

Evaluating land invertebrate species: prioritizing endangered species

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Invertebrates dominate terrestrial ecosystems in Galapagos, far outnumbering all other animal species. They play a key role in insular ecosystems as fundamental components of the mechanisms for pollination of plants, decomposition of organic matter, and soil building. They are present in nearly all habitats and form part of the food chain for many bird and reptile species.

The land invertebrate fauna in Galapagos is rich in endemic species but poor in diversity when compared to the South American mainland. Nearly 3,000 species of land invertebrates have been reported in Galapagos, 51.7% of them endemic. The most sizable group is insects, with 1,555 species, followed by arachnids and nematodes (Annex 1). Some groups, such as acarids and nematodes, have been little studied as yet or have a complex taxonomy, requiring more in-depth studies to identify all species.

It is vital to determine the conservation status of endemic species for the development of management strategies. To ensure that ecosystems function properly, it is necessary to restore communities with key species,

such as invertebrates. In the last few years, one of the priorities of the Charles Darwin Foundation (CDF) has been to evaluate the conservation status of endemic species of land invertebrates according to World Conservation Union (IUCN) criteria. As of 2006, land snail species of the *Bulimulus* genus and species of the Lepidoptera order (moths and butterflies) have been assessed.

Threat status of groups of land invertebrates as of 2006

The final findings of the assessment of 103 species indicate that 2 are already Extinct, 26 are Critically Endangered, 9 are Endangered, 26 are Vulnerable, and 40 are apparently in no immediate danger of extinction (Table 1).

Out of 103 species of endemic land invertebrates evaluated as of 2006, two are extinct and 61 are under a Threatened Category

Table 1. Number and percent of taxa in each Threat Category as of 2006.

Year	Group	No. Taxa Evaluated	IUCN Threat Category					
			EX	CR	EN	VU	NT	LC
2006	Total Taxa	103	2	26	9	26	—	40
	Percent		2	25	9	25	—	39
	Lepidoptera	53	—	—	2	11	—	40
	Percent		—	—	4	21	—	75
	<i>Bulimulus</i>	50	2	26	7	15	—	—
	Percent		4	52	14	30	—	—

Source: CDF databases.

Notes

Symbols Legend: **EX** = Extinct, **CR** = Critically Endangered, **EN** = Endangered, **VU** = Vulnerable, **NT** = Near Threatened, **LC** = Least Concern.

Lepidoptera

Moths and butterflies belong to one of the most diverse orders (Lepidoptera) in the class Insecta and are the second most diverse taxonomic group in Galapagos. This order comprises over 340 species in the archipelago. At this time, approximately 200 native species have been recorded, of which some 100 species are endemic¹.

Most representatives of this group have nocturnal habits. Nearly all larvae of these species are herbivorous, but there are some exceptions. Some genera, such as *Galagete*, have many species adapted to live in diverse habitats and to feed on a wide variety of resources, ranging from decomposing plant leaves to giant tortoise droppings². On the other hand, adults in most species simply feed on the nectar of flowers. For these reasons, Lepidoptera play a key role in ecosystem processes. Many birds and some insects eat their larvae. Bats, birds, and spiders eat adult butterflies and moths, whereas some flies and wasps are parasites of their larvae.

Assessments of 53 species in this group indicate that 2 species are Endangered, 11 are Vulnerable, and 40 are apparently not in any danger of extinction (Table 1, Annex 2).

Bulimulus land snails

Among land invertebrates, the mollusk fauna of Galapagos occupies a significant position, dominated by the Bulimulidae, a genus of endemic land snails that comprises about 90% of land snail species in the archipelago.

Of the 33 species of land snails recorded in Santa Cruz, 25 still lived there prior to 1973, but only 7 have been found live in recent monitoring efforts.

All *Bulimulus* land snails in Galapagos are endemic. They have undergone a spectacular process of speciation, resulting in 65 described species, with several subspecies and a total of 93 taxa³. The morphological diversity observed in the Galapagos *Bulimulus* is surprising, including variation in the shape of the shell, the opening, and the navel, as well as the sculpture, color, and size of the shell surface.

Bulimulus snails have adapted to a broad range of climatic conditions and habitats. Some species live in semi-desert situations and others are found only in moist forests with more temperate climates. The distribution of some *Bulimulus* species is restricted to very limited areas, such as a valley in the highlands or on an isolated hill, characterized by a particular microclimate or a special type of vegetation. *Bulimulus* land snails are often very sensitive to microclimatic changes; therefore, they could be used as ecological indicators of the state of habitats in order to assess ecological changes in Galapagos³.

