America, although their ranges do not overlap and are separated by more than 1,000 kilometers (km; Gastanaga et al. 2007, p. 63). The species' ranges occur primarily within Yungas Lower Montane Pluvial Palm Forest and in Amazonian Preandean Upper High Evergreen Forest (Appendix A, Tables 1 and 2). The Yungas occur throughout the eastern side of the Central Andes Mountains from Peru, Bolivia, and northern Argentina. They are associated with a discontinuous sub-Andean Mountain system with an altitudinal range of 500 to 4,000 meters above sea level (asl), with northerly running rivers to the east that form a wide valley before transitioning to the Amazon lowlands (Cabrera and Willink 1973 and Josse et al. 2009a, in Josse et al. 2011, p. 155).

Figure 2. Location of the Sira curassow in Peru and the southern helmeted curassow in Bolivia (Image from MacLeod et al. 2006, p. 63).

Habitat types range from montane forest and cloud forest to lowland forest and adjacent evergreen forest. The ecosystems form spatial mosaics in the valleys above 1,000 meters, surrounded by steep slopes covered in montane forest. Above 2,000 meters forest types differentiate (Josse et al. 2011, p. 155). In Peru and Bolivia, humid cloud forests may also be referred to as Yungas, which comprise a transition zone between the lowlands and mountain forests (Mee 1999, p. 18; Young et al. 2011, p. 175).

The Sira curassow is resident in cloud forest at mid to high elevation (1,100 to 1,500 meters asl); Begazo 2022, unpaginated; Beirne *et al.* 2017, p. 150; Gastanga et al. 2011, p. 268). The range of the Sira curassow is estimated at 550 km^2 (BirdLife International (BLI) 2023a, unpaginated). The Sira curassow is known only from the Cerros del Sira in central Peru, with almost all its range in the El Sira Communal Reserve (BLI 2023a, unpaginated; Gastañaga *et al.* 2011, p. 269; Gastañaga *et al.* 2007, p. 63; Tobias and del Hoyo 2006, p. 61). The reserve is between the Río Pachitea on the west and the Río Ucayali on the east and falls within the Administrative Departments of Huánuco, Pasco, and Ucayali (Figure 3). The Cerros del Sira is a rugged mountain outcrop of the Peruvian Andes, isolated from the main Andean chain by the Río Pachitea and a broad swath of lowland forests (Finer et al. 2016, in Beirne et al. 2017, p. 146).

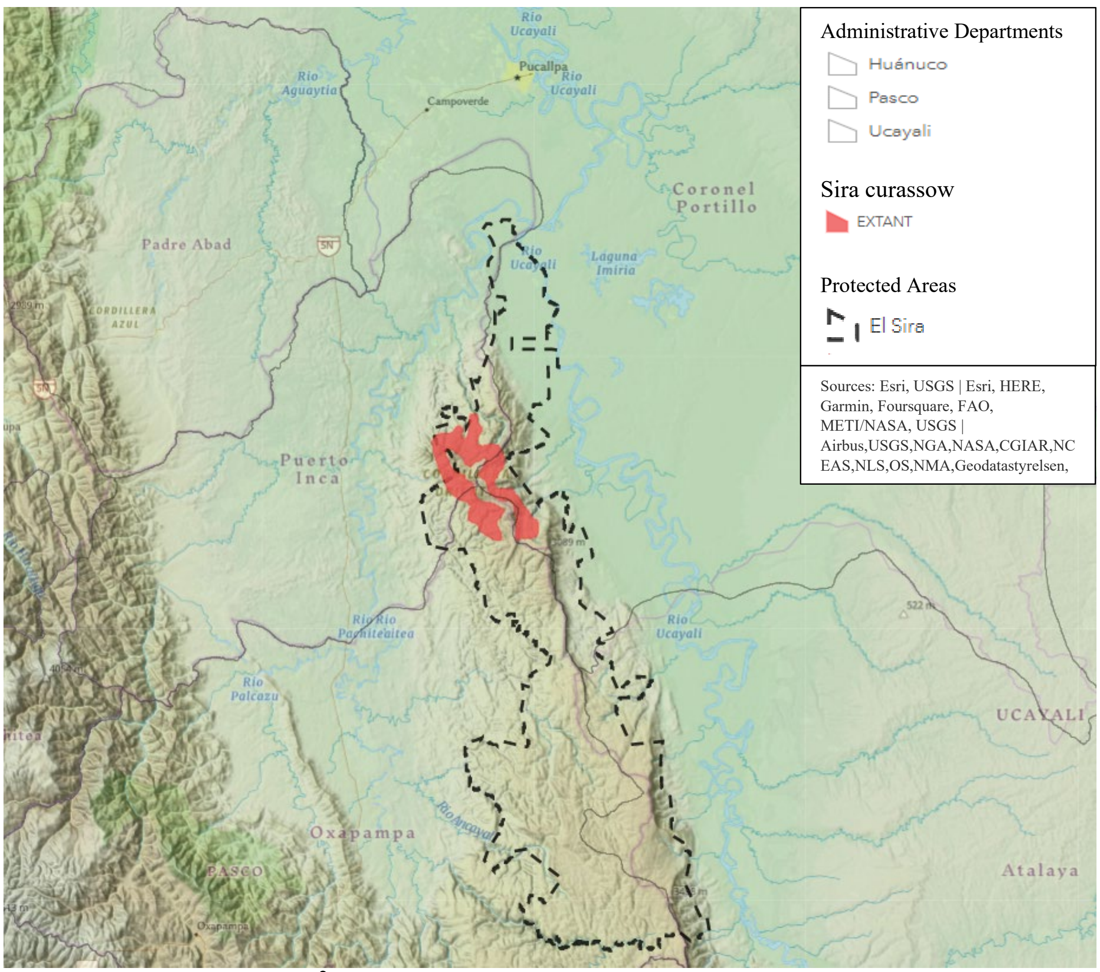


Figure 3. Range (550 km^2) of Sira curassow (from the IUCN Red List (IUCN 2023a, unpaginated)) and location of El Sira Communal Reserve.

The southern helmeted curassow is resident at lower elevation (400 to 1,400 meters asl) in upper tropical and lower montane zones in central Bolivia (Herzog and Kessler 1998, pp. 46–47; Cox *et al.* 1997, p. 200; Cordier 1971, p. 10; Birds of Bolivia 2021, unpaginated; Beirne *et al.* 2017, p. 150). Although most observations are between 500 and 900 meters asl (Asociación Armonía (Armonía) 2021, p. 3). The species' range is estimated at 10,700 km^2 and most of its current range is within three national parks (Amboró, Carrasco, and Isiboro-Securé Indigenous Territory and National Park (TIPNIS; BLI 2023b, unpaginated). The Administrative Departments of Cochabamba, Beni, and Santa Cruz in Bolivia contain the area of the three national parks where the southern helmeted curassow occurs (Figure 4). Based on the best available information, there is no evidence the species occurs outside of the national parks (MacLeod 2009, p. 16). Additionally, the northern possible extent is within TIPNIS, although no observations have occurred in this part of the range. The possible extent to the south, near Santa Cruz, is not realistic and the species does not occur there (Boorsma 2023, pers. comm.).

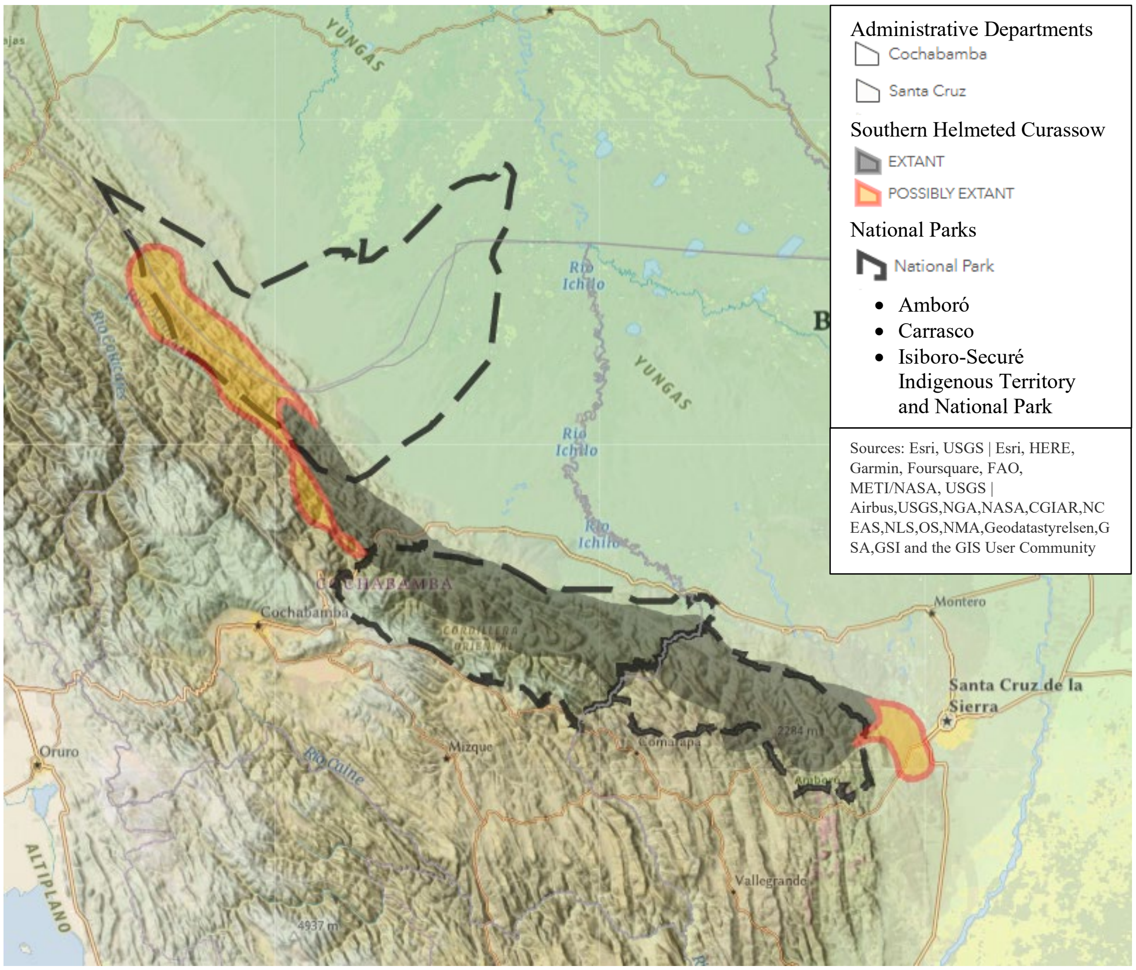


Figure 4. Range of southern helmeted curassow (from the IUCN Red List (IUCN 2023b, unpaginated)) and location of national parks. We consider the extant area of 10,700 km^2 the current range of the species.

While both species occupy a similar ecosystem – the Yungas and adjacent evergreen forest in the eastern Andes before it transitions to the Amazon lowlands to the east – the difference in their habitats include more than the elevation where each species occurs. Habitat for the Sira curassow is characterized by high density of epiphytes and frequent presence of moisture (derived from clouds). The habitat for the southern helmeted curassow is humid forest on the edge of tropical lowlands in lower montane forest with lower density of epiphytic cover, higher canopy, and moisture usually derived from precipitation. Therefore, the difference in habitats occupied by the two taxa is greater than a simple comparison of altitudinal ranges (Gastañaga et al. 2011, p. 275).

Additionally, the species' upper and lower range limits are likely conditional, based on ecotones between major habitats and the presence of elevationally exclusive competitors (Forero-Medina 2011, p. 4).

Population Estimates

The Sira curassow is rare with very few observations, although individuals have been heard singing and local people know of the species through observation or hunting (Gastañaga and Hennesy 2005, in Macleod et al. 2006, p. 61). Surveys in 2006 and 2008 observed the species at four locations, all located within 30 km of each other (Gastañaga et al. 2011, p. 273). At one point, a potential population estimate for the Sira curassow up to 400 individuals was based on an assumption that the species could occur throughout the Cerros del Sira at appropriate altitudes; however, this has been determined unlikely (Gastañaga in litt. 2007, Gastañaga et al. 2011, BLI 2018a, unpaginated). The best available information estimates that the population consists of 50 to 249 mature individuals and is decreasing (BLI 2023a; unpaginated; MacLeod and Gastañaga in litt. 2014, cited in BLI 2018a, unpaginated).

The southern helmeted curassow is believed to be extirpated from much of its historical range and has declined by at least 90% in the last 20 years (Birds of Bolivia 2019, unpaginated; (Armonía 2021, p. 2). Available information suggests that the number of subpopulations could range between 2 and 100 (BLI 2023b, unpaginated). However, a large number of subpopulations seems unlikely. Ten records have been confirmed at scattered localities (Boorsma 2023, pers. comm.). In 2017 and 2018, a total of 14 individuals were recorded at five of six surveyed locations in Amboró and Carrasco National Parks (Armonía 2018, pp. 3–4). The highest density of birds observed was in Amboró. The species was not observed in TIPNIS; however, in 2021, camera traps captured 17 individuals for the first time in TIPNIS (Boorsma 2023, pers. comm.). Additionally, interviews of the local community confirmed the species occurs in TIPNIS, an area that is likely to hold the largest remaining population (Armonía 2018, pp. 3–4; Armonía 2022, unpaginated; Boorsma 2023, pers. comm.). The total population of the southern helmeted curassow is estimated at 1,000 to 4,999 mature individuals and decreasing (BLI 2023b, unpaginated; BLI 2018b, unpaginated).

Population densities for both species is assumed to be less than one individual per km^2 (Gastañaga et al. 2011, p. 276; Cox et al. 1997, p. 206). Density of the southern helmeted curassow during surveys in 2017 and 2018 ranged from 0.12 to 0.44 individuals per kilometer surveyed (Armonía 2018, p. 4). The density of the Sira curassow is likely less than one individual per km^2 (Gastañaga et al. 2011, p. 276). Densities may increase in particular areas during the breeding season; such lek social strategies have been observed for other curassows during the breeding season (Strahl et al. 1997, in Gastañaga et al. 2011, p. 276). Additionally, annual variation suggests that densities change seasonally because these species may follow an unpredictable food source to ensure the young are raised in the most productive areas (Cox et al. 1997, p. 209).

