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Palms community structure and associated animals in disturbed and undisturbed zones of the Secoya territory.

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DEDICATION

This work is lovingly dedicated to my parents, Alfredo and Elena, who have been my greatest inspiration and motivation. Thank you for believing in me unconditionally, for supporting every decision I have made, and for always offering your unwavering love. I owe you all my gratitude and recognition.

To my nieces and nephew, Ana Paula, Victoria, and Gabriel, for being a constant source of joy. Your love fills me with energy and inspires me to improve every day.

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RESUMEN

Las palmas son componentes fundamentales de los ecosistemas tropicales debido a su valor ecológico, cultural y económico. En la Amazonía norte de Ecuador, donde la deforestación y la expansión agrícola amenazan cada vez más estos ecosistemas, es crucial comprender cómo la perturbación humana afecta a las comunidades de palmas y sus interacciones con la fauna asociada.

Este estudio evaluó la riqueza y abundancia de palmas y vertebrados terrestres en dos tipos de ambientes dentro del territorio Secoya: zonas perturbadas (sujetas a tala y cultivo de palma africana) y zonas no perturbadas (libres de actividades extractivas). Se muestrearon un total de 56 parcelas (5 × 5 m) distribuidas en 14 estaciones (siete por zona), complementadas con cinco meses de datos de cámaras trampa (julio–noviembre de 2022).

Se registraron 12 especies de palmas (seis de sotobosque y seis de dosel) y 33 especies de vertebrados terrestres, clasificadas en cinco grupos funcionales. Si bien la riqueza total fue similar entre zonas, la abundancia de plántulas y juveniles fue mayor en áreas perturbadas. La abundancia de fauna también fue superior en zonas perturbadas, y la composición de especies varió entre ambientes.

Modelos Lineales Generalizados Mixtos (GLMMs) revelaron una riqueza significativamente mayor de palmas juveniles y una mayor abundancia de especies de sotobosque en áreas perturbadas, junto con asociaciones marcadas entre variables faunísticas (dispersores, herbívoros, depredadores) y la estructura de las comunidades de palmas.

Estos hallazgos sugieren que la perturbación puede favorecer la regeneración de ciertas especies de palmas, al tiempo que altera interacciones ecológicas clave. Este estudio destaca la importancia de integrar datos ecológicos y conocimientos tradicionales Secoya en las estrategias de conservación de la biodiversidad y manejo territorial.

Palabras clave: abundancia, comunidades, dispersores, fauna, palmas tropicales, perturbaciones.

ABSTRACT

Palms are key components of tropical ecosystems due to their ecological, cultural, and economic value. In the northern Ecuadorian Amazon, where these ecosystems face increasing pressure from deforestation and agricultural expansion, understanding how human disturbance affects palm communities and their relationship with associated fauna is essential.

This study evaluated the richness and abundance of palms and associated animal species in two types of environments within the Secoya territory: disturbed zones (affected by logging and oil palm cultivation) and undisturbed zones (free from extractive activities). A total of 56 plots (5 × 5 m) were sampled across 14 stations (seven per zone), and camera trap data were collected over five months (July–November 2022) to record terrestrial vertebrate activity.

We recorded 12 palm species (six understory and six canopy) and 33 terrestrial vertebrate species, grouped into five functional categories. Total palm richness was similar between zones (12 species), but seedling (n = 219) and juvenile (n = 160) abundance was higher in disturbed zones. Faunal richness was also comparable (disturbed = 27 species; undisturbed = 26 species), yet total abundance was greater in disturbed zones (n = 311 vs. 237 records), and species composition differed between zones.

Generalized Linear Mixed Models (GLMMs) indicated that juvenile palm richness was significantly higher in disturbed zones (estimate = –1.09; AIC = 114.32), as was understory palm abundance (estimate = –0.67; AIC = 230.62). We also found significant associations between faunal variables—particularly dispersers, herbivores, and seed predators—and palm community structure.

These results suggest that disturbance may favor the regeneration of certain palm species while also altering key ecological interactions. This study highlights the importance of addressing both ecological impacts and traditional Secoya knowledge for integrated biodiversity conservation and territorial management.

Key words: abundance, communities, disperser, disturbances, tropical palms, richness.

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1. INTRODUCTION

The Amazon is one of the biomes with the greatest diversity globally, containing approximately 10% of the world's species (Zapata-Ríos et al. 2021). Its importance lies not only in its unique biodiversity but also in the ecosystem services it provides. Within the Amazonian biome, palm species are considered a key component due to the multiple ecological roles and services they offer (Cámara-Leret et al. 2014). They play a crucial role in provisioning food for animals, thus maintaining overall diversity of these tropical ecosystems (Borchsenius and Moraes 2006), regulating important nutrient cycles, and providing food and materials for human settlers who depend on them to sustain their livelihoods (Bhomia et al. 2019; García 2009; Gilmore, Endress, and Horn 2013).

