

Ecological Decay on Isolated Forest Fragments

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ASSIGNMENT

For this exercise, imagine that you belong to a Non-Governmental Organization which advises the Government of Venezuela on all domestic environmental issues. Eleven years ago, the Government created a large hydroelectric reservoir by submerging a large area of pristine tropical forest leaving only islands of forest where the high elevation areas remain above water. The Department of Environment and Natural Resources (DENR) is now keen to evaluate the potential of developing the site for **ecotourism** and as an **ecological research station**. The DENR assumes that ecotourists would be particularly interested in viewing the highly diverse flora and fauna at the site. Large mammals (e.g. capuchin and howler monkeys, deer), reptiles (iguana), birds (macaws) and invertebrates (leaf-cutter ants) could be potentially attractive to ecotourists. Simultaneously, the DENR feels that the site has potential for development as an ecological research station for scientific investigation. The DENR seeks your professional technical advice on specific ecological issues that would influence its decision on whether it should pursue one or both options. Information from faunal inventories that were conducted on the islands last year (hence 10 years following inundation) is available to help your analysis.

Some of the background information in the exercise is real but everything else is hypothetical.

Lago Guri is a large hydroelectric reservoir that was created in 1986, following the construction of the Raul Leoni Dam along the Rio Caroni in east-central Venezuela (see Figure 1). The inundation of over 4300 km² of hilly terrain resulted in the conversion of a once continuous forested landscape into hundreds of isolated islands. The habitat of all islands and the mainland is semi-deciduous tropical forest.

Faunal inventories were conducted on six “small” islands (0.25 to 0.9 ha), four “medium” islands (4 to 12 ha), two “large” islands (> 150 ha), and two sites on the mainland ten years following inundation. Through these inventories, scientists measured the abundance at each site of selected vertebrates and invertebrates (Terborgh et al., 2001). The inventories revealed that small and medium islands already lacked more than 75% of the vertebrate species known to occur on the nearby mainland, whereas the two large islands retained nearly all species. **The scientists designated the two large islands along with the two stations on the mainland as control sites.** (Tables 1 and 2).

Figure 1. The Location of the dam and the hydroelectric plant are indicated by the narrow portion of the lake in the extreme northwest. The islands referred to in this exercise are located in the centre of the lake around Danto Machado (one of the large islands). Map by Gerardo Aymard.

Figure taken from: Norconk, M.A., and B.W Grafton. 2003. Changes in forest composition and potential feeding tree availability on a small land-bridge island in Lago Guri, Venezuela. Pages 211–228 in L.K. Marsh, editor. In Primates in Fragments: Ecology and Conservation. Kluwer/Plenum Press.

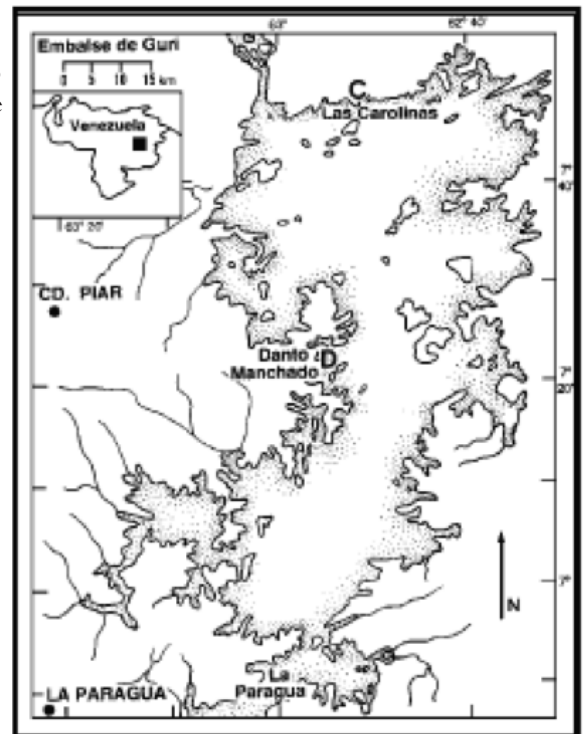


Table 1. Presence-absence Data for Various Trophic Levels on Small, Medium, and Large Guri Landmasses

