

1 **The taxonomy, status and conservation of serpent eagles (Circaetinae) and booted eagles**
2 **(Aquilinae).**

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8
9 **Abstract** Serpent and booted eagles as groups are generally imperilled. Eagles within these groups
10 often have small population sizes, limited distribution (sometimes confined to islands), and occupy
11 habitats (especially tropical forests in Asia and Africa) under threat. In addition, the ecology of many of the
12 species in these groups is not well known and this undermines conservation efforts. As a first step in
13 understanding which species should be made a conservation priority we aimed to assemble the dispersed
14 data on population size and conservation status, main conservation threats and main on-going
15 conservation activities. Because of new taxonomy resulting from recent genetic work, we made some
16 effort to clarify species nomenclature within the context of the main aims of assembling the data. We
17 review information from a variety of sources for 61 eagle species in the (current and historical) genera:
18 *Eutriorchis*, *Spilornis*, *Pithecophaga*, *Terathopius*, *Circaetus*, *Dryotriorchis*, *Nisaetus*, *Stephanoatus*,
19 *Spizaetus*, *Hieraaetus*, *Polemaetus*, *Lophaetus*, *Lophotriorchis*, *Ictinaetus*, and *Aquila*. In reviewing all
20 species in these groups we sought also to identify species where relatively low cost solutions to
21 conservation problems might be applied. The authors intend to publish a peer-reviewed paper on this
22 topic, using information in this manuscript. We recognize that there are gaps in the information. We are
23 working to fill those gaps and ensure that the manuscript we submit for publication will be up to date,
24 however we thought it important to make this information available in case it might be put to good use to
25 conserve eagles.

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27 **THIS MANUSCRIPT HAS NOT BEEN PEER-REVIEWED. USE THE INFORMATION WITHIN WITH**
28 **CAUTION. THE STATUS OF SOME SPECIES IS CHANGING AND SO OLDER DATA MAY BE LESS**
29 **RELIABLE. THE DATA PRESENTED HEREIN WERE “CURRENT” IN MID 2009. CITE THIS**
30 **MANUSCRIPT AS “UNPUBLISHED DATA”.**

31
32 **INTRODUCTION**

33
34 Large raptors, including eagles, are often species of conservation concern and are sometimes seen as
35 good surrogates for biodiversity, whether as indicator or umbrella species, which can be used to identify
36 areas of conservation importance and aid in conservation planning (Sergio et al 2006). This view is not
37 universally held (See, for example: Andelman and Fagan 2000, Roberge and Angelstam 2004, Ozaki et al
38 2006). Less contentious is that eagles are also seen as iconic and their appeal can be used to leverage
39 conservation effort for less charismatic species or communities (Sergio et al 2006), and in this way they
40 can be a flagship for conservation efforts, especially through education and fund raising. Despite their

41 size, appeal and potential importance to their ecosystems and conservation, the ecology of many species
42 of eagle is poorly known (Sergio et al 2008).

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44 Some eagle species are both rare and occur in places where they are difficult to observe and study.
45 Poorly known or rare eagles tend to be forest dwelling and reside at lower latitudes, often on islands, in
46 countries where the human population is poor and poorly educated. Although a large percentage of eagle
47 species is classed as having a poor conservation status, many are simply too poorly known to enable
48 classification. Compounding the difficulty of conserving these little-known, rare eagles is the fact that gaps
49 exist in our knowledge of even the best-known, most common eagles (Watson 1997). This means that
50 some basic principals of the ecology of K selected eagle species that could be gleaned from research on
51 common eagle species is not available to conserve rarer ones.

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53 Recent genetic work on eagles (e.g Haring et al 2007, Helbig 2005, Lerner and Mindell 2005)) has not
54 only clarified relationships between species and genera, it has, in general, resulted in more species, and
55 as a consequence more species are imperilled. This imperilment is often accentuated by the fact that it is
56 difficult to study and conserve long-lived species that, in many cases, occur naturally at low densities.

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58 At meetings of the Eagle Conservation Alliance in 2006 and 2007, the assembled eagle experts from
59 around the world identified the serpent eagles and booted eagle groups as having a large proportion of
60 imperilled species and being generally poorly known. Based on that expert assessment we undertook to
61 review the status and conservation of these eagles. There have been a number of reviews of the status of
62 raptor populations, and given the distribution of the species we consider here, the most germane are
63 those that deal with tropical raptors (e.g. Thiollay 1985a, b, 1994, Bildstein et al 1998, van Balen 1998).

64

65 **METHODS**

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67 Because there has been active genetic research on these groups in recent years aimed at clarifying
68 taxonomic relationships (Helbig *et al.* 2005, Gamauf *et al.* 2005 a, b, Lerner & Mindell 2005, Gjershaug
69 2006, Haring *et al.* 2007, Griffiths *et al.* 2007), we first reviewed the taxonomy of these eagle groups, and
70 adopted taxonomic changes that had been or were likely to be approved by ornithological taxonomic
71 committees. However, to avoid confusion we recorded the old names for genera/species. In some cases,
72 what is recognized as a species by one authority is not by another. We considered 61 eagle species in the
73 (current and historical) genera: *Eutriorchis*, *Spilornis*, *Pithecophaga*, *Terathopius*, *Circaetus*, *Dryotriorchis*,
74 *Nisaetus*, *Stephanoatus*, *Spizaetus*, *Hieraaetus*, *Polemaetus*, *Lophaetus*, *Lophotriorchis*, *Ictinaetus*, and
75 *Aquila*.

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77 We tried to track down, in any way possible, information on the species we considered. Our primary
78 sources of information were the Global Raptor Information Network (GRIN)(The Peregrine Fund, Inc
79 <http://www.globalraptors.org/grin/indexAlt.asp>. Last accessed 22 Dec 2008), the IUCN Red List Database
80 (<http://www.iucnredlist.org/search/search-expert.php> Last accessed 22 Dec 2008) and Raptors of the

81 World (ROW)(Ferguson-Lees et al 2001). We accessed the Birdlife Species Factsheets
82 <http://www.birdlife.org/datazone/species/index.html> for all species for which these were available. These
83 data were supplemented with information from Handbook of Birds of the World (BOW) Thiollay *in del Hoyo*
84 *et al* (1994), Collar et al (1994), BirdLife International (2000) and Stattersfield et al (1998). We then
85 looked for additional data on the internet, starting our search at the Zipcodezoo.org web site
86 (<http://zipcodezoo.com/default.asp> Last accessed 1 September 2008) and the ARKIVE web site
87 (<http://www.arkive.org/species/GES/birds/> Last accessed 1 September 2008). We then used the common,
88 current and past species names and the word “conservation” in the Google Scholar search engine
89 <http://scholar.google.com/> Last accessed 22 Dec 2008), in our search for additional information. We
90 checked the information from our different sources for agreement and rationalized the data, wherever
91 possible. When discrepancies between our reference sources existed, we tried to access the original
92 papers upon which the accounts in the reference texts were based and judge for ourselves. Having
93 gathered what data we could from the published literature and internet sources, we sought other
94 unpublished information through our own extensive network of contacts. We provide information on all
95 species that were either in GRIN or on the IUCN web sites and some purported species for which recent
96 evidence exists (e.g Legge’s Hawk Eagle (*Nisaetus (Spizaetus) kelaarti*)).

97
98 We posted our initial results on a blog site [http://eagleconservationalliance.org/discussions/hawk-and-](http://eagleconservationalliance.org/discussions/hawk-and-serpent-eagles/serpent-and-booted-eagle-conservation/)
99 [serpent-eagles/serpent-and-booted-eagle-conservation/](http://eagleconservationalliance.org/discussions/hawk-and-serpent-eagles/serpent-and-booted-eagle-conservation/) (Last visited 1 September 2008), and then
100 encouraged people to comment on our results. The blog enabled us to receive and filter data and to
101 contact sources to clarify information, and to create a blog thread that kept a “discussion” going. We
102 advertised the blog by sending emails to contacts we had and by posting an announcement of the blog on
103 the Raptor Biology, Asian Raptor Research and Conservation Network (ARRCN), Imperial Eagle, Satellite
104 Ornithology (SatTelOrn) list serves and on the GRIN website. We solicited comment on Table 1 during
105 mid March – September 2008 and Table 2 during mid April – September 2008). We also created a poster
106 and solicited help from attendees at the ARRCN conference in Hanoi, Vietnam (April 2008). The blog and
107 poster gave us potential access to unpublished data from people outside our network of contacts.