Within the global distribution of palms (Arecaceae), Ecuador is the American country with the highest number of recorded palm species in the continent, reaching 136 up to date. Of these 136 species, 105 are utilized by local communities (Valencia et al. 2013) and more than half (73 species) are endemic to the Ecuadorian Amazon (Alvez-Valles, Balslev, Carvalho, et al. 2018; Dransfield et al. 2008).

The fruits and seeds of palms are a fundamental food source for wildlife and are consumed more frequently than those of any other plant family (Beck, 2006).In natural systems, among the main palm consumers are birds and mammals, which can act as seed dispersers or predators (Rojas-Robles, Gary Stiles, and Muñoz-Saba 2012) depending on how they treat palm propagules. In particular, mammals establish both positive and negative interactions with palms: they contribute to seed dispersal but can also affect regeneration through seed predation, herbivory, and seedling trampling (Kuprewicz 2013). Mammals for instance, play a crucial role in dispersing palm fruits by transporting a large number of seeds, depositing them in microzones with proper ecological conditions and ensuring seedling establishment far from parent plants (Álvarez-Solas et al., 2020; Beckman & Muller-Landau, 2007; Roldán & Simonetti, 2001).

Despite their role in the functioning of local ecosystems and the livelihoods of Amazonian settlers, palms face serious threats from global climate change (Walther et al. 2007), habitat loss, land-use change, fragmentation, and direct extraction (Etter et al. 2006). These factors have led to a significant decline in natural palm populations throughout the Amazon (Alvez-Valles, Balslev, Garcia-Villacorta, et al., 2018; Blach-Overgaard et al., 2015).

Additionally, the extensive and increasing hunting pressure over the main mammal dispersers (e.g., monkeys, ungulates, rodents) that eat and move tree palm species fruits in the Amazon, is threatening the survival of the populations of this plant taxa (Beckman and Muller-Landau 2007; Condit, Hubbell, and Foster 2019). In parallel, the local extirpation of palm disperses can lead to major shifts in the structure of palm communities in zones where these vertebrates are absent, making them markedly dissimilar from communities in regions where dispersers persist (Galetti et al. 2006).

Since the early 1990s, when the Ecuadorian government began systematically monitoring land use and forest cover, Ecuador has recorded some of the highest deforestation rates in South America. Between 1990 and 2014, the country experienced an annual forest loss of approximately 0.37%, equivalent to 47,000 hectares per year(Cuesta et al. 2017). Particularly alarming is the case of the Northern Ecuadorian Amazon (NEA), where forest cover has declined by up to 30% in recent years due to pressures such as road expansion, oil exploitation, and agricultural frontiers (López 2022)). However, the drivers of deforestation are not only ecological or economic but also deeply embedded in social structures. In the northwestern lowlands, for instance, deforestation has been driven by productive coalitions between small-scale settlers and timber companies, reflecting broader dynamics of resource exploitation, weak governance, and informal economies(Sierra and Stallings 1998).

Addressing deforestation in Ecuador requires not only technical conservation strategies but also a critical understanding of the deep-rooted socioeconomic and political forces that enable forest loss. In the Northern Ecuadorian Amazon (NEA), oil extraction has been the primary driver of deforestation, catalyzing the opening of roads, the influx of settlers, and the expansion of agricultural and extractive frontiers(Rome and Holmgren 1999). This process has significantly reshaped the region's landscape, triggering a chain reaction of land use changes. In addition to oil development, the region has also been heavily disturbed by large-scale oil palm (*Elaeis guineensis*) cultivation, which demands extensive land conversion and further threatens native forests (Meijaard et al. 2018; Mendes-Oliveira et al. 2017). Other contributing factors include agricultural expansion, logging, monocultures, and mining activities (Vijay et al. 2018). Together, these forces constitute a complex deforestation frontier that extends beyond environmental degradation to broader issues of governance, economic policy, and land tenure.

Reductions in palm and disperser populations can have cascading effects on ecological networks, spreading the impact to many other species and affecting entire ecosystems in which these species interact (Schleuning et al. 2016). Therefore, understanding the relationships between palms and their associated species when such impacts are present and in zones where these are absent, is of paramount importance (Schleuning et al. 2016). This knowledge is essential for developing management and conservation strategies for important zones such as the NEA. In addition, it contributes to protect species, especially those highly valued by local communities for their utility, such as palms.

The evidence has indicated that a decrease in species dispersal also leads to a reduction in the number of plants (Wright and Duber 2001), thereby influencing the intensity of interactions between plants and animals (Álvarez-Solas, Peñuela-Mora, and Ramis 2019; Beckman and Muller-Landau 2007). These interaction alterations can potentially modify the diversity, abundance, and composition of seedlings, and adults, within tropical ecosystems, which could impact the structure and composition of forests like those in NEA (Roldán and Simonetti 2001). Therefore, it is essential to strengthen studies that enable the monitoring of these key populations and the identification of potential changes in their structure (including the ontogeny) and population dynamics.