Mainland	Large Islands	Medium Islands	Small Islands
FRUGIVORES (Seed dispersers)			
Capuchin monkeys, birds, bats, etc.	Capuchin monkeys, birds, bats, etc.		
PREDATORS OF VERTEBRATES			
Jaguar, puma, ocelot, other medium and small felids	Jaguar, puma, ocelot, other medium and small felids		
PREDATORS OF INVERTEBRATES			
Spiders, anurans, lizards, birds, armadillos	Spiders, anurans, lizards, birds, armadillos	Spiders, anurans, lizards, birds, armadillos	Spiders, anurans, lizards, birds
SEED PREDATORS			
Primates, rodents	Rodents	Rodents	Rodents
HERBIVORES			
Deer, tapirs, peccaries, howler monkeys, iguanas, leaf-cutter ants	Deer, tapirs, peccaries, howler monkeys, iguanas, leaf-cutter ants	Howler monkeys, iguanas, leaf-cutter ants	Howler monkeys, iguanas, leaf-cutter ants

Table 2. Faunal and Floral Inventories for Guri Landmasses of Different Sizes

Parameter	Small Islands					
	S1	S2	S3	S4	S5	S6
Area (ha)	0.3	0.7	0.3	0.6	0.5	0.9
No. of stems > 1m tall < 1cm DBH/500m ²	42	85	65	63	54	76
Howler monkeys per ha	4.0	8.6	7.1	6.9	-	-
No. leaf cutter colonies per ha	4.0	4.3	6.7	6.7	4.0	4.1
Number of Agoutis per ha	0	0	0	0	0	0
Number of adult <i>Hymenaea courbaril</i> trees/ha	4.3	4.0	3.9	4.4	5.0	5.3
Number of <i>Hymenaea courbaril</i> seedlings > 1m tall < 1cm DBH/500m ²	4	3	0	1	3	2

Parameter	Medium Islands				Controls			
	M1	M2	M3	M4	C1	C2	C3	C4
Area (ha)	8	5	11	12	350	150		
No. of stems > 1m tall < 1cm DBH/500m ²	214	311	375	236	304	321	379	340
Howler monkeys per ha	1	0.2	0.00	0.03	0.2	0	1	0.01
No. leaf cutter colonies per ha	0.25	0.20	0.18	0.17	0.1	0.01	0.2	0.25
Number of Agoutis per ha	1.4	1.9	1.2	1.0	8.2	7.9	8.3	7.6
Number of adult <i>Hymenaea courbaril</i> trees/ha	8.7	9.6	7.9	8.5	9.4	8.2	8.9	8.3
Number of <i>Hymenaea courbaril</i> seedlings > 1m tall < 1cm DBH/500m ²	4	2	1	2	25	18	22	19

Relict animal populations persisting on **small** islands fall into three trophic categories: predators of invertebrates (spiders, anurans, lizards, and birds), seed predators (small rodents), and herbivores (howler monkeys, common iguanas, and leafcutter ants). Leaf-cutter ants are dominant herbivores with the potential to harvest vast quantities of foliage from seedlings, saplings, and mature adult trees. These highly selective herbivores, whose populations are assumed to be limited primarily by predation by armadillos, avoid plant species with high levels of tannins (Rao, 2000; Rao et al., 2001). Red howler monkeys (*Alouatta seniculus*) are also herbivorous, feeding predominantly on canopy foliage (Milton, 1981). In a study at another site with similar habitat quality, scientists found that increased howler monkey density resulted in increased tree growth rates, potentially due to accelerated nutrient cycling and increased above-ground plant productivity (Feeley and Terborgh, 2005). Howler monkeys have poor nutrient assimilation rates, and hence their waste excretions tend to be nutrient rich (Nagy and Milton, 1979) and are quickly returned to the system (<24 hours) and made available for plant uptake. The scientists also discovered that increased above-ground plant productivity led to a positive, indirect effect on bird species richness; (Feeley and Terborgh, In Press). These results highlight the potential for disparate taxonomic groups to be related through indirect interactions and trophic cascades.