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109
110 We report our results on species grouped in descending level of endangerment. Where there were
111 disagreements among the references, we try to rationalize these or report on the disagreements. We are
112 conservative in our categorization, so that if one source classes a species as having a poorer
113 conservation status than another source, we place that species in the lower conservation status category,
114 and report on the discrepancy. The population status categories used by IUCN and GRIN differed
115 somewhat. IUCN and GRIN classed eagles as Critically Endangered (CE), Endangered (E), Vulnerable
116 (VU), Near Threatened (NT), Lower Risk/Least Concern (LR/LC) or Data Deficient (DD). For species
117 classed as DD, we made a judgement about their likely status for tabulation.

118
119 In Table 2 we have tried to list the threats to eagles in a subjective descending order of importance. The
120 order in which we list the conservation efforts is random. In general we report on the threats to species at

121 the population level, but for some species we also list important threats that occur at local levels (e.g.
122 persecution, electrocution, collisions with human made objects).

123

124 We could not list all the conservation efforts because (for example) there are many, many conservation
125 programs for some common species like the golden eagle (*Aquila chrysaetos*), while for other species
126 there was no way to know that we had complete knowledge of existing efforts. In most cases we describe
127 conservation efforts in general terms, but in a few cases we are able to point to particular efforts regarding
128 the eagles upon which this review focuses.

129

130 Zoos have the potential to promote conservation in the field by educating the public and supporting field
131 research or conservation, including providing captive bred individuals for reintroduction or population
132 supplementation. So, we report on numbers of individuals and their location and breeding status. These
133 data came from the International Species Information System (ISIS), American Zoo and Aquaria
134 Association (AZA) contacts, European Association of Zoos and Aquaria (EAZA) other zoo contacts. We
135 understand these data to be incomplete because not all holders of live birds register their animals on ISIS
136 or are known to us or our contacts. For some species (e.g. cheela), the great majority of holders of birds
137 are unknown to us.

138

139 RESULTS

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141 We report on species status, population trend and population size (Table 1), and tabulate the main threats
142 to each species and the current conservation efforts being made (Table 2).

143

144 Taxonomy

145

146 Ferguson-Lees et al (2001) proposed changes to the taxonomy in the serpent eagle group. They gave
147 species status to seven distinctive island subspecies of Crested Serpent Eagle *Spilornis cheela*. As these
148 changes are not based on research, we think they are premature. Rasmussen & Anderton (2005) did not
149 consider *Spilornis minimus* as a distinct species, as it was less compelling than for e.g. *Spilornis klossi*. A
150 phylogenetic study of these eagles is much needed before we can understand their taxonomy.

151 Compromising while waiting for such study, we have listed them as allospecies under the superspecies

152 *Spilornis* [cheela], indicating their supposed close relationships. The Philippine Eagle *Pithecophaga*
153 *jefferyi* is distantly related to the serpent eagles, and not to the harpy eagles as earlier believed (Lerner &
154 Mindell 2005). The Madagascar Serpent eagle *Eutriorchis aster* is not a real serpent eagle, as it is more
155 related to *Gypaetus* and *Gypohierax*. We have included it in our review because of its historical
156 taxonomy.

157

158 The taxonomy of booted eagles is the subject of recent phylogenetic studies. Wink & Sauer-Gürth (2004)
159 proposed that the genus *Hieraaetus* should be included in the genus *Aquila*. Helbig *et al.* (2005) included
160 only *Hieraaetus fasciatus* and *H. spilogaster* in *Aquila*, and retained the genus *Hieraaetus* for *H. pennatus*,

161 *H. morphnoides*, *H. ayresii* and *H. wahlbergi*. They suggested including *Aquila clanga* and *A. pomarina* in
162 the genus *Lophaetus* together with *L. occipitalis*. The Taxonomic Sub-Committee of BOU Records
163 Committee (Sangster *et al.* 2005) has decided to place *Hieraaetus pennatus* in the genus *Aquila*, with the
164 new name *Aquila pennata*. We used a broad definition of the genus *Aquila* for taxonomic stability. The
165 phylogenetic relationships within the genus can be shown by use of *Hieraaetus* and *Lophaetus* as
166 subgenus names. The Indian Black Eagle *Ictinaetus malayensis* is probably closely related to the spotted
167 eagles (Lerner & Mindell 2005, Haring *et al.* 2007), so we place it here in the genus *Aquila*.

168
169 Ferguson-Lees & *et al.* (2005) treat the Indian Tawny Eagle *Aquila vindhiana* as a distinct species. We
170 regard it as a subspecies of *Aquila rapax*. Rasmussen & Anderton (2005) and Ferguson-Lees *et al.* (2005)
171 treat the Change-able Hawk Eagle *Nisaetus limnaeetus* as a distinct species. The latter authors also treat
172 Andaman Hawk Eagle *Nisaetus andamanensis* and Simeuluë Hawk Eagle *Nisaetus vanheurni* as distinct
173 species. We regard them all as subspecies of *Nisaetus cirrhatus*.

174
175 Phylogenetic studies show that the genus *Spizaetus* is polyphyletic, consisting of an Old World and a New
176 World lineage (Gamauf *et al.* 2005, Helbig *et al.* 2005a, Lerner & Mindell 2005, Haring *et al.* 2007, Griffiths
177 *et al.* 2007). Brown & Amadon (1968) stated that *Spizaetus africanus*, *S. ornatus* and *S. tyrannus* are not
178 obviously tied with any of the other species of the *Spizaetus* genus, but they did not draw any taxonomical
179 consequences from that. This was also recognized by Jollie (1976-77) based on morphological analysis.
180 Based on the same molecular genetical analyses, the genera *Spizastur* and *Oroaetus* should be included
181 in the genus *Spizaetus* Viellot 1816, and the ten Asian *Nisaetus* species are monophyletic. They should
182 be assigned to a different genus, for which the name *Nisaetus* (Hodgson 1836) is available. We therefore
183 use this name here.

184
185 Cassin's Hawk-eagle *Spizaetus africanus* of Central and West Africa should be placed in the genus *Aquila*
186 based on its phylogenetical position (Lerner & Mindell 2005), with the new name *Aquila africana*. The
187 Rufous-bellied Eagle *Hieraaetus kineerii* is phylogenetically distant from its current congeners in
188 *Hieraaetus* (Lerner & Mindell 2005) and is also morphologically very distinct, and should be placed in its
189 own genus. The genus name *Lophotriorchis* has been suggested (Haring *et al.* 2007).

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191 One new hawk-eagle, Pinsker's Hawk Eagle *Nisaetus pinskeri*, has been described for the southern
192 Philippine islands (Preleuthner & Gamauf 1998); it has been split from *N. philippensis* (Gamauf *et al.*
193 2005). Also, Flores Hawk Eagle *Nisaetus floris* has been split from *N. cirrhatus* (Gjershaug *et al.* 2004),
194 Legge's Hawk Eagle *Nisaetus kelaarti* has been split from *Nisaetus nipalensis* (Gjershaug *et al.* 2008),
195 and Pygmy Eagle *Aquila weiskei* is also a distinct species based on molecular genetics (Bunce *et al.*
196 2005, Lerner & Mindell 2005) and morphology (Parry 2001, Gjershaug *et al.* in prep.). The tables below
197 show current and older names for species in Latin, and our consensus most common English name.

198 199 **Status, trends and population size**

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201 Table 1 lists the status, population trend and global population estimate for the booted and serpent eagles.

