

## INVESTIGATION TO COMPARE THE BIODIVERSITY OF DISTURBED AND UNDISTURBED AREAS IN TAMBOPATA, PERU

### The issue:

The current exponential growth of human population results in habitat loss, habitat fragmentation, pollution, overexploitation of resources, spread of disease, introduction of exotic species and finally agricultural processes that trigger the loss of biodiversity (1) Every year our school takes students to the Tambopata National Reserve, located in the Peruvian Amazon Basin, in the department of Madre de Dios. The reserve was established in 1990, and biodiversity is calculated at 165 species of trees, 103 species of mammals, 1300 species of butterflies, 90 species of amphibians and others (2)

Refugio Amazonas and the Tambopata Research Center (TRC) are located in this reserve at different distances from the city of Puerto Maldonado. See maps 1 and 2.

Refugio Amazonas is a lodge about 4 hours by motorboat from Puerto Maldonado city. It is located in a 200-hectare private reserve owned by Rainforest Expeditions and situated within the buffer zone of the Tambopata National Reserve. This is an area previously disturbed by humans.

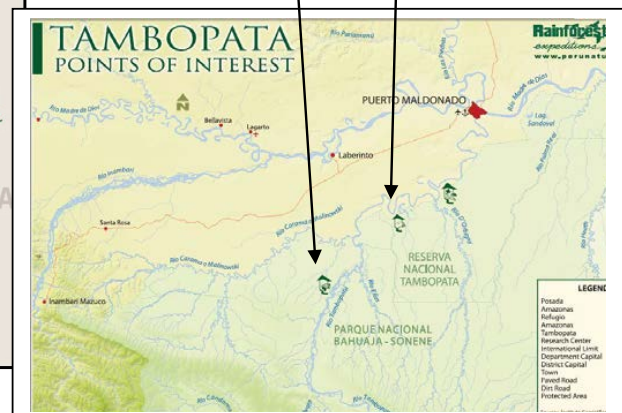
TRC is between 8–9 hours from Puerto Maldonado city (4.5 hours further from Refugio Amazonas). It lies within the Tambopata National Reserve and is considered primary forest, so undisturbed.

Map 1 (3)



Refugio Amazonas

Tambopata Research Center (TRC)



Map 2 (4)

**Research question:**

To what extent has human disturbance impacted the biodiversity, as measured by Simpson’s Diversity Index, found in two areas of Tambopata National Reserve?