The habitat of both species is characterized by steep, densely forested terrain that is not easily accessible (Cox et al 1997, p. 201). Detailed information on the biology of both species is limited, because despite their relatively large size, these species are difficult to detect and not well studied. When undisturbed, they stay mostly on the forest floor and in dense vegetation

(Banks 1998, p. 153; Renjifo and Renjifo 1997, pp. 89–90; BLI 2023a and BLI 2023b, unpaginated). Both species have small populations and are considered rare to uncommon and decreasing (BLI 2018a, 2018b, unpaginated; Birds of Bolivia 2019, unpaginated; BLI 2023a and BLI 2023b). Therefore, the species' apparent rarity is likely a combination of both low population density and its occurrence at elevations rarely frequented by humans (Mee et al. 2002, p. 48).

Life History

Curassows are principally terrestrial frugivores but have opportunistic and broad diets. Information on the species diet is anecdotal, but they are presumed to feed on nuts, fruits, seeds, soft plants, and invertebrates (Banks 1998, p. 153; Renjifo and Renjifo 1997, pp. 89–90; BLI 2023a and 2023b, unpaginated; Boorsma 2023, pers. comm.). The species' daily patterns indicate that they are strictly diurnal and adhere to ground-based foraging behaviors that peak in the afternoon (Beirne *et al.* 2017, p. 150). Although if the species are alarmed, they have been observed making a repeated "chip" sound in flight and may fly to the lower branches of nearby large trees (Cox et al. 1997, p. 204; Boorsma 2023, pers. comm.).

Breeding season is inferred based on when display songs are most frequently heard (Gastañga et al. 2011, p. 275; BLI 2023a and BLI 2023b, unpaginated). The Sira curassow's peak singing period, and thus breeding season, is at the end of the wet season in February to March (del hoyo et al. 2020, unpaginated). Males of the southern helmeted curassow start to sing at the beginning of the wet season in July/August, and the breeding season is presumed to be from July/August until about January (Birds of Bolivia 2019, unpaginated).

Large species of cracids, which include curassows, guans, or chachalacas, have intrinsically low rates of reproduction (Barrio 2011, p. 225). The Sira curassow and southern helmeted curassow likely take at least 2 to 3 years to reach sexual maturity and have low reproductive outputs as females lay one to two eggs per clutch (Banks 1998, p. 154). Generation time, which is the average time between two consecutive generations in lineages of a population, is estimated at 14.5 years (BLI 2023a and 2023b, unpaginated). However, precise estimates of reproductive output and longevity of both species are not well known given the sparse information on their life histories.

Curassows generally nest in trees and both species are assumed to build nests near the ground (Banks 1998, p. 154; Cox et al. 1997, p. 207). The only nest observed in the wild was of a southern helmeted curassow; the nest contained one egg and was a 30-cenimeter bowl made of branches, mosses, and leaves, in a fork of a low-growing tree at 600 meters asl. The nest was on the bank of a river with the cover of trees and bushes, surrounded by other secondary vegetation, and isolated from the forest edge by approximately 4 meters (Cox et al. 1997, p. 207). In captivity, the clutch size of southern helmeted curassow also contained one egg (Banks 1998, p. 154).

Species Needs/Ecological Requirements

The Sira curassow and southern helmeted curassows are both large, ground dwelling birds very similar in appearance and life history. These species occur in the Yungas and adjacent evergreen forest and rely on dense to semi-open forested areas with relatively open understory. However, because their ranges are more than 1,000 km apart and occur at different elevations in the Andes Mountains, the species may have different ecological requirements. Regardless, both species are primarily frugivores that move within their respective ranges in response to fruit availability to find the most productive areas for breeding and feeding. The forested areas and steep slopes where the species occur provide protection and camouflage from native predators and reduce the probability of human influence.

Large body size in tropical birds is often associated with large territory size, small population size, and low reproductive rate (Pearson et al. 2010, p. 508). In general, larger species need larger areas. The forest area or patch size required for the Sira curassow and southern helmeted curassow is unknown. Therefore, we looked to similar, large-bodied species for information. The great curassow (*Crax rubra*) in Guatemala (along with three large species of birds) were the least common species in forest patches that varied from 2.9 to 445 ha in area (Thorton et al. 2012, p. 572). The red-billed curassow (*Crax blumenbachii*) in Brazil preferred relatively large forest patches (>3,700) with a high proportion of forest cover (Rios et al. 2021, p. 418).

Large ground-dwelling species, such as the Sira and southern helmeted curassows, may easily move between forested areas with low or moderate fragmentation (Lees and Peres 2006, entire; Lees and Peres 2009, p. 286). However, when fragmentation increases and patch size decreases, understory large-bodied species are generally at a disadvantage because of greater habitat needs than small ranging species. Roads and linear clearing can create barriers to movements (Laurance et al. 2009, p. 661).

Curassows are not known to have great dispersal capabilities. The limited data available for other curassow species show that bare-faced curassow (*Crax fasciolata*) did not cross any gaps in a study of Amazonian Forest patches (Lees and Peres 2009, p. 285). Red-billed curassows did not move across open areas larger than 750 m wide (Rios et al. 2021, p. 418). In general, understory dwelling species are most affected by increasingly wider gaps (Lees and Peres 2009, p. 286). For example, narrow forest roads (<70 meters) may inhibit regular movement patterns in some understory forest birds that are not likely to be strong fliers but may not present a major barrier to rarer dispersal events and ultimately meta-population dynamics. Although, in tropical forests a high proportion of species avoid even narrower clearings (<30 meters; Laurance et al. 2009, p. 661). Wider gaps (>70 meters) represent a near complete barrier to gene flow for all but the most competent gap-crossers (Lees and Peres 2009, p. 280), for which curassows are not.

It is reasonable to assume that both the Sira curassow and southern helmeted curassow require intact dense to semi-open mature/primary forest habitat in areas large enough and away from human disturbance to have adequate space to forage and nest (Kattan et al. 2016, pp. 27–28; Rios et al. 2021, pp. 416–418; Thorton et al. 2012, p. 572). Because the species are primarily frugivores, they are more vulnerable to fragmentation and smaller forested patch sizes because they depend on naturally patchy resources in larger home ranges. Fragmentation into smaller forest patches could cause scarcity and a reduction of food resources within those smaller fragments (Kattan et al. 1994, pp. 141–143; Lees and Peres 2009, pp. 286–288; Lees and Peres 2010, p. 619; Vetter et al. 2011, p. 6). However, smaller fragments can be used by forest-dependent species with large area requirements if resources within in the smaller patch are supplemented by neighboring patches if they are accessible (Dunning et al. 1992, p. 173).

Therefore, curassows need large enough areas to move within their habitat when food resources are patchy and may vary in location.

Factors Influencing Viability

Hunting, habitat loss and degradation, small population size, climate change, and protected areas are the main factors that affect the species viability throughout their ranges. Hunting and habitat loss and degradation are the two primary factors that negatively affect the Sira curassow and southern helmeted curassow throughout their respective ranges (del Hoyo et al. 2020a, 2020b, unpaginated). However, the persistence of these species is likely more affected by hunting than habitat loss and degradation (Rios et al. 2021, p. 418). Literature reviews of several species in the cracid family demonstrate that they are more likely to persist in forested landscapes with low human density, primarily because these forested areas would be unaffected, or minimally affected by hunting pressure (Kattan et al. 2016, pp. 27–28; Rios et al. 2021, pp. 416–418). Specifically for curassow species, they are more likely to persist in patches located further from settlements and in areas with few settlements (Thorton et al. 2012, p. 572).

Because habitat loss and hunting pressure often work in tandem, further encroachment into their habitats that result in deforestation, roads, and other land clearance creates opportunities to increase human encounters and hunting opportunities (Laurance et al. 2009, p. 662). The habitat of the Sira curassows and southern helmeted curassows are steep, densely forested, and not easily accessible. However, roads and nearby human settlements/villages increases hunting pressure and allows people easier access to these species and their habitats. The most accessible forest areas are likely to be both the most structurally disturbed and the most heavily hunted, whereas remote primary forest tracts generally have higher overall habitat quality, and little or no hunting (Thiollay 2005, p. 1122).

Climate change is also likely to affect the species by reducing their ranges because warming temperatures are projected to cause tropical bird species and habitats to shift upslope to higher elevations (del Rosario Avalos and Hernández 2015, pp. 465–466; Peh 2007, p. 439; Chen et al 2011, p. entire). The risk from climate change increases as a particular species' elevational ranges narrow. In combination with both species' small population size and limited ranges, the primary threats of hunting and habitat loss and degradation, which will be exacerbated by the effects of climate change, are threats to the viability of the Sira curassow and southern helmeted curassow.

Hunting

Subsistence hunting is a cause of decline of curassow species in many areas of Latin America. The Sira curassow and southern helmeted curassow are no exception, and hunting is ongoing and likely to continue in the future. Subsistence hunting of large avian frugivores provides an important source of protein for local indigenous communities (Strahl and Grajal 1991, p. 51; Begazo and Bodmer 1998, p. 301). Additionally, some species of gallinaceous birds are hunted for use in local crafts or ceremonial purposes (Strahl and Grajal 1991, p. 51), and are major game birds for sport hunters, especially cracids. Generally, curassows rank as the highest category of avian biomass taken by subsistence hunters (Strahl and Grajal 1991, p. 51).

The Sira curassow and southern helmeted curassow are large-bodied, and their ground-dwelling behaviors make them easier targets for hunting (Rios et al. 2021, p. 412; Thiollay 1999, pp. 522–523). Larger species are usually absent or at very low population densities in forests with medium to high hunting pressure (Begazo and Bodmer 1998, pp. 307–308; Barrio et al. 2011, p. 228). Conversely, in areas with low or minimal hunting pressure larger cracid species seem to thrive (Torres 1997 and Yahuarcani et al. 2009, in Barrio 2011, p. 225). Low rates of reproduction and recovery of curassow populations make it difficult for them to tolerate high levels of continuous hunting (Strahl and Grajal, 1991, p. 52; Begazo and Bodmer 1998, p. 307; Thiollay 2005, p. 1133).

Precise estimates of hunting pressure on the Sira curassow and southern helmeted curassow do not exist given the difficulty of monitoring and documenting hunting activities. However, at one site in Carrasco National Park in Bolivia, the largest known population of southern helmeted curassow declined from 20 singing males to zero between 2001 and 2004 because the birds were hunted by incursions of coca growers into the area (MacLeod et al. 2006, p. 62; MacLeod 2009, p. 16). However, in 2017–2018, curassows were observed at this site (Boorsma 2023, pers. comm.). In TIPNIS, there are records of southern helmeted curassows being hunted and eaten by community members (Boorsma 2023, pers. comm.). For the Sira curassow, a survey around El Sira confirmed that the species was hunted by the local indigenous community (Gastañaga et al. 2011, pp. 268, 277). Camera traps captured images of the Sira curassow and multiple individuals engaged in hunting activity within the range of the species, with one instance of a hunter killing a razor-billed curassow (*Mitu tuberos*a), a co-occurring member of the cracid family. It is likely that hunters will encounter the species in the region where it was detected by camera traps (Beirne *et al.* 2017, pp.149– 150).

Deforestation

Habitat loss and fragmentation within the range of the species occurs because of selective logging to extract commercially valuable timber for sale, for firewood by locals, and for clearing land to grow legal and illegal crops (Armonía 2022, unpaginated; Macleod 2009, p. 16; Pauquet et al. 2005, p. 42). The rugged and steep topography where the species occur is almost beyond existing human development pressures, and most of the land clearance activities near the range of the species occurs outside the range of the species, at lower elevations in lowland forests where the land is more favorable to agriculture and cattle ranching. However, small-scale forest-clearing activities occur within the range of both species. Regrowth of forests likely offsets some of the minimal loss of primary forest in upland regions, in contrast to lower elevations where forests are more likely to be permanently converted to non-forests (Bucklin 2010, p. 38).

Near existing settlements, small-scale slash and burn agriculture clear areas gradually and increase fragmentation of primary forest patches. The degradation of a tropical forest area often begins with the building of a road that is quickly used by hunters, followed by logging companies and eventually by shifting cultivators (Thiollay 1999, p. 514). Formal and informal roads associated with logging and other forest-clearance activities often lead to further habitat loss because the roads create a double abrupt edge, changes in vegetation structure, invasions of nonnative species, and increase access to previously intact forested areas (Thiollay 1999, p. 514; Riveros et al. 2019, p. 74; van Gils and Armand Ugon 2006, p. 81).

We assessed the loss of forest cover in the regions where the species occur over a 20-year period, 2000 to 2020. We first assessed the forest cover within the Administrative Departments in Peru and Bolivia where the species occur. Then we assessed the forest cover within the range of the species and within a 20-km buffer around the range of each species.

Sira curassow
The Sira curassow is only known to occur in the Cerros del Sira in Peru, with almost all the species' range within the El Sira Communal Reserve (Figure 3). Land use changes do not generally affect forests above 700 meters in Sira (Forero-Medina 2011, p. 3), which is below the elevation where the Sira curassow occurs. Loss of forest happens mostly on the periphery and west of the El Sira Communal Reserve, and along the Río Pachitea and the Río Ucayali corridors that run north to south, and are west and east of the reserve, respectively. Construction of roads, disorganized agriculture, cattle ranching, and gold mining are around the reserve, although gold mining is generally of less concern because of frequent government crackdowns (Novoa et al. 2016, unpaginated). The bulk of deforestation around the El Sira Communal Reserve is likely illegal (Novoa et al. 2016, unpaginated).

