Regeneration of soils contaminated by illegal mining and Environmental Awareness Center in Puerto Maldonado

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Abstract

The objective of this research is to propose an architectural design of an Environmental Awareness Center that allows the regeneration of the soils of Puerto Maldonado used by illegal mining, being the sectors most affected by the change of use of preestablished soils, damaging the biodiversity of nearby nature reserves, impacting water networks, soil, and environment. The methodology included a historical and physical analysis, taking into account the natural environment, using the bioclimatic chart (Olgyay, Givoni - Milne) and the Mahoney table, as well as the application of sustainable design strategies (thermal, lighting, acoustic, visual comfort), with the support of digital tools. As a result, 20% of the proposal was allocated to the built area (1 ha.), while 80% to the landscape treatment (4 ha.), used for the conservation of chestnut trees; a valuable species for the region, accompanied by an infrastructure for the development of research, recreation and culture. Promote ecotourism through the rehabilitated spaces. Taking advantage of the damaged context, using design criteria together with sustainable and climatic strategies. In conclusion, the proposal allows to generate environmental awareness, identity and reflection on the importance of environmental preservation. Thus, contributing to the solid permanence of our natural and ecological biodiversity.

Keywords: Illegal mining, Deforestation, Deforestation, Brazil nut, Ecotourism, Reforestation.

I. INTRODUCTION

Illegal mining, Deforestation, Deforestation, Brazil nut, Ecotourism, Reforestation But, what differentiates informal mining from illegal mining? The former is the one that violates and disregards administrative, technical, environmental and social norms that regulate mining activities. The latter, in addition to the above, is carried out in areas where this activity is expressly prohibited [1] [2].

Until 1993, most of the gold production (gold extracted from rivers) came from "alluvial and washery" production activities. With the entry into production of large gold deposits such as Yanacocha (Cajamarca), Pierina (Ancash), Ares (Arequipa), Santa Rosa (La Libertad), the participation of informal mining decreased, which does not mean that this type of activity has not continued to grow in several areas of the country [3].

Of the aforementioned areas with a presence of this activity, Madre de Dios, and therefore Puerto Maldonado, will be one of the sectors most visibly affected by the change in the use of preestablished soils, damaging the biodiversity of nearby natural reserves, impacting water networks, soil and the environment [3][4]. Among these, we will find illegal mining [5]. According to scientific organizations, such as MAAP (Monitoring of The Andean Amazon Project), they have documented a large presence of deforestation due to this activity, especially in three areas belonging to the sector: Alto Malinowski, Camanti and Pariamanu [6]. In February 2019, the Peruvian government initiated Operation Mercury, a multisectoral mega operation to eradicate mining activity in the area known as La Pampa, the buffer zone of the Tambopata National Reserve (Madre de Dios). As a result, mining deforestation decreased by 92% between 2018 (900 hectares) and 2019 (66.7 hectares), the period before and after the start of Operation Mercury [7]. Causing totally defor-ested spaces and the disappearance of the vegetation cover pattern. It is always developed on chestnut forest sectors. There are even chestnut concessionaires who have acquired machinery to extract gold from the land dedicated to the conservation of these trees.

Figure 1. Deforestation between 2020 and 2021.

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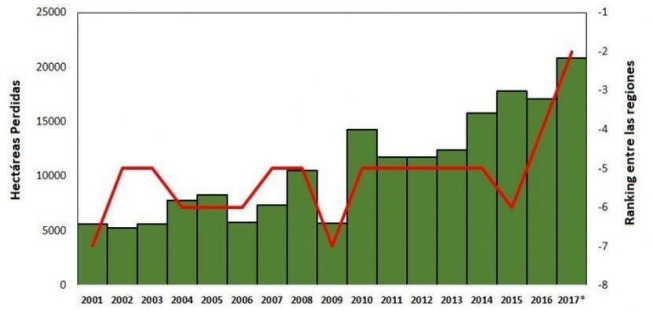

Figure 2. Forest losses in the Madre de Dios region 2001 - 2017.

The study is based on early warnings issued by the National Forest Program of the Ministry of Environment (PNCB/MINAM). It is estimated at 20,826 hectares as of the first week of November [8].

Figure 3. Physical results of illegal mining in Madre de Dios.