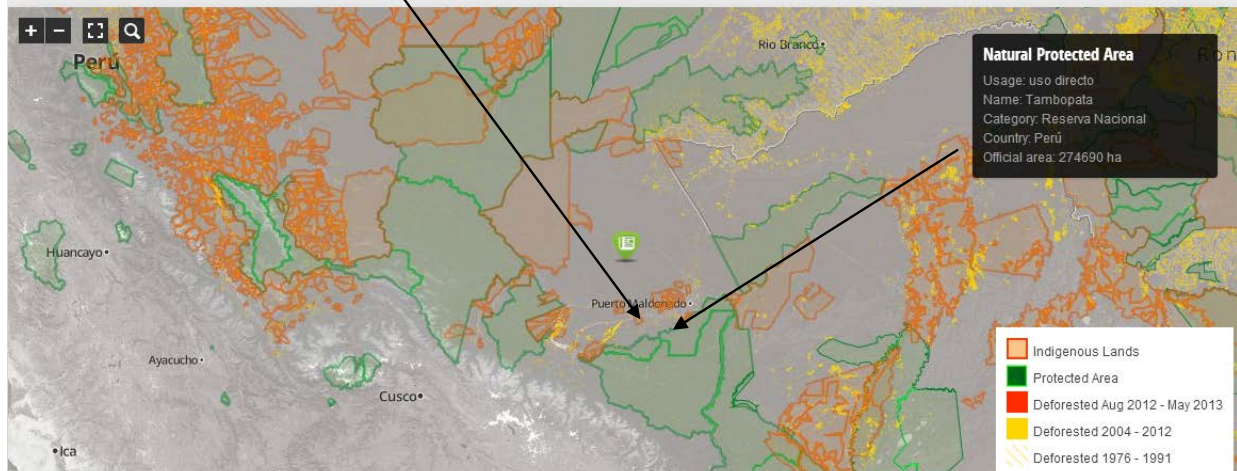
**Justification:**

The rainforests of this region probably first had nomadic people from 10,000 years ago. Today “the main people ... belong to the Ese-Eja culture ... Communities of Ese-Eja people continue to live near the boundaries of the national park ... Although people use the forests in the reserve, attempts are made to control activities and ecotourism is one of the main economic activities in the area.” (2)

The buffer zone is used by the local communities and the guides told me it is policed by them too. However, there are some problems: deforestation on the edges, and illegal mining in the buffer zone, as seen in Figure 1. So the buffer zone has more human disturbance than the reserve. Therefore, Refugio Amazonas should have lower biodiversity than the TRC.

**Figure 1**

**Operation against illegal mining in buffer zone of Tambopata Reserve**



(5)

**VARIABLES:**

**Independent:**

The human disturbance level in:

1. Refugio Amazonas – the buffer zone = disturbed
2. Tambopata Research Center – the Primary forest = undisturbed.

**Dependent:**

Amount of biodiversity measured using Simpson’s Diversity Index calculation. Animal data collected only.

**Controlled:**

Place – The same biome: the tropical rainforest of the Tambopata National Reserve, part of the Amazon Rainforest.

Species – Under their natural conditions.

Viewer – Same person during the entire experiment.

Time of the year – Dry season or the winter season. 19 May–26 May.

**MATERIALS:**

- Binoculars
- Book of Amazon birds
- Guides (I am unsure of their names)

**PROCEDURE:**

1. At each center, TRC and Amazonas, identify a walk (transect) that includes the river, an open/grassy/bushy area, the forest. Away from the actual center – ask the guides for assistance.
2. A systematic approach of “transects” was taken. Three sample spots on each transect, see above. Sampled at three times of the day.
3. Times: 7–8 am; 12–1 pm; 5–6 pm.
4. Take at least one guide, more if possible.
5. At the start of each sub-area, for example, forest, take 100 paces and stop.
6. Sit quietly, hidden from sight, face north in the forest; face the river; face north in the grassy area.
7. Do not record for 1 minute when in position to allow animals to settle to your presence.
8. Record all the animal species seen by the guide and yourself for 10 minutes.
9. Move onto the next area and repeat steps 5–8.
10. Repeat transects on at least three days.

**RESULTS:**

**Data:**

Amazonas: Three days of full transects

TRC: Two full days and one afternoon and one morning on two separate days.

All recorded on one table. Individual transect data was transcribed at centers onto a master table. The original raw data notebook was lost.

**Table 1** Animals seen in Refugio Amazonas

Species	River area	Forest area	Open grassy area	Total seen
Cattle Egret	6	0	0	6
Great Egret	1	0	0	1
Snowy Egret	3	0	0	3
Capped Heron	6	0	0	6
White-Necked Heron	1	0	0	1
White Caiman	3	0	0	3
Side-Necked Turtle	5	0	0	5
Capibara	7	0	0	7
Night Monkey	2	0	0	2
Blue and Yellow Macaw	0	2	0	2
Tropical Kingbird	0	2	0	2
White-Winged Swallow	0	2	0	2
King Vulture	0	1	0	1
Black Vulture	49	2	0	51
Semi-Collared Puff Bird	0	1	0	1
Red Brocket Deer	0	1	0	1
Dusky Titi Monkey	0	2	0	2
Agouti	1	2	0	3