The Administrative Departments of Huánuco, Pasco, and Ucayali encompass 100% of the El Sira Communal Reserve. We quantified the forest cover lost within these three departments, which ranged from 6% to 12% between 2000 and 2020 (Appendix A, Tables 7 and 8). The Puerto Inca region in the Department of Huánuco, which lies just west of the northern portion of the El Sira Communal Reserve and includes the northern portion the species' range, lost approximately 30% of total primary forest from 2002 to 2020 (GFW 2022, unpaginated). An analysis based on high-resolution maps showed deforestation hotspots just west (and outside) of the reserve where approximately 25,000 hectares was deforested from 2013 through 2015, with approximately half of the deforestation because of small-scale events (50 hectares) and cattle ranching (Finer et al. 2016, unpaginated). Additional deforestation has encroached into the reserve to create space for crops, cattle ranching, and gold mining. Approximately 1,600 hectares of deforestation from small-scale events occurred between 2013 and 2016, with an upward trend between 2015 and 2016 (Novoa et al. 2016, unpaginated).

The northern and eastern portion of El Sira Communal Reserve are within the Administrative Department of Ucayali, which has lost 6.5% of forest cover between 2000 and 2020 (Appendix A, Tables 7 and 8). The Coronel Portillo region includes the capital city of this department, Pucallpa, which is approximately 120 km north of the El Sira Communal Reserve. Minimal deforestation has occurred within the northern end of the reserve. In the Department of Pasco that encompasses the western portion of the reserve and range of the species, 6.7% of forest cover has been lost between 2000 and 2020 (Appendix A, Tables 7 and 8).

Scaling down, we quantified the forest cover lost within the range of the species, and within a 20-km buffer around the range of the species that is made up of protected and non-protected areas within that buffer (Appendix A, Tables 3 and 4). Throughout the species range and the El Sira Communal Reserve, there has been minimal loss of forest cover between 2000 and 2020. The data show that most of the forest loss is outside of the reserve, and outside the range of the Sira curassow. The area where the Sira curassow occurs within the reserve is classified as intact forest landscape that shows no to minimal signs of human alteration (GFW 2022, unpaginated).

Table 1. Percent loss of forest cover from 2000 to 2020 within range of the Sira curassow and in 20-km area surrounding the species' range that is made up of protected and non-protected lands.

Range of the species	20-km buffer area, protected areas	20-km buffer, non-protected areas
0.02%	2.34%	17.65%

Southern helmeted curassow

The southern helmeted curassow occurs in Amboró, Carrasco and Isiboro-Securé (TIPNIS) National Parks within the Administrative Departments of Cochabamba and Santa Cruz, and possibly in Beni in central Bolivia. The amount of forest cover lost between 2000 and 2020 from Cochabamba is approximately 5%, from Santa Cruz is 14%, and from Beni is approximately 3% (Appendix A, Tables 9 and 10; GFW 2023, unpaginated). Most of the deforestation in this region occurs around the city of Santa Cruz and in lowland forests to the east, as well as to the northeast and southeast of the range of the species (GFW 2022, unpaginated; Killeen et al. 2007, p. 602). The human population around the city has grown since the 1950s and coupled with agricultural expansion and cattle ranching has made the area a global hotspot for tropical deforestation (Steininger et al. 2001, in Bucklin 2010, p. 13; GFW 2022, unpaginated). Santa Cruz is approximately 30 km east of the boundary of Amboró National Park (Bucklin 2010, p. 13).

The national parks where the species occurs have been subject to forest cover loss within their boundaries over the past 20 to 30 years. The deforestation rates in all three national parks increased in the beginning of the 21st century after showing declines during the 1990s (Killeen et al. 2007, pp. 604–605). National parks seem relatively attractive for expansion of colonist farming by people living in the more densely populated Andean Highlands, particularly coca farming, which accounts for much of the land-clearance activities within the range of the southern helmeted curassow. Nevertheless, the protected areas have experienced low annual rates of change compared with areas outside of the protected areas (Killeen et al. 2007, p. 603).

Within Amboró National Park and the Integrated Management Natural Area surrounding the park, which together make up the protected area of Amboró, small-scale farming (i.e., shifting agricultural practices) is not a major threat to the ecosystem at the southern end of the species range. Within the park, forest cover has experienced minimal change. From the mid-1980s through 2021, only 1% of forest cover has been lost with 99% of the primary forest remaining (GFW 2022, unpaginated). Overall, the protected area of Amboró's forest cover is almost completely unchanged over the past 35 years (Bucklin 2010, p. 29; GFW 2022, unpaginated).

Carrasco National Park has experienced some forest loss within its protected area boundary over time (Bucklin 2010, p. 41). The national park has lost 5% of forest cover since 2000, and still has 97% of its primary forest cover (GFW 2022, unpaginated). The extension of road infrastructure triggered the expansion of colonist agriculture (e.g., pineapple, coca, citrus; van Gils and Armand Ugon 2006, p. 81). Even with the steep terrain of the protected area, roads increase access to the otherwise relatively inaccessible protected areas of Carrasco National Park (Van Gils and Armand Ugon 2006, p. 85). Additionally, deforestation occurring in low slope, river-adjacent areas in the Carrasco Province to the northwest of the park, could spread into Amboró if left unchecked, simply due to the lack of difficult terrain or enforcement at this boundary (Bucklin 2010, p. 44).

The third national park where the species occurs, Isiboro Sécure Indigenous Territory and National Park (TIPNIS), is one of the largest pristine forest complexes in Bolivia. Between 2000 and 2014, 46,000 hectares of forest was lost to deforestation, with more than 58% of deforestation concentrated 5 km or less away from existing roads (Fernández-Llamazares 2018, unpaginated). Since 2000, TIPNIS has lost 5% of forest cover and has 96% of its primary forest cover remaining (GFW 2022, unpaginated).

The production of coca leaves is not a new activity in the area and is expanding. Coca plays an intricate and complex role regarding land clearance in the region where the southern helmeted curassow occurs (Bradley and Millington, 2008, entire; Bucklin 2010, pp. 19–20). Deforestation rates in protected areas are highest near peasant colonization zones where the cultivation of illicit crops is widespread (Killeen et al. 2007, p. 603). Most coca cultivation in Bolivia occurs in the Chapare region of Cochabamba, to the northwest of Amboró, and is more notable near and within Carrasco National Park (Pauquet et al. 2005, p. 40). Coca cultivation is also common and related to most land clearance in TIPNIS, which is evident in the south end of the protected area in lowland forests, downslope and just west of the range of the southern helmeted curassow. Coca farming is rapidly expanding in TIPNIS, particularly in the area known as the colonization area, or Polígono Siete, where the rate of deforestation is eight times higher than within the rest of TIPNIS. From 2015 to 2016, coca plantations increased 43% within the colonized area (ITRN 2019, p.12).

Additionally, a controversial 305-km highway has been proposed to cut through TIPNIS but faces significant opposition from indigenous communities and local environmental advocacy groups (Fernández-Llamazares 2015, entire). At the current rate of deforestation this highway project is projected to lead to deforestation of 64% (610,848 ha) of the protected area in the next 18 years (PIEB, 2012, in ITRN 2019, p. 12). If the highway is not built, 43% would be deforested if the expansion of the colonization area is not controlled (PIEB, 2012, in ITRN 2019, p. 12).

Scaling down to the range of the species, we quantified the forest cover lost/remaining within the range of the species and within a 20-km buffer around the range of the species that includes protected and non-protected areas within that buffer (Appendix A, Tables 5 and 6). Throughout the southern helmeted curassows' range and the three national parks, there has been a small loss of forest cover between 2000 and 2020. However, the loss of forest cover markedly increases within the 20-km buffer of the species range.

Table 2. Percent loss of forest cover from 2000 to 2020 within range of the southern helmeted curassow and in 20-km area surrounding the species' range that is made up of protected and non-protected lands.

Range of the species	20-km buffer area, protected areas	20-km buffer, non-protected areas
3.33%	7.76%	27.08%

Summary of Deforestation

The El Sira Communal Reserve where the Sira curassow occurs is approximately 120 km south of the capital city of this region, Pucallpa. The City of Santa Cruz is about 30 km from the boundary of Amboró National Park at the southern end of the southern helmeted curassow's range. The vast majority of deforestation stemming from agriculture and cattle ranching is adjacent to these urban areas that lie outside and downslope of the known ranges of the species and outside of the protected areas where the populations for each species reside. Thus, the protected areas have been effective at minimizing deforestation, partly because enforcement is somewhat effective at limiting clearance of forests on public lands, and the steep and rugged slopes of these areas render them less accessible to human impacts. However, small-scale agriculture and other land-clearance activities are encroaching into the protected areas and within the known range of both species, which is currently more of a threat for the southern helmeted curassow in Bolivia than for the Sira curassow in Peru. The habitat for the southern helmeted curassow in the three national parks is affected by illegal coca agriculture and human invasion. Deforestation within the range of the southern helmeted curassow has increased over the last 10 years, including more fires and road building (Armonía 2021, p. 3).

The existence of roads fragments the landscape and could disrupt species movements within forested areas, increase development, and allow access to previously undisturbed areas which in turn can increase hunting risk. Forest loss tends to spread around newly built roads that increases the network of secondary roads and spatial extent of habitat disturbance (Barber et al. 2014, p. 205; Laurance et al. 2009, pp. 662–663). For the most part, no roads exist within the protected areas where the species occur. El Sira Communal Reserve in Peru does not have roads within the reserve, neither does Amboró National Park in Bolivia. However, roads exist in Carrasco National Park and TIPNIS, with a major highway proposed to cut right through the center of TIPNIS that would cause considerable loss of forest cover and severe disturbance to the ecosystem. Permanent roads generate a considerably larger deforestation footprint than secondary roads, which often become inaccessible during the wet season (Fernández-Llamazares 2018, unpaginated).

Climate Change

Climate change refers to long-term shifts in temperatures and weather patterns. The magnitude of climate change in the future depends in part on the level of heat-trapping gases emitted globally and how sensitive the Earth's climate is to those emissions, as well as any human responses to climate change by developing adaptation and mitigation policies (NASA 2023, unpaginated; IPCC 2014, p. 17; Terando et al. 2020, p. 14).

Climate change is a global phenomenon, but the impacts may manifest differently at local, national, and regional scales. In the tropical forests of the Andes Mountains in South America, rising temperatures because of climate change will likely cause shifts of habitat and species. The shift in climatic conditions implies a suite of changes that may directly or indirectly impact biodiversity in the future, including changes in rainfall patterns, reduced cloud formation, temperature increases and associated drought stress, compositional changes in current species assemblages and rising incidence of invasive species (Foster 2001 p. 73, Fadrique et al 2018 and Báez et al 2016, in Bax et al 2021, p. 8). At higher elevations, temperature increase is the main driver of climate change-caused habitat loss, whereas precipitation changes are the main cause in lowlands (Enquist 2002 and Li et al. 2009, in Sekercioglu et al. 2012, p. 2). Although, a lifting cloud base and changing precipitation also appear to be driving upslope range shifts of species in the tropics (Larsen et al. 2011, p. 52). Cloud forests are dependent on fragile atmospheric conditions that can change rapidly as climates warm (Foster 2001, pp. 88–92). Thus, cloud forests are recognized as one of the world's terrestrial ecosystems most affected by climate change due to their high sensitivity to rising temperatures and changes in precipitation and cloud distribution patterns (Still et al 1999, entire; Lutz et al 2013, in Bax et al 2021, p. 2).

Peru's average temperature has increased 1 °C since the 1960s. Warming is occurring more rapidly along the coast and in the southeastern highlands. In Bolivia, the mean annual temperature has increased about 1 °C from the 1940s to present day (WorldBank Group 2022, unpaginated). The annual mean temperatures and precipitation for Peru and Bolivia have been projected into the future under Intergovernmental Panel on Climate Change (IPCC) climate change scenarios using an ensemble of Coupled Model Intercomparison Project phase 6 (CMIP6) climate change models from the IPCC 6th assessment emissions scenarios of Shared Socioeconomic Pathways (SSPs). Projections of future temperatures and precipitation in Peru and Bolivia are based on historical data from 1986 to 2005 (WorldBank Group 2022, unpaginated). Climate change projections are explored using scenarios that are designed to span a wide range of possible future conditions.

The projections of temperature and precipitation for Peru and Bolivia are similar across future emissions scenarios. Mean annual temperature is projected to increase under all future emissions scenarios, but the magnitude of the increase depends on the scenario and future timeframe. In Peru and Bolivia, under the lowest emissions scenario, SSP1-1.9, temperature is projected to increase approximately 4% to 5% around 2040 and maintain steady through 2100. However, projected global emissions from NDCs[1] make limiting global warming to 1.5 °C beyond reach and make it harder after 2030 to limit warming to 2 °C (high confidence; Pathak et al. 2022, p. 70; Riahi et al. 2022, p. 298). Under higher emissions scenarios, temperatures are projected to increase slightly under SSP2-4.5 and SSP5-8.5 (6% to 8%) in 2040, and increase steadily over time, from 12% to 28% by 2100 (WorldBank Group 2022, unpaginated). The projected precipitation is less variable between emissions scenarios in Peru and Bolivia. Precipitation slightly increases or decreases over time, but the differences in precipitation under the lowest, moderate, and highest emissions scenarios in 2040, 2070, and 2100 do not show a substantial change from historical conditions in Peru or Bolivia (WorldBank 2022, unpaginated).

Tropical species and those that inhabit mountain regions are predicted to make altitudinal shifts (Chen 2011, entire; Sekercioglu et al. 2008, entire; La Sorte and Jetz 2010, pp. 3405–3406). A shift upslope would result in a reduction of the species' ranges because the geometric shape of mountains means there is less area on mountains and steep slopes as elevation increases (Chen et al. 2011, entire; Freeman et al. 2018, p. 11983; Forero-Medina et al. 2011, entire; Sekercioglu et al. 2012, p. 3). Because birds are endothermic and may tolerate a wider range of temperatures, species that shift their ranges may be responding more to gradual changes in habitat availability, food resources based on long-lived elements of their ecosystem (trees), and response of competitors, than to temperatures, per se (Forero-Medina et al. 2011, p. 4). However, habitat expansion to newly suitable areas will not take place at the same rate as habitat loss due to climate change, especially for relatively sedentary tropical forest species (Sekercoiglu et al. 2012, p. 12). Vegetation changes dramatically in structure and composition with elevation and it will become more difficult in the future for species to find suitable habitat that will provide their preferred climate envelope and nesting and foraging needs (Forero-Medina et al. 2011, p. 4).

