

Priority conservation areas for birds in El Salvador

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Abstract

El Salvador has the smallest protected areas system in Central America. High levels of habitat destruction and disturbance throughout the country make the reserve system especially important for conservation of biodiversity. I used complementarity approaches to assess the relative conservation importance of ten reserves in El Salvador. The principal criterion was presence of nationally threatened and endangered bird species. Additional criteria included residency status (resident species were more important than migratory non-breeding species) and regionally endemic species. Montecristo National Park was the most important area, with 42% of all nationally threatened birds present. El Imposible National Park, El Salvador's largest park (5000 ha), scored second, followed by Laguna El Jocotal wildlife refuge and Barra de Santiago wildlife refuge. In all, these four areas provide refuge for 83% of El Salvador's 268 nationally threatened bird species in less than 7600 ha of natural habitat. Because of small reserve sizes, all of El Salvador's threatened birds may need additional protection.

INTRODUCTION

El Salvador is a small country (2100 km²) situated in the heart of the northern Central America bioregion (southern Mexico, Belize, Guatemala, Honduras and northern Nicaragua). The country's rich soils and volcanic landscape have been widely altered by extensive agricultural and urban development during the nineteenth and twentieth centuries (Daugherty, 1972). Compared to other Latin American countries, relatively little natural habitat remained, but none the less El Salvador established a protected areas system in the 1970s. The system developed little during the 1980s owing to a civil war, but a surge in environmental awareness in the early 1990s, spurred by growth in ecotourism in nearby countries (especially Belize and Costa Rica), led to renewed conservation efforts (Secretaría Ejecutiva de Medio Ambiente, 1994). The environmental movement during the last decade has inspired widespread interest and support for wildlife and protected areas among the general populace. Nevertheless, El Salvador's protected areas system is by far the smallest in the region, in terms of both overall area and proportion of national territory (Rodríguez, 1998).

Although the protected areas are small, they are important for maintaining high levels of biodiversity for El Salvador and the northern Central America region.

The ten reserves considered in this paper are home to 237 locally threatened bird species (most are habitat specialists). Despite the country's small size and high population density (highest in Latin America with over 6 million human inhabitants), El Salvador has relatively high species richness. Over 520 species of birds have been reported (Komar & Domínguez, 2001), 121 terrestrial mammals (Owen, Knox & Baker, 1991), and 130 reptiles and amphibians (Dueñas, Wilson & McCranie, 2001). Because of its small size and extensive deforestation, El Salvador is frequently considered of little importance for global-level biodiversity conservation. However, the country contains some natural resources of global significance. New species are still being described (e.g., Kilian & Smalla, 2001), some of which may be completely restricted to the country. Little biological research has been undertaken (Winker, 1998; Johnson, 2001), and the extent and value of El Salvador's biological resources is still poorly known (Ministerio de Medio Ambiente y Recursos Naturales, 2000). Six regionally threatened ecoregions occur in El Salvador (Dinerstein *et al.*, 1995), including five forest ecosystems of high conservation priority at a regional scale, and one of moderate conservation priority. They are Central American Montane Forests, Central American Pine–Oak Forests, Central American Dry Forests, Sierra Madre de Chiapas Moist Forest, Gulf of Fonseca Mangroves and Northern Dry Pacific Coast Mangroves, the latter best represented by the extensive Jiquilisco Bay mangroves in El Salvador. These eco-

systems occur globally over a relatively small area on the Pacific slope of Central America.

With limited financial resources available for conservation in El Salvador, it would be useful for maximum efficiency to base conservation action on biological data. I conducted the present analysis to identify protected areas most important for the conservation of avian diversity, such that conservation agencies working in El Salvador could prioritize the allocation of budgets among the protected areas. I used only birds because sufficiently complete species lists for other taxa were not available. I based the analysis on nationally threatened and regionally endemic bird species (rather than overall species richness) because the primary goal of conservation is to prevent extinction of species. To include all species would bias reserve selection towards sites with large numbers of common, widespread species that occur in areas with high levels of habitat disturbance. Only one bird species in El Salvador is globally endangered (Hilton-Taylor, 2000), so using globally threatened species for the analysis would not have been useful. Williams *et al.* (1996) and Dobson *et al.* (1997) argued that a complementarity scheme was the most effective way to plan conservation, as it does not depend on subjective indices, and identifies areas where conservation action is most needed to protect a regional biota.

METHODS

I included in the analysis the ten protected areas (Fig. 1) for which reasonably complete bird lists have

been prepared by experienced observers (Komar & Herrera, 1995; Ramírez-Sosa & Komar, 1996; Komar, 2000; N. Herrera, unpubl. data; O. Komar, unpubl. data). These are the largest protected areas in the country (Table 1), and have park guards, signage and recognition by Salvadoran society.