On the other hand, this vulnerable and damaged area is part of the 25 most biodiverse areas on the planet: Tambopata National Reserve and Manu National Park, along with Bahuaja Sonene, which are part of the Vilcabamba Amboró Conservation Corridor [9].

"Madre de Dios is the only region in Peru where Amazonian Brazil nut trees are found in sufficient density to allow for the economic exploitation of its nut", being 30% of the department's surface area [10]. Considering the importance of conserving this species, MINAM will implement projects against deforestation, promoting productive activities such as bio-business, agroforestry and others that help mitigate deforestation among communities and forest users. This will make it easier for citizens to opt for activities that are friendlier to the forest around them [11]. Likewise, ecotourism will integrate tourism with nature, and will involve education, environmental conservation and the active participation of the local population [12]. Or taking foreign references, analyzing, and implementing the traditional system of chestnut cultivation carried out in Kuancheng and, attributing knowledge, strategies, avoiding industrialization and exploitation of the fields [13]. Research work is much more common and relevant in our current time, therefore, carrying out a research center, in addition to providing intellectual advancement will awaken comprehensive development in communities.

As a consequence of the above, we seek to generate an opportunity to strengthen cultural interest and environmental awareness [14], carrying out an integral proposal to revitalize the spaces and ecosystems that were damaged and deforested by illegal mining, through the design of an Awareness Center, through strategies, techniques, criteria, and bioclimatic systems, considering and prioritizing the perpetuity of the natural environment.

II. LITERATURE REVIEW

A. Pattern of vegetation cover

Its fundamental principle is the coexistence of vascular flora of spontaneous origin and its patches with ornamental plant complexes. The structure of the pattern should be controlled by varied gardening practices in terms of method and intensity of maintenance. A relatively high level of biodiversity should be provided by autogenous (tall tree group, thicket, tall herb community) and semi-natural anthropogenic elements [15].

B. Research Center

The application of the model would contribute to an integrated and multidimensional analysis that could be a useful tool for local and regional politicians, local development associations, tourism entities, environmental groups and business associations. New initiatives must be designed and evaluated through four questions: Is the initiative promoting the rural development of the territory through the creation of synergies between agroforestry and tourism activities? Does the initiative promote inclusive and sustainable tourism based on the resources of the territory? Is heritage and collective memory preserved and valued through the initiative? Is the initiative promoting the empowerment of local communities? [16].

C. Urban Park

Urban green spaces make an invaluable contribution to the health and well-being of all city dwellers. They indicate a problem of accessibility of urban parks for people with mobility difficulties. Therefore, we start from the assumption that accessibility is more than physical comfort. Cultural and social activities play an important role in motivating people with disabilities to visit a park [17].

D. Bioclimatic strategies

A bioclimatic strategy is a set of design actions in relation to passive and active systems that are carried out to achieve a state of thermal comfort while producing energy savings. Those structures that, in a given environment, reduce unnecessary stresses by taking advantage of all natural resources that favor human comfort, can be categorized as "climatically balanced" [18].

One of them is thermal comfort, which is defined in ISO 7730 as "that mental condition in which satisfaction with the thermal environment is expressed". Thermal environment is taken into account along with other factors, such as air quality, light and noise level, when we evaluate our work environment. If we do not feel that the daily work environment is satisfactory, our efficiency will inevitably suffer [19].

E. Vernacular architecture

If there is something the indigenous peoples should be proud of, it is how they were able to adapt to the climate of the Amazon, by means of the maloca they achieved harmony with their environment. The constructions have butts [20].

Figure 4. Vernacular architecture.

Figure 4 shows the maloca and its ventilation system achieved mainly through its steep slope that favors air renewal [20].

F. Green roof strategy

Artificial system that provides a natural green space, created by the addition of plants to a growing medium composed of layers that fulfill different functions, such as irrigation, drainage and root barrier [21]. It is installed on rooftops, partially or totally covered

with vegetation, on the ground or in suitable growing media, using habitat-enhancing or energy-saving technologies [22][23].