Of the 93 taxa in this genus described for Galapagos, only two species are officially considered Extinct (*B. kublerensis* and *B. steamani*) and known only by fossil records. However, there are many other species that have not been sighted in the last 30 years, especially on Santa Cruz. Out of the 33 species known for that island, 25 still lived there prior to 1973³, but only seven have been found live in recent monitoring efforts⁴. More intensive searches are required to determine whether the species not recorded recently are extinct or whether there are still populations in areas not yet studied.

Assessments of this group indicate that a total of 26 species are Critically Endangered, 7 are Endangered, and 15 are Vulnerable (Table 1, Annex 2).

Principal threats to the groups evaluated

Habitat destruction

Destruction and loss of habitat is the main threat to these species. Many of them are especially sensitive to habitat alteration, such as conversion of natural forest to pasture for grazing of introduced species and urban expansion. In the last few years, there has been acceleration in the alteration of natural habitats on the four populated islands.

Table 2 shows the distribution of the two groups evaluated (Lepidoptera and *Bulimulus* land snails) by island and threat category. Most threatened species are on the populated islands such as Santa Cruz, and the only known extinctions have occurred on those islands (Fig. 1).

Table 2. Distribution of threatened species of land invertebrates evaluated as of 2006.

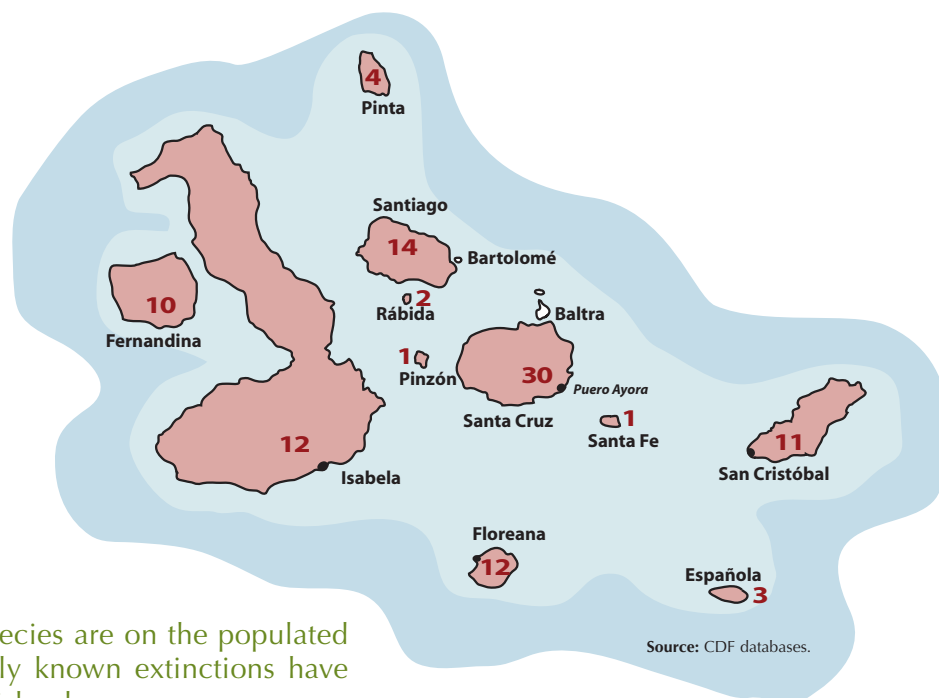
ISLAND	IUCN Threat Category			Total
	CR	EN	VU	
Santa Cruz	16	1	13	30
Santiago	3	3	8	14
Floreana	1	6	5	12
Isabela		2	10	12
San Cristóbal	5	4	2	11
Fernandina			10	10
Pinta		1	3	4
Española	1	1	1	3
Rábida			2	2
Pinzón	1			1
Santa Fe		1		1

Note

CR: Critically Endangered, EN: Endangered; VU: Vulnerable

Source: CDF databases.

Figure 1. Distribution of threatened species of endemic land invertebrates evaluated as of 2006 by island



Source: CDF databases.

Most threatened species are on the populated islands and the only known extinctions have occurred on those islands.

The process of land snail extinction is recent and may be directly related to human settlement of the different islands of the archipelago³. Transformation of their natural habitat for farming and ranching has significantly influenced the distribution of species on Floreana and San Cristóbal since 1847 and on Santa Cruz since 1920. This modification of the natural habitat in colonized zones has seriously harmed many land snail species and other species of land invertebrates whose natural habitats were the moist *Scalesia* forests and transitional woodlands³.