I identified conservation priorities for the reserves using an iterative, heuristic complementarity algorithm (Kirkpatrick, 1983; Williams *et al.*, 1996; Peterson, Ball & Brady, 2000a; Peterson *et al.*, 2000b), in which reserves were selected (prioritized) based on the number of additional species of threatened birds protected by conserving the reserve. I used a list of 268 threatened or endangered bird species (Komar & Domínguez, 2001) modified from a similar list (Komar, 1998) that included habitat specialists (species sensitive to habitat destruction), species suspected of population declines due to pollution or water contamination, or species subject to excessive hunting or commercialization. The presence/absence of threatened species in each protected area is given in Appendix 1. Species not likely to be regular components of a local avifauna, but nevertheless reported, were considered absent. The algorithm has four steps: (1) Select the reserve that protects the greatest number of threatened species. (2) Of the remaining reserves, select the one that adds to the system the most additional threatened species. (3) In the case of two reserves contributing the same number of additional species (a tie for step 2), I used as a second criterion residency status, considering adding threatened breeding residents to be more important than adding non-breeding

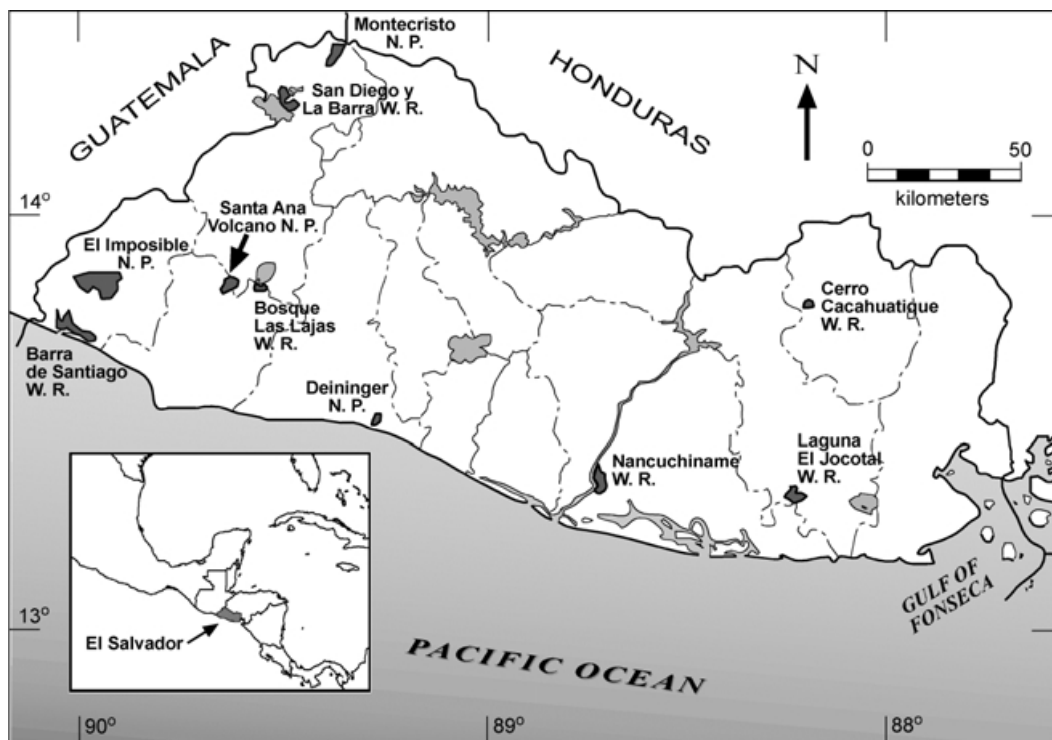


Fig. 1. Ten protected areas in El Salvador for which reasonably complete information about bird populations was available. These are also the ten largest protected areas.

migratory birds. If a reserve could still not be selected, a third criterion was the number of regionally endemic species added to the system. For regionally endemic birds of northern Central America I used the list given by Peterson, Escalona-Segura & Griffith (1998). A final tiebreaker criterion was the overall number of threatened bird species present at the reserve. (4) Repeat steps 2 and 3 until all reserves have been added to the system.

RESULTS

Montecristo National Park (cloud forest, pine–oak forest) was ranked first, because it protected 112 (42%) nationally threatened bird species. El Imposible National Park (tropical semi-deciduous and evergreen forests) was second; El Imposible combined with Montecristo protected 167 species (62%). Third was Laguna El Jocotal wildlife refuge (freshwater marsh habitat), adding 40 species and increasing the total to 207 (77%). Adding Barra de Santiago wildlife refuge (mangroves and coastal estuaries) protected an additional 15 species, raising the total to 222 (83%). The fifth reserve was San Diego y La Barra (dry deciduous forest and freshwater lake), adding seven species. Walter Thilo Deininger National Park (dry semi-deciduous forest) was sixth, adding three species. Seventh was Cerro Cacahuatique reserve (tropical semi-deciduous forest and oak forest), adding two species. The eighth position was tied three ways, but the tiebreaker criteria selected Las Lajas reserve, a tropical evergreen and semi-deciduous forest that forms part of the Complejo San Marcelino wildlife refuge, adding one regionally endemic species. The ninth position was also tied, but the final tiebreaker criterion selected the Santa Ana Volcano, a cloud forest and xeric scrub habitat reserve, that protected 49 threatened species. The tenth position, the Nancuchiname gallery forest reserve, protected only 38. The whole combina-

tion protected 236 species, 88% of El Salvador's threatened birds (Table 2).