[1] Nationally determined contributions (NDCs) are at the heart of the Paris Agreement and the achievement of its long-term goals. NDCs embody efforts by each country to reduce national emissions and adapt to the impacts of climate change (UN Climate Change 2023, unpaginated)

Furthermore, because cloud forests species occupy such small areas and tight ecological niches, they are not likely to colonize regions damaged by climate change and other anthropogenic factors (Foster 2001, p. 73). Most Andean species occupy relatively narrow altitudinal and temperature ranges (Larsen et al. 2011, p. 54). Therefore, a reduction in the range and distribution of resources are particularly harmful to endemic species that have smaller ranges (Velasquez et al. 2012, p. 235).

A meta-analysis of existing data for a suite of taxonomic groups across multiple geographic regions and a study of tropical birds within the El Sira Communal Reserve in Peru showed a median shift to higher elevations of approximately 10 meters per decade (Chen et al 2011, p. 1024; Forero-Medina et al. 2011, p. 4). In the case of tropical bird species in the El Sira Communal Reserve, a gradual, upward shift occurred because of changes in temperature, habitat conditions, and the availability of food resources (Forero-Medina et al. 2011, p. 4). The Sira curassow is within the reserve but was not part of the study. Nonetheless, an assessment of the potential effect to montane forests projected that most montane forest ecosystems in the El Sira Communal Reserve will undergo severe effects from climate change under the highest emissions scenario of the IPCC's 5th assessment (i.e., RCP 8.5) (Bax et al. 2021, p. 11). In 50 years (2070), nearly no montane forest ecosystems within El Sira Communal Reserve will exist (Bax et al. 2021, p. 11). The Sira curassow is resident in Peru at mid to high elevation (1,100 to 1,500 meters asl), and 97% of the projected loss of montane forest would occur within the elevational range between 800 and 2,000 meters asl (Bax et al. 2021, p. 6). The southern helmeted curassow is resident in central Bolivia at lower elevation (400 to 1,400 meters asl), and we assume a similar situation would also be the case for the tropical forest habitat within the range of the southern helmeted curassow because both species have similar life histories and occupy similar cloud forest ecosystems, which are highly susceptible to climate change (Foster 2001, p. 97).

Conservation Measures and Regulatory Mechanisms

The Sira curassow and southern helmeted curassow are not included in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Trade is not a threat to either species. Both species are listed as critically endangered under the International Union for Conservation of Nature and Natural Resources (IUCN) due to their small population sizes that are decreasing because of hunting and habitat destruction (BLI 2018a; BLI 2018b, unpaginated).

Within Peru and Bolivia, we do not have information on whether either of these species are protected species under existing laws in their range countries. However, the Sira curassow and southern helmeted curassow reside in protected areas throughout their respective ranges. Almost all the Sira curassow's range is within the El Sira Communal Reserve in Peru. The southern helmeted curassow's range in Bolivia is within three national parks, Amboró, Carrasco, and TIPNIS. Local or indigenous communities inhabit the protected areas where the species occur.

Peru

Policy on protected areas was established in the Natural Protected Areas Act (1997), the Master Plan for Natural Protected Areas (1999), and the General Environmental Act (Solano 2010, pp. 6–7, 46–49). The primary objective of the protected areas is the conservation of biological diversity (Solano 2010, pp. 12–13). Protected natural areas are monitored by the Intendancy of Protected Natural Areas and managed by the National Service for Natural Protected Areas, a specialized technical body under the Ministry of the Environment (Solano 2010, p. 6; Parkswatch 2003, p. 6). Protected areas have limited staff and resources, and the areas are generally located in remote areas far from government services. Thus, enforcement of protected areas is not particularly effective (Solano 2010, p. 37).

The first national park in Peru was established in 1963. Since then, 63 protected areas have been established at the national level and 4 at the regional (departmental) level, along with 16 private conservation areas. The Natural Protected Areas System covers nearly 20 million hectares, or about 15% of the country's total area (Solano 2010, p. 6). Communal reserves are under the umbrella of the national park system; they were created to acknowledge indigenous community's rights over their lands and consider the traditions and culture of the local communities (World Bank 2007, pp. 13–14; Solano 2010, pp. 10–13).

A Supreme Decree (038-2001-AG) established the El Sira Communal Reserve in 2001. The reserve is 616,413 hectares and was the second communal reserve created in Peru (Solano 2010, p. 50; WorldBank 2007, p. 15; Parkswatch 2003, p. 5). The reserve was established for the conservation of wildlife and for the benefit of neighboring communities and local groups. The area includes traditional hunting grounds and sustainable use of resources is allowed within the reserve under an established management plan (Parkswatch 2003, p. 5; Solano 2010, pp. 10, 15). The local indigenous communities oversee managing the reserve in coordination with the National Service for Natural Protected Areas (World Bank 2007, p. 13). The reserve is classified as IUCN category VI, which are protected areas that conserve ecosystems and habitats together with associated cultural values and traditional natural resource management systems. Category VI protected areas are generally large with most of the area in a natural condition. A proportion of the area is under sustainable natural resource management and where low-level non-industrial use of natural resources compatible with nature conservation is seen as one of the main aims of the area (IUCN 2023c, unpaginated; United Nations Environment Programme 2020, unpaginated).

Additionally, a pilot environmental education campaign was initiated in 2005 to raise awareness and discourage hunting of the species (Gastañaga 2006, p. 11). We do not have information on the effectiveness of this education campaign (Gastañaga et al. 2011, p. 277; Gastañaga 2006, p. 11; Gastañaga and Hennessey 2005, p. 21).

Bolivia

The Political Constitution of the State (2009) defines protected areas as a common good that is part of the natural and cultural heritage of the country; and they fulfill environmental, cultural, social, and economic functions for sustainable development. Likewise, the Framework Law of Mother Earth (No 300; 2012) indicates the System of Protected Areas as one of the main instruments for biodiversity (Elkins et al. 2014, p. 102; Lexivox 2023, unpaginated).

The Bolivian National Protected Area System (SNAP) was established in 1992 through Environmental Law No.1333 as a collective of interlinked protected areas of different categories (WCS 2017, unpaginated). The core of the system is the national protected areas, which includes 123 protected areas (22 national, 23 departmental and 78 municipal protected areas), covering approximately 20% of the country`s area. The National Service of Protected Areas (Sernap) oversees safeguarding the protected areas whose mission is to coordinate the operation and management of protected areas of national interest to conserve biological and cultural diversity (Sernap 2023, unpaginated). The involvement of local and indigenous communities in park management plays a vital role to recognize the rights of indigenous and local communities to preserve their cultural identity, value systems, knowledge and traditions, and territory (WCS 2017, unpaginated). However, institutional and financial weaknesses limits or prevents protected areas from effective implementation (Armonía 2018, p. 7).

The Asociatión Armonía is a nonprofit, nongovernmental conservation organization in Bolivia. Armonía initiated a horned curassow program to help prevent extinction of the species by supporting captive breeding in the local communities and carrying out an educational and pride campaign with local communities (Armonía 2018, p. 1; Armonía 2022, unpaginated). The program works with local and indigenous communities to protect the country's wild bird populations through management of protected areas, reducing threats, and research. Their conservation strategy is designed to be executed in the next 10 years (Armonía 2018, p. 1).

Summary
Land tenure in the protected areas where the Sira curassow and southern helmeted curassow exist is a historical and ongoing issue in Peru and Bolivia. The protected areas where the species occur are primarily inhabited by local indigenous communities that share management responsibilities of the areas with government ministries. The protected areas were designated by laws and have been relatively successful to limit the magnitude of negative effects to biodiversity within the protected area boundaries. However, the lack of personnel and financial resources makes the enforcement of the protected areas difficult, which has resulted in loss of wildlife and primary forest within their boundaries.

Current Condition

We used the ecology of the species and factors that influence the species viability to assess the species' current condition, including the resiliency, redundancy, representation, and overall viability of the species. We know of minimal occurrence records and both species are narrow endemics; thus, we assess the 3Rs at the full range-wide unit for both species.

<u>Resiliency</u>
The resilience of the Sira curassow and southern helmeted curassow is based on population abundance, the availability of quality habitat throughout their respective ranges, the extent and magnitude of threats to the species and their habitats, life history traits that minimize the species' ability to rapidly recover from disturbances and population losses, and existing conservation and regulatory measures. Considering all these factors, the Sira curassow and southern helmeted curassow currently have low resiliency to adapt and withstand environmental and demographic stochasticity.

Table 3: Southern helmeted curassow and Sira curassow population size, country of origin, and distribution.

Species	**Population**	**Country**	**Range/Distribution**
Sira curassow	50 to 249 mature individuals	Peru	Cerros del Sira; in the El Sira Communal Reserve

Southern helmeted curassow	1,000 to 4,999 individuals	Bolivia	Amboró, Carrasco National Parks, and Isiboro-Securé Indigenous Territory and National Park (TIPNIS)

Population Abundance: Both the Sira curassow and southern helmeted curassow are considered rare, locally uncommon, and decreasing (BLI 2023a, 2023b). Rangewide surveys are not available for either species. The Sira curassow was surveyed in 2006 and 2008. The southern helmeted curassow was surveyed in 2018 and 2021 in portions of its range and supplemented with anecdotal information. Population densities for both species is estimated at less than one individual per km^2. The Sira curassow's population is very small (50–249 mature individuals) and occurs within 550 km^2 in Peru. The southern helmeted curassow's population is also small, less than what it was historically, and estimated at 1,000–4,999 individuals within 10,700 km^2 in Bolivia.

Habitat Lost/Remaining: The species are endemic to small areas in relatively narrow elevational bands. The species' habitats are subject to deforestation from small-scale illegal agriculture and/or road construction that spawn additional small-scale development. For the Sira curassow, the data show that the vast majority of forest cover loss is outside of the range of the species and outside the protected areas where the species occur. The species' range is relatively intact forest landscape that shows no to minimal signs of human alteration. From 2000 to 2020, less than 1% of forest cover was lost within the range of the Sira curassow. However, forest cover loss within 20 km of the species' ranges, particularly in non-protected areas, was approximately 18%. Habitat loss within the range of the southern helmeted curassow shows a similar pattern, with approximately 3% of forest cover loss within the range of the species and 27% loss of forest cover within 20 km in non-protected areas. However, a major highway has been proposed to cut through TIPNIS within the range of the southern helmeted curassow that would result in significant impacts to the ecosystem and loss of forest cover, and deforestation has increased in the last 10 years. Thus, loss of forest cover is currently more of a threat for the southern helmeted curassow in Bolivia than for the Sira curassow in Peru (Table 4).

Table 4. Estimates and percentage of remaining forest cover from 2000 to 2020 within the range of the species, in the protected areas within a 20-km buffer of the species' range, and in the non-protected areas within a 20-km buffer of the species' range.

Total Forest Cover Lost from 2000–2020	**Forest Cover Lost (Kilo hectares (Kha))**		
	Within Range of Species	Within Buffer – Protected Areas	Within Buffer – Non-protected Areas
Sira curassow	*0.062*	*3.629*	*27.985*
Southern helmeted curassow	*27.315*	*61.002*	*144.199*
Percent Forest Cover Lost from 2000–2020	**Percent Forest Cover Lost (Kilo hectares (Kha))**		
	Within Range of Species	Within Buffer – Protected Areas	Within Buffer – Non-protected Areas
Sira curassow	*0.16%*	*2.34%*	*17.65%*
Southern helmeted curassow	*3.33%*	*7.76%*	*27.08%*

Hunting Pressure: The Sira curassow and southern helmeted curassow are large-bodied, and their ground-dwelling behaviors make them easier targets. Precise estimates of hunting pressure on the species do not exist given the difficulty of monitoring and documenting hunting activities. Although, we know that hunting is ongoing and will continue in the future. The forested areas and steep and rugged slopes where the species occur reduce the probability of human influence. The areas where the species occur are traditional hunting grounds and subsistence hunting of large birds provides an important source of protein for local indigenous communities. Generally, curassows rank as the highest category of avian biomass taken by subsistence hunters. The concern with hunting is the overexploitation of the birds from local communities in addition to others that may encroach into the species' habitats because of activities such as small-scale agriculture (i.e., coca) or roads. Low rates of reproduction and slow recovery of the species' populations make it difficult for these species to tolerate high levels of continuous hunting.

Life History: The forest area or patch size required for the Sira curassow and southern helmeted curassow is unknown, but the species are more likely to persist in patches located further from settlements and in forested landscapes with low human density, primarily because these areas would be unaffected, or minimally affected by hunting. Curassows have opportunistic and broad diets but are primarily frugivores, which are more vulnerable to fragmentation because they depend on naturally patchy resources in larger home ranges and fragmentation could cause a reduction of food resources within those smaller fragments. The reproductive phenology of the species is unknown, although these large curassow species have intrinsically low rates of reproduction and low reproductive outputs, similar to other large species in the cracid family. Generation time for these species is estimated at 14.5 years; however, the longevity of the species is not well known given the sparse information on their life histories.

Conservation/Regulatory Measures: Both the Sira curassow and southern helmeted curassow reside in protected areas within their respective ranges. Almost all the Sira curassow's range is within the El Sira Communal Reserve in Peru. The southern helmeted curassow's range in Bolivia is almost entirely within three national parks, Amboró, Carrasco, and TIPNIS. The involvement of local and indigenous communities in management of the protected areas plays a vital role in shared management of the protected areas, although subsistence hunting is allowed in these protected areas. The protected areas in Peru and Bolivia were designated by laws and have been relatively successful to limit the magnitude of negative effects to biodiversity within the protected area boundaries. But the lack of personnel and financial resources makes the enforcement of the protected areas difficult, which to date has resulted in loss of wildlife and minimal primary forest.