III. METHODOLOGY

A. Methodological scheme

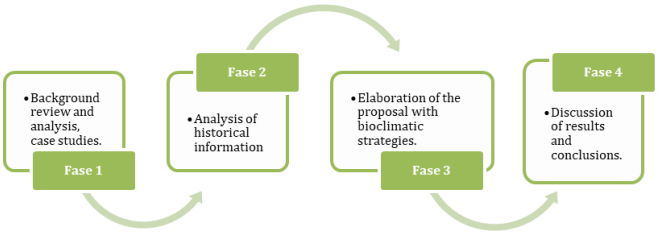

Figure 5. Study phases.

B. Place of study

Puerto Maldonado is the capital of the Madre de Dios region in southeastern Peru. It is also known as the gateway to the southern Amazon rainforest. Near the city is the biodiverse Tambopata National Reserve [24].

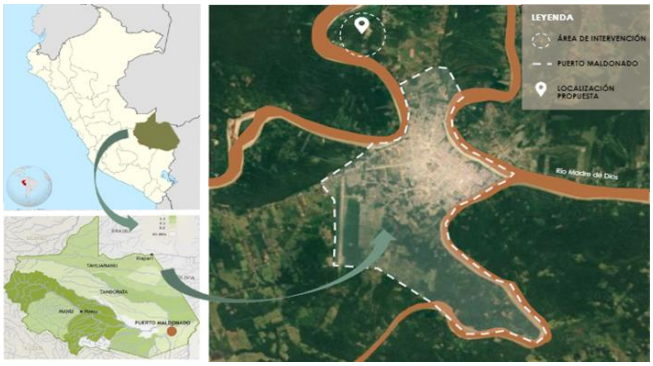

Figure 6. Map of the study site.

C. Place of study

1)Solar radiation and precipitation

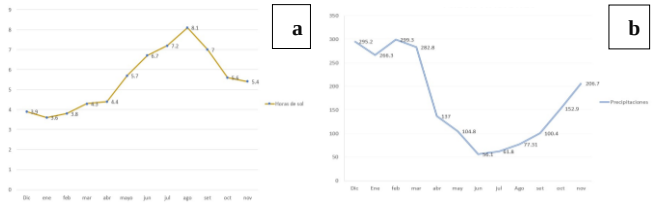

Figure 7. (a) Sunshine hours. (b) Precipitation.

Figure 7 (a) shows that the daily average shortwave solar energy per square meter does not vary considerably during the year and stays within plus or minus 3.6 kWh. of 8.1 kWh [25].

Figure 7 (b) shows that the amount of rainfall in a 31-day interval in Puerto Maldonado varies considerably during the year and stays within 100 millimeters [24].

2) Humidity and wind

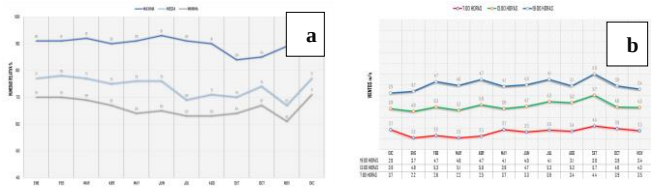

Figure 8. (a) Sunshine hours. (b) Precipitation.

Figure 8 (a) shows that the temperature drops at night and that on a humid day there is usually humidity at night. The perceived humidity level in Puerto Maldonado, due to the percentage of time when the humidity comfort level is sultry, oppressive or unbearable, does not vary considerably during the year, and remains between 80% [24].

Figure 8 (b) shows that the average hourly wind speed in Puerto Maldonado has slight seasonal variations throughout the year. The windiest day has an average wind speed of 5.8 meters per second. The least windy or calmest day has an average wind speed of 2 meters per second. The prevailing hourly mean wind direction in Puerto Maldonado is from the southwest throughout the year [24].

3) Temperature

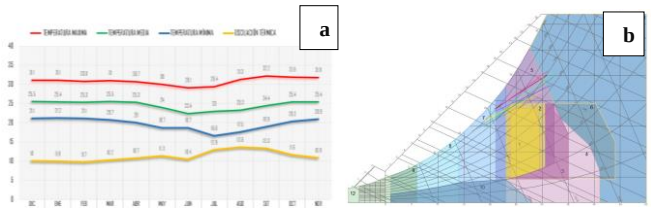

Figure 9. (a) Temperature. (b) Psychometric abacus of Puerto Maldonado.