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“Critically Endangered” and “Endangered” Species

Nine (14.7 % of all species considered) species were classed as Critically Endangered or Endangered by either GRIN or IUCN. Two species (Madagascar Serpent Eagle, *Eutriorchis astur*, and Javan Hawk Eagle, *Nisaetus bartelsi*), are considered to be Endangered by IUCN and GRIN. The Madagascar Serpent Eagle is also considered Endangered by BOW, but Javan Hawk Eagle is considered vulnerable outside of reserves by that reference. GRIN classes Flores Hawk Eagle (*N. floris*) as Critically Endangered and IUCN lists it as Endangered (<http://www.birdlifeforums.org/WebX/.2cba5b3e>) last visited 26 March 08), though this its status is being reviewed (<http://www.birdlifeforums.org/WebX?13@@.2cba5b3e> last visited 22 Dec 2008), while BOW appears to list it as a subspecies of Changeable Hawk Eagle (*N. cirrhatus*) (See also Gamauf et al. 2005). Unlike GRIN, IUCN does not recognize the Bawean Serpent Eagle (*Spilornis [c.] baweanus*) or Ryukyu Serpent Eagle (*Spilornis [c.] perplexus*) as species, but as a subspecies of the Crested Serpent Eagle *S. cheela*, which it classes as “Least Concern”. The Philippine Hawk Eagle (formerly *Spizaetus philippensis*) has been split into two species, Philippine Hawk Eagle (*N. philippensis*) and Pinsker’s Hawk Eagle (*N. pinskeri*) (Gamauf et al. 2005, Haring et al. 2007); the population size for *N. philippensis* is considered to be about 200-220 pairs and for *N. pinskeri* is considered to be 320-340 pairs (Preleuthner & Gamauf 1998). IUCN categorizes Philippine Hawk Eagle as Vulnerable, and does not recognize Pinsker’s Hawk Eagle as a separate species. Thiollay (1994) states that Philippine Hawk Eagle is “not globally threatened”

Almost by definition the populations of all of the Critically Endangered or Endangered species are small, and 8 of 9 species populations are declining; the population trend of Ryuku Serpent Eagle is unknown although see discussion. Eight of 9 species are found only on islands, albeit some are on large islands. Only *Aquila (Lophaetus) hastata* has a continental distribution.

“Vulnerable” and “Near-Threatened” Species

Nineteen (31.1%) species are classed either by GRIN or IUCN (or both) as “Vulnerable” or “Near-Threatened” (or Data Deficient, but likely being vulnerable or near-threatened).

The splitting of *Spilornis cheela*, a “species” considered common, has spawned four allospecies that are considered by GRIN as being Data Deficient (*S. minimus*, *S. asturinus*, *S. sipora*, *S. natunensis*). IUCN does not split *S. cheela*.

Legge’s Hawk eagle has been proposed to be classed as Near-Threatened by BirdLife International (<http://www.birdlifeforums.org/WebX/.2cba5227>, Last visited 26 March 08), but (Gjershaug et al. in manuscript) argues that it should be considered Vulnerable under IUCN criteria C2a(i) (no sub-population contains > 1000 mature individuals). BOW classes Wallace’s Hawk Eagle as Endangered, though it is considered Vulnerable by both IUCN and GRIN.

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243 As one would expect, the population size estimates for some Near-threatened or Vulnerable species are
244 small, and the population trend for most of the species in this category was down, although the trend for
245 Southern Banded Eagle (*Circaetus fasciolatus*) was up. This was the only species in any category of
246 endangerment whose population seemed to be increasing.

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248 *“Least concern” or “Lower Risk” Species*

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250 The IUCN “Least Concern” category equates with the “Lower Risk” category in GRIN. BOW uses a less
251 specific, “Not Globally Threatened” class that seems to be a near equivalent. Most (33 out of 61, 54.1%)
252 species considered by us fall into this category. Some species classed as Least Concern by IUCN are
253 classed by GRIN as “Data Deficient”, and these cases are spread across the genera reviewed. The
254 population trend for at least 20 species (60.6% of species in this category) was not known, and the
255 population of only seven species was thought to be stable. The population trends were not up for any of
256 the species in this category. Some species, especially within the “*Aquila*”, have very large populations,
257 and the breeding ranges of these species were in general larger than those for species in the other
258 endangerment groupings we used.

259

260 **Table 1.** Status, population trend and current population estimates for booted and serpent eagles.

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Species	Common Name	Status IUCN	Status GRIN	Population Trend	Estimated Population Size (individuals) [GRIN unless otherwise noted]
Critically Endangered or Endangered					
<i>Eutriorchis astur</i> ^{*S}	Madagascar Serpent Eagle	EN	EN	Down	101 -1000
<i>Spilornis [c.] perplexus</i> ^{*S}	Ryukyu Serpent Eagle		EN	?	100-200 prs
<i>Spilornis [c.] baweanus</i> ^{*S}	Bawean Serpent Eagle		CE	Down	11 - 100 ⁷
<i>Pithecophaga jefferyi</i> ^{*S}	Philippine Eagle	CE	CE	Down	101 - 1000
<i>Nisaetus (Spizaetus) floris</i> ^{*S}	Flores Hawk Eagle	EN	CE	Down	~200 adult individuals ⁸
<i>Nisaetus (Spizaetus) bartelsi</i> *	Javan Hawk Eagle	EN	EN	Down	270-600 pairs ⁴
<i>Nisaetus (Spizaetus) philippensis</i> ^{*S}	Philippine Hawk Eagle	VU	EN	Down	101 – 1000; 200 – 220 pairs ¹
<i>Nisaetus (Spizaetus) pinskeri</i> ^{*S}	Pinsker’s Hawk Eagle		EN	Down	1001 – 10000; 320 - 340 pairs ²
<i>Aquila (Lophaetus) hastata</i> *	Indian Spotted Eagle	VU	EN	Down	~ 550
Near-threatened or Vulnerable					
<i>Spilornis elgini</i> ^{*S}	Andaman Serpent Eagle	NT	NT	?	~ 550
<i>Spilornis [c.] minimus</i> ^{*S}	Central Nicobar Serpent Eagle		DD	?	11 -100
<i>Spilornis [c.] abbotti</i> ^{*S}	Simeulue Serpent Eagle		DD	?	101 - 1000
<i>Spilornis [c.] asturinus</i> ^{*S}	Nias Serpent Eagle		DD	?	101 - 1000
<i>Spilornis [c.] sipora</i> ^{*S}	Mentawai Serpent Eagle		DD	?	~ 550
<i>Spilornis [c.] natunensis</i> ^{*S}	Natuna Serpent Eagle		DD	?	101 - 1000
<i>Spilornis klossi</i> ^{*S}	Great Nicobar Serpent Eagle	NT	NT	Down	~ 550
<i>Spilornis kinabaluensis</i> ^{*S}	Kinabalu Serpent Eagle	VU	VU	Down	~ 55
<i>Terathopius ecaudatus</i> *	Bateleur	LC	NT	Down	15251 - 38750
<i>Circaetus beaudouini</i> *	Beaudouin’s Snake Eagle	VU	DD	Down	1001 - 10000
<i>Circaetus fasciolatus</i> *	Southern Banded Snake Eagle	NT	NT	Up	1001 - 10000
<i>Nisaetus (Spizaetus) nanus</i> (2)	Wallace’s Hawk Eagle	VU	VU	Down	~ 550
<i>Nisaetus (Spizaetus) kelaarti</i> *	Legge’s Hawk Eagle	VU/NT		Down	< 2000 adult individuals ³
<i>Spizaetus (Oroaetus) isidori</i> *	Black-and-chestnut Eagle	NT	NT	?	~ 550
<i>Polemaetus bellicosus</i> *	Martial Eagle	LC	NT	Down	10001 -100000