As for Lepidoptera, 15 of the species listed as threatened are mainly jeopardized by loss of habitat, especially because of their limited distribution. The drastic reduction of the *Scalesia pedunculata* forest on Santa Cruz affects many species, especially those that feed on plants found only in this zone⁵.

Introduced species

Introduced species are the second greatest threat to endemic invertebrates, whether from direct predation or by habitat destruction and the destruction of their vegetative food resources.

Introduced predators, such as black rats (*Rattus rattus*) and little fire ants (*Wasmania auropunctata*), have a direct negative impact on land snail populations through predation or by destroying their eggs and limiting their reproduction³. Curiously, two potential competitors of endemic snails that were introduced accidentally (the small pan-tropical snail, *Subulina octona*, and a small black slug, *Deroceras laeve*³) have apparently not suffered serious consequences from these same threats. Another mollusk present on the archipelago is the well-known slug, *Vaginulus (Sarsinula) plebeius* (Veronicellidae), probably introduced into Galapagos in 1984. This species has become successfully established and is currently found in all settled areas, where it seems to have contributed to eliminating some endemic land snail species³.

Host plant destruction is the second most important threat to the 13 endangered species of Lepidoptera. The larvae of many endemic moths are specific to one or a few species of plants that have been severely disturbed by introduced species. Roque-Albelo (2003)⁶ reported a decrease in the populations of three endemic species of Lepidoptera specifically associated with shrubs of the genus *Darwiniothamnus*; this decline was caused by the introduction of the cottony cushion scale, *Icerya purchasi*, into Galapagos. There are no known cases of introduced parasitic species of Hymenoptera or Diptera insects that directly attack endemic butterfly or moth species in Galapagos, although a more intensive study of this issue is needed⁵. Similarly, fire ants (*Solenopsis geminata* and *W. auropunctata*), which eat Lepidoptera eggs and larvae, are also affecting many endemic species of moths and butterflies.

Conclusions

The land invertebrate fauna of Galapagos is endangered. The only two groups for which the conservation status has been assessed show a large number of species that are seriously threatened. The factors most influencing the conservation status of these species are habitat destruction and alteration resulting from human activities and the effect of introduced species such as fire ants, goats, and rats. For the 35 species with a high degree of threat (Critically Endangered or Endangered), it is urgent to take conservation action to prevent their probable extinction. However, the main limiting factor to designing restoration programs is the lack of knowledge about the biology and distribution of these species. Therefore, it is an immediate priority to study these issues.

Introduced species are the second greatest threat to endemic invertebrates, mainly black rats and fire ants (direct predation), and goats (habitat destruction).

Annex 1. Diversity of land invertebrate species in Galapagos.

		Native species	Endemic species	Notes
Phylum Arthropoda				
Subphylum Chelicerata				
Class Arachnida	Arachnids (spiders, scorpions, acarids, etc.)	207	184	1, 2, 3, 4, 5, Unpublished information
Subphylum Myriapoda				
Class Chilopoda	Centipedes	2	6	6, 7
Class Diplopoda	Millipedes	0	1	6, 7
Class Symphyla	Centipede-like animals	0	0	7
Subphylum Crustaceae	Crustaceans	24	7	8
Subphylum Hexapoda				
Class Elliplura	Collembola	22	10	9
Class Diplura	Springtails	1	0	9
Class Insecta	Insects	823+	735+	9, Unpublished information
Phylum Tardigrada	Water bears	14	2	10, 11
Phylum Mollusca	Land snails	3	80	12
Phylum Nematoda	Nematodes	100+	5	13

Source: CDF database.

Annex 2. Species of Land invertebrates Evaluated as of 2006.