Four of the ten protected areas stood out as having relatively large numbers of threatened species found at no other park; such species are referred to hereafter as 'singletons' (Table 2). Ranking area priorities by singleton threatened species, but not by overall richness, gave the same order as the complementarity analysis for the top five priority areas (Fig. 2). For resident species, singletons numbered 38, 20, 13, ten, and five, respectively. Laguna El Jocotal stood out as especially important for migrants, with six migratory singletons (Table 2). All ten areas included at least one species that received protection at no other area, but 31 threatened species (28 resident, three migrant) were not found at any of the ten areas, indicating that more protected areas are needed.

The area with the most regionally endemic birds was Montecristo National Park (Table 3). Only Montecristo and Las Lajas forest protected endemic species that bred at no other protected areas in El Salvador (singletons). Montecristo was followed by Santa Ana Volcano in overall richness of regionally endemic species.

DISCUSSION

The complementarity analysis demonstrated the relative importance of four existing protected areas which, combined, provided protection for 83% of El Salvador's threatened bird species in a space of less than 7600 ha. These four areas each protected different sectors of the country's avifauna, and thus all should be of the highest conservation priority. Increasing the size of these areas should be planned, as their current sizes may not be large enough to maintain viable populations of any species for the long term. The relatively small populations of birds and other vertebrates that can live in such small reserves make virtually all of the threatened

Table 1. The ten largest El Salvador protected areas include eight principal habitat types, totaling 11,310 ha (0.54% of El Salvador).

Protected area	Habitat	Estimated area (ha)
Barra de Santiago wildlife refuge	Mangrove forest	1550 ¹
	Tropical semi-deciduous forest	233 ²
Cerro Cacahuatique wildlife refuge	Tropical semi-deciduous forest and scrub	110 ³
	Oak forest	10 ³
	Tropical semi-deciduous forest and scrub	1600 ⁴
El Imposible National Park	Tropical evergreen forest	2400 ⁴
	Freshwater marsh	300 ³
El Jocotal Lagoon wildlife refuge	Tropical evergreen forest	400 ⁵
Las Lajas forest (part of Complejo San Marcelino wildlife refuge)	Cloud forest	300 ⁶
	Pine–oak forest	1000 ⁶
Montecristo National Park	Tropical semi-deciduous forest	200 ⁶
	Tropical semi-deciduous floodplain forest	1100 ³
Nancuchiname Forest wildlife refuge	Tropical deciduous forest	687 ³
San Diego y La Barra wildlife refuge	Cloud forest	488 ²
Santa Ana Volcano (Cerro Verde and Los Andes National Parks)	Tropical montane scrub	200 ²
	Tropical semi-deciduous forest and scrub	732 ²
Walter Thilo Deininger National Park		
Totals		11,310

¹ Salazar de Jurado *et al.*, 1995

² Secretaría Ejecutiva de Medio Ambiente, 1994

³ Néstor Herrera, pers. comm.

⁴ Enrique Fuentes, SalvaNATURA, pers. comm.

⁵ Komar & Herrera, 1995

⁶ Komar, 2002

Table 2. Both richness of threatened species and the presence of singleton threatened species indicated that the two largest national parks are the most important conservation areas in El Salvador.

Protected area	Ranking by complementarity	Threatened resident species	Singleton resident species	Threatened migratory species	Singleton migratory species
Montecristo National Park	1	108	36	6	0
El Imposible National Park	2	94	20	10	0
El Jocotal Lagoon wildlife refuge	3	32	6	20	6
Barra de Santiago wildlife refuge	4	44	8	12	2
San Diego y La Barra wildlife refuge	5	45	1	16	4
Walter Thilo Deininger National Park	6	46	2	5	0
Cerro Cacahuatique wildlife refuge	7	49	2	8	0
Las Lajas (Complejo San Marcelino wildlife refuge)	8	41	1	4	0
Santa Ana Volcano complex (Cerro Verde and Los Andes National Parks)	9	48	1	1	0
Nancuchiname Forest wildlife refuge	10	30	1	8	0

Table 3. Distribution of El Salvador's 18 regionally endemic bird species. Fifteen breed in Montecristo National Park, more than in any other protected area (1 = present, 0 = absent, bold indicates present in only one area)