Species	Common Name	Status IUCN	Status GRIN	Population Trend	Estimated Population Size (individuals) [GRIN unless otherwise noted]
<i>Aquila (Lophaetus) clanga</i> *	Greater Spotted Eagle	VU	VU	Down	~ 5000
<i>Aquila heliaca</i> *	Eastern Imperial Eagle	VU	VU	Down	1001 - 10000
<i>Aquila gurneyi</i> *	Gurney's Eagle	NT	NT	Down	1001 - 10000
<i>Aquila weiskei</i>	Pygmy Eagle		DD	Down	1001-10000
<i>Aquila adalberti</i> *	Spanish Imperial Eagle	VU	VU	Stable	101 -1000; 236 pairs ⁹
Lower Risk or Least Concern					
<i>Spilornis cheela</i> (14)	Crested Serpent Eagle	LC	LR	?	100001 - 1000000
<i>Spilornis holospilus</i> ^{ss}	Philippine Serpent Eagle	LC	DD	?	~ 5000
<i>Spilornis rufipectus</i> (2) ^s	Sulawesi Serpent Eagle	LC	LR	?	10001 -100000
<i>Dryotriorchis spectabilis</i> (2)	Congo Serpent Eagle	LC	DD	?	~ 5000
<i>Circaetus gallicus</i> *	Short-toed Eagle	LC	LR	Stable/Up in some places	10001 -100000
<i>Circaetus pectoralis</i> *	Black-breasted Snake Eagle	LC	DD	?	~ 50000
<i>Circaetus cinereus</i> *	Brown Snake Eagle	LC	DD	?	10001 -100000
<i>Circaetus cinerascens</i> *	Western Banded Snake Eagle	LC	DD	?	1001 - 10000
<i>Nisaetus (Spizaetus) lanceolatus</i> ^{ss}	Sulawesi Hawk Eagle	LC	DD	?	~ 5000
<i>Nisaetus (Spizaetus) cirrhatus</i> (5)	Changeable Hawk Eagle	LC	LR	?	10001 -100000
<i>Nisaetus (Spizaetus) nipalensis</i> (2)	Mountain Hawk Eagle	LC	DD	?	~ 10000
<i>Nisaetus (Spizaetus) alboniger</i> *	Blyth's Hawk Eagle	LC	DD	Down?	1001 - 10000
<i>Spizaetus tyrannus</i> (2)	Black Hawk Eagle	LC	LR	?	100000 – 1000000
<i>Spizaetus (Spizastur) melanoleucus</i> *	Black-and-white Hawk Eagle	LC	LR	?	10001 -100000
<i>Spizaetus ornatus</i> (2)	Ornate Hawk Eagle	LC	LR	Down	~ 50000
<i>Stephanoaetus coronatus</i> *	Crowned Hawk Eagle/African Crowned Eagle	LC	LR	Down	~ 5000
<i>Lophotriorchis (Hieraetus) kienerii</i> (2)	Rufous-bellied Eagle	LC	LR	Stable?	~ 5000
<i>Aquila (Lophaetus) occipitalis</i> *	Long-crested Eagle	LC	LR	?	~ 50000
<i>Aquila (Ictinaetus) malayensis</i> *	Black Eagle	LC	LR	Stable	10001 -100000
<i>Aquila (Lophaetus) pomarina</i> *	Lesser Spotted Eagle	LC	LR	Down	~ 50000; 15000 pairs in Europe ⁵
<i>Aquila (Hieraetus) wahlbergi</i> *	Wahlberg's Eagle	LC	LR	Stable	100001 - 1000000

Species	Common Name	Status IUCN	Status GRIN	Population Trend	Estimated Population Size (individuals) [GRIN unless otherwise noted]
<i>Aquila (Hieraaetus) ayresii</i> *	Ayres's Hawk Eagle	LC	DD	?	1001 - 10000
<i>Aquila (Hieraaetus) pennata</i> *	Booted Eagle	LC	LR	?	10001 - 100000
<i>Aquila (Hieraaetus) morphnoides</i> *	Little Eagle	LC	LR	Down	10001 - 100000
<i>Aquila nipalensis</i> (2)	Steppe Eagle	LC	LR	?	100001 - 1000000
<i>Aquila rapax</i> (3)	Tawny Eagle	LC	LR	Stable	100001 - 1000000
<i>Aquila chrysaetos</i> (6)	Golden Eagle	LC	LR	Stable	100001 - 1000000
<i>Aquila verreauxii</i> *	Verreaux's Eagle	LC	LR	Stable	10001 - 100000
<i>Aquila audax</i> (2)	Wedge-tailed Eagle	LC	LR	Stable	100000 - 1000000
<i>Aquila (Spizaetus) africana</i> *	Cassin's Hawk Eagle	LC	LR	?	~ 5000
<i>Aquila (Hieraaetus) fasciata</i> (2)	Bonelli's Eagle	LC	LR	? Down ⁶	10001 - 100000
<i>Aquila (Hieraaetus) spilogaster</i> *	African Hawk Eagle	LC	LR	?	~ 50000

262 * = monotypic, () = number of subspecies, ^S = single country distribution, ¹ Gamauf et al. 2005, ² Preleuthner & Gamauf 1998, ³ Gjershaug et al. in manus, ⁴
263 Gjershaug 2006, ⁵ Mebs & Schmidt ⁶ Real & Mañosa 1997, ⁷ Nijman 2006, ⁸ Birdlife 2008, ⁹ Grupo de Trabajo del Aguila Imperial Ibérica, Ministerio de Medio
264 Ambiente (unpublished data)

265
266
267

268
269 *"Data Deficient" species.*

270
271 Although it is an IUCN classification, none of the eagles in this review were classed by IUCN as Data
272 Deficient; 15 were classed by GRIN as Data Deficient (24.6 % of total). We placed six of these species in
273 the Near-threatened/Vulnerable category and 9 in the Lower Risk/Least Concern category

274
275 *Trends*

276
277 The population trend for many species was unknown (28 of the 61 species (45.9%)), 20 of which were
278 categorized as "Least Concern". The Ryukyu Serpent Eagle is the only Endangered species for which
279 IUCN lists a stable population trend, but Yamazaki (unpublished data) considers the population trend to be
280 unknown. for all other Endangered species the population trends are downward.

281
282 Populations of 20 other species were thought to be declining, 9 were thought to be stable or with small
283 declines, and only one (Southern Banded Snake Eagle) was thought to be increasing. IUCN (up) and GRIN
284 (unknown) did not agree on the trend for Gurney's Eagle. We think it unlikely that the trend is upward for
285 this eagle because it occurs in forests and generally these are in decline throughout the eagle's range
286 (See discussion).

287
288 *Range geography and estimated population size*

289
290 24 (39.3%) species have distributions that are exclusively on small islands, large islands or groups of
291 islands. All of the endangered or critically endangered species are on islands, albeit Madagascar and
292 Java are large islands (where appropriate habitat is limited).

293
294 Most species occur in Africa or Southeast Asia. Although some species (e.g. golden eagle) span a
295 number of zoogeographic regions, at least half of the species occur in the Indomalayan Zoogeographic
296 Region. Only one, the golden eagle, occurs in the Nearctic. Species that occur away from the tropics
297 tend to have a better conservation status and to be better known (e.g. Short-toed eagle, Bonelli's Eagle,
298 Mountain Hawk Eagle, Golden Eagle).

299
300 Small populations are a feature of the Vulnerable and Near Threatened species. Central Nicobar Serpent
301 Eagle is thought to have a population of less than 100 individuals. Seven species (all but one from
302 islands) have populations between 51 and 1000 individuals. Spanish Imperial Eagle is the only species
303 that has a continental distribution, and a population of < 1000 individuals.

304
305 For many species (e.g. golden eagle???) that have larger population sizes, distribution within historical
306 range is declining. Also, trends are not uniform across species distribution. For example, short-toed
307 eagle appears to be increasing in part of its range (e.g. Israel S. Darawshi pers. comm.), and declining in
308 other parts.

309

310

311 *Threats and ongoing conservation work*

312

313 The greatest threat to booted and serpent eagles worldwide is habitat destruction or degradation in one
314 form or another (Table 2). Because so many of the species dealt with in this paper utilize forests for
315 hunting and nesting, “deforestation” is the specific form of habitat destruction that affects most species,
316 and it has been identified as the main threat to all the species considered Endangered or Critically
317 Endangered. Except for Beaudouin’s Serpent Eagle and Eastern Imperial Eagle, all Near Threatened or
318 Vulnerable Species for which there were data are threatened by habitats loss or degradation. The five
319 species for which data are deficient are all recently split from *Spilornis cheela* and so are forest species,
320 and are therefore likely threatened by deforestation.

321

322 All species are protected by CITES regulations; however for most species in this group we were unable to
323 find evidence of active conservation work in the field.