Common name	Scientific Name	Class:Order	Threat Category	Islands
Land snail	<i>Bulimulus achatellinus</i>	Gastropoda: Stylommatophora	CR	San Cristóbal, Española
Land snail	<i>Bulimulus adelphus</i>	Gastropoda: Stylommatophora	CR	Santa Cruz
Land snail	<i>Bulimulus aderseni</i>	Gastropoda: Stylommatophora	CR	Santa Cruz
Land snail	<i>Bulimulus chemitzioides</i>	Gastropoda: Stylommatophora	CR	San Cristóbal
Land snail	<i>Bulimulus curtus</i>	Gastropoda: Stylommatophora	CR	San Cristóbal
Land snail	<i>Bulimulus deridderi</i>	Gastropoda: Stylommatophora	CR	Santa Cruz
Land snail	<i>Bulimulus duncanus</i>	Gastropoda: Stylommatophora	CR	Pinzón
Land snail	<i>Bulimulus eos</i>	Gastropoda: Stylommatophora	CR	Santa Cruz
Land snail	<i>Bulimulus eschariferus</i>	Gastropoda: Stylommatophora	CR	San Cristóbal
Land snail	<i>Bulimulus galapaganus</i>	Gastropoda: Stylommatophora	CR	Floreana
Land snail	<i>Bulimulus habeli</i>	Gastropoda: Stylommatophora	CR	San Cristóbal
Land snail	<i>Bulimulus hirsutus</i>	Gastropoda: Stylommatophora	CR	Santa Cruz
Land snail	<i>Bulimulus indefatigabilis</i>	Gastropoda: Stylommatophora	CR	Santiago
Land snail	<i>Bulimulus jacobii</i>	Gastropoda: Stylommatophora	CR	Santiago
Land snail	<i>Bulimulus lycodius</i>	Gastropoda: Stylommatophora	CR	Santa Cruz
Land snail	<i>Bulimulus ochsneri</i>	Gastropoda: Stylommatophora	CR	Santa Cruz
Land snail	<i>Bulimulus reibischi</i>	Gastropoda: Stylommatophora	CR	Santa Cruz
Land snail	<i>Bulimulus saeronius</i>	Gastropoda: Stylommatophora	CR	Santa Cruz
Land snail	<i>Bulimulus sculpturatus</i>	Gastropoda: Stylommatophora	CR	Santiago
Land snail	<i>Bulimulus sp. nov. josevillani</i>	Gastropoda: Stylommatophora	CR	Santa Cruz
Land snail	<i>Bulimulus sp. nov. krameri</i>	Gastropoda: Stylommatophora	CR	Santa Cruz
Land snail	<i>Bulimulus sp. nov. nilsondinneri</i>	Gastropoda: Stylommatophora	CR	Santa Cruz
Land snail	<i>Bulimulus sp. nov. tuideroi</i>	Gastropoda: Stylommatophora	CR	Santa Cruz
Land snail	<i>Bulimulus sp. nov. vanmali</i>	Gastropoda: Stylommatophora	CR	Santa Cruz
Land snail	<i>Bulimulus tanneri</i>	Gastropoda: Stylommatophora	CR	Santa Cruz
Land snail	<i>Bulimulus wolffi</i>	Gastropoda: Stylommatophora	CR	Santa Cruz
Land snail	<i>Bulimulus cinerarius</i>	Gastropoda: Stylommatophora	EN	Floreana, Santiago, Isabela
Land snail	<i>Bulimulus cucullinus</i>	Gastropoda: Stylommatophora	EN	Española, Floreana, Santa Fe
Land snail	<i>Bulimulus nux</i>	Gastropoda: Stylommatophora	EN	San Cristóbal, Floreana
Land snail	<i>Bulimulus olla</i>	Gastropoda: Stylommatophora	EN	Santiago
Land snail	<i>Bulimulus perspectivus</i>	Gastropoda: Stylommatophora	EN	San Cristóbal, Floreana
Land snail	<i>Bulimulus planospira</i>	Gastropoda: Stylommatophora	EN	San Cristóbal, Floreana
Land snail	<i>Bulimulus rugulosus</i>	Gastropoda: Stylommatophora	EN	San Cristóbal, Floreana, Pinta
Nocturnal butterfly	<i>Macaria cruciata cruciata</i>	Insecta: Lepidoptera	EN	Santa Cruz, Santiago
Nocturnal butterfly	<i>Macaria cruciata isabellae</i>	Insecta: Lepidoptera	EN	Isabela
Land snail	<i>Bulimulus akamatus</i>	Gastropoda: Stylommatophora	VU	Santa Cruz
Land snail	<i>Bulimulus alethorhytidus</i>	Gastropoda: Stylommatophora	VU	Santa Cruz