Endemic species	Protected areas ¹									
	B	C	D	E	J	L	M	N	S	V
White-bellied chachalaca <i>Ortalis leucogastra</i>	1	1	1	1	1	1	1	1	1	0
Highland guan <i>Penelopina nigra</i>	0	0	0	0	0	0	1	0	0	0
Ocellated quail <i>Cyrtonyx ocellatus</i>	0	0	0	0	0	0	0	0	0	0
Pacific parakeet <i>Aratinga strenua</i>	0	0	0	0	0	1	0	0	0	0
Fulvous owl <i>Strix fulvescens</i>	0	0	0	0	0	0	1	0	0	0
Rufous sabrewing <i>Campylopterus rufus</i>	0	0	0	1	0	0	0	0	0	1
Green-throated mountain-gem <i>Lampornis viridipallens</i>	0	0	0	0	0	0	1	0	0	1
Slender sheartail <i>Doricha enicura</i>	0	0	0	0	0	0	1	0	0	1
Wine-throated hummingbird <i>Atthis ellioti</i>	0	0	0	0	0	0	1	0	0	1
Blue-throated motmot <i>Aspatha gularis</i>	0	0	0	0	0	0	1	0	0	0
Belted flycatcher <i>Xenotriccus callizonus</i>	0	0	0	0	0	0	1	0	0	0
Bushy-crested jay <i>Cyanocorax melanocyaneus</i>	0	1	1	1	0	1	1	0	0	1
Black-throated jay <i>Cyanolyca pumilo</i>	0	0	0	0	0	0	1	0	0	0
Black-capped swallow <i>Notiochelidon pileata</i>	0	0	0	0	0	0	1	0	0	0
Rufous-browed wren <i>Troglodytes rufociliatus</i>	0	0	0	0	0	0	1	0	0	1
Rufous-collared robin <i>Turdus rufitorques</i>	0	0	0	0	0	0	1	0	0	1
Blue-and-white mockingbird <i>Melanotis hypoleucus</i>	0	1	0	0	0	0	1	0	0	1
Bar-winged oriole <i>Icterus maculialatus</i>	0	1	0	1	0	1	1	0	0	1
Endemic species present	1	4	2	4	1	4	15	1	1	9
Singleton endemics present	0	0	0	0	0	1	6	0	0	0

¹ B = Barra de Santiago W. R., C = Cerro Cacahuatique W. R., D = Deininger N. P., E = El Imposible N. P., J = Laguna El Jocotal W. R., L = Bosque Las Lajas W. R., M = Montecristo N. P., N = Bosque Nancuchiname W. R., S = San Diego y La Barra W. R., V = Santa Ana Volcano (N. P.).

species subject to high risks of local extinction in the short term (Meffe & Carroll, 1997a).

The order of importance for the remaining areas is probably not meaningful, and could change with improvements to the bird lists for those areas. Although not indicated as of prime importance by the complementarity analysis, those areas are potentially important for maintaining genetic diversity and long-term survival of threatened species. Also, the present analysis does not reflect differences in abundance and local extinction risks for individual species among protected areas. Thus a species may have its most important population at the Santa Ana Volcano (e.g., *Grallaria guatemalensis*, *Rhynchocyclus brevirostris* and *Troglodytes rufociliatus*, O. Komar, unpubl. data) but not add to that area's complementarity value because those same species occur, with smaller populations, at Montecristo National Park. Thus, the 'species' may not be the most significant unit for planning the conservation of biodiversity (Meffe &

Carroll, 1997b). Genetically, the isolated populations at the volcano may be important for conservation, and indeed at least two subspecies are endemic to the volcano (Dickey & van Rossem, 1938). Unfortunately, avian taxonomy of the northern Central American region is not complete enough to permit an analysis at the subspecies level, and no studies of avian genetic diversity or metapopulations in El Salvador have been published.

Montecristo National Park ranked highest in importance for bird conservation in El Salvador. How important is the park on a regional scale? The park protects 2000 ha in an isolated mountain range located at the intersection of El Salvador, Guatemala and Honduras. The area has been proposed as an international biosphere reserve, yet lands in Honduras and Guatemala are not yet officially protected, or at least have no infrastructure or presence of park guards. The contiguous forested area may be as large as 20,000 ha, although a thorough analysis has not been published. Ecosystems include Central

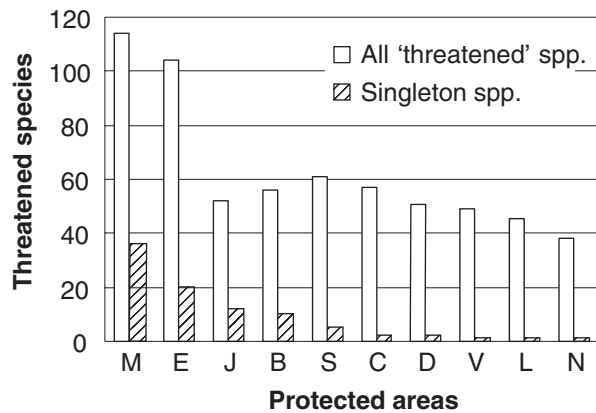


Fig. 2. Ranking area priorities by singleton threatened species, but not by all threatened species, matched ranking by complementarity (for the top five ranks). Singleton species are those that occur at a single protected area. (Key: B = Barra de Santiago W. R., C = Cerro Cacahuatique W. R., D = Deininger N. P., E = El Imposible N. P., J = Laguna El Jocotal W. R., L = Bosque Las Lajas W. R., M = Montecristo N. P., N = Bosque Nancuchiname W. R., S = San Diego y La Barra W. R., V = Santa Ana Volcano (N. P.).)