<u>Redundancy</u>

Aside from climate change that is expected to result in the loss of a substantial amount of montane forest ecosystems within the species ranges in the future, the increase of fires in humid forest habitat and road building that are directly drying the landscape combined with climate change could be catastrophic for the southern helmeted curassow. Redundancy also depends on availability of quality habitat throughout the species' respective ranges. Because most of the current habitat is intact, even though the species are restricted to relatively narrow ranges, we expect the species to have some redundancy.

The Sira curassow is restricted to a small area in Cerros del Sira. Surveys in 2006 and 2008 observed the species in one population at four locations, all located within 30 km of each other. Because the population and range are very small, we assume minimal populations of the species exist; however, we do not have any information on the number of populations that exist for the Sira curassow throughout its range. The southern helmeted curassow is known to occur at 10 sites and was recently observed (2017–2021) in Amboró, Carrasco, and TIPNIS, which is an area that is likely to hold the largest remaining population. However, the range of the species is smaller than it was historically. Moreover, we have no information on the connectivity between local populations (Armonía 2018, p. 7). Overall, the available data of population size and distribution is minimal and there is uncertainty regarding the number of extant populations for both species.

Representation
The Sira curassow and southern helmeted curassow have low representation. The species were determined to be distinct species in 2014 because of morphological differences and their ranges are separated by more than 1,000 km. Microhabitats within the species' ranges are likely present because the birds move within their respective habitats in response to resource availability. However, both species are restricted to narrow elevational bands in the Yungas and adjacent evergreen forest on the east side of the Andes Mountains. We have no information about the genetic diversity of either species, and there is no information on the degree to which the species exhibits behavioral plasticity, so the ability to assess representation is limited for these species.

Species Viability

In summary, the populations of both the Sira curassow and southern helmeted curassow are considered rare, locally uncommon, and decreasing. The species have few extant populations and are not likely to be highly resilient to ongoing threats. The Sira curassow and southern helmeted curassow are narrow endemics that have small population sizes with low areas of occurrence and occupancy. The species are long-lived, have long generation times, and have low reproductive output. Low reproductive output in conjunction with other factors like a high degree of habitat specialization, small population size, and low vagility typically equate to low innate adaptive capacity (Thurman et al. 2020, entire).

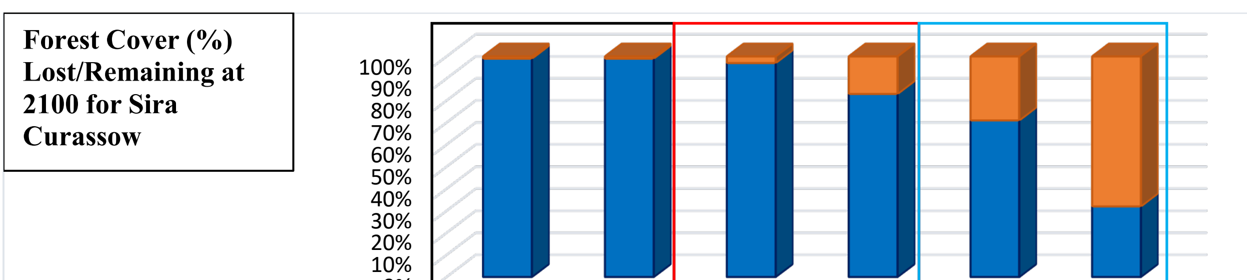
The species require intact dense to semi-open mature/primary forest habitat to have adequate space to nest and forage, with forest patches that are relatively large and away from human disturbance. Hunting and habitat loss and degradation are the two main factors that currently affect these species throughout their respective ranges. The persistence of these species is likely more affected by hunting than habitat loss. Most of the habitat loss currently occurs outside of the range of the species, outside of the protected areas, and at lower elevations. The species occur within protected areas and are afforded some protections because of where they occur. Enforcement of the protected areas is somewhat effective at limiting clearance of forests on public lands, and the steep and rugged slopes of these areas render them less accessible to human impacts. However, the designation of the communal reserve and the national parks offer limited protections because small-scale agriculture, road construction, ongoing illegal land-clearance activities are encroaching into these protected areas, and there is a lack of personnel and resources for enforcement. In fact, within the range of the southern helmeted curassow, deforestation has increased the last 10 years because of fire and coca agriculture within the national parks. Overall, both species seem more likely than not to maintain populations into the near future (~10 years). Although, the low to moderate redundancy combined with low resiliency of the species and minimal capacity to adapt to ongoing threats limits the viability of both species in the face of ongoing threats.

Future Condition

The future condition for the Sira curassow and southern helmeted curassow reflects the best available estimates of the species' current population sizes and projected future threats that are based on the historical threats to the species. We expect the populations for both the Sira curassow and southern helmeted curassow to decline in the future because of ongoing hunting, loss of habitat from anthropogenic deforestation, and effects from climate change. Therefore, the future resiliency, redundancy, and representation of both species depends on the level of hunting, rate of habitat loss from human development, effectiveness of the protected areas boundaries, and magnitude of climate change.

We expect hunting by local communities to continue in the future, but we have no way to quantify the magnitude of future hunting efforts. Additionally, as human activities such as illegal agriculture and road construction encroach into the protected areas, species-human interactions are likely to increase, which will intensify the existing hunting pressure by locals and by outsiders that encroach into the species' habitats. Habitat loss and hunting often work in tandem because encroachment into undisturbed habitat creates opportunities for humans to access previously inaccessible areas, which increases the risk to these species being hunted. Therefore, it is reasonable to assume that hunting pressure on the species would, at a minimum, be at the same level as current conditions.

The species occur in protected areas that are remote with minimal habitat disturbance. The rugged and steep topography where the species occur is almost beyond the existing human development pressures, but the lower elevation areas on the periphery of the species' ranges are near urban centers that are deforestation hotspots. We quantified the forest cover lost (or forest cover remaining) into the future and projected the loss of forest cover through the end of the century (2100) within the range of each species and within a 20-km buffer surrounding the range of the species that consists of protected areas and non-protected areas within that buffer. The future forest cover loss is based on the lowest and highest average deforestation rates that occurred within 5-year increments over the past 20 years (2000–2020).



	Within Range of Species - Low Rate	Within Range of Species - High Rate	Within Buffer: Protected Area - Low Rate	Within Buffer: Protected Area - High Rate	Within Buffer: Nonprotected Area - Low Rate	Within Buffer: Nonprotected Area - High Rate
Percent Forest Cover Lost	1	1	3	17	29	68
Percent Forest Cover Remaining	99	99	97	83	71	32

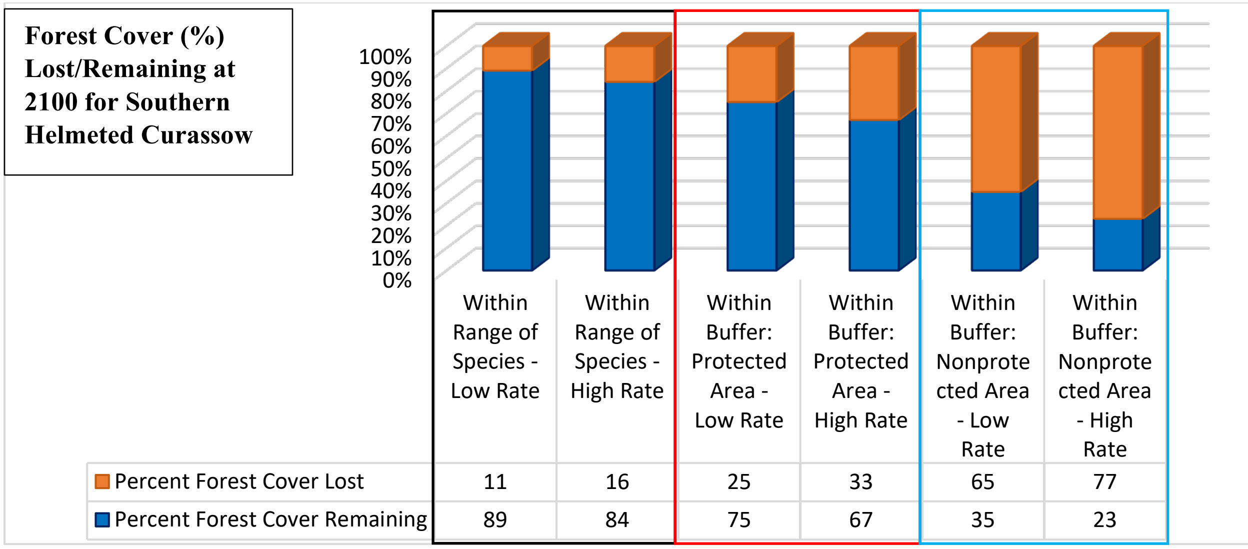


Figure 5. Projected forest cover lost/remaining through 2100, within the range of the Sira curassow and southern helmeted curassow, and within 20-km of the species' ranges that consist of protected and non-protected areas.

Minimal forest loss is projected within the range of the species. The assumption being that if the same proportion of forest loss occurs within the range of the species and in protected and non-protected areas based on historical averages, a substantially higher percentage of forest cover loss will occur outside of the range of the species and even more loss occurring outside of protected areas. However, the loss of forest cover has increased within the range of the southern helmeted curassow in the national parks over the last 10 years (Boorsma 2023, pers. comm.). Therefore, more forest loss is projected to occur within the range of the southern helmeted curassow compared to the Sira curassow. This is consistent with forest loss currently occurring at a greater level because of illegal crops and roads within the range of the southern helmeted curassow.

For the most part, roads are minimal within the protected areas where the species occur, which helps reduce the probability of deforestation or degradation of the forest ecosystem within the range of the species. We do not have any information to anticipate road building in El Sira or Amboró protected areas in the future. However, roads in Carrasco National Park and TIPNIS, where there are high rates of deforestation in the colonization area in TIPNIS and major highway proposed to cut right through the center of TIPNIS would result in substantial deforestation. If that highway is constructed, it was predicted that 64% of the protected area would be deforested and 43% would be deforested if the highway is not built but expansion of the colonization area is not controlled (PIEB, 2012, in ITRN 2019, p. 12), which is an area with substantially higher deforestation than the rest of the protected areas. Paved roads generate large deforestation footprints and spawn secondary roads and increase the overall loss of forest cover.

Additionally, climate change is projected to cause the species' preferred climate conditions, and potentially the habitat, to shift upslope over time, resulting in loss of habitat for the species. Temperature increase at higher elevations is the main driver of climate change-caused habitat loss, whereas precipitation changes are the main cause in lowlands (Enquist 2002 and Li et al. 2009, in Sekercioglu et al. 2012, p. 2), although, a lifting cloud base and changing precipitation also appear to drive upslope range shifts of species in the tropics (Larsen et al. 2011, p. 52). Cloud forests are dependent on fragile atmospheric conditions that can change rapidly as climates warm. The shift in climatic conditions is also likely to shift extractive actions in the forest from low-lying areas towards higher elevations (Bax et al. 2021, p. 9; Ovalle-Rivera et al. 2015, pp. 7–10). The combination of changes in climate conditions and land use would challenge the conservation of montane forest ecosystems in the future (Bax et al. 2021, p. 9). A shift upslope would result in a reduction of the species' ranges because there is less area on mountains and steep slopes as elevation increases. A reduction in the range and distribution of resources are particularly harmful to endemic species that have smaller ranges (Velasquez et al. 2012, p. 235). Moreover, habitat expansion to newly suitable area will not keep pace with the loss of habitat due to climate change (Sekercoiglu et al. 2012, p. 12). Thus, changes in vegetation structure and composition and the fact that cloud forests species occupy small areas and tight ecological niches will make it more difficult for these species to find suitable habitat that will provide their preferred climate envelope and nesting and foraging needs (Forero-Medina et al. 2011, p. 4).

A study projected that nearly no montane forest ecosystems within El Sira Communal Reserve and habitat of the Sira curassow will exist by 2070 under the highest emissions scenario (using CMIP5 projections). We assume a similar situation would also be the case for the tropical forest habitat within the range of the southern helmeted curassow in Bolivia because both species have similar life histories, occupy similar ecosystems, and the species overlap elevational ranges that are projected to experience substantial loss of montane forests under climate change (Bax et al. 2021, p. 11).

Future Viability of the Species

The Sira curassow and southern helmeted curassow are endemics restricted to narrow elevational bands with small populations that are considered rare, locally uncommon, and decreasing. Low rates of reproduction and slow recovery of the species' populations make it difficult for these species to tolerate high levels of continuous and ongoing hunting, which is a primary threat to the species. Even though the species occur within protected areas on steep slopes that are not easily accessible and minimal loss of forest cover has occurred to date, humans will encroach into the areas where the species occur, particularly if small-scale agriculture (i.e., coca) continues to increase and future climatic conditions displace extractive actions in the forest from low-lying areas towards higher elevations. While the protected areas are relatively effective at minimizing the primary threats of hunting and habitat loss, the protected areas are not wholly protective, and the primary threats will continue to negatively affect the populations and habitats of the species over time. Additionally, climate change would reduce the species' overall habitat as the species respond to gradual changes of long-lived elements of their ecosystem (trees) and the response of competitors.

The resilience of the species to adapt and withstand ongoing hunting and habitat loss in the future is minimal. The drying of the forest because of fires and road building, combined with climate change could lead to catastrophic events for the southern helmeted curassow, and the primary threats of habitat loss and hunting will cause a decline of both species' populations and available habitat over time, thereby decreasing the redundancy and representation of both species from current conditions. Less redundancy of populations, combined with low resiliency of the species whose life history traits limit their capacity to adapt to ongoing threats and changing environmental conditions makes the species unlikely to remain viable in the future.

Uncertainty

Uncertainty in this analysis include specifics regarding the life history, population size, and distribution of both the Sira curassow and southern helmeted curassow. The species are not well studied and minimal surveys for the species have occurred. Life history traits and species needs are mostly inferred based on similar large species in the cracid family. We expect the areas where the species occur will provide some protection from human influences simply because of features of their ecosystems. However, threat factors have uncertainty because we have no way to quantify the magnitude of hunting on the species and we assume that land-use trends will continue at the same rates in the future. Furthermore, there is uncertainty with how the species and ecosystems will respond to climate change. The expectation is that the species will shift their ranges to maintain preferred niches, but it is difficult to predict which species will shift first and how far, and unclear whether long-lived species like trees can shift upslope fast enough to track climate conditions.