Common name	Scientific Name	Class: Order	Threat Category	Islands
Land snail	<i>Bulimulus amastroides</i>	Gastrópoda: Stylommatophora	VU	Santa Cruz
Land snail	<i>Bulimulus blombergi</i>	Gastrópoda: Stylommatophora	VU	Santa Cruz
Land snail	<i>Bulimulus calvus</i>	Gastrópoda: Stylommatophora	VU	Santa Cruz, Floreana
Land snail	<i>Bulimulus cavagnaroi</i>	Gastrópoda: Stylommatophora	VU	Santa Cruz
Land snail	<i>Bulimulus darwini</i>	Gastrópoda: Stylommatophora	VU	Santiago
Land snail	<i>Bulimulus hoodensis</i>	Gastrópoda: Stylommatophora	VU	Española
Land snail	<i>Bulimulus jervisensis</i>	Gastrópoda: Stylommatophora	VU	Rábida
Land snail	<i>Bulimulus nestoticus</i>	Gastrópoda: Stylommatophora	VU	Santiago
Land snail	<i>Bulimulus perrus</i>	Gastrópoda: Stylommatophora	VU	Fernandina
Land snail	<i>Bulimulus rabidensis</i>	Gastrópoda: Stylommatophora	VU	Rábida
Land snail	<i>Bulimulus tortuganus</i>	Gastrópoda: Stylommatophora	VU	Isabela
Land snail	<i>Bulimulus unifasciatus</i>	Gastrópoda: Stylommatophora	VU	Floreana
Land snail	<i>Bulimulus ustulatus</i>	Gastrópoda: Stylommatophora	VU	Floreana
Nocturnal butterfly	<i>Epilema becki</i>	Insecta: Lepidoptera	VU	Isabela, Fernandina
Nocturnal butterfly	<i>Eupithecia galapagosata</i>	Insecta: Lepidoptera	VU	Isabela, San Cristóbal, Santiago
Nocturnal butterfly	<i>Eupithecia perryvriesi</i>	Insecta: Lepidoptera	VU	Fernandina, Floreana, Isabela, Santa Cruz, Santiago
Nocturnal butterfly	<i>Platypitia vilema</i>	Insecta: Lepidoptera	VU	Fernandina, Isabela, Pinta
Nocturnal butterfly	<i>Semiothisa cerussata</i>	Insecta: Lepidoptera	VU	Isabela, Santa Cruz, San Cristóbal
Nocturnal butterfly	<i>Tebenna galapagoensis</i>	Insecta: Lepidoptera	VU	Fernandina, Isabela, Pinta, Santa Cruz, Santiago
Nocturnal butterfly	<i>Trachea cavagnaroi</i>	Insecta: Lepidoptera	VU	Isabela, Santa Cruz
Nocturnal butterfly	<i>Tyrintheina umbrosa</i>	Insecta: Lepidoptera	VU	Fernandina, Floreana, Isabela, Santa Cruz, Santiago
Nocturnal butterfly	<i>Utetheisa devriesi</i>	Insecta: Lepidoptera	VU	Pinta, Isabela, Fernandina, Santiago
Nocturnal butterfly	<i>Utetheisa perryi</i>	Insecta: Lepidoptera	VU	Isabela, Santa Cruz, Santiago
Nocturnal butterfly	<i>Xylophanes norfolki</i>	Insecta: Lepidoptera	VU	Fernandina, Isabela, Santa Cruz
Land snail	<i>Bulimulus albermalensis</i>	Gastrópoda: Stylommatophora	DD	Isabela
Land snail	<i>Bulimulus elaeodes</i>	Gastrópoda: Stylommatophora	DD	Isabela
Land snail	<i>Bulimulus hemaerodes</i>	Gastrópoda: Stylommatophora	DD	Isabela, Fernandina
Land snail	<i>Bulimulus nucula</i>	Gastrópoda: Stylommatophora	DD	San Cristóbal, Floreana
Land snail	<i>Bulimulus pallidus</i>	Gastrópoda: Stylommatophora	DD	Isabela, Pinta
Land snail	<i>Bulimulus rugatinus</i>	Gastrópoda: Stylommatophora	DD	San Cristóbal, Isabela
Land snail	<i>Bulimulus rugiferus</i>	Gastrópoda: Stylommatophora	DD	Santa Cruz, Santiago
Land snail	<i>Bulimulus simrothi</i>	Gastrópoda: Stylommatophora	DD	Isabela
Land snail	<i>Bulimulus trogonius</i>	Gastrópoda: Stylommatophora	DD	Isabela

Notes

Symbols Legend: **EX** = Extinct, **CR** = Critically Endangered, **EN** = Endangered, **VU** = Vulnerable, **NT** = Near Threatened, **LC** = Least Concern.

Source: CDF databases.