American Montane Forest, Central American Pine–Oak Forest, and Central American Pacific Dry Forest, all regionally threatened ecoregions (Dinerstein *et al.*, 1995). The wildlife at Montecristo park benefits from the existence of adjacent forest land, but that land is not adequately protected. The park is an important reserve for nearly 100 habitat-specialist bird species of pine–oak and cloud forest habitats (Komar, 2002). Studies of humid montane habitats in northern Central America showed Montecristo National Park to be regionally important for the conservation of passalid beetles (Schuster, Cano & Cardona, 2000) and staphylinid and curculionid beetles (Anderson & Ashe, 2000), insect groups considered indicators for other taxa. The isolated highland area that includes Montecristo park is home to several endemic taxa that occur nowhere else in the world, including at least one plant (Zamudio, 1997), a beetle (Schuster, 1989) and a lizard (Hidalgo, 1983).

If Montecristo National Park and the surrounding forests were destroyed, the loss would have a significant impact on global biodiversity conservation, given the presence of several endemic non-avian taxa, and 15 regionally endemic bird species. Almost all of the protected areas in this analysis offer some benefits to global biodiversity conservation, through the protection of globally endangered ecosystems, locally endemic taxa (non-avian) and genetic diversity. El Imposible National Park protects a significant patch of Sierra Madre de Chiapas Moist Forest ecosystem at the eastern limit of that ecoregion, and contains several plants and trees not known from any other protected area. The Santa Ana volcano is home to endemic populations (subspecies) of birds, as is Cerro Cacahuatique (Dickey & van Rossem, 1938).

Undisturbed natural habitat is at a premium in El Salvador. Only about 0.8% of the country is protected

in national parks or wildlife refuges, and only half of this area has been legally declared protected (Rodríguez, 1998). The birds and wildlife that find refuge in most of these areas share them with people. The 2000 ha Montecristo National Park encompasses two villages with a population of 704 (El Salvador Park Service, unpubl. data, 1998); El Imposible National Park still has about 250 people living inside the protected zone (E. Fuentes, pers. comm.). A crucial refuge for freshwater bird species, Laguna El Jocotal wildlife refuge, is also among the most disturbed. A small town was built alongside the 1000 ha lagoon. Villagers constantly search for fish and shellfish; ranchers graze cattle all around the lagoon. Relict wooded swamplands are visited daily by firewood gatherers (pers. obs.). At present, truly protected areas are difficult to distinguish from paper parks. In some areas, park guards cannot prevent looting of natural resources. Other areas appear protected, but are privately owned, without guarantee of future conservation measures. Human disturbance issues should be major concerns of the protected areas' managers.

The present analysis has addressed bird conservation within the existing protected areas, suggesting priorities for assuring long-term protection and adequate management of selected reserves. A future analysis must address how to complete the protection of El Salvador's threatened and endangered birds, initially focusing on the distribution of the 31 unprotected species, and identifying potential reserves for these species. Significant areas of unprotected pine–oak forests exist in Chalatenango and Morazán departments (northwestern and northeastern El Salvador, near the Honduras border). The largest forest patch in El Salvador, about 22,900 ha, is the Bahía de Jiquilisco mangrove estuary (Salazar de Jurado, Guillén Morales & Ulloa, 1995). Although local laws protect mangroves and wildlife, the area is not declared a protected area and is not managed as one. In addition to El Salvador's natural habitats, corridor lands that serve to connect wildlife populations in protected areas may be important for conservation. Shaded coffee plantations may play such a role for some species. Several locally threatened species (*Dendrortyx leucophrys*, *Dactylortyx thoracicus* and *Xiphorhynchus flavigaster* among others) regularly occur in some of El Salvador's coffee plantations, even at distances greater than 5 km from natural forest habitat (O. Komar, unpubl. data).

Six of the unprotected bird species have not been reported in El Salvador since the 1940s (Dickey & van Rossem, 1938; Marshall, 1943), and may now be extirpated. These are jabiru (*Jabiru mycteria*), ocellated quail (*Cyrtonyx ocellatus*), scarlet macaw (*Ara macao*), unspotted saw-whet owl (*Aegolius ridgwayi*), royal flycatcher (*Onychorhynchus coronatus*) and Steller's jay (*Cyanocitta stelleri*). The ornate hawk-eagle (*Spizaetus ornatus*) was last reported in the early 1980s (Thurber *et al.*, 1987). Owing to small reserve sizes, all threatened birds in El Salvador need additional protection. Other countries in Central America have declared 10–35% of their territories as protected lands, while El

Salvador has less than 1% (Rodríguez, 1998). I suggest that the biodiversity present in El Salvador merits expanding protected areas drastically. Increasing protected areas to 10% would benefit wildlife greatly, even if much of the newly protected area is highly disturbed initially. Over time, disturbed habitats will recuperate. Unfortunately, the socio-political challenges encountered to meet that goal will be daunting.