Such studies are therefore essential to strengthen research programs that support conservation policies in the Amazon, with a focus on key species such as palms and the ecological interactions maintain with other taxa, as dispersers, floral visitors, pollinators, as well as with other plants.

The Secoya community, also known as the Siekopai, are a group of Indigenous people who inhabit the Amazon region of northeastern Ecuador and northeastern Peru. In Ecuador, their population is estimated to range between 380 and 600 people, distributed across three communities located in the province of Sucumbíos: San Pablo de Catëtsiaya, Siecoya Remolino Ñe'ñena, and Eno (Figure 1). Their worldview is deeply connected to the forest, the river, and their ancestral land management practices, where the rainforest represents not only a physical space but also a spiritual and cultural one. Despite the impacts of colonization, oil expansion, and deforestation caused by crops like oil palm plantations(Baynard, Ellis, and Davis 2013), the Secoya have maintained a strong cultural identity rooted in traditional knowledge, the Paicoca language, and a social organization that values collectivity, respect for nature, and the intergenerational transmission of knowledge. Today, they continue to fight for the defense of their territory and the recognition of their rights as an Indigenous people (Carlson 2020; CONAIE 2014).

Given the ecological, cultural, and economic significance of palms in tropical ecosystems—and particularly within the Amazon and for the Siekopai—understanding how human-driven disturbances affect palm and vertebrates' populations, and their ecological interactions is critical.

Despite of all the mentioned above, few studies have directly examined how anthropogenic pressures influence palm community composition and abundance across different life stages, or how these effects vary between disturbed and undisturbed forest zones in the Northern Ecuadorian Amazon. By focusing on palm ontogeny in zones with contrasting levels of human impact, this study provides valuable insights into how disturbance alters key ecological processes, like interactions between palms and animals that use them. Furthermore, by conducting this research within Secoya territory—a landscape managed through generations of traditional ecological knowledge—this study not only contributes to conservation science but also supports Indigenous-led stewardship for biodiversity conservation. The results can inform more inclusive and effective conservation strategies that prioritize both ecological integrity and the cultural values of Amazonian peoples.

Therefore, this study aims to address this knowledge gap through the following objectives:

1. Assess if palm richness and abundance differ between disturbed and undisturbed zones within a Secoya community, located in Shushufindi – Sucumbios, northern Ecuadorian Amazonia.

2. To assess whether the richness and abundance of palms at different stages—e.g., seedling, juvenile, or adult—vary between the disturbed and undisturbed study zones.
3. Assess if richness and abundance of animals associated with palms, differ between disturbed and undisturbed zones of the Secoya community.
4. Evaluate, using a full model, whether the palm-related variables are being affected by the animal variables

2. METHODS

2.1. Study zone

Fieldwork was conducted in a portion of the Secoya community (Figure 1), located in Shushufindi county from Sucumbíos province (0° 17' 36.40'' S, 76° 17' 06.88'' W), at an overage altitude of 230 m.a.s.l. At the landscape level, this zone can be defined as a Aguarico lowland evergreen forest– Putumayo – Caquetá (Ministerio del Ambiente del Ecuador, 2012). Over the years, the Secoya community and its surroundings have undergone significant changes, including an increase in agricultural activities particularly for oil palm plantations, deforestation, and the expansion of oil fields (Vindal and Rivera 2019).

In this study, we identified two categories of land use: (1) disturbed zones and (2) undisturbed zones, primarily characterized by the proximity of oil palm plantations to the sampling points (Figure 2).

The disturbed forest at this Secoya zone is characterized by its proximity to and density of roads, evidence of selective or medium-scale logging, hunting activities and its surrounding landscape of oil palm plantations. In contrast, the undisturbed zone lacks these impacts and is better preserved as a contiguous forest block (Figure 2). Additionally, is important to mention that the so-called disturbed zone has been facing extractive activities for at least 50 years, and oil palm plantations and other similar activities have started there since year 1990.

2.2. Sampling design

The present research was conducted within the framework of the DISES project: *Resilient Socio-Environmental Systems: Indigenous Territories Facing Change*, which aims to assess how Secoya territories have managed to preserve both cultural and biodiversity attributes despite ongoing threats from resource extraction. As part of this initiative, the DISES project installed (from July to November in 2022) 30 camera trap stations—each consisting of two cameras positioned face-to-face—arranged in a grid across two forest conditions: disturbed and undisturbed zones, with 15 stations in each (Figure 1.). This paired camera setup was specifically designed to estimate fauna density across both disturbed and undisturbed zones.

From these 30 stations, a subset of 14 was selected for our study. Specifically, we chose seven stations within each zone (Figure 1., red color), based on their location relative to disturbance. At the landscape level, we defined two zones: the *disturbed zone*, located less than 1000 m from visible disturbances such as roads, oil palm plantations, or villages; and the *undisturbed zone*, located more than 3000 m away from such features and with no records of hunting and timber extraction. Palms

At each chosen station, four 5 m × 5 m plots separated by 10 m, were established using the camera traps as the center for this setting (Figure 2.). This means these plots covered a zone of 100 m² per station. We stablished 28 plots in the disturbed zone and 28 in the undisturbed zone.

Within each plot all palm individuals where counted, identified to the species level and defined within a developmental stage, i.e. seedlings, juveniles and adults. Following the criteria proposed by Ceccon-Valente 2013; Gamba-Trimiño, Bernal, and Bittner 2011; Isaza et al. 2017; Vallejo et al. 2014, all palm species were defined according to the development of an underground stem during their early stages, which is not easily visible or measurable. Therefore, individuals without a visible stem were classified as "stemless," and their development was assessed based on leaf attributes. Once the stem emerged and became visible, it was considered a measurable variable, and the palm was classified as "with stem."

Using this classification system as a basis, within each plot, all individuals of palm species were recorded at different developmental stages: seedling (no stem), juvenile (stem without signs of flowering), and adult (stem present and signs of flowers and/or fruits). Thus, the classification into these categories was based on morphological criteria, considering attributes such as stem size and the presence of reproductive structures.

Therefore, the full classification of palm individuals by developmental stage was as follows:

- *Seedlings:* Individuals originating from seeds, with bifid or pinnate leaves and no visible stem.
- *Juveniles:* Individuals with a visible stem but without reproductive structures or any remnants of them.
- *Adults:* Individuals with a visible stem and the presence of reproductive structures (flowers or fruits) or evidence of having had them.

2.2.1. Canopy vs understory palms classification

Once the palm species were identified and ontogeny was assigned, we classified them based on their habit, distinguishing between canopy and understory species. A canopy palm is defined as a species that, in adulthood, reaches the upper strata of the forest. In contrast, an understory palm is a species that, even at full maturity, does not grow beyond the first or second forest strata. i.e. not higher than 15 meters tall.

2.4. Animals

As previously explained, this study used seven camera traps per zone (disturbed and undisturbed), which were installed by the DISES Project. These cameras remained active for four months, from July to November 2022. Each camera, corresponding to a sampling station, was checked every two weeks, and all captured photographs were stored as digital files. This work was carried out by members of the Secoya community, who agreed to share the data.

Subsequently, the images were identified to the species level by the community promoters who are part of the DISES Project team as well. Based on this information, databases were created including the following fields: station number, zone type (disturbed or undisturbed), time and date of the photo, scientific name of the recorded vertebrate, and common name of the identified animal.

Using the resulting species list, we conducted a literature review (Cornell Lab 2024; Ojeda 2016; Tirira 2007; Tirira S., 2000) to classify each taxon into one of the following categories: carnivores, seed predators, potential seed dispersers, herbivores, and insectivores.

2.5. Variables

Based on the resulting database, which included all the variables mentioned above, the following metrics were calculated.

2.5.1. Dependent variables

In Table 1**,** the dependent variables used in the analyses are described. These variables are grouped into three main categories: palm population attributes (palm abundances and palm species richness), palm community structure (divided by canopy vs understory palms, and ontogeny), composition and abundance of fauna recorded by camera traps, and functional classification of animals based on diet. All variables were calculated per sampling station and later aggregated by zone (disturbed vs. undisturbed).

2.5.2. Independent variables

The variable *zone* (disturbed vs. undisturbed) was used as the independent variable to assess whether there were differences in the previously mentioned dependent variables, based on the level of disturbance of the evaluated zones. Thus, *zone* was chosen as independent variable on the basis that the disturbed zone refers to zones that have undergone significant landscape-level alterations due to human activities such as deforestation, agriculture, urbanization, or intensive resource use. In contrast, the undisturbed zone includes zones that have remained in their natural state, without major modifications caused by human intervention. This last zone serves as reference points for comparison with disturbed zone, as they preserve their original conditions and provide insight into the pristine state of the ecosystem and its palm and vertebrates biodiversity.

2.6. Data analyses

For data analyses, we used R software (R Core Team, 2024). First, we tested for normality of each variable using the Shapiro-Wilk test, which indicated that the data did not follow a normal distribution. Additionally, because data from the four plots within each station—and the fact that only one animal data point was recorded per station—could lead to non-independence and potential pseudo replication, we used generalized linear mixed models (GLMMs) implemented via the *lme4* package, for the below mentioned analyses.

We applied these models to explain the richness and abundance of palms and animals (dependent variables) in the two studied zones—disturbed vs undisturbed—while considering differences in data distributions between zones.

The GLMMs were constructed based on the following general structure:

$$Y \sim X + (1|id_{station})$$

Where:

Y is the dependent variable (e.g., rich_palms, abun_palms, etc.),

X represents the independent variable (e.g., zone),

(1|id_station) is the random effect associated with each station.

This structure was used for the first group of models, which aimed to evaluate the effect of zone type (disturbed vs. undisturbed) on dependent variables such as the richness and abundance of palms, animals, potential dispersers, among others.

In a second group of models, zone type was no longer included as an independent variable. Instead, other ecological variables from the study were used as predictors for palm abundance and palm richness, such as animal richness, richness of potential dispersers, among others. These variables, which had acted as dependent variables in the first set of models, were used as independent variables in order to explore their relationship with other dependent variables related to plants, animals, dispersers, etc. This approach allowed for the analysis of ecological associations between different functional groups and palm population attributes and community structure (dependent variable).

To select the best models, we used p-values, ecological relevance, and the Akaike Information Criterion (AIC). This criterion is used to identify the optimal combination of fixed and random effects in the model. The model with the lowest AIC value is selected, as it reflects a better balance between model fit and parsimony (Burnham and Anderson 2010).

3. RESULTS

3.1. Richness and abundance of palms

We recorded 418 palm individuals in total across both disturbed and undisturbed zones, including 318 seedlings, 39 juveniles, and 41 adults. We identified 12 species overall, with an even distribution between understory (6) and canopy (6) species (Table 2). Although we found slightly higher species richness in the disturbed zone (10 species) compared to the undisturbed zone (8), the difference was not statistically significant

When we do a species-by-species analysis, *Iriartea deltoidea* was the most abundant canopy species, representing 34.5% of total canopy individuals in the disturbed zone and 32.1% in the undisturbed zone (Figure 3a). Within the understory stratum, *Geonoma macrostachys* stood out as the most abundant species, accounting for 39.3% of individuals in the disturbed zone and 50.6% in the undisturbed zone (Figure 3b).

Some palm species were recorded exclusively in one of the zones. For instance, *Aiphanes ulei* and *Wettinia maynensis* were only found in the undisturbed zone, while

Aphandra natalia, *Euterpe precatoria*, *Astrocaryum chambira*, and *Mauritia flexuosa* were recorded exclusively in the disturbed zone.

3.2.Richness and abundance of animals

A total of 33 animal species and 584 individuals were recorded in this study, including 8 bird and 25 mammal species. Both the disturbed and undisturbed zones exhibited the same species richness (26). However, total abundance was higher in the disturbed zone (316 individuals) compared to the undisturbed zone (268 individuals). The three most abundant species in both zones were *Dasyprocta fuliginosa* (111 individuals in the disturbed vs. 59 in the undisturbed zone), *Mazama americana* (66 vs. 43), and *Cuniculus paca*, which showed a notably lower abundance in the disturbed zone (35 individuals vs. 72 in the undisturbed; Table 3.).

Species composition differed notably between the two zones. In the disturbed area, we exclusively observed species such as *Cebus yuracus*, *Philander andersoni*, *Metachirus nudicaudatus*, *Ramphastos tucanus*, *Leopardus pardalis*, *Myrmecophaga tridactyla*, and *Tamandua tetradactyla*. In contrast, *Nothocrax urumutum*, *Crypturellus soui*, *Didelphis marsupialis*, *Mitu salvini*, *Saimiri cassiquiarensis*, *Atelocynus microtis*, and *Puma concolor* were found only in the undisturbed area (Figure 4).

From the five functional groups, we found that potential seed dispersers were the most represented category, with 374 individuals (64.0% of the total), followed by herbivores with 134 individuals (22.9%). Seed predators accounted for 7.0% of the total (41 individuals), while carnivores and insectivores were the least abundant groups, with 24 (4.1%) and 11 individuals (1.9%), respectively (Figure 4.) (Table 3.).

When comparing both zones, carnivores were more abundant in the disturbed zone (13 individuals) than in the undisturbed one (11 individuals) (Figure 4b). A similar pattern was observed for insectivores, with 8 individuals in the disturbed zone compared to only 3 in the undisturbed (Figure 4d**)**. In contrast, seed predators were more frequent in the undisturbed zone (24) than in the disturbed one (17) (Figure 4e). For herbivores and potential dispersers, abundance was slightly higher in the disturbed zone (70 and 208 individuals, respectively) than in the undisturbed zone (64 and 166) (Figure 4a and 4c).

3.3.Relationship between palms and animals

Of the 1129 GLMM models analyzed that correspond to all possible combinations between dependent and independent variables used here, seven had p-values below 0.05, which are considered significant (Table 4.).

The most significant models (Models 1–7) show that both palm richness and abundance tend to be higher in disturbed zones. Model 1 (Figure 5a.), which had the best fit (AIC = 114.32), indicates that juvenile palm richness is significantly lower in the undisturbed zone (–1.09). This pattern is also observed in Model 2 (Figure 5b.), for understory palm richness (–0.45; AIC = 143.27) and in Model 3 (Figure 5c.) for total palm richness (–0.38; AIC = 184.81), suggesting that disturbance does not necessarily reduce palms species richness in the studied zone. In terms of abundance, Models 4 and 5 (Figure 5d and 5e**.)** support that there are higher number of palm individuals in disturbed zones, both in the understory (–0.67; AIC = 230.62) and overall (–0.63; AIC = 289.07). Model 6 (Figure 5f.) shows a weaker but consistent effect for canopy palm abundance (–0.25; AIC = 294.12)

Finally, Model 7 (Figure 5g**.**) shows that seedlings are also more abundant in disturbed zones (–0.78; AIC = 297.55). Although the models suggest greater richness and abundance of palms in disturbed zones, this pattern should be interpreted with caution, as other ecological factors may be involved, as discussed below in the next section.

It is important to note that the GLMMs including *zone* as a fixed effect were only significant for variables related to palms. In contrast, none of the models assessing animal richness or abundance —with zone as the explanatory variable— yielded *p*-values below 0.05 (Burnham and Anderson 2010). This suggests that, under this modeling approach, the type of zone (disturbed vs. undisturbed) did not have a statistically significant effect on the animal communities that were assessed.

The models for this part of the results section are visually summarized in the forest plot (Figure 6.), where each point represents the estimated effect size (±1.96 SE) for a given model. Models are numbered 1 to 11 for cross-reference with Table 5. A positive estimate indicates a direct relationship between the independent (e.g. rich juvenile, abundance adults palm, abundance adults, abundance herbivore abundance seedling, canopy abundance, seedlings) and the dependent variable (e.g. predator abundance, disperser abundance, predator abundance, insectivore abundance, predator richness, carnivore richness, carnivore abundance, herbivore, while a negative estimate reflects an inverse relationship. Confidence intervals that do not cross zero suggest statistically significant effects. The plot also includes models where faunal variables are predictors (dependent variables) of other faunal attributes, highlighting interactions within the animal community in addition to fauna–flora associations. Among the 11 models, most effects were positive, although several negative associations were also identified, particularly involving juvenile palms.

We identified 11 significant GLMMs explaining how faunal variables influence the structural attributes of the palm community (Table 5). Predator abundance was positively related to both adult palm richness (estimate = 0.48, AIC = 132.21) and abundance (0.53, AIC = 129.17). Similarly, insectivore abundance showed a positive association with adult palm abundance (0.61, AIC = 144.88). In contrast, juvenile palm richness decreased with increasing herbivore richness (–0.37, AIC = 138.90) and predator richness (–0.29, AIC = 139.40). Disperser abundance had a slight positive effect on juvenile palm richness (0.19, AIC = 141.33), whereas disperser richness showed a negative relationship with adult palm richness (–0.21, AIC = 140.20). Seedling abundance increased with both herbivore richness (0.47, AIC = 136.65) and carnivore richness (0.52, AIC = 132.04). Likewise, canopy palm abundance was positively associated with carnivore richness (0.44, AIC = 143.79). Finally, seedling richness was negatively associated with juvenile abundance (–0.41, AIC = 130.92), and predator and herbivore richness were positively correlated (0.66, AIC = 128.50).

4. DISCUSSION

4.1. Richness and palm abundance

The results indicate that the disturbed zone consistently exhibits higher levels of both palm richness and abundance compared to the undisturbed zone, with this pattern being especially pronounced in early life stages (seedlings and juveniles) and in the lower forest strata (understory).

Many Amazonian palm species consistently show a clear pattern: they have far more seedlings than juveniles or adults. This happens because these plants produce a large number of seeds, but most do not survive. In species like *Astrocaryum murumuru*, *Euterpe edulis*, and *Mauritia flexuosa*, high mortality rates occur due to seed predation by insects, poor light conditions, or excess water in the soil (Cintra and Horna 1997; Porto, Nunes, and Ribeiro 2018; Rother et al. 2013) Although palms invest heavily in seed production, only a small fraction of seedlings successfully reach adulthood, creating a strong demographic bottleneck.

Although the differences in total palm species richness between zones were not statistically significant, the disturbed zones showed a notably greater abundance and richness of palms at these early stages (Capers et al. 2005). These findings suggest that anthropogenic disturbances may create microenvironmental conditions that favor palm regeneration and establishment—such as increased light availability, soil disruption, or reduced interspecific competition (Martínez-Ramos, Anten, and Ackerly 2009; Svenning 1999).

The dominance of species such as *Iriartea deltoidea* and *Geonoma macrostachys* in both zones highlights their ability to adapt to varying levels of disturbance. These species exhibit prolonged reproductive cycles, with fruit availability throughout much of the year, which may favor both seed dispersal and seedling establishment under diverse environmental conditions (Karubian et al. 2012; Sezen, Chazdon, and Holsinger 2009). This phenological consistency has been reported for several neotropical palm species and may help explain their success in human-modified landscapes (Kahn 1992)

Phytelephas macrocarpa, *Astrocaryum* sp., and *Prestoea schultzeana* were present in both disturbed and undisturbed areas, but they were more abundant in disturbed zones. This may be because these palms tolerate or benefit from human-induced environmental changes. The genus *Astrocaryum* is commonly found in altered areas, where increased light and open space favor its growth (Ramos et al. 2022; Schroth et al. 2004). *Phytelephas macrocarpa* continues to attract diverse pollinating insects even in modified habitats, which supports its reproduction (Ramírez-Castillo et al. 2024) , and

Prestoea schultzeana can persist and flower in disturbed areas if sufficient time is allowed for forest recovery (Ervik and Feil 1997).

The exclusive presence of certain species in specific zones—such as *Aiphanes ulei* in undisturbed zones and *Mauritia flexuosa* in disturbed ones—suggests possible differences in disturbance tolerance. This finding is consistent with studies showing that understory palm species tend to be more sensitive to changes in habitat structure than others (Baraloto, Goldberg, and Bonal 2005). Such distributional differences may reflect the loss of more specialized species in degraded zones and the colonization of generalist or disturbance-tolerant species (Devictor, Julliard, and Jiguet 2008)

Mauritia flexuosa and *Euterpe precatoria* were found only in the disturbed area. In the case of *Mauritia*, this may be because it grows well in flooded and open areas, where human access and natural seed dispersal support its presence. *Euterpe precatoria* is also common in disturbed zones and is widely used by local communities, which may explain its greater abundance in modified zones (Isaza et al. 2017).

On the other hand, *Aiphanes ulei* and *Wettinia maynensis* were found only in the undisturbed area. The genus *Aiphanes* is sensitive to forest changes, possibly because it depends on insects like bees and beetles for pollination (Borchsenius and Moraes 2006). *Wettinia maynensis* also requires stable humidity and temperature, which are typical of undisturbed forests (Peñuela et al. 2019).

Nevertheless, while these results could be interpreted as a sign of ecological resilience, it is important to consider that increased individual abundance does not necessarily imply greater ecosystem stability. In some cases, disturbance may favor the dominance of a few generalist species, reducing functional diversity and limiting key ecological processes over the long term (Marquis 2009). Similarly, palms may become more common simply because they are able to exploit short-term favorable conditions, such as increased light availability or reduced competition, that often arise after a disturbance (Capers et al. 2005)

4.2. Richness and abundance of animals

Although animal species richness was similar between zones, total abundance was higher in the disturbed zone. This result may reflect greater availability of secondary resources fallen fruits) or habitat structure changes that favor generalist species (Laurance et al. 2018).

The difference in species composition between disturbed and undisturbed areas may be explained by the varying tolerance of species to habitat changes. In the disturbed area, we recorded species such as *Cebus yuracus*, *Philander andersoni*, and *Leopardus pardalis*. In particular, *L. pardalis* has been reported in other studies as a species that can adapt to fragmented environments due to its flexible diet and ability to move across habitat patches (Michalski and Peres 2007). On the other hand, species like *Mitu salvini*, *Saimiri cassiquiarensis*, and *Puma concolor* were found only in the undisturbed area. The presence of *P. concolor* agrees with studies showing that large carnivores tend to avoid areas with high human disturbance (Rosa et al. 2021). Similar patterns have also been observed in birds, where disturbance alters species composition, favoring generalist species and reducing the presence of those that depend on primary forest(Moura et al. 2013). This suggests that disturbance not only reduces wildlife presence but also changes the types of species found.

The dominance of potential seed dispersers such us *Dasyprocta fuliginosa* and it will be in zone tribune highlights their key role in forest dynamics, aligning with previous research that emphasizes the importance of frugivores in post-disturbance forest regeneration (Michalski and Peres 2005b)

4.3. Relationship between palms and animals

The GLMM models showed that palm-related variables were more strongly influenced by the type of zone (disturbed vs. undisturbed) than by animal-related variables. This suggests that palm communities respond more directly and immediately to local disturbances such as logging or land use change. In contrast, the response of terrestrial fauna may be shaped by broader-scale factors—including landscape connectivity, hunting intensity, and availability of resources across the region(Laurance et al. 2018).

The greater palm richness and abundance of seedlings and juveniles in disturbed zones may be linked to higher disperser activity, as shown by their positive association with juvenile palms. However, negative associations with herbivores and predators (found in section 3.3 of Results) suggest that early-stage predation or competition may also play a role in the studied system (Beckman and Muller-Landau 2007). These patterns highlight that palm regeneration is influenced by multiple biotic interactions shaped by disturbance, and this may be a complex set of interactions that require follow-up studies that help to better understand such scenarios.

The positive relationship between carnivore richness and seedling abundance or canopy cover may be explained by shared use of well-preserved habitats or by indirect trophic interactions. Carnivores and dense vegetation often occur in the same undisturbed areas. In addition, large carnivores can reduce herbivore populations, such as deer or rodents, that feed on seedlings. By lowering herbivory pressure, they help more plants survive and support forest regeneration—a dynamic known as a cascading effect (Ripple et al. 2014).

The negative associations between disperser richness and adult palms (found here, Table 5) could result from resource saturation, fruit competition, or shifts in frugivore composition, that have been reported in other similar investigations (Galetti and Dirzo 2013).

Altogether, the findings recording here, emphasize the importance of functionally intact faunal communities and long-term studies to better understand ecological dynamics in disturbed Amazonian forests.

Finally, the higher abundance of palm seedlings and juveniles in disturbed areas may be related to the presence of agoutis (*Dasyprocta spp.*), which are well-known for their role as effective dispersers of large seeds through scatter-hoarding behavior, a strategy that promotes seed germination and seedling establishment. Previous studies have shown that agoutis prefer large-seeded species, including palms, and contribute significantly to seedling recruitment in tropical forests(Galetti and Dirzo 2013). Supporting this, (Acevedo-Quintero and Zamora-Abrego 2015) found that *Dasyprocta fuliginosa* was responsible for more than 60% of the seed dispersal of *Mauritia flexuosa* in the Colombian Amazon, highlighting their relevance in palm regeneration dynamics. Although our study did not directly identify specific dispersal events, the presence of these rodents in disturbed zones may be contributing to the regeneration patterns observed under moderate disturbance conditions.

One limitation of this study is that cameras were used only at ground level. This may result in missing animals that live in the canopy, such as some mammals and birds that disperse seeds. Studies have shown that many species are only detected with canopy cameras (Vargas-Daza et al. 2023). Therefore, some seed dispersers present in the area may not have been recorded.

This study has some limitations, particularly the small number of sampling stations (14 in total), which restricts the ability to detect broad patterns. In addition, camera traps only record terrestrial vertebrates, so birds and other flying vertebrates—which may also play important roles in palm dispersal or pollination—were not included. Despite these limitations, the results show some notable trends in palm and fauna abundance and composition between disturbed and undisturbed areas. These observations can serve as a basis for future, larger-scale studies that include other faunal groups and broader spatial coverage.

5. CONCLUSIONS

• Disturbed zones showed greater palm regeneration, especially at early life stages like seedlings and juveniles, suggesting that disturbance may create favorable conditions for palm establishment.

• Palm species composition differed between zones, with some species exclusive to disturbed or undisturbed zones, reflecting varying levels of disturbance tolerance in that floral group.

• Although animal richness was similar across zones, total abundance was higher in disturbed zones, likely due to the presence of generalist species adapted to habitat changes.

- Seed dispersers were the most abundant animal group and were positively associated with juvenile palm richness, highlighting their role in regeneration of that group of trees. Negative effects from herbivores and predators were also observed on some palm stages.

- Palm variables responded more clearly to disturbance than animal variables, suggesting that vegetation is more directly affected by recent changes in the landscape studied here.

- Interactions between fauna and palms are key to understanding forest dynamics, and their alteration by human activities may impact essential ecological processes, that need further attention and study.

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7. TABLES

Table 1. Description of the dependent variables used in the analyses

Variables	Description
rich_palms	Indicates the number of palm species recorded in all the plots established per camera station. This variable was added up to count the total number of species per zone (disturbed vs. undisturbed).
abun_palms	Indicates the total number of individual palms recorded in all the plots established per camera station. This value was summed to calculate the total abundance of palms per zone (disturbed vs. undisturbed).
rich_canopy	Indicates the number of palm species classified as canopy palms recorded in all the plots established per camera station. This value was summed to determine the total canopy palm species richness per zone.
abun_canopy	Indicates the total number of individual canopy palms recorded in all the plots per camera station. This value was summed to calculate total canopy palm abundance per zone.
rich_understory	Indicates the number of understory palm species recorded in all the plots per camera station. This value was summed to determine understory palm species richness per zone.
abun_understory	Indicates the total number of individual understory palms recorded in all the plots per camera station. This value was summed to calculate total understory palm abundance per zone.
rich_adults	Indicates the total number of individual adult palms recorded per camera station. This value was summed to calculate total adult palm abundance per zone.
abund_adults	Indicates the number of juvenile palm species recorded in all the plots per