Long Nose Bat	0	13	0	13
Brown Capuchin Monkey	0	5	0	5
Blue Headed Parrot	0	0	3	3
Yellow Ram Cacique	0	0	3	3
Scarlet Macaw	0	0	3	3
Milly Parrot	0	0	5	5
Silver-Beaked Tanager	0	4	2	6
Crested Oropendola	8	0	5	13
White Eyed Parakeet	0	0	6	6
Saddleback Tamarin	0	0	1	1
Great Jacamar	0	0	1	1
White Fronted Nunbird	0	0	3	3
Gilded Barbed Split	0	0	2	2
Tropical Rainforest Toad	0	0	1	1
Golden Collared Toucan	1	0	0	1
Violaceous Jay	2	0	0	2
Yellow Headed Vulture	1	0	0	1
Cobalt Winged Parakeet	2	0	0	2
			Total all (N)	170

**Table 2** Animals seen in Tambopata Research Center

Species	NUMBER OF SIGHTINGS			
	Grassy open area	Forest area	River area	Total found
Cattle Egret	3	0	0	3
Great Egret	2	0	1	3
Snowy Egret	29	0	14	43
Capped Heron	0	1	3	4
White Caiman	1	0	0	1
Side-Necked Turtle	7	0	4	11
Capibara	15	0	17	32
King Vulture	0	0	2	2
Black Vulture	11	0	23	44
Brown Capuchin Monkey	0	5	0	5
Blue Headed Parrot	0	10	0	10
Scarlet Macaw	0	2	2	4
Crested Oropendola	2	3	0	5
Laughing Falcon	1	0	0	1
Giant Cowbird	6	0	2	8
Yellow Headed Vulture	3	0	0	3
Collared Plover	1	0	0	1
Black Caracara	4	3	0	7
Red Headed Vulture	1	0	0	1
White Winged Swallow	4	0	0	4
Squirrel Monkey	2	30	0	32
Anhinga (Snake Bird)	5	0	4	9
Cocoi Heron	2	0	2	4
Turkey Vulture	1	0	1	2
Horned Screamer	2	0	0	2
Sand Colored Night Hawk	30	0	0	30
Social Fly Catcher	2	1	0	3

Orinoco Goose (*)	25		2	27
Red Howler Monkey	1	1	0	2
Roadside Hawk	1	0	0	1
Violaceous Jay	0	5	0	5
Chestnut Fronted Macaw	0	2	0	2
Yellow Crowned Parrot	0	20	0	20
Black Caiman	0	1	0	1
Red Bellied Macaw	0	6	0	6
Great Black Hawk	0	1	2	3
White Throated Toucan	0	1	0	1
Spix's Guan	0	2	0	2
Pale Winged Trumpeter	0	5	5	10
Red Amazon Squirrel	0	1	0	1
Dusky Titi Monkey	0	5	0	5
Black Fronted Nun bird	0	1	0	1
Red Necked Wood Pecker	0	2	0	2
Peccary	0	15	0	15
Golden Cynodon Snake	0	1	0	1
Amazon King Fisher	0	0	1	1
Yellow Beaked Dern	0	0	2	2
American Wood Storm	0	0	2	2
Red and Green Macaw	0	0	2	2
Jaguar	0	0	2	2
Razor-Billed Curacao	0	0	1	1
Amazon Tayra	0	0	1	1
<b>TOTAL all (N)</b>				390

As only the level of disturbance was required, the data was all processed together. The sub-areas were only there to ensure a coverage of ecosystems within the reserve.

**Processed data:**

Simpson's Index (D):  $D = N(N-1) / \sum n(n-1)$

**Refugio Amazonas:**

Full calculations shown (all species of 1 not included in  $n(n-1)$  as it = 0)

$$D = 170 \times 169 \div (6 \times 5 + 3 \times 2 + 6 \times 5 + 3 \times 2 + 5 \times 4 + 7 \times 6 + 2 \times 1 + 2 \times 1 + 2 \times 1 + 2 \times 1 + 51 \times 50 + 2 \times 1 + 3 \times 2 + 13 \times 12 + 5 \times 4 + 3 \times 2 + 3 \times 2 + 3 \times 2 + 5 \times 4 + 6 \times 5 + 13 \times 12 + 6 \times 5 + 3 \times 2 + 2 \times 1 + 2 \times 1)$$