From time to time, conservation priorities in a protected area system should be re-evaluated. Because of small population sizes, rapidly changing climate and other factors, birds living in the protected areas should be monitored, and other faunal groups should be inventoried. Various studies have shown that individual taxa are poor indicators for other taxa (Dobson *et al.*, 1997; van Jaarsveld *et al.*, 1998), so conservation analyses should be based on many taxa. Perhaps the priorities for bird conservation are different from priorities for the conservation of reptiles, mammals, plants or other groups. None the less, single-taxon studies are frequent in the literature for various reasons (examples include Cofré & Marquet, 1999; Peterson *et al.*, 2000a; Schuster, *et al.*, 2000). Kark *et al.* (1999) suggested conservation priorities based on the distribution of a single species. In the present case, species lists for non-bird taxa were not available. Land managers and biologists in El Salvador's protected areas should conduct inventories of many taxa to permit less biased analyses of priorities for resource allotment.

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APPENDIX 1

Distribution of nationally threatened birds in ten protected areas in El Salvador

Species	Protected areas ^{1,2}									
	B	C	D	E	J	L	M	N	S	V
<u>Resident species</u>										
<i>Crypturellus cinnamomeus</i>	p	x	x	x		x	x		x	p
<i>Tachybaptus dominicus</i>					x	p	p			
<i>Podilymbus podiceps</i>					x				x	
<i>Phalacrocorax brasilianus</i>	p				x				x	
<i>Anhinga anhinga</i>	x				x					
<i>Botaurus pinnatus</i>					x					
<i>Ixobrychus exilis</i>					x					
<i>Tigrisoma mexicanum</i>	x									
<i>Ardea alba</i>	x				x				x	
<i>Egretta tricolor</i>	x									
<i>Cochlearius cochlearius</i>	x									
<i>Eudocimus albus</i>	x									
<i>Sarcoramphus papa</i>		p		x			p			
<i>Dendrocygna bicolor</i>	p				x					
<i>Cairina moschata</i>	x				x			x		
<i>Nomonyx dominicus</i>					x				x	
<i>Leptodon cayanensis</i>	p		x	x						
<i>Chondrohierax uncinatus</i>				x						
<i>Rostrhamus sociabilis</i>					x				x	
<i>Ictinia plumbea</i>	x			x						
<i>Busarellus nigricollis</i>	x									
<i>Accipiter striatus chionogaster</i>		p					x			
<i>Geranospiza caerulescens</i>	p		x					x	x	
<i>Leucopternis albicollis</i>				x						
<i>Asturina nitida</i>	x	x	x	x			x		x	
<i>Buteogallus anthracinus</i>	x	x	x	x					x	
<i>Buteogallus subtilis</i>	x									
<i>Buteogallus urubitinga</i>	x		p	x			p	p		
<i>Parabuteo unicinctus</i>	p									
<i>Harpyhaliaetus solitarius</i>							p			
<i>Buteo magnirostris</i>	x		x	x	x			x	x	
<i>Buteo brachyurus</i>	p	x	x	x		x	x	x	x	p
<i>Buteo albicaudatus</i>		p					p		p	
<i>Buteo jamaicensis</i>		x		x		x	x			x
<i>Spizaetus tyrannus</i>				x						x
<i>Spizaetus ornatus</i>	p			p						
<i>Micrastur ruficollis</i>		x		x			x			x
<i>Micrastur semitorquatus</i>	x		x	x		x	x	x	x	
<i>Caracara cheriway</i>	x	p		p	p			x	x	