Figure 9 (a) shows the temperate season with an average daily maximum temperature of more than 25 °C. The hottest day has an average maximum temperature of 32 °C and an average minimum temperature of 29 °C. The temperate season has an average daily minimum temperature greater than 22 °C. The coldest day of the year is with an average minimum temperature of 16 °C and average maximum of 21 °C [26].

Figure 9 (b) presents climatic data of temperature and relative humidity of the air in the city of Puerto Maldonado. It is shown that the months of December, January and March generate a temperature of 31 °C with a humidity between 90 % being these months with more heat, so it is sought to achieve comfort spaces [25].

4) Climatic Classification

Air temperature and precipitation were measured, in addition to an analysis of trees, and the study illustrates that the use of systematic principles of planting water bodies and trees in urban areas can be an effective strategy to cool urban temperature and improve human thermal comfort conditions.

5) Flora

The flora includes aguajales in the sedimentation plains, nut groves, terrace forests and gallery forests. Seventeen plant associations per forest type and a total of 1,255 plant species have been identified [21].

A very important conserved species is the Brazil nut (Bertholletia excelsa). In Peru, it is found exclusively in the eastern fringe of the

department of Madre de Dios and is the most important non-timber commercial species, with great impact on the local economy [22]. For its development, the Brazil nut needs: a tropical climate of 24.3° to 27.2°, a rainfall of 1400 to 2800 mm, a humidity of 79 to 81%, sunshine of 2000 to 2500 hours and a lot of sun exposure. It grows in non-flooded terraces of the Amazonian low forest, if they reach a good development has the following characteristics: They reach a maximum height of 60 m, presents simple concave leaves of dark green and yellowish color, cylindrical trunk, without branches to the mature crown of 15 years 800 to 1500 years, is harvested annually (25 years of life), [27].

It is important to note that Brazil nut forests occupy an area of more than 2 million hectares in the Madre de Dios region. In Madre de Dios, 20% of the population depends directly or indirectly on the collection, processing and/or commercialization of Brazil nut (Bertholletia excelsa), also known as Amazon nut or chestnut. This is a non-timber forest activity, which means that it depends on the existence of forests to collect and process its seeds or nuts, which have a high value for the food industry [28].

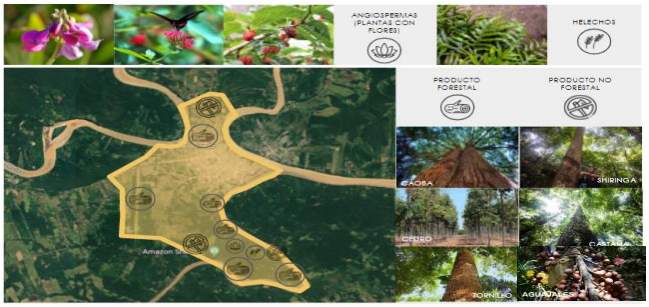

Figure 10. Flora of Puerto Maldonado.

Figure 10 shows the flora of Puerto Maldonado taking into account angiosperms (flowering plants), ferns and timber and non-timber trees.

IV. RESULTS

A. Project location

The location of the project belongs to the parallel sector of the Puerto Arturo Highway with an intervention area of 5 hectares and belongs to the Humid Tropical climate zone, with a latitude of -12.537188° and a longitude of -69.220028° [29].

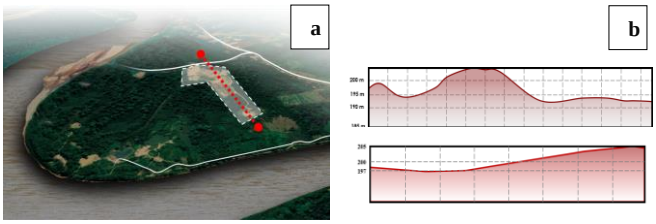

Figure 11. (a) Location of the proposal. (b) Topography sections.

B. Project location

1) Solar panels

For this proposal, 550W 24V monocrystalline photovoltaic panels will be implemented with an efficiency that can reach up to 21.28%.

Table 1. Energy demand.