Literature Cited

Asociación Armonía. 2018. Armonía's species action plan for Pauxi unicornis. Received via electronic mail from Tjalle Boorsma. November 5, 2021. 12pp.

Asociación Armonía. 2021. Horned curassow conservation program. 2021 Annual Report. 7 pp.

Asociación Armonía. 2022. Horned curassow conservation program. https://armoniabolivia.org/horned-curassow-program/.

Barber, C.P., M.A. Cochrane, C.M. Souza Jr., and W.F. Laurance. 2014. Roads, deforestation, and the mitigating effect of protected areas in the Amazon. Biological Conservation 177, 203–209. http://dx.doi.org/10.1016/j.biocon.2014.07.004.

Banks, K. 1998. Breeding the Southern Helmeted Curassow at Birdworld. Avicultural magazine, 104, 152-156.

Barrio, J. 2011. Hunting pressure on cracids (Cracidae: Aves) in forest concessions in Peru. Revista Peruana de Biologia, 18(2), 225–230.

Bax, V., A. Castro-Nunez, and W. Francesconi. 2021. Assessment of potential climate change impacts on montane forests in the Peruvian Andes: Implications for conservation prioritization. Forests, 12, 375. https://doi.org/10.3390/f12030375.

Begazo, A.J. and R.E. Bodmer. 1998. Use and conservation of Cracidae (Aves: Galliformes) in the Peruvian Amazon. Oryx, 32(4), 301–309. https://doi.org/10.1046/j.1365-3008.1998.d01-60.x.

Begazo, A. (Ed.). 2022. Peru Aves. An online guide to birds of Peru: Sira curassow (*Pauxi koepckeae*) CORBIDI, Lima, Peru. [Online]. Available at http://www.peruaves.org. Accessed: October 31, 2022.

Beirne, C., Pillco-Huarcaya, R., Serrano-Rojas, S. J., and A. Whitworth. 2017. Terrestrial camera traps: essential tool for the detection and future monitoring of the Critically Endangered Sira curassow *Pauxi koepckeae*. Endangered Species Research, 32, 145–152.

Birds of Bolivia. 2019, *Pauxi unicornis* species account. https://birdsofbolivia.org/species-fact-sheets-2/guans-and-chachalacas-pavas-y-afines/pauxi-unicornis/.

BirdLife International. 2018a. *Pauxi koepckeae* (amended version of 2016 assessment). The IUCN Red List of Threatened Species 2018: e.T45090459A126994703. https://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T45090459A126994703.en. Accessed on 23 January 2023.

BirdLife International. 2018b. *Pauxi unicornis* (amended version of 2016 assessment). The IUCN Red List of Threatened Species 2018: e.T45090397A126746836. https://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T45090397A126746836.en. Accessed on 23 January 2023.

BirdLife International. 2023a. Sira curassow (*Pauxi koepckeae*). Birdlife species factsheet. http://datazone.birdlife.org/species/factsheet/sira-curassow-pauxi-koepckeae.

BirdLife International. 2023b. Horned curassow (*Pauxi unicornis*). Birdlife species factsheet. http://datazone.birdlife.org/species/factsheet/horned-curassow-pauxi-unicornis.

Boorsma, T. 2023. Peer review comments on the Species Status Assessment for the Sira Curassow and Southern Helmeted Curassow.

Bradley, A.V., and A.C. Millington. 2008. Coca and colonists: Quantifying and explaining forest clearance under coca and anti-narcotics policy regimes. Ecology and Society 13(1): 31. [online]: http://www.ecologyandsociety.org/vol13/iss1/art31/.

Bucklin, D.N. 2010. Protected-area effectiveness near dynamic colonization zones: Forest clearance in and around Amboró National Park, Bolivia. A Research Paper submitted to the Department of Geosciences Oregon State University. In partial fulfillment of the requirements for the degree of Master of Science Geography Program.

Chen, I-Ching, J.K. Hill, R. Ohlemüller, D.B. Roy, and C.D. Thomas. 2011. Rapid range shifts of species associated with high levels of climate warming. Science, Vol. 333, 1024–1026.

Cordier, C. 1971. The quest for the horned curassow. Animal Kingdom, April 1971.

Cox, G., J.M. Read, R.O.S. Clarke, and V.S. Easty. 1997. Studies of horned curassow Pauxi unicornis. Bird Conservation International, 7:199–211.

del Hoyo, J., N.J. Collar, D.A. Christie, A. Elliott, and L.D.C. Fishpool. 2018a. HBW and BirdLife International Illustrated Checklist of the Birds of the World. Volume 1: Non-passerines. Lynx Edicions BirdLife International, Barcelona, Spain and Cambridge, UK. Accessed through IUCN Red List. BirdLife International. 2018. *Pauxi unicornis* (amended version of 2016 assessment). The IUCN Red List of Threatened Species 2018: e.T45090397A126746836. https://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T45090397A126746836.en. Accessed on 23 January 2023.

del Hoyo, J., N.J. Collar, D.A. Christie, A. Elliott, and L.D.C. Fishpool. 2018b. HBW and BirdLife International Illustrated Checklist of the Birds of the World. Volume 1: Non-passerines. Lynx Edicions BirdLife International, Barcelona, Spain and Cambridge, UK. Accessed through IUCN Red List. BirdLife International. 2018. *Pauxi koepckeae* (amended version of 2016 assessment). The IUCN Red List of Threatened Species 2018: e.T45090459A126994703. https://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T45090459A126994703.en. Accessed on 23 January 2023.

del Hoyo, J., G.M. Kirwan, and D. Christie. 2020. Horned Curassow (*Pauxi unicornis*), version 1.0. In Birds of the World (J. del Hoyo, A. Elliott, J. Sargatal, D. A. Christie, and E. de Juana, Editors). Cornell Lab of Ornithology, Ithaca, NY, USA. https://doi.org/10.2173/bow.horcur3.01.

del Hoyo, J., N. Collar, D.A. Christie, and G.M. Kirwan. 2020. Sira Curassow (*Pauxi koepckeae*), version 1.0. In Birds of the World (J. del Hoyo, A. Elliott, J. Sargatal, D. A. Christie, and E. de Juana, Editors). Cornell Lab of Ornithology, Ithaca, NY, USA. https://doi.org/10.2173/bow.horcur2.01.

del Rosario Avalos, V. and J. Hernández. 2015. Projected distribution shifts and protected area coverage of range-restricted Andean birds under climate change. Global Ecology and Conservation 4, 459–469. http://dx.doi.org/10.1016/j.gecco.2015.08.004.

Dunning, J.B., H.R. Pulliam, and B.J. Danielson. 1992. Ecological processes that affect populations in complex landscapes. Oilos 65(1):169–175. DOI:10.2307/3544901.

Elkins, Z., T. Ginsburg, and J. Melton. Constitute: The World's Constitutions to Read, Search, and Compare. Online at constituteproject.org. Bolivia's Constitution of 2009.

Fernández-Llamazares, A., J. Helle, J. Eklund, A. Balmford, M. Moraes, V. Reyes-García, and M. Cabeza. 2018. New law puts Bolivian diversity hotspot on road to deforestation. Current Biology 28, R1–R16. https://doi.org/10.1016/j.cub.2017.11.013.

Fernández-Llamazares, A. and R. Rocha. 2015. Bolivia set to violate its protected areas. Nature 523, 158 (2015). https://doi.org/10.1038/523158c.

Finer, M., S. Novoa, C. Cruz, and N. Peña. 2016. Deforestation Hotspot in the central Peruvian Amazon. Monitoring of the Andean Amazon Project (MAAP): 37. https://maaproject.org/2016/hotspot-huanuco/.

Forero-Medina, G, J. Terborgh, S.J. Socaloar, and S.L. Pimm. 2011. Elevational ranges of birds on a tropical montane gradient lag behind warming temperatures. PLoS ONE 6(12): e28535. doi:10.1371/journal.pone.0028535. 5pp.

Freeman, B.G., M.N. Scholer, V. Ruiz-Gutierrez, and J.W. Fitzpatrick. 2018. Climate change causes upslope shifts and mountaintop extirpations in a tropical bird community. PNAS, Vol. 115 (47), 11982–11987. https://doi.org/10.1073/pnas.1804224115.

Foster, P. 2001. The potential negative impacts of global climate change on tropical montane forest clouds. Earth-Science Reviews 55, pp. 73–106. https://doi.org/10.1016/S0012-8252(01)00056-3.

Gastañaga, M. and A.B. Hennessey. 2005. Uso de información local para reevaluar la población de Pauxi unicornis en Perú. Cotniga 23: 18–22.

Gastañaga, M. 2006. Assessment of conservation status of the newly rediscovered southern horned curassow and associated biodiversity in Peru. Final report. 53 pp.

Gastañaga, M., A.B. Hennessey, and R. MacLeod. 2007. Rediscovery of southern horned curassow *Pauxi unicornis koepckeae* in Cerros del Sira, Peru. Cotinga 28: 63–66.

Gastañaga, M., R. MacLeod, D.M. Brooks, and B. Hennessey. 2011. Distinctive morphology, ecology, and first vocal descriptions of Sira curassow (Pauxi [unicornis] koepckeae): evidence for species rank. Ornitologia Neotropical. 22: 267–279.

Global Forest Watch (GFW). 2022. Analysis of Peru and Bolivia. https://www.globalforestwatch.org/map/. Accessed 2022.

Herzog, S.K., and M. Kessler. 1998. In search of the last Horned Curassows (Pauxi unicornis) in Bolivia. Cotinga 10, Pp. 46–48.

Hosner, P.A., E.L. Braun, and R.T. Kimball. 2016. Rapid and recent diversification of curassows, guans, and chachalacas (Galliformes: Cracidae) out of Mesoamerica: Phylogeny inferred from mitochondrial, intron, and ultraconserved element sequences. Molecular Phylogenetics and Evolution. Vol. 102, Pp. 320–330.

International Union for Conservation of Nature. 2023a. Red list assessment for Sira curassow (*Pauxi koepckeae*). https://www.iucnredlist.org/species/45090459/126994703.

International Union for Conservation of Nature. 2023b. Red list assessment for horned curassow (*Pauxi unicornis*). https://www.iucnredlist.org/species/45090397/126746836.

International Union for Conservation of Nature (IUCN). 2023c. Protected area and land use. https://www.iucn.org/.

Intergovernmental Panel on Climate Change (IPCC). 2014. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151pp.

International Tribunal for the Rights of Nature (ITRN). 2019. Report of the Commission of the International Rights of Nature Tribunal on the case of the Isiboro Sécure Indigenous Territory and National Park (TIPNIS - Bolivia). 29pp.

Josse, C., F. Cuesta, GF. Navarro, V. Barrena, M.T. Becerra, E. Cabrera, E. Chacón-Moreno, W. Ferreira, M. Peravlo, J. Saito, A. Tovar, and L.G. Naranjo. 2011. Physical Geography and ecosystems in the tropical Andes. Chapter 10, pp. 153–169. In Climate Change and Biodiversity in the Tropical Andes. Edited by: Sebastian K. Herzog, Rodney Martínez, Peter M. Jørgensen, Holm Tiessen. 2011. Inter-American Institute for Global Change Research

(IAI) and Scientific Committee on Problems of the Environment (SCOPE), 348 pp. ISBN: 978-85-99875-05-6.

Kattan, G.H., H. Alvarez-Lopez, and M. Giraldo. 1994. Forest fragmentation and bird extinctions: San Antonio eighty years later. Conservation Biology, Vol. 8, No. 1, pp. 138–146. https://www.jstor.org/stable/2386728.

Kattan, G.H., M.C. Muñoz, and D.W. Kikuchi. 2016. Population densities of curassows, guans, and chachalacas (Cracidae): Effects of body size, habitat, season, and hunting. The Condor: Ornithological Applications 118:24–32. DOI: 10.1650/CONDOR-15-51.1.

Killeen, T.J., V. Calderon, L. Soria, B. Quezada, M.K. Steininger, G. Harper, L.A. Solórzano, C.J. Tucker. 2007. Thirty years of land-cover change in Bolivia. Ambio, Vol. 26, No. 7, pp. 600–606. https://www.jstor.org/stable/25547819.

Larsen, T.H., G. Brehm, H. Navarrete, P. Franco, H. Gomez, J.L. Mena, V. Morales, J. Argollo, L. Blacutt, and V. Canhos. 2011. Range shifts and extinctions driven by climate change in the Tropical Andes: Synthesis and directions. Chapter 3, pp. 47–67. In Climate Change and Biodiversity in the Tropical Andes. Edited by: Sebastian K. Herzog, Rodney Martínez, Peter M. Jørgensen, Holm Tiessen. 2011. Inter-American Institute for Global Change Research (IAI) and Scientific Committee on Problems of the Environment (SCOPE), 348 pp. ISBN: 978-85-99875-05-6.

La Sorte, F.A. and W. Jetz. 2010. Projected range contractions of montane biodiversity under global warming. Proc. R. Soc. B 277, 3401–3410. doi:10.1098/rspb.2010.0612.

Lauranc, W.F., M. Goosem, and S.G.W. Laurance. 2009. Impacts of linear clearings. Trends in Ecology and Evolution. Vol. 24, No. 12, pp. 659–669. https://doi.org/10.1016/j.tree.2009.06.009.

Lees, A.C. and C.A. Peres. 2006. Rapid avifaunal collapse along the Amazonian deforestation frontier. Biological Conservation 133, 198–211.

Lees, A.C. and C.A. Peres. 2009. Gap-crossing movements predict species occupancy in Amazonian forest fragments. Oikos 118: 280–290. doi: 10.1111/j.1600-0706.2008.16842.x.

Lees, A.C. and C.A. Peres. 2010. Habitat and life history determinants of antbird occurrence in variable-sized Amazonian forest fragments. Biotropica, Vol. 42(5): 614–621. https://www.jstor.org/stable/40863798?seq=1&cid=pdf-reference#references_tab_contents.