Species	Protected areas ^{1,2}									
	B	C	D	E	J	L	M	N	S	V
<i>Herpetotheres cachinnans</i>	x	x	x	x	x	x	x	x	x	
<i>Falco sparverius tropicalis</i>							x			
<i>Falco ruficularis</i>	p			p						
<i>Ortalis leucogastra</i>	x	x	x	x	x	x	x	x	x	
<i>Penelope purpurascens</i>				x						
<i>Penelopina nigra</i>							x			p
<i>Crax rubra</i>	p			x						
<i>Dendrortyx leucophrys</i>		x				x	x			x
<i>Dactylortyx thoracicus</i>		x		x		x	x			x
<i>Cyrtonyx ocellatus</i>										
<i>Laterallus ruber</i>					x				x	
<i>Aramides axillaris</i>				x		x				
<i>Aramides cajanea</i>	x			p						
<i>Porzana flaviventer</i>					x					
<i>Porphyryla martinica</i>	x				x				x	
<i>Gallinula chloropus</i>					x				x	
<i>Fulica americana</i>	p				x				p	
<i>Aramus guarauna</i>	p				x				x	
<i>Burhinus bistriatus</i>	p				x			x		
<i>Charadrius wilsonia</i>	p									
<i>Haematopus palliatus</i>	p									
<i>Himantopus mexicanus</i>	p				x			p	x	
<i>Sterna antillarum</i>										
<i>Rynchops niger</i>										
<i>Columba fasciata</i>		p					x			
<i>Claravis pretiosa</i>	p							x		
<i>Geotrygon albigacies</i>				x			x			x
<i>Geotrygon montana</i>				x			x			
<i>Aratinga holochlora</i>		p								
<i>Aratinga strenua</i>	p		p	p		x		p		
<i>Aratinga canicularis</i>	x		x	x		x		x	x	
<i>Ara macao</i>										
<i>Brotogeris jugularis</i>	x	x	x	x		x	x	x	x	
<i>Amazona albifrons</i>	x	p					p		x	
<i>Amazona auropalliata</i>	x		p	p	p			x	x	
<i>Coccyzus minor</i>	p			p	p			p	p	p
<i>Dromococcyx phasianellus</i>		x		p						
<i>Geococcyx velox</i>		x	p	x			x			x
<i>Tyto alba</i>	x		x		x	x		x	x	
<i>Otus cooperi</i>	x		x	x	x				x	
<i>Otus trichopsis</i>		x								
<i>Pulsatrix perspicillata</i>	x		x	x			x			
<i>Bubo virginianus</i>		p					x			
<i>Ciccaba virgata</i>	x	x	x	x		x	x		x	x
<i>Ciccaba nigrolineata</i>				x						
<i>Strix fulvescens</i>							x			
<i>Pseudoscops clamator</i>										
<i>Aegolius ridgwayi</i>										
<i>Chordeiles acutipennis</i>	p							p		
<i>Nyctibius jamaicensis</i>	x		x	x			x		x	
<i>Panyptila sanctihieronymi</i>						p	p			
<i>Campylopterus rufus</i>				x						x
<i>Campylopterus hemileucurus</i>		x	x	x		x	x			x
<i>Colibri thalassinus</i>		x					x			x
<i>Abeillia abeillei</i>				x						x
<i>Hylocharis eliciae</i>			x	x		x				
<i>Hylocharis leucotis</i>		x					x			
<i>Amazilia cyanocephala</i>		x					x			
<i>Amazilia cyanura</i>										
<i>Lampornis viridipallens</i>							x			x
<i>Lampornis amethystinus</i>							x			
<i>Lamprolaima rhami</i>							x			
<i>Eugenes fulgens</i>							x			x
<i>Heliomaster longirostris</i>			x			x				
<i>Heliomaster constantii</i>			x	x		x	x			
<i>Doricha enicura</i>							x			x
<i>Tilmatura dupontii</i>		x		x			x			p
<i>Atthis ellioti</i>							x			x
<i>Trogon melanocephalus</i>	x		x	x	x			x		
<i>Trogon violaceus</i>	p	x	x	x		x	x	x		
<i>Trogon elegans</i>	p	x	x	x		x	x	x		
<i>Trogon collaris</i>							x			
<i>Pharomachrus mocinno</i>							x			