$$D = 28730 \div 3140$$

$$D = 9.15$$

**Tambopata Research Center**

$$D = 390 \times 389 \div 8208$$

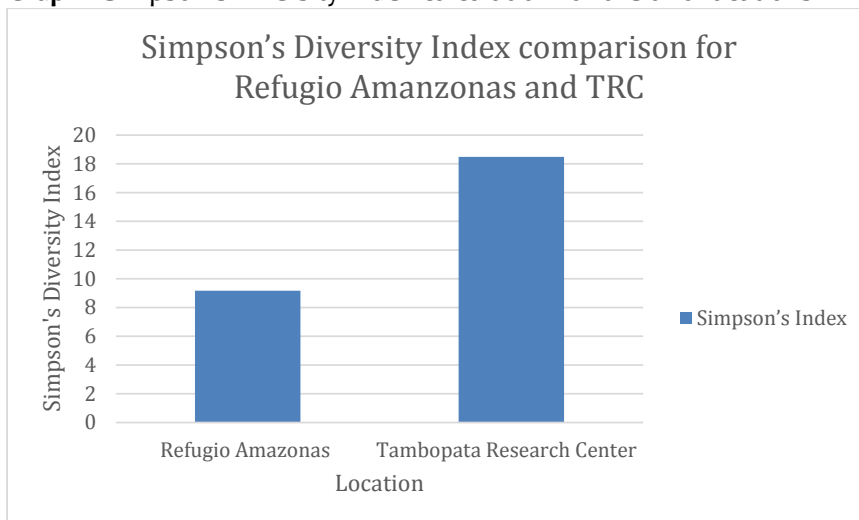
$$D = 151710 \div 8208$$

$$D = 18.48$$

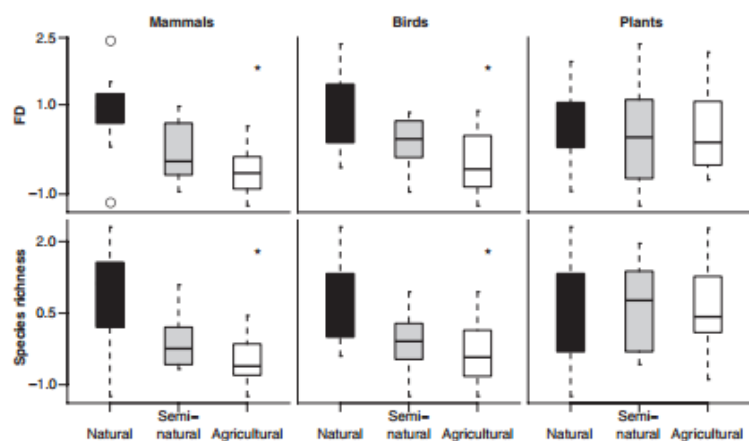
**Table 3** Simpson's Index calculation for the two locations

Level of disturbance	Simpson's Index
Refugio Amazonas – disturbed	9.15
Tambopata Research Center – undisturbed	18.48

**Graph 1** Simpson's Diversity Index calculation for the two locations



**Graph 2** FD (functional diversity) comparing land use areas. (6)



**Figure 2** Petchey and Gaston's FD (top row) consistently declines with greater land use intensity for mammals and birds, and remains flat for plants. Species richness (bottom row) demonstrates similar responses to land use intensification. (\* $P \leq 0.05$ , Kruskal-Wallis test).

**CONCLUSION:**

The data collected indicates a clear answer to the research question: To what extent has human disturbance impacted the biodiversity, as measured by Simpson's Diversity Index, found in two areas of Tambopata National Reserve?