Sectors	Consumption w/h	Consumption kW/h	Daily consumption
Administration + Topic	2040 W/h	2.04 kW/h	20.4 kW/h
Artistic Dissemination	10090 W/h	10. 09 kW/h	100.9 kW/h
workshops	2010 W/h	2.01 kW/h	20.1 kW/h
SUM	750 W/h	0.75 kW/h	7.5 kW/h
Food court	5500 W/h	5.50 kW/h	55 kW/h
Sales area	1200 W/h	1.20 kW/h	12 kW/h
Restaurants	6100 W/h	6.10 kW/h	61 kW/h
exhibits	3100 W/h	3.10 kW/h	31 kW/h
General services	700 W/h	0.70 kW/h	7 kW/h
Public parking	600 W/h	0.60 kW/h	6 kW/h
Free area	1900 W/h	1.90 kW/h	19 kW/h
TOTAL	33 990 W/h	33.99 kW/h	339.9 kW/h

Table 1 shows the energy demand of the sectors of the Environmental Awareness Center, which, according to the calculations made, is estimated to use 65 550 W solar panels.

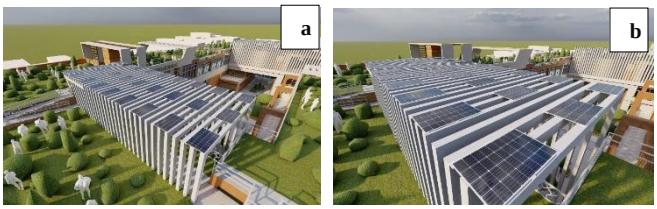

Figure 12. Solar Panels.

Figure 12 shows that the 550W solar panels, absorbing the solar radiation of Puerto Maldonado, which is 8.1 kWh, achieved an efficiency of 21.28%.

C. Cross ventilation and lattices

The project will have the implementation of louvers in the large windows that will reduce direct solar entry generating a comfortable environment, providing a better educational quality in the interior, as well as the project will have cross ventilation that will constantly renew the hot air inside the environment allowing thermal comfort.

Figure 13. Exterior of the project.

Figure 13(a) shows the use of louvers in the windows to reduce solar radiation. Figure 13 (b) shows the use of cross ventilation in the environment to achieve thermal comfort through the use of a passive strategy.

1) Green roofs:

Figure 14. Green roof construction system.

Figure 14 shows green roofs, in vegetation and xerophytic plants have been proposed because we need little amount of water, unlike grass that needs more water.

The specific benefits of using green roofs in the project [30].

Table 2. Benefits of green roofs.

For the inhabitant	For the community	For the environment
Reduce conditioning costs	Reduce pollution and improve air quality	Reduce greenhouse gas emissions
Improves the thermal sensation inside spaces	Add slow green percentage	Create a habitat for wildlife.
Transform unused spaces into usable gardens	Prevent overflow due to rain	Allows the use of recycled materials.
Allows the cultivation of a wide variety of plants	noise reduction	The architecture would be less invasive with the natural environment
Reduces the amount of heat absorbed from the sun.	Regulates water runoff as it retains rainwater.	The architecture will be less invasive with the natural environment.
Improves comfort as it is an acoustic insulator.	They favor biodiversity in the urban environment.	Improves the landscape of Puerto Maldonado.

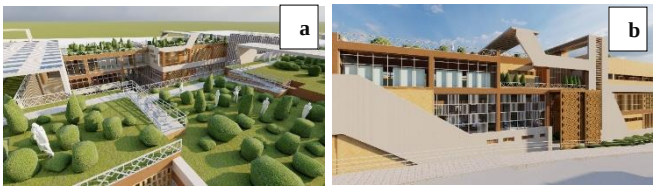

Figure 15. Green roof construction system

Figure 15(a) shows the use of green roofs that operate with a sprinkler system that will save a large percentage of water. Figure 15(b) shows the use of lattices as architectural elements that will control the entry of solar radiation and reduce glare, generating thermal and lighting comfort inside the Environmental Awareness Center [31].

Figure 16. Green roof construction system.

Figure 16 shows that the building has a water treatment system with a storage tank in the basement that will allow water to be stored and reused. The water will reach the treatment plant by gravity and through a PVC pipe system and will then be reused for irrigation of the green roofs through a sprinkler system on the green roof and for the faucet system in the core of the bathrooms. This saves up to 100% of the water consumption in the landscaping.

2) Materiality:

The materials used in the proposal were recycled concrete as an aggregate to be used with the new concrete in the building structures. Certified wood will be used in the cladding to ensure sustainable forest management, reducing the risk of fires, avoiding defor-estation, and conserving biodiversity. Recycled glass will also be used in the facades.