Species	Protected areas ^{1,2}									
	B	C	D	E	J	L	M	N	S	V
<i>Hylomanes momotula</i>				x						
<i>Aspatha gularis</i>							x			
<i>Ceryle torquata</i>	x				x				x	
<i>Chloroceryle amazona</i>	p								x	
<i>Chloroceryle americana</i>	x		x	x	x		x	x	x	
<i>Chloroceryle aenea</i>	x									
<i>Notharchus macrorhynchos</i>	p		x							
<i>Aulacorhynchus prasinus</i>		x	p	x			x			x
<i>Pteroglossus torquatus</i>	p	p	x	x		x	x	x		
<i>Melanerpes formicivorus</i>		x					x			
<i>Picoides villosus</i>							x			
<i>Veniliornis fumigatus</i>	p			x				x		
<i>Colaptes auratus</i>							x			
<i>Dryocopus lineatus</i>	x	x	x	x			x	x	x	
<i>Campephilus guatemalensis</i>	p	p	p	x				x		
<i>Synallaxis erythrothorax</i>	p		p	x						
<i>Anabacerthia variegaticeps</i>							x			
<i>Automolus rubiginosus</i>							x			
<i>Sclerurus mexicanus</i>							x			
<i>Dendrocincla homochroa</i>				x			x			
<i>Sittasomus griseicapillus</i>		x	p	x			x	x		
<i>Xiphocolaptes promeropirhynchus</i>		p		x						
<i>Dendrocolaptes sanctithomae</i>		p		x						
<i>Xiphorhynchus flavigaster</i>	x	x	x	x		x	x	x	x	
<i>Lepidocolaptes souleyetii</i>	x	x	x	x					x	
<i>Lepidocolaptes affinis</i>		x					x			x
<i>Grallaria guatemalensis</i>				x			x			x
<i>Campostoma imberbe</i>			x	x	x				x	
<i>Elaenia frantzii</i>							x			x
<i>Mionectes oleagineus</i>	p			x						
<i>Zimmerius vilissimus</i>			x	x		x				
<i>Oncostoma cinereigulare</i>	p		p	x						
<i>Todirostrum cinereum</i>				x						
<i>Rhynchocyclus brevirostris</i>				x			x			x
<i>Platyrinchus cancrominus</i>			p	x						
<i>Onychorhynchus coronatus</i>	p									
<i>Xenotriccus callizonus</i>							x			
<i>Mitrephanes phaeocercus</i>		p		p			p			
<i>Contopus pertinax</i>		x					x			
<i>Contopus cinereus</i>	x	x	x	x		x	x	x	x	
<i>Empidonax albigularis</i>				x			p			
<i>Empidonax flavescens</i>		x		x		x	x			x
<i>Empidonax fulvifrons</i>							p			p
<i>Sayornis nigricans</i>			x	x			x		x	
<i>Attila spadiceus</i>	x	p	x	x						
<i>Myiarchus tyrannulus</i>	p		p	p	p	p	p	p	p	
<i>Pachyrhynchus major</i>		p		x						
<i>Chiroxiphia linearis</i>	p			x		x				
<i>Vireo pallens</i>	x		p		x					
<i>Vireo solitarius montanus</i>							x			
<i>Vireo leucophrys</i>							x			x
<i>Vireolanius pulchellus</i>				x						
<i>Cyanocitta stelleri</i>										
<i>Cyanocorax melanocyaneus</i>		x	x	x		x	x			x
<i>Cyanolyca pumilo</i>							x			
<i>Aphelocoma unicolor</i>							x			
<i>Corvus corax</i>		p					p			
<i>Tachycineta albilinea</i>	x			p	x			x		
<i>Notiochelidon pileata</i>							x			
<i>Certhia americana</i>							x			
<i>Campylorhynchus zonatus</i>							x			
<i>Salpinctes obsoletus</i>										x
<i>Thryothorus maculipectus</i>	p	x	x	x		x	x		x	x
<i>Thryothorus rufalbus</i>	p			x		x	x			x
<i>Thryothorus pleurostictus</i>	p	p	x	x	p				x	
<i>Troglodytes rufociliatus</i>							x			x
<i>Cistothorus platensis</i>					p					
<i>Henicorhina leucophrys</i>							x			
<i>Ramphocaenus melanurus</i>			x	x						
<i>Polioptila albiloris</i>	p		x	x					x	
<i>Sialia sialis</i>		x		p			x			x
<i>Myadestes occidentalis</i>		x		x			x			x
<i>Myadestes unicolor</i>							x			

Species	Protected areas ^{1,2}									
	B	C	D	E	J	L	M	N	S	V
<i>Vireo flavifrons</i>		x	x	x		x			x	
<i>Vireo philadelphicus</i>		x		x			x			
<i>Petrochelidon fulva</i>			p	p	x					
<i>Vermivora chrysoptera</i>				x	x		x			
<i>Dendroica chrysoparia</i>				p						
<i>Setophaga ruticilla</i>	x			p	x					
<i>Protonotaria citrea</i>					x					x
<i>Seiurus noveboracensis</i>	x		x	p	x			x		
<i>Seiurus motacilla</i>		x	x	x			x			
<i>Ammodramus savannarum</i>										x
<i>Passerina cyanea</i>	x	x	x	x	x	x	x	x		x
<i>Passerina ciris</i>	x	x	x	x	x	x	x	x		x

Sources: Komar & Herrera, 1995; Komar & Rodríguez, 1995; Ramírez-Sosa & Komar, 1996; Komar, 2000; N. Herrera, unpubl. data for Barra de Santiago and Nancuchiname; N. Herrera, R. Ibarra & R. Rivera, unpubl. data for San Diego y La Barra; N. Herrera and R. Rivera, unpubl. report for Cerro Cacahuatique; R. Ibarra and N. Herrera, unpubl. data for Deininger; O. Komar, unpubl. data for Cerro Cacahuatique, Deininger, Laguna El Jocotal, and Santa Ana Volcano; see Methods for criteria for inclusion of species.

¹B = Barra de Santiago W. R., C = Cerro Cacahuatique W. R., D = Walter Thilo Deininger N. P., E = El Imposible N. P., J = Laguna El Jocotal W. R., L = Bosque Las Lajas W. R., M = Montecristo N. P., N = Bosque Nancuchiname W. R., S = San Diego y La Barra W. R., V = Santa Ana Volcano (N. P.).

²x = present, x = present in just one area, p = possible: reported but breeding now unlikely and undocumented, or, in the case of migratory birds, potentially only transient at site.