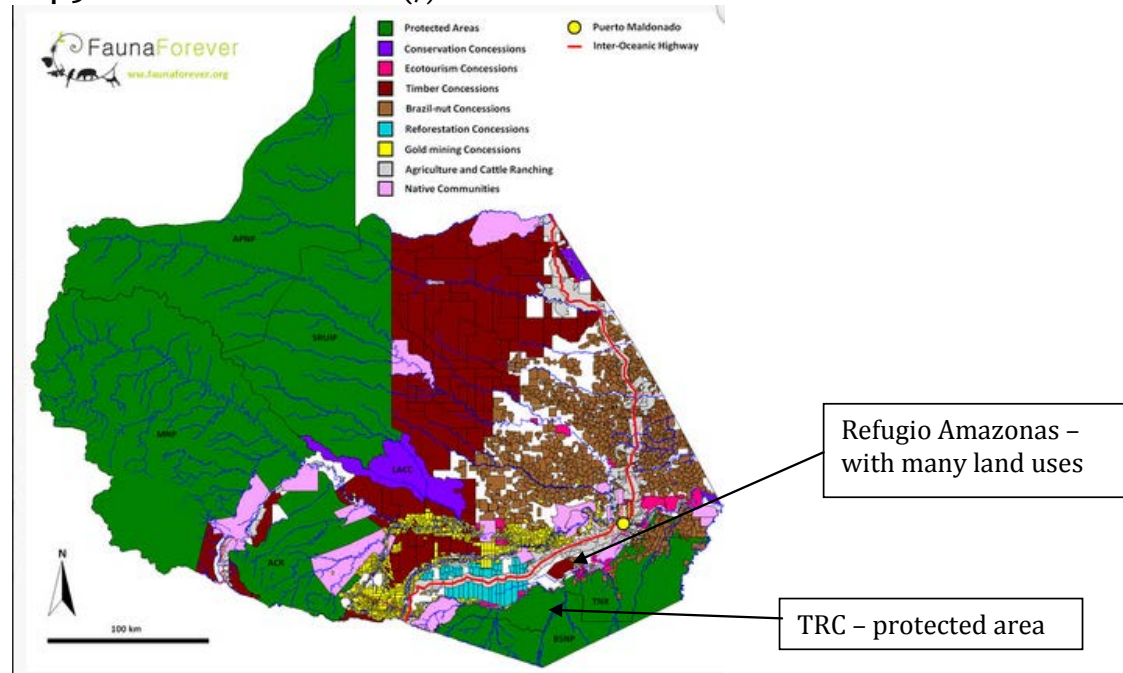
Where the disturbance is less, in TRC, Simpson's diversity is higher: 18.48. The Refugio Amazonas in the buffer zone, which is more disturbed, has a Simpson's diversity of less than half of TRC: 9.17 (graph 1). TRC had more species, and the abundance of many of those species was much higher than Refugio Amazonas – seen in tables 1 and 2. The diversity index results indicate that TRC is “old-growth Amazonian rainforest” (2) while Refugio Amazonas is a secondary forest as part of the buffer zone.

No specific secondary data for Simpson's Diversity Index could be found but the functional diversity from Flynn et al. indicates that mammal and bird diversity will be lower in semi-natural areas, like the buffer zone, as seen on graph 2.

**DISCUSSION:**

The TRC is inside the Tambopata National Reserve where no commercial hunting, logging or agricultural practices are allowed. The local indigenous people of the area, Ese-Eja, have concessions to harvest Brazil nuts and other commodities that do not damage the forest. The ecosystems around TRC are complex climax communities.

Refugio Amazonas is in the buffer zone of the reserve, thus closer to large human settlements and under different regulations. The Refugio, now under the concession of Rainforest Expeditions, used to have Brazil nut concessions, hunting activities and logging for expensive trees (mahogany and cedar) as part of a selective timber extraction (2) These activities decreased the biodiversity of the area due to the disturbance by humans, see map 3.

**Map 3** Land use in Madre de Dios (7)

The Refugio should be recovering as the logging and hunting have officially been stopped. The TRC is also protected from threatening activities such as hunting, logging or agriculture, as it is inside a national reserve. Access is complicated – only by boat – so protecting it from disturbance. Tambopata National Reserve also borders Bahuaja Sonene National Park, where only researchers and scientists can go. This reduces edge effects.