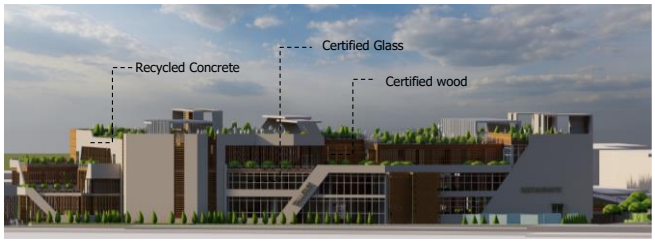

Figure 17. Materials used in the project.

Figure 17 shows the use of materials in the proposal, as well as the use of recycled materials such as recycled concrete, certified glass and certified wood.

D. Solar trajectory analysis

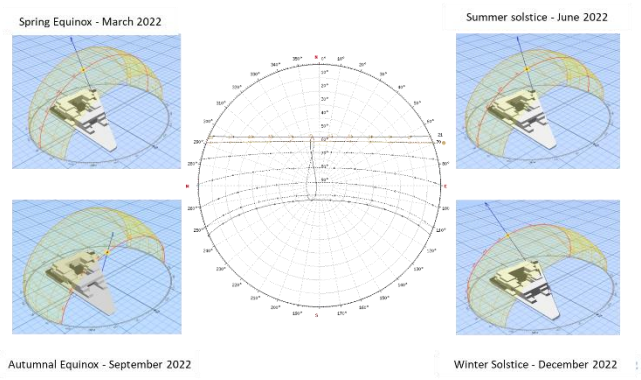

Figure 18. Solar tour.

Figure 18 shows that the north side receives the most sunlight during the year.

V. DISCUSSION

In Montesinho's research we seek to develop an analytical model using a literature review, the study of the specificities of the region with a focus on the preservation of the environment and heritage to promote tourism. The work proposes to achieve the analysis, synthesis and interpretation of the literature and the characterization of the territory. As a result, new initiatives should be designed and evaluated through four questions: Does the initiative promote rural development of the territory through the creation of synergies between agroforestry and tourism activities? Does the initiative promote inclusive and sustainable tourism based on the resources of the territory? Does the initiative preserve and value the heritage and collective memory? Does the initiative promote the empowerment of local communities?

The work developed in the EU (European Union) that seeks to investigate the perception and acceptance of students of a vegetation cover is highlighted. It was based on the concept of canopy pattern, as well as questionnaires and surveys. In view of the results, the students' participation in the study was a valuable professional experience for them. This allowed for a deeper and more critical look at factors influencing biodiversity, such as green maintenance standards.

So, looking at the previous proposals in the proposal developed in the city of Puerto Maldonado, it seeks to generate environmental sensitivity to deforestation and mining damage by applying bioclimatic design strategies based on climatic variables and identity reinforcement. Create awareness with an Environmental Awareness Center that highlights the importance of the area's trees, prioritizing the Brazil nut. In conclusion, it can be highlighted that the proposed Environmental Awareness Center manages to create in the population a sense of cultural identity and a greater awareness of the richness that surrounds them.

VI. CONCLUSIONS

Therefore, it will enhance the economic growth of the locality and its surroundings, increasing local and foreign tourist interest, providing a different experience with an ecological vision, through ecological services, providing the acquisition of cultural identity, greater awareness, and reflection on the importance of preserving the environment. Thus, contributing to the solid permanence of our natural and ecological biodiversity,

The sustainable architectural proposal of the Environmental Awareness Center influences the rehabilitation of the soils of Puerto Maldonado occupied by illegal mining since the proposal in addition to meeting the standards of bioclimatic conditioning, helps the repotentiation of the sectors affected by illegal mining and gives a better vision to the citizens of Puerto Maldonado.

The green roofs proposed in the design help minimize environmental pollution, provide thermal comfort inside the building, and the solar panels with the proposed wind energy system help the building generate clean energy, which reduces pollution. It also makes the architecture less invasive to the natural environment.

The consideration of native species in the landscaping treatment of the Environmental Awareness Center's architectural proposal generates microclimates and enhances the diversity of Puerto Maldonado, as well as producing a wide variety of animal and insect species.

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