Medium islands harbor, in addition to the above, armadillos (*Dasypus* sp., predators of young leaf-cutter ant colonies) and agoutis (*Dasyprocta* sp., the only known effective seed dispersers of *Hymenaea courbaril* trees). Armadillos are known to occur at low densities on large and medium islands but do not occur on small islands

Density information for two of the three dominant herbivores found on the Guri landmasses are given in Table 2. Iguana populations on the islands are difficult to estimate accurately, since they are usually found high in the canopy and are well-camouflaged.

Patterns of Species Loss: What is Missing and Why?

LEVEL I

In order to develop the islands for ecotourism and as an ecological research station the Department of Environment needs information on the ecological integrity of the islands. Specifically, your mandate is to provide an analysis of the patterns of species loss on the islands. Which species are missing, why, and what are the potential consequences of their loss? In your report, explain 1) the absence of certain trophic levels on medium and small islands in Lago Guri, and 2) the factors that tend to be associated with high extinction risk (Use Table 1)?

LEVEL II**Altered Trophic Interactions**

Altered diversity of species and in particular, the absence of certain trophic levels on medium and small islands has resulted in highly aberrant communities. Such highly altered communities are ideally suited for scientific investigations as they provide an excellent opportunity to systematically examine the consequences of species loss.

- 1) As an illustrative example of the value of the site as an ecological research station, can you predict and compare variation in levels of herbivory across small, medium, and large Guri landmasses using Tables 1 and 2? Using data in table 2, estimate average densities of the two herbivores (leaf-cutter ants and howler monkeys).
- 2) Trophic cascades in tropical systems are of broad scientific interest given the complexity of species-rich tropical ecosystems. Can you identify one example of a potential cascade involving three trophic levels from the system described above?

LEVEL III**Agoutis and *Hymenaea Courbaril* Recruitment**

The Department of Environment and Natural Resources in Venezuela is particularly interested in conserving healthy populations of the neotropical canopy tree *Hymenaea courbaril* (Caesalpiniaceae) at the site. Many populations of *H. courbaril* are declining in other parts of Venezuela due to unknown causes; hence, DENR is keen to protect and conserve the species at the Guri site and seeks your advice on how they can do this.

Ecology of H. courbaril

It is hypothesized that the tree depends on a small rodent—the agouti (*Dasyprocta* spp., Rodentia) for the effective dispersal of its seeds. Fruiting *H. courbaril* trees produce 100 to 500 indehiscent, hard, 10 ± 20 -cm long pods, each of which contains up to seven seeds. Paca (*Agouti paca*), peccaries (*Peccari* spp.) and tapirs (*Tapirus* spp.) can open *H. courbaril* pods, but all are seed predators and are unlikely to be efficient dispersers (Hallwachs 1986). Any seeds dispersed by these animals usually remain on the soil surface, available to other seed predators such as small and medium-sized rodents. In contrast, rodents of the genus *Dasyprocta* bury scatter-hoarded pods and seeds below the soil surface where they are relatively safe from predation (Asquith et al., 1999). Moreover, *Dasyprocta* spp. disperse *H. courbaril* pods up to at least 225 m. For this exercise, we will assume that *H. courbaril* recruitment is largely influenced by Agoutis, which are so critical for the regeneration of this tree that in the absence of *Dasyprocta*, *H. courbaril* would go extinct in areas where its other seed predators are present.

Questions

Based on the information on the ecology of *Hymenaea courbaril* trees and hypothetical abundance information for adults and saplings of *H. courbaril* in Table 2, can you:

1. Examine the abundance patterns of adults and seedlings of *H. courbaril* trees on the islands?
2. Provide one potential explanation for observed variation in seedling density of *H. courbaril* trees on small, medium and large Guri landmasses?
3. Based on your response to (a) and (b) above, what would be your advice on conserving populations of *H. courbaril* trees on small and medium Guri islands?

LEVEL IV**Ecotourism or Ecological Research Station or Both?**

Based on your findings and responses to questions 1–3 above, write up a brief report to the DENR with your recommendation on whether the site is more suitable for ecotourism or as an ecological research station for scientific investigation, or a combination of both? Clearly state the factors that support your recommendation.

Discussion question:

What might some other factors be that could influence this decision?

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