Lexivox. 2023. Bolivia: Framework Law on Mother Earth and Integral Development for Living Well, October 15, 2012. Obtained from: https://www.lexivox.org/norms/BO-L-N300.xhtml?.

MacLeod, R. R. Soria, and M. Gastañaga. 2006. Horned curassow (Pauxi unicornis). Pp. 60–63. In: Conserving Cracids: the most Threatened Family of Birds in the Americas (D.M. Brooks, Ed.). Misc. Publ. Houston Mus. Nat. Sci., No. 6, Houston, TX.

MacLeod, R. 2009. Threatened birds of Bolivia Project 2004 to 2009. Final Report. Division of Ecology & Evolutionary Biology Graham Kerr Building, Glasgow University Glasgow G12 8QQ, UK. 106 pp.

Mee, A. 1999. Habitat associations and notes of southern helmeted curassow (Pauxi unicornis) in the national par Carrasco, Bolivia. Pp. 17–20.

Mee, A. and J.I. Ohlson. 2002. The Cerros Del Sira revisted: Birds of sub-montane and montane forest. Cotinga 18: 46–57.

National Aeronautics and Space Administration (NASA). 2020. Global Climate Change. Facts. https://climate.nasa.gov/.

Novoa, S. M. Finer, and C. Snelgrove. 2016. Threats to Peru's El Sira Communal Reserve. Monitoring of the Andean Amazon Project (MAAP): 45. https://maaproject.org/2016/el-sira-reserve/.

Pathak, M., R. Slade, P.R. Shukla, J. Skea, R. Pichs-Madruga, and D. Ürge-Vorsatz. 2022. Technical Summary. In: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, J. Malley, (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA. doi: 10.1017/9781009157926.002. https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_TechnicalSummary.pdf.

Pauquet, S., A. Monjeau, J. Marquez, and V.F. Montoni. 2005. Diagnosis of Amboro National Park and Integrated Management Natural Area. Parkswatch Park Profile Series (http://www.parkswatch.org/parkprofiles/pdf/amnp_eng.pdf.

Parkswatch. 2003. Profile of protected area – Peru El Sira Communal Reserve. 5pp. www.parkswatch.org.

Pearson, D.L., C.D. Anderson, B.R. Mitchell, M.S. Rosenberg, R. Navarrete, and P. Coopmans. 2010. Testing hypotheses of bird extinctions and Rio Palenque, Ecaudor, with informal species lists. Conservation Biology, Vol. 24, No. 2, pp. 500–510. https://www.jstor.org/stable/40603375.

Peh, K.S.H. 2007. Potential effects of climate change on elevational distributions of tropical birds in Southeast Asia. The Condor, Vol. 109(2), pp. 437–441. https://www.jstor.org/stable/4500973.

Renjifo, J. and J.T. Renjifo. 1997. *Pauxi unicornis*: Biologia y Ecologia. CDC 4830; Santa Cruz; Bolivia. 4pp.

Riahi, K., R. Schaeffer, J. Arango, K. Calvin, C. Guivarch, T. Hasegawa, K. Jiang, E. Kriegler, R. Matthews, G.P. Peters, A. Rao, S. Robertson, A.M. Sebbit, J. Steinberger, M. Tavoni, and D.P. van Vuuren. 2022. Mitigation pathways compatible with long-term goals. In IPCC, 2022: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, J. Malley, (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA. doi: 10.1017/9781009157926.005. https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_Chapter03.pdf.

Rios, E., P.J.K. McGowan, N.J. Collar, A. Benchimol, G.R. Canale, F. Olmos, M. Santos-Filho, and C.S.S. Bernardo. 2021. Which is worse for the red-billed curassow: habitat loss or hunting pressure? Oryx, 55(3), 412–420. Published by Cambridge University Press on behalf of Fauna & Flora International doi:10.1017/S0030605319000711.

Sekercioglu, C.H., S.H. Schneider, J.P. Fay, and S.R. Loarie. 2008. Climate change, elevational range shifts, and bird extinctions. Conservation Biology, Volume 22, No. 1, 140–150. DOI: 10.1111/j.1523-1739.2007.00852.x.

Sekercioglu, C.H., R.B. Primack, and J. Wormworth. 2012. The effects of climate change on tropical birds. Biological Conservation 148, pp. 1–18.

Shaffer, M.L., and M.A. Stein. 2000. Safeguarding our precious heritage. In: Stein BA, Kutner LS, Adams JS, editors. Precious heritage: the status of biodiversity in the United States. New York: Oxford University Press. pp. 301-321.

Smith, D.R., N.L. Allan, C.P. McGowan, J.A. Szymanski, S.R. Oetker, and H.M. Bell. 2018. Development of a species status assessment process for decisions under the U.S. Endangered Species Act. Journal of Fish and Wildlife Management, 9:302–320.

Solano, P. 2010. Legal framework for protected areas: Peru. Gland, Switzerland: IUCN. 51pp.

Still, C.J., P.N. Foster, and S.H. Schneider. 1999. Simulating the effects of climate change on tropical montane cloud forests. Nature, Vol. 398, 608–610. https://doi.org/10.1038/19293.

Strahl, S.D. and A. Grajal. 1991. Conservation of large avian frugivores and the management of Neotropical protected areas. Oryx, Vol. 25(1), pp. 50–55. https://doi.org/10.1017/S0030605300034074.

Terando, A., D. Reidmiller, S.W. Hostetler, J.S. Littell, T. Douglas Beard, Jr.S.R. Weiskopf, J. Belnap, and G.S. Plumlee. 2020. Using information from global climate models to inform Policymaking—The role of the U.S. Geological Survey. Obtained from: https://pubs.er.usgs.gov/publication/ofr20201058.

The National Service of Protected Areas (Sernap). 2023. http://sernap.gob.bo/.

Thiollay, J-M. 1999. Responses of an avaian community to rain forest degradation. Biodiversity and Conservation, 8: 513–534. DOI: 10.1023/A:1008912416587.

Thiollay, J-M. 2005. Effects of hunting on Guianan forest game birds. Biodiversity and Conservation 14: 1121–1135. DOI 10.1007/s10531-004-8412-4.

Thorton, D.J., L.C. Branch, and M.E. Sunquist. 2012. Response of large galliforms and tinamous (Cracidae, Phasianidae, Tinamidae) to habitat loss and fragmentation in northern Guatemala. Oryx, 46(4), 567–576 doi:10.1017/S0030605311001451.

Thurman, L.L., B.A. Stein, E.A. Beever, W. Foden, S.R. Geange, N. Green, J.E. Gross, D.J. Lawrence, O. LeDee, J.D. Olden, L.M. Thompson, and B.E. Young. 2020. Persist in place or shift in space? Evaluating the adaptive capacity of species to climate change. Front Ecol Environ 2020; 18(9): 520–528, doi:10.1002/fee.2253.

Tobias, J.A., and J. del Hoyo. 2006. Birding in Bolivia: putting two rare curassows on the map. Neotropical Birding. Pp. 61–65. CROWES NeoBird1-060726.qxp.

Tobias, J.A., N. Seddon, C.N. Spottiswoode, J.D. Pilgrim, L.D.C. Fishpool, and N.J. Collar. 2010. Quantitative criteria for species delimitation. The International Journal of Avian Science. Ibis. doi: 10.1111/j.1474-919X.2010.01051.x.

Riveros, J.C., M. Martir-Torres, C. Ipenza, and P. Tello. 2019. USAID/Peru 118/119 Tropical forest and biodiversity analysis. United States Agency for International Development (USAID). 142pp.

United Nations Climate Change. 2023. National Determined contributions (NDCs). The Paris Agreement and NDCs. https://unfccc.int/ndc-information/nationally-determined-contributions-ndcs.

United Nations Environment Programme. 2020. IUCN category VI – protected areas with sustainable use of natural resources. https://www.biodiversitya-z.org/content/iucn-category-vi-protected-area-with-sustainable-use-of-natural-resources#:~:text=Category%20VI%20%28Protected%20area%20with%20sustainable%20use%20of,conservation%20and%20sustainable%20use%20can%20be%20mutually%20beneficial.

United States Fish and Wildlife Service (FWS). 2016. USFWS Species Status Assessment Framework: an integrated analytical framework for conservation. Version 3.4 dated August 2016.

Van Gils, H.A.M.J. and A.V.L. Armand Ugon. 2006. What drives conversion of tropical forest in Carrasco Province, Bolivia? Ambio, Vol. 35, Vol. 2, pp. 81–85. https://www.jstor.org/stable/4315690.

Velasquex-Tibata, J.I., C. Graham, and P. Salaman. 2012. Effects of climate change on species distribution, community structure, and conservation of birds in protected areas in Colombia. Regional Environmental Change 13:235–248. doi:10.1007/s10113-012-0329-y.

Vetter, D., M.M. Hansbauer, Z. Végvári, and I. Storch. 2011. Predictors of forest fragmentation sensitivity in Neotropical vertebrates: a quantitative review. Ecography 34: 1–8. doi: 10.HH/j.1600-0587.2010.06453.x.

Wildlife Conservation Society (WCS). 2017. Protected area management. WCS Bolivia > Global Initiatives > Protected area management.

WorldBank Group. 2007. Peru - Indigenous Management of Protected areas in the Peruvian Amazon Project (GEF) (English). http://documents.worldbank.org/curated/en/225791468758385095/Peru-Indigenous-Management-of-Protected-areas-in-the-Peruvian-Amazon-Project-GEF.

WorldBank Group. 2022. Climate change knowledge portal. For development practitioners and policy makers. https://climateknowledgeportal.worldbank.org/.

Young, B.E., K.R. Young, and C. Josse. 2011. Vulnerability of tropical Andean Ecosystems to climate change. Chapter 11, pp. 170–181. In Climate Change and Biodiversity in the Tropical Andes. Edited by: Sebastian K. Herzog, Rodney Martínez, Peter M. Jørgensen, Holm Tiessen. 2011. Inter-American Institute for Global Change Research (IAI) and Scientific Committee on Problems of the Environment (SCOPE), 348 pp. ISBN: 978-85-99875-05-6.

Appendix A: SSA support for curassow

11/15/2021

Species:

- Sira curassow (*Pauxi koepckeae*)
- Southern helmeted curassow (*Pauxi unicornis*)

Request:

- Identify the habitat used by each species, based on the South American Terrestrial Ecosystems layer and IUCN range maps.
- The sira currassow range is almost entirely within the El Sira Communal Reserve. The Reserve falls within the Departments of Huánuco, Pasco, and Ucayali. The request is to quantify forest lost over time within the range of the species, and within the three Departments. We will also buffer an area 20 km around the range of the species, and report the forest loss over time in the protected and non-protected areas within this buffer.
- The southern helmeted curassow range is almost entirely within three national parks: Amboró, Carrasco, and Isiboro-Securé Indigenous Territory and National Parks. These National parks are within the Departments of Cochabamba and Santa Cruz. The request is to quantify forest lost over time within the range of the species, and within each of the two Departments. We will also buffer an area 20 km around the range of the species, and report the forest loss over time in the protected and non-protected areas in this buffer.

Methods

We used range maps generated by the IUCN to specify the range for the sira curassow (BirdLife International, 2018a) and southern helmeted curassow (BirdLife International, 2018b). For the helmeted curassow, we specifically used the shapefile for the extant range. We retrieved administrative boundaries for Bolivia and Peru from the United Nation's Office for the Coordination of Human Affairs (OCHA) Regional Office for Latin America and the Caribbean. We retrieved the protected area boundaries for each country from The World Database on Protected Areas (UNEP-WCMC and IUCN 2021).

To assess the habitat used by each species, we used the 100-m resolution South America Terrestrial Ecosystems layer, which was produced by the U.S. Geologic Survey, NatureServe, and the Nature Conservancy in 2008 based on climate, landform, and geologic data. To characterize the habitat in which each species' occurred, we reported the % cover of the different ecosystem types within each species' range.

To assess habitat loss over time, we used 30-m resolution forest loss data based on time-series Landsat imagery (Hansen et al. 2013). The forest loss data developed by Hansen et al. (2013) are annually updated by the Global Land Analysis and Discovery (GLAD) laboratory at the

University of Maryland, in partnership with Global Forest Watch (GFW), and currently span 2000- 2020. We also retrieved rasters from the GLAD site that delineate areas of missing data and open water within the study site. We summarized the total forest loss from 2000-2005; 2006-2010; 2011-2015; and 2016-2020 across each species' range. Since these species have small endemic ranges, we also sought to characterize local habitat loss surrounding the areas the species inhabit. To this end, we summarized forest loss over time in protected and non-protected land within a 20km buffer around each of each species' range. Finally, we also summarized forest loss over time within the political districts surrounding each species' range, to help describe forest loss at a larger regional context.

We used ArcGIS Pro to mosaic the series of forest loss rasters covering the study area, and the series of raster layers representing areas of missing data or open water. We masked the forest loss rasters by the latter, to exclude areas of missing data or open water from the analysis. We buffered each species' range by 20 km, and subdivided the land area in each buffer by protected status. We subsequently used the "Tablulate Area" tool in ArcGIS Pro to tally the area of forest loss (in kha) by year within each of the spatial areas of interest.

Results

Habitat use

The Yungas Lower Montane Pluvial Palm Forest was the most abundant habitat type within the range of each species, and the SE Amazonian Preandean Upper Hill Evergreen Forest was the second most abundant.