However, there are still threats to the buffer area especially, but also to the reserve. ParksWatch identifies four: gold mining, illegal logging, extraction of forest resources and agriculture/land encroachment (8, 9). The solutions are multifaceted, from laws and enforcement by authorities, registration and monitoring of activities, zonation and management of land, awareness campaigns with all groups to infrastructure and support for the reserve.(10) Alongside this the ecotourism should work with the community to support their economic development and culture.

#### **EVALUATION:**

##### **Strengths:**

Having the expert guides help identify and count the animals. The clear distinction between the areas.

##### **Main modification:**

Fixed quadrats in both areas to obtain biodiversity data on the flora and smaller animals. At least five 10 x 10 m quadrats should have been sampled for the flora at each site. Also five 50 x 50 cm quadrats for the litter macroinvertebrates. This would strengthen the results.

##### **Further areas of research:**

How biodiversity in terms of flora varies in the two areas, as mentioned above. Does the plant biodiversity compare to the animal biodiversity found? How does biodiversity change with the seasons? How quickly can areas recover from human disturbance – looking at the reforestation areas seen in map 3? What is the biodiversity of Bahuaja Sonene National Park? How do the local communities feel/interact with the reserve? Finding secondary data to compare my data to, as this was very difficult.



Limitation/Error	Description/Manipulated	Suggested improvements
Data collection times varied	TRC had a split day and one midday recording was missed. Daily times varied in each site, due to other activities.	Equal number of days for data collection. Data collection at both locations have same times of day.
Only large visible animals sampled	Only animals seen on the walks and from the boat were counted.	Set traps for Lincoln Index. Quadrats used. Both fauna and flora sampled
Lack of focus	Attention was not always 100% on the surroundings – some species might have passed unspotted.	While data collecting avoid doing anything else. Shorter set times for collection. Use quadrats.
Estimates of numbers	Animals in flocks/groups were estimated.	Take a photo.
Focused on diurnal animals	Data collected only during the day.	Set traps for night collection.
Mistaken classification	Moving animals and those viewed from a distance.	Use experts or take photos and use a key/book.
“Double-counting” animals	Transect meant animals may be counted twice.	Use experts or take photos.
Uncertain/subjective level of disturbance	Assumed one area was undisturbed.	Have more areas with known dates of last disturbance.
Date of experiment	May, during the dry season, winter time.	Repeats over five years during the same week of the year. Repeat in different seasons.

**APPLICATION:**

Maintaining protected areas as high biodiversity areas is a problem. As the data shows, the less disturbance the higher the diversity is in Tambopata. To keep this situation keep the reserve difficult to access and develop new economic initiatives for local communities.

As Claudia Torres, a biologist at TRC stated, “el humano es quien impacta y modifica” (“the human is who impacts and modifies”)(11). So, to avoid natural human tendencies, we need to be active with protection.

Five initiatives are currently being promoted in the area.

- Ñape ethnobotanical center
- The port
- The handicraft workshop
- The fruit plant
- The fish farm (“Ecotourism – Sustainability in Tambopata”)

This is challenging as it is mainly the young men involved and their wages are still being spent on rifles and chainsaws – maybe to log and hunt in other areas. The women, culturally, cannot leave their home villages to spend time at the lodges working. The

elderly are considered too old for the physical work demands. However, both the elderly and the women are involved in the management/decision side.

A consideration may be to look at other protected areas in the world where local communities have worked with the tourism industry to improve the activities of the buffer zone and outside areas. For example, the butterfly farm in Watamu, Kenya: “Kipepeo (Swahili for butterfly) is a community based enterprise that supports the livelihoods of people living around Arabuko Sokoke forest” (12). They sell the pupae alive. These are shipped round the world for butterfly enclosures. Also honey and silk are produced. As the butterflies’ eggs are collected, the butterflies have to have their natural environment. The locals are earning money from a pristine environment so they are encouraged to keep it undisturbed/very limited disturbance. Careful management is required to ensure no overharvesting of the eggs and that some pupae are placed back in the environment.

Word count: approx. 2000 (not including the data tables or bibliography)

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