324

325

326 **Table 2.** Main threats to booted and serpent eagles and ongoing activities to conserve them.

Species	Common Name	Main Threats	Conservation Activities
Endangered			
<i>Eutriorchis astur</i>	Madagascar Serpent Eagle	Deforestation and habitat fragmentation	CITES II. The Peregrine Fund, World Wide Fund for Nature (WWF). Project Masoala and Association pour la Gestion des Aires Protégées. Establishment of a rainforest reserve, research, monitoring and education.
<i>Spilornis [c.] perplexus</i>	Ryukyu Serpent Eagle	Destruction of foraging habitat, collisions with cars	Formal legal protection. Planned research, activities to reduce collisions and restoration of wetlands where they hunt. Public education. Genetic research.
<i>Spilornis [c.] baweanus</i>	Bawean Serpent Eagle	“Recreational hunting”. Habitat loss to logging and burning. ²	Genetic research.
<i>Pithecophaga jefferyi</i>	Philippine Eagle	Habitat fragmentation and destruction due to logging and slash and burn farming, mining activities, persecution. Persecution. Accidental trapping in snares set for deer and wild pig. Overhunting of prey. Political Instability. Ineffective law enforcement. ⁵	CITES I. Legal protection in Philippines. Various Philippine legislation to support education, protection and protection of habitat. Government agencies involved in PE conservation include Protected Areas and Wildlife Bureau (PAWB) of the Department of Environment and Natural Resources (DENR). Philippine Eagle Foundation conduct and coordinate conservation breeding, conservation education, capacity building among government workers in monitoring and research, field research and community-based conservation initiatives. 10 Regional Eagle Watch Teams (REWTS) that educate the public, rescue and rehabilitate injured raptors, captive breeding and experimental release of captive-bred and rehabilitated eagles. Philippine Eagle Conservation Program based in Mindanao: captive breeding and egg and chick removal from forest fragments to create viable captive population. ⁵
<i>Nisaetus (Spizaetus) floris</i>	Flores Hawk Eagle	Deforestation, persecution, live pet trade	ARRCN <i>Spizaetus</i> Collaboration Project. Survey. Genetic research
<i>Nisaetus (Spizaetus) bartelsi</i>	Javan Hawk Eagle	Deforestation for tea and coffee plantations, illegal hunting, live pet trade, ineffective law enforcement.	CITES II. ARRCN Javan Hawk Eagle Project. ARRCN <i>Spizaetus</i> Collaboration Project. ⁴ Protected as “National Bird” of Indonesia. Action plan compiled. Public conservation education. Training. Research. Survey and Monitoring. Nest-guarding. ³ Rehabilitation
<i>Nisaetus (Spizaetus) philippensis</i>	Philippine Hawk Eagle	Massive and continuing deforestation. Illegal hunting and trapping (even in nominal protected areas), ineffective law enforcement	Legal protection, including CITES Appendix II and national laws. ARRCN <i>Spizaetus</i> Collaboration Project. Genetic research.
<i>Nisaetus (Spizaetus) pinskeri</i>	Pinsker’s Hawk Eagle	Massive and continuing deforestation. Illegal hunting and trapping (even in nominal protected areas), ineffective	ARRCN <i>Spizaetus</i> Collaboration Project. Philippine Eagle Foundation – breeding for conservation. Genetic research.

Species	Common Name	Main Threats	Conservation Activities
		law enforcement	
<i>Aquila (Lophaetus) hastata</i>	Indian Spotted Eagle	Habitat loss due to drainage of forests and meadows. Confusion with <i>A. clanga</i> undermines survey and monitoring	
Near Threatened or Vulnerable			
<i>Spilornis elgini</i>	Andaman Serpent Eagle	Deforestation, potential pressures due to increased human population on island.	CITES II.
<i>Spilornis [c] minimus</i>	Central Nicobar Serpent Eagle	Data deficient. Restricted range.	Genetic research.
<i>Spilornis [c] abbotti</i>	Simeulue Serpent Eagle	Data deficient. Restricted range.	Genetic research.
<i>Spilornis [c] asturinus</i>	Nias Serpent Eagle	Data deficient. Restricted range.	Genetic research.
<i>Spilornis [c] sipora</i>	Mentawai Serpent Eagle	Data deficient. Restricted range.	Genetic research.
<i>Spilornis [c] natunensis</i>	Natuna Serpent Eagle	Data deficient. Restricted range.	Genetic research.
<i>Spilornis klossi</i>	Great Nicobar Serpent Eagle	Data deficient, potential pressures due to increased human population within restricted range	CITES II.
<i>Spilornis kinabaluensis</i>	Kinabalu Serpent Eagle	Deforestation, but poorly known.	CITES II.
<i>Terathopius ecaudatus</i>	Bateleur	Habitat destruction, lack of carrion, nest disturbance, pesticides, inadvertent poisoning from baits set to kill other predators seen to damage livestock	CITES II. Endangered Wildlife Trust educating farmers about collateral damage due to predator control using poisons
<i>Circaetus beaudouini</i>	Beaudouin's Snake Eagle	None known.	CITES II.
<i>Circaetus fasciolatus</i>	Banded Snake Eagle	Deforestation and habitat degradation, especially along rivers, human persecution.	CITES II.
<i>Nisaetus (Spizaetus) nanus</i>	Wallace's Hawk Eagle	Low land forest loss, fragmentation and degradation. Some illegal hunting. Ineffective law enforcement, including in protected areas.	Legal protection, including CITES II. ARRCN <i>Spizaetus</i> Collaboration Project. Some protected areas
<i>Nisaetus (Spizaetus) kelaarti</i>	Legge's Hawk Eagle	Deforestation, especially of evergreen forests. Forest fragmentation	ARRCN <i>Spizaetus</i> Collaboration Project
<i>Spizaetus (Oroaetus) isidori</i>	Black-and-chestnut Eagle	Probably deforestation. Appears to occupy narrow altitudinal range. Little known.	CITES II.
<i>Polemaetus bellicosus</i>	Martial Eagle	Persecution. Bird trade and collateral	CITES II.

Species	Common Name	Main Threats	Conservation Activities
		mortality of a proportion of birds taken into captivity for trade.	
<i>Aquila (Lophaetus) clanga</i>	Greater Spotted Eagle	Habitat destruction including drainage of wetlands, forestry, and intensification of farming. Abandonment of traditional flood plain management, nest disturbance, nest robbing, shooting, poisoning. Hybridisation with lesser spotted eagle (<i>Aquila pomarina</i>), but as yet it is not clear whether this is a natural phenomenon or a result of an increasing difficulty in finding a mate. Thought to be competing for food with the introduced American mink (<i>Mustela vison</i>) in Belarus. Threats likely different in wintering and summering ranges and on migration.	CITES II. Legally protected on national scale. Regionally protected in Europe by the EU Birds Directive and indirectly by Habitats Directive. International Lesser and Greater Spotted Eagle Working Group formed. Research on hybridisation with lesser spotted eagle habitat requirements and site protection measures in Belarus. RSPB/BirdLife research in Belarus. European Action Plan published in 2000.
<i>Aquila heliaca</i>	Eastern Imperial Eagle	Habitat change (conversion of native forests to commercial forests with introduced species with consequent loss of prey), loss of nest sites (large trees), human disturbance, nest robbing, illegal trade, shooting, poisoning, shortage of prey species, and electrocution, live bird trade. Threats likely different in wintering and summering ranges and on migration.	CITES I. Legally protected in most countries in its range. The Eastern Imperial Eagle Working Group established in 1990. European Action Plan (1996). LIFE Project in Hungary.
<i>Aquila gurneyi</i>	Gurney's Eagle	Possibly threatened by deforestation. Little known.	CITES II. Survey
<i>Aquila weiskei</i>	Pygmy Eagle	Possibly threatened by deforestation. Little known.	
<i>Aquila adalberti</i>	Spanish Imperial Eagle	Electrocution and accidental trapping and poisoning.	CITES I. Modifying transmission poles, education. Mostly protected on the local or national scale. Regionally protected in Europe by the EU Birds Directive and indirectly by Habitats Directive. Captive breeding.
Least Concern			
<i>Spilornis cheela ssp.</i>	Crested Serpent Eagle	No immediate threats to population and seen as adaptable, but deforestation and keeping as pets in	CITES II. Survey. Genetic work.

Species	Common Name	Main Threats	Conservation Activities
		their range are problems. Taxonomic questions exist and resolution of these may give rise to new species that are imperilled.	
<i>Spilornis holospilus</i>	Philippine Serpent Eagle	Deforestation, but seems adaptable.	CITES II. Genetic work.
<i>Spilornis rufipectus</i>	Sulawesi Serpent Eagle	Deforestation and disturbance, but may be adaptable. Little known. Deforestation seems less of an immediate threat than on other islands in the region.	CITES II. Survey. Genetic work
<i>Dryotriorchis spectabilis</i>	Congo Serpent Eagle	Deforestation	CITES II.
<i>Circaetus gallicus</i>	Short-toed Snake Eagle	Habitat loss due to intensified agriculture, shooting on migration, locally windfarms (mostly in Spain)	CITES II. Regionally protected in Europe by the EU Birds Directive and indirectly by Habitats Directive. Mostly conservation efforts on the local or national scale.
<i>Circaetus pectoralis</i>	Black-breasted Snake Eagle	Data deficient, but occurs in a wide range of habitats.	CITES II.
<i>Circaetus cinereus</i>	Brown Snake Eagle	Data deficient. Perhaps vulnerable to habitat degradation.	CITES II.
<i>Circaetus cinerascens</i>	Western Banded Snake Eagle	Deforestation of riverine forests and habitat degradation.	CITES II.
<i>Nisaetus (Spizaetus) lanceolatus</i>	Sulawesi Hawk Eagle	Deforestation and disturbance. Little known. Deforestation seems less of an immediate threat than on other islands in the region.	CITES II. ARRCN <i>Spizaetus</i> Collaboration Project
<i>Nisaetus (Spizaetus) cirrhatus</i>	Changeable Hawk Eagle	Deforestation, human disturbance, subspecies may be threatened due to small ranges (islands)	CITES II. ARRCN <i>Spizaetus</i> Collaboration Project
<i>Nisaetus (Spizaetus) nipalensis</i>	Mountain Hawk Eagle	Deforestation. Loss of big trees in which it nests	CITES II. ARRCN <i>Spizaetus</i> Collaboration Project
<i>Nisaetus (Spizaetus) alboniger</i>	Blyth's Hawk Eagle	Deforestation. Loss of big trees in which it nests	CITES II. ARRCN <i>Spizaetus</i> Collaboration Project
<i>Spizaetus tyrannus</i>	Black Hawk Eagle	Deforestation.	CITES II.
<i>Spizaetus (Spizastur) melanoleucus</i>	Black-and-white Hawk Eagle	Deforestation, but appears relatively tolerant of habitat change. Range contracting.	CITES II.
<i>Spizaetus ornatus</i>	Ornate Hawk Eagle	Deforestation. Declining at various localities across range	
<i>Stephanoaetus coronatus</i>	Crowned Eagle	Deforestation, shooting, trapping, nest disturbance. Overhunting of prey.	CITES II.

Species	Common Name	Main Threats	Conservation Activities
		Declining at various localities across range	
<i>Lophotriorchis (Hieraaetus) kienerii</i>	Rufous-bellied Eagle	Habitat destruction (deforestation)	CITES II. Survey
<i>Aquila (Lophaetus) occipitalis</i>	Long-crested Eagle	Adaptable, but potentially vulnerable to degradation of woodland and drainage of wetland	CITES II.
<i>Aquila (Ictinaetus) malayensis</i>	Indian Black Eagle	Habitat destruction (deforestation)	Survey. ARRCN Indian Black Eagle Collaboration Project.
<i>Aquila (Lophaetus) pomarina</i>	Lesser Spotted Eagle	Shooting, habitat loss due to drainage of forests and meadows. Disturbance due to human recreational activities. Locally windfarms. Threats likely different in wintering and summering ranges and on migration.	CITES II. Conservation mostly on the local or national scale. Regionally protected in Europe by the EU Birds Directive and indirectly by Habitats Directive. European Action Plan.
<i>Aquila (Hieraaetus) wahlbergi</i>	Wahlberg's Eagle	Some threat from loss of habitat and locally by accidental poisoning.	CITES II.
<i>Aquila (Hieraaetus) ayresii</i>	Ayres's Hawk Eagle	Locally shooting and habitat destruction.	CITES II.
<i>Aquila (Hieraaetus) pennata</i>	Booted Eagle	Deforestation and loss of low intensity agricultural systems, human disturbance, persecution, locally windfarms. Threats likely different in wintering and summering ranges and on migration.	CITES II. Regionally protected in Europe by the EU Birds Directive and indirectly by Habitats Directive.
<i>Aquila (Hieraaetus) morphnoides</i>	Little Eagle	Locally habitat destruction, but seems to be adaptable. Declines in prey availability due to control of rabbits with RCV (rabbit calicivirus)	CITES II.
<i>Aquila nipalensis</i>	Steppe Eagle	Electrocution. Conversion of steeper into agricultural fields, some persecution. Shooting on migration. Threats likely different in wintering and summering ranges and on migration.	CITES II
<i>Aquila rapax</i>	Tawny Eagle	Accidental and non-accidental poisoning, persecution, shooting. Declines in prey availability.	CITES II
<i>Aquila chrysaetos</i>	Golden Eagle	Habitat loss including plantation	CITES II. Regionally protected in Europe by the EU Birds Directive

Species	Common Name	Main Threats	Conservation Activities
		forestry, declines in prey, locally direct persecution, targeted as well as inadvertent poisoning from baits set for other predators, human disturbance, electrocution, windfarms. Threats likely different in wintering and summering ranges and on migration for non-resident proportion of population.	and indirectly by Habitats Directive. Protected in North America by Migratory Bird Treaties. Many conservation efforts, mostly on the local or national scale. In the Middle East and Japan, subspecies are considered threatened or endangered.
<i>Aquila verreauxi</i>	Verreaux's Eagle	Effects of growing human population including declines in main prey due to overgrazing and hunting. Persecution. Drought.	CITES II.
<i>Aquila audax</i>	Wedge-tailed Eagle	Habitat and nest tree destruction, locally persecution, inadvertent human disturbance, accidental and intentional poisoning, windfarms. Lead poisoning. Threatened with extirpation in Tasmania.	CITES II. Nesting habitat and nest sites of Tasmanian race afforded some protection in state forests through Forest Code.
<i>Aquila (Spizaetus) africana</i>	Cassin's Hawk Eagle	Apparently relatively adaptable. Deforestation, human disturbance. Poorly known.	CITES II.
<i>Aquila (Hieraetus) fasciata</i>	Bonelli's Eagle	Persecution, Habitat loss due to intensified agriculture, Declines in prey ¹ , Collision with power lines. Persecution. Locally windfarms. Endangered in its western European distribution. Destruction of nests and nest sites (India)	CITES II. Mostly conservation efforts on the local or national scale. Regionally protected in Europe by the EU Birds Directive and indirectly by Habitats Directive.
<i>Aquila (Hieraetus) spilogaster</i>	African Hawk Eagle	Habitat change, some shooting and poisoning.	CITES II.

327 ¹ Carrete et al 2002; ² Nijman 2006 ³ Prawiradilaga 2006; ⁴ Yamazaki 2000; ⁵ Salvador and Ibanez 2006

328

329 DISCUSSION

330

331 Differences in nomenclature notwithstanding, there is general agreement between our sources on the
332 conservation status of booted and serpent eagle species. Collar et al (1994) lists only five eagles (1
333 Critical, 1 Endangered and 5 Vulnerable), but perhaps that list is out of date. It is worrying that so many
334 species classed as Least Concern by IUCN are classed as Data Deficient by GRIN. At least in part, this
335 may be because IUCN criteria for classifying species rely more exclusively upon peer-reviewed evidence
336 whereas GRIN sometimes make judgements based on circumstantial evidence (e.g. primary forest is
337 declining, so obligate forest species must be declining).

338

339 Over one third of populations of the eagle species we examined are declining, even if their current
340 conservation status is of lower concern. Taken in the context of the population trends of 46% (28 of 61) of
341 the species being unknown, this statistic is worrying. This bleak situation has probably come about
342 because so many of the species considered here thrive in relatively pristine forests that have not been
343 fragmented. Because eagles mostly require relatively large home ranges, those species that are
344 dependent on unfragmented habitats may be more susceptible to fragmentation than smaller raptor
345 species. The known or likely declines in the species we considered are not surprising when seen against
346 the background of 46% of all tropical raptors being threatened by habitat loss, and the effects being
347 greatest in Afrotropical, Indomalayan and Australotropical areas (Bildstein et al 1998, Hannah et al
348 1994). Indeed, Thiollay (1985 a, b, 1994) detailed habitat loss in the tropics as being caused by
349 deforestation, disturbance and fragmentation, and recorded that despite these threats being well known,
350 little had been done to address this loss either by slowing it or creating more protected areas, enlarging
351 existing protected areas or having effective enforcement of protected areas

352

353 A feature of our results, and something we predicted from the outset, is that so many species are poorly
354 known. GRIN does not even classify the population status of many species because data are deficient.
355 Related to that, we found that the trends of populations were unknown for many species (see above).
356 Sadly, this state of affairs was not limited to small island populations or species that have been recently
357 identified after genetic analyses. We could not even determine the population trends of relatively well
358 studied species like Booted Eagles (although fairly well known in its European distribution (Mebs and
359 Schmidt 2006)) or Bateleur, though perhaps these determinations have been made and are published
360 somewhere.

361

362 Obviously, very basic data on population sizes and trends are important in determining what species are
363 priorities, so when these data are lacking conservation is undermined. However, for the most part we are
364 largely ignorant about almost all aspects of the vast majority of these eagle species. Identification of new
365 species is a case in point. Many new species have been identified in recent years, due mostly to
366 advances in genetic analyses. *Spilornis cheela* is probably the most common serpent eagle 'species'.
367 However, in recent years seven 'new' species have been split from it, and these new species, as one

368 might expect, tend to have small population sizes and be located on island. The current 'cheela'
369 distribution includes many islands, which along with high morphological variation suggest that more 'new'
370 species will be 'discovered', and split from *cheela*. If the current new species are indicative then this
371 process will result in a new, rare or poorly understood species, and concurrently the core *cheela*
372 population will be reduced in size and geographic distribution.

373

374 The data we present consider global status and trends. For some species, most notably those on islands,
375 these reflect the situation across their range. However, the national status of species with ranges that
376 include many countries may be different from these global values. For example Black-and-chestnut Eagle
377 is a species classed as Near Threatened by IUCN, but is considered Endangered by Renjifo et al (2002)
378 and the Mountain Hawk Eagle is considered of Least Concern by IUCN but is Endangered in Japan. For
379 some taxa differences in status coincide with subspecific designation, so while *A. chrysaetos* is probably
380 one of the commonest eagles worldwide and of Least Concern for IUCN and Lower Risk for GRIN, the
381 golden eagle in Japan, *A. c. japonica*, is Endangered.

382

383 In general, for any species, their national status in range countries is equal to or poorer than their global
384 status, and this is a result of declining population sizes and distribution. Of course limited range and low
385 populations dispose a species toward imperilment. On the other hand, aspects of conserving species
386 could be easier if their distribution was within a single country because laws would be consistent and
387 policing and management efforts could be logistically easier. Thiollay (1994) suggests that island endemic
388 raptors may have life history traits that make them better able to deal with the anthropogenic threats, but
389 that is probably less true for the subset of eagle species that we consider here. A web site exists that lists
390 species that are threatened and forest-dwelling single country endemics, but seems either out of date
391 because new species have been discovered or it is incomplete.

392 <http://www.fao.org/docrep/006/ad655e/ad655e12.htm>

393

394 Eight of nine species that are Critically Endangered or Endangered live on islands, though some are on
395 very large islands. All suffer the effects of habitat change and fragmentation due to deforestation. The
396 populations of Bawean Serpent Eagle and Flores Hawk Eagle are extremely small. Flores Hawk Eagle
397 distribution is disjunct; it occurs on five islands, but it is presumed that individuals can move between
398 these because they are close to one another (<http://www.birdlifeforums.org/WebX/.2cba5b3e> last visited
399 26 March 08 and <http://www.birdlifeforums.org/WebX?13@@.2cba5b3e> last visited 22 Dec 2008)

400

401 Of these Endangered Species, Philippine Eagle, Javan Hawk Eagle and Madagascar Serpent Eagle are
402 receiving the most attention in conservation terms. Efforts to conserve the Philippine Eagle extend back
403 nearly 40 years () and include public education, captive breeding for eventual release and research
404 components. Teams of researchers from Indonesia, Norway, Japan, and Netherlands have been working
405 on and have published on Javan Hawk Eagle (e.g. van Balen 1993, Sözer and Nijman 1995a, Gjershaug
406 et al. 2004, Prawiradilaga 2006). A team of researchers from Norway and Indonesia have published on

407 Flores Hawk Eagle (Gjershaug *et al.* 2004). Researchers from the Peregrine Fund are working on the
408 Madagascar Serpent Eagle.

409

410 All threats could be said to be anthropogenic. The main threat to eagles worldwide is the loss of habitat.
411 Because so many of the eagles considered in this paper are (rain) forest dependent species, deforestation
412 was the threat most common among the eagles for which we had information. Stating the obvious then,
413 declines in quality and quantity of forest habitats will inevitably lead to declines in the eagle populations
414 that inhabit them. Other threats, such as food shortages or loss of nest sites will mostly be proximate to
415 the larger, ultimate problem of habitat (forest) loss. Persecution was identified as a threat to a few species
416 and it may have a local effect on species that have a large range. However, even relatively low levels of
417 persecution could have a very large effect on species with a small population and/or inhabiting a small
418 range (islands). For many species details of threats were not known, though it seems likely that in cases
419 where data are lacking, loss of habitat would be a best-guess threat faced by these eagles. Although it is
420 hard to predict, large scale changes linked to processes like global warming could affect eagle populations
421 in the future by affecting the vegetation or prey availability in their ranges. A species like the Southern
422 Banded Snake Eagle may be particularly susceptible to changes in climate because it inhabits a relatively
423 broad range of latitude.

424

425 A good proportion of the recent published work on some species is related to better understanding their
426 taxonomic position. Some of these studies have supported the idea of a superspecies complex for some
427 groupings (Sibley & Monroe 1990) and some have split what were once subspecies off into distinct
428 species (e.g., BirdLife International 2000, Ferguson Lees *et al.* 2001, 2005). See discussion in (Gamauf *et al.*
429 *et al.* 2005 and Haring *et al.* 2007). Arguments about taxonomy may seem removed from effective
430 conservation, but most conservation is about prioritizing the saving of species, and is less concerned
431 about conserving subspecies. For that reason, justification of effort and funding can be more easily made
432 for species, and it is therefore important that genetic relationships are clarified. Experience with the
433 Hierofalcons has shown that one can not always find speciation in taxa where speciation is presumed,
434 especially when those taxa are phylogenetically “young”. Vocalizations and other behavioural differences
435 might separate species that can not be separated by genetic evidence. Perhaps counter-intuitively,
436 taxonomy and genetic relationships of a species are sometimes studied before its general ecology. This
437 reflects to some extent the availability of genetic samples in collections, but also the importance of
438 establishing the validity of a particular species and the relative ease of a more lab based approach that
439 might use museum specimens as research material.

440

441 Although it is easier to justify efforts to save species, Thiollay (1994) reminds us that subspecies represent
442 part of biodiversity, and should not be lost. Indeed, some of the currently recognized species were
443 themselves considered subspecies and races not so many years back (e.g. Lerner and Mindell 2005, Väli
444 2006), and *A. chrysaetos japonica* is quite different from other subspecies of golden eagle (Watson 1997)

445

446 Though understanding the taxonomic position of some populations can be important, especially when
447 allocating rare conservation funds, we do not want differences in opinion in taxonomy to get in the way of
448 conservation. Conservation or maintenance of populations should be the driver in setting priorities and
449 initiating actions, and research should play a supporting role. The corollary to that is that long-term
450 effective conservation is underpinned by high-quality research. For most of these species data from field
451 work will be difficult and expensive to gather. Many of the species that we examined in this paper
452 (including those that are most endangered), live in remote places, in sometimes difficult terrain and habitat
453 (sometimes even dangerous places). As defined by their conservation status, many populations are small
454 and declining. It may also be the case that some valid species may not yet be recognised as such and
455 therefore not afforded a status that accurately describes their situation. An example of this may be the
456 Bawean Serpent Eagle, which is recognized as a Critically Endangered Species by GRIN, but which is
457 considered a subspecies of *Spilornis cheela* by IUCN. Although *S. cheela* is considered at low risk (see
458 below) the “new” species that are poorly known may face challenges because they are on small islands
459 and perhaps have small population sizes. That said, conservation resources, especially funding, are rare
460 and priorities need to be set.

461
462 Across species conservation efforts are very uneven, and there has been no prioritization. Even within
463 species, very few seem to have coordinated conservation efforts underway. For some this is due, at least
464 in part, to their wide distribution. We found it difficult to identify ongoing conservation efforts apart from
465 those whose results have been published. Even these published works tended to describe scientific
466 research rather than direct conservation activities (e.g. education, captive breeding, habitat-related
467 management programs, etc.). Although it is likely that conservation groups specializing on particular
468 species or working in a certain region are aware of one another,

469 470 *Action plans*

471
472 Species conservation action plans are important tools in conservation, as they focus on endangered
473 species and prioritize activities aimed at halting the decline of populations and, if possible restoring
474 species to a favourable conservation status. The European species’ action plans have been produced by
475 BirdLife International, with the support of the European Union, Bern convention, Dutch Government and
476 the African Eurasian Waterbird Agreement. Species action plans are available for five booted eagles:
477 *Aquila heliaca*, *A. adalberti*, *A. clanga*, *A. pomarina* and *A. fasciata*
478 (http://ec.europa.eu/environment/nature/conservation/wildbirds/action_plans/. Last accessed 30 Jan
479 2009). Some effort has been put into an action plan for *Nisaetus bartelsi* (Sözer *et al.* 1998), but this
480 effort is not complete, but for the most part action plans are not planned for the species most imperilled
481 and they are generally lacking for the part of the world where most endangered and threatened eagles
482 occur, Southeast Asia. Although it is important to draft action plans for eagles should have a high priority,
483 as they are important framework for conservation action. They are also a reference for fundraising.

484 485 **Other aspects**

486

487 For some species, populations were likely always small (e.g. Johnson et al 2009), even when their habitat
488 was unaffected by human activity and they were not persecuted. Indeed, population sizes of some of the
489 island species are limited by the size of the islands on which they occur, and although island distribution is
490 a factor in endangerment, it is not, by force, the rule. Whether occurring at naturally low numbers or not,
491 for species occurring on single or few islands local threats are also population threats and small changes
492 in habitat area or stochastic events can greatly affect them. Because of this it seems to us that these
493 species are those that should be targeted by zoos and a “bank” of breeding individuals should be created
494 to insure against catastrophic declines.

495

496 Although we highlight the splitting of *S. cheela* as creating new species to be conserved, this should not
497 be used as justify unwarranted splitting of species to enhance local conservation efforts. That said,
498 conservation efforts should also battle against loss of range of even the most common species. Range
499 extent of even the most common species should not be sacrificed on the altar of species concept. So,
500 although the golden eagle is perhaps the most numerous eagle worldwide, the japonica subspecies is
501 threatened, its range has no doubt decreased in Mexico and persecution/habitat loss/disturbance probably
502 has affected its range in the UK.

503

504 Some of the most basic information needed to conserve these eagles is lacking, and is difficult to gather.
505 So, for example, misidentification of Blyth’s Hawk Eagle and Wallace’s Hawk Eagle may mean that the
506 conservation status of one or both of these species is incorrect, undermining conservation efforts.
507 Downstream of this, conservation efforts (e.g. public education, habitat management and conservation,
508 etc.) are mostly lacking

509

510 Most of the most-endangered species we dealt with here are sub-tropical and tropical, and migration is not
511 the feature it is for temperate species. Migration notwithstanding, conservation efforts may need to be
512 considered in terms of season. Obviously, a Lesser Spotted Eagle breeding in Europe will face a different
513 conservation environment than the one it faces in the winter in Africa, but similarly tropical eagles that live
514 through wet and dry seasons, but do not migrate require conservation strategies that take this into
515 account.

516

517 **Setting an agenda for conservation**

518

519 Thiollay 1994, in considering raptors in general suggested that there should be emphasis placed on
520 surveys of priority areas, increases in ecological studies, habitat management (including hunting pressure)
521 and captive breeding. We think these emphases could be applied to the narrower world of the eagle
522 species we consider.

523

524 Table 3 is our “hit list” of the 15 species we think should be priorities for conservation action. We have
525 tried to rank these by weighing the relative imperilment and conservation opportunities that exist for each
species, but appreciate that, in the end, the list is a subjective one.

526

527 The outlook for a number of species seems particularly gloomy. Small populations in developing countries
528 where habitat is being destroyed at an alarming rate seem to be hopeless cases. However, on a positive
529 note, the species we looked at are almost all located in places where labour costs are low. So, if we can
530 identify good partners with which to work we have the potential to provide good-value-for-money
531 conservation. The down side of the geography of this group is that if outside expertise or equipment is
532 needed, it will be relatively costly in terms of money, time, and fossil fuels to provide. Also, the human
533 population in the places where most imperilled eagles occur is poor, undereducated and growing. In
534 general people in these areas rely on the extractive use of natural resources, including timber and farming
535 for their livelihoods, which threatens habitat or prey availability or both.

536

537 The main threat to the eagles we examined was the loss of habitat, in particular the loss of tropical and
538 subtropical forests. For this reason conservation of many of the serpent and booted eagles can be
539 supported by conserving this resource. Because forests in general have been high on the list of
540 conservation priorities for a long time, partnering with ongoing forest conservation efforts would make
541 sense. Beyond the ecological importance of what is likely to be the top diurnal avian predator (if not the
542 top predator of any type), the eagle species that we are concerned with are often charismatic species and
543 can be a useful symbol for forest conservation efforts.

544

545 *In situ* conservation initiatives are probably underway for most Endangered species, but those for Javan
546 Hawk Eagles, Madagascar Serpent Eagles and Philippine Eagle are most substantial. Some conservation
547 efforts for the Javan and Flores Hawk Eagles have been aimed at establishing their taxonomic position.
548 Some researchers involved in some of these studies have proven track records of effective conservation,
549 it seems that support for new and existing concrete conservation projects that include them would be
550 good. We are not aware of any conservation initiatives on the Bawean Serpent Eagle. A more concerted
551 effort should be made to identify ongoing conservation efforts for this eagle, if any. If no initiatives exist to
552 which positive contributions can be made, then the ECA should support and maybe initiate new efforts. A
553 first step might be a field survey of the species concerned.

554

555 Of the species classed as Vulnerable, Wallace's Hawk Eagle, Philippine and Pinsker's Hawk Eagle
556 appear to be the species on which to concentrate because they are teetering toward Endangerment. In
557 fact, because of the splitting of the species, it could be reasonably argued that Philippine and Pinsker's
558 Hawk Eagle are endangered, but have yet to be formally classified as such.

559

560 Like many of the other hawk eagles, including those that are already Endangered, some work has been
561 done on the taxonomy of Wallace's Hawk Eagle. Although this can form the basis from which to launch
562 conservation efforts, this is not yet the case. Wallace's Hawk Eagle does fall within the ARRCN Spizaetus
563 Collaboration Project, but as yet little tangible conservation work has been undertaken. Of the other
564 Vulnerable species, it may be that efforts applied to the Southern Banded Snake Eagle could be promoted

565 because a high-quality group of raptor conservationists and researchers are known from East and
566 Southern Africa.

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571

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