Table 1. Ecosystems within the range of the sira curassow, with the percent cover of each ecosystem listed.

ecosystem	percent cover
Yungas Lower Montane Pluvial Palm Forest	53.73
SE Amazonian Preandean Upper Hill Evergreen Forest	44.50
Yungas Montane Pluvial Forest	1.71
Blue Range Marsh Palm	0.06

Table 2. Ecosystems within the range of the southern helmeted curassow, with the percent cover of each ecosystem listed.

ecosystem	percent cover
Yungas Lower Montane Pluvial Palm Forest	39.41
SE Amazonian Preandean Upper Hill Evergreen Forest	33.11

Septentrional Chaco-Chiquitania Transitional Alluvial Plain Forest	10.56
Barren, converted, water, or unknown land cover	8.36
Chiquitania-Beni Subhumid Semi-deciduous Forest	4.31
Bolivian-Tucuman-Yungas Transitional Subandean Forest	1.87
Yungas Montane Pluvial Forest	1.34
SW Amazonian Whitewater Alluvial Plain Floodplain Forest	0.52
Amazonian Whitewater Riparian Successional Vegetation Complex	0.32
Pino de Monte Bolivian-Tucuman Montane Forest	0.13
Bolivian-Tucuman Upper Montane Grassland	0.03
Yungas Pluvio Seasonal Montane Forest	0.02
SE Amazonian Piedmont Forest	0.01
Humid Puna Upper Andean Aquatic and Marsh Vegetation	0.01

Habitat loss over time

Sira curassow

Table 3 Estimates of remaining forest cover over time (in kha), within the range of the sira curassow, in the protected areas within a 20 km buffer of the species' range, and in the non-protected areas within a 20 km buffer of the species' range.

year	range	protected	non-protected
2000	39.444	155.199	158.561
2005	39.439	154.923	155.141
2010	39.425	154.429	150.991
2015	39.389	153.342	140.456
2020	39.382	151.570	130.576

Table 4 Forest loss over time for the sira curassow. The values include the total forest cover lost in each time span (in kha) and the percent of forest cover lost in each time span within three spatial extents: 1) the species' range, 2) the protected areas within a 20 km buffer of the range, and 3) the non-protected areas within a 20 km buffer of the range.

year	range kha	range %	protected kha	protected %	non-protected kha	non-protected %

2001-2005	0.005	0.013	0.276	0.178	3.420	2.157
2006-2010	0.014	0.037	0.494	0.319	4.150	2.675
2011-2015	0.035	0.090	1.087	0.704	10.535	6.977
2016-2020	0.007	0.017	1.773	1.156	9.880	7.035

Southern helmeted curassow

Table 5 Estimates of remaining forest cover over time (in kha) within the range of the southern helmeted curassow, in the protected areas within a 20 km buffer of the species' range, and in the non-protected areas within a 20 km buffer of the species' range.

year	range	protected	non-protected
2000	819.632	785.761	532.522
2005	812.635	771.310	492.977
2010	806.735	757.711	460.377
2015	801.103	743.090	427.769
2020	792.317	724.759	388.323

Table 6 Forest loss over time for the southern helmeted curassow. The values include the total forest cover lost in each time span (in kha) and the percent of forest cover lost in each time span within three spatial extents: 1) the species' range, 2) the protected areas within a 20 km buffer of the range, and 3) the non-protected areas within a 20 km buffer of the range.

year	range kha	range %	protected kha	protected %	non-protected kha	non-protected %
2001-2005	6.997	0.854	14.451	1.839	39.546	7.426
2006-2010	5.899	0.726	13.599	1.763	32.600	6.613
2011-2015	5.633	0.698	14.621	1.930	32.608	7.083
2016-2020	8.785	1.097	18.331	2.467	39.445	9.221

Forest loss across Peru

Table 7 Estimates of remaining forest cover over time (in kha) within the three districts surrounding the range of the sira curassow in Peru.

year	Huanuco	Pasco	Ucayali
2000	3325.877	2229.741	9833.713
2005	3258.285	2208.372	9753.944

2010	3177.462	2182.661	9651.336
2015	3042.347	2134.736	9453.737
2020	2910.531	2080.332	9199.252

Table 8 Total forest cover lost in each time span (in kha), and the percent of forest cover lost in each time span in the three districts surrounding the range of the sira curassow in Peru.

year	Huanuco kha	Huanuco %	Pasco kha	Pasco %	Ucayali kha	Ucayali %
2001-2005	67.592	2.032	21.369	0.958	79.769	0.811
2006-2010	80.823	2.481	25.711	1.164	102.608	1.052
2011-2015	135.115	4.252	47.926	2.196	197.599	2.047
2016-2020	131.816	4.333	54.403	2.548	254.485	2.692

Forest loss across Bolivia

Table 9 Estimates of remaining forest cover over time (in kha) within the two districts surrounding the range of the southern helmeted curassow in Bolivia.

year	Santa_Cruz	Cochabamba
2000	32274.28	5190.884
2005	31656.05	5132.863
2010	30668.90	5071.001
2015	29831.58	5012.233
2020	27780.05	4946.089

Table 10 Total forest cover lost in each time span (in kha), and the percent of forest cover lost in each time span in the two districts surrounding the range of the southern helmeted curassow in Bolivia.

year	Santa Cruz kha	Santa Cruz %	Cochabamba kha	Cochabamba %
2001-2005	618.226	1.916	58.021	1.118
2006-2010	987.153	3.118	61.862	1.205
2011-2015	837.313	2.730	58.767	1.159
2016-2020	2051.533	6.877	66.144	1.320

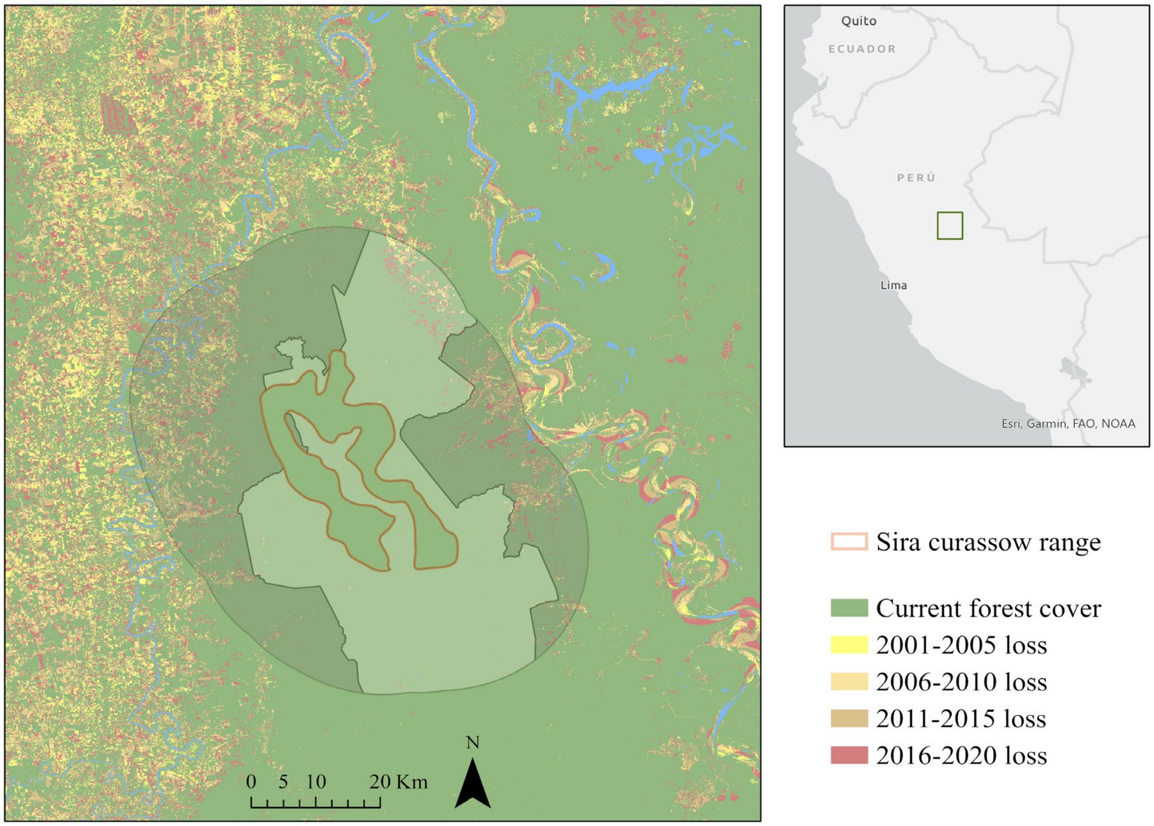


Figure 1. *Current forest cover and forest loss over time in the range of the sira curassow, with open water in blue. A shaded 20 km buffer is displayed around the species' range, with the lighter area in protected status and the darker area in non-protected status. The location of the species' range within Peru is shown in the inset.*

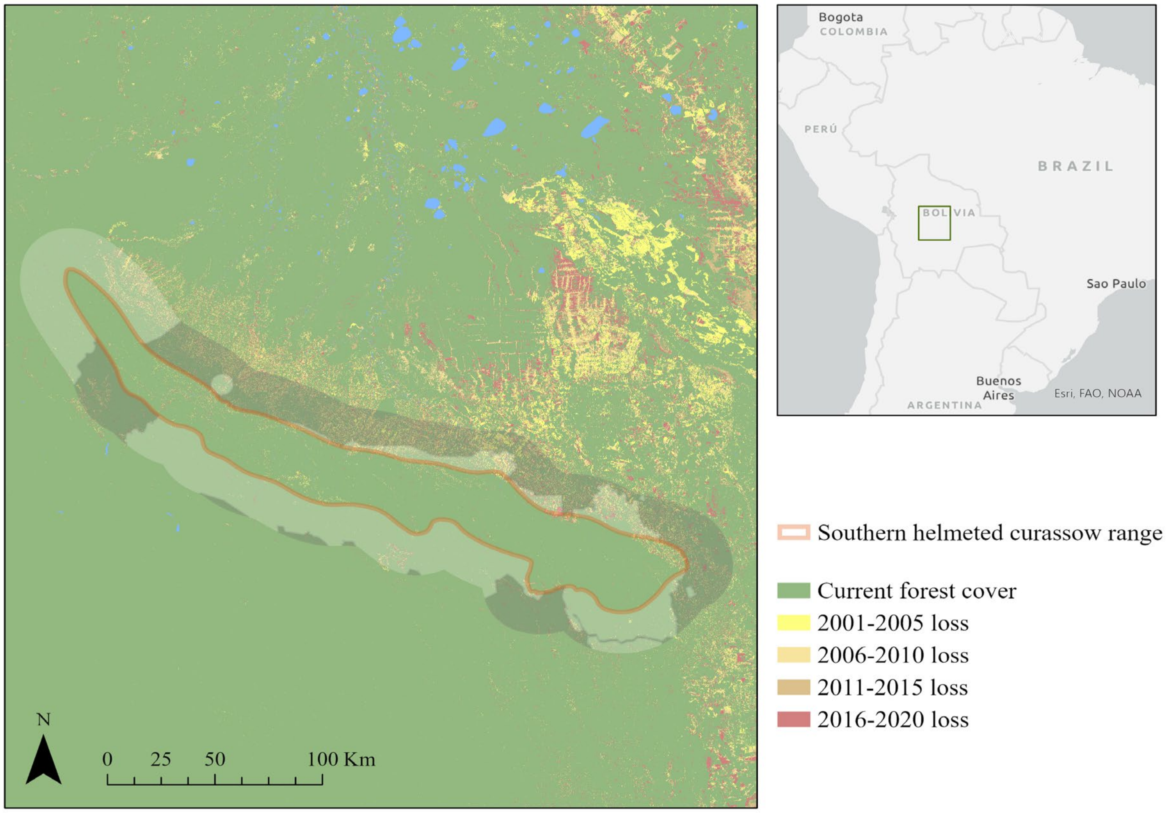


Figure 2. *Current forest cover and forest loss over time in the range of the southern helmeted curassow, with open water in blue. A shaded 20 km buffer is displayed around the species' range, with the lighter area in protected status and the darker area in non-protected status. The location of the species' range within Bolivia is shown in the inset.*

Assumptions and uncertainty

There are number of key assumptions and sources of uncertainty that must be considered when interpreting historical loss of forest cover. The forest cover layers we used to estimate temporal patterns in forest cover are based on the statistical classification model of Hansen et al. (2013), which has inherent uncertainties and error. Furthermore, as noted by researchers at the Global Land Analysis and Discovery laboratory, improvements in Landsat mapping technology have improved the efficacy of mapping land change over time, which in turn has led to minor year-to-year inconsistencies in forest cover data. These improvements include variation in 1) Landsat sensor technology, 2) the number of viable land observations available as inputs to analysis, and 3) algorithms (including adjustments of input image feature space and training data), 4) the ability to detect smallholder rotation agricultural clearing in tropical regions, and 5) the ability to detect selective logging. These data sources are therefore not appropriate for generating absolute, definitive estimates of forest cover area or temporal trends, but can be considered "viable relative indicator of trends". Finally, it is important to note that disturbance events smaller than the 30-m resolution of the forest loss raster data are difficult to detect, particularly when they occur on the edge of regions with existing loss (Vieilledent et al. 2018).

Citations

BirdLife International. 2018a. Pauxi koepckeae (amended version of 2016 assessment). The IUCN Red List of Threatened Species 2018: e.T45090459A126994703. https://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T45090459A126994703.en. Downloaded on 03 November 202

BirdLife International. 2018b. Pauxi unicornis (amended version of 2016 assessment). The IUCN Red List of Threatened Species 2018: e.T45090397A126746836. https://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T45090397A126746836.en. Downloaded on 03 November 2021.

Hansen, M.C., Potapov, P.V., Moore, R., Hancher, M., Turubanova, S.A., Tyukavina, A., Thau, D., Stehman, S.V., Goetz, S.J., Loveland, T.R., Kommareddy, A., Egorov, A., Chini, L., Justice, C.O., Townshend, J.R.G., 2013. High-resolution global maps of 21st-century forest cover change. Science 342, 850–853.

UNEP-WCMC and IUCN (2021), Protected Planet: The World Database on Protected Areas (WDPA) and World Database on Other Effective Area-based Conservation Measures (WD-OECM) [Online], November 2021, Cambridge, UK: UNEP-WCMC and IUCN. Available at: www.protectedplanet.net.

Vieilledent, G., Grinand, C., Rakotomalala, F.A., Ranaivosoa, R., Rakotoarijaona J., T.F., Achard, F., 2018. Combining global tree cover loss data with historical national forest-cover maps to look at six decades of deforestation and forest fragmentation in Madagascar. Biological Conservation 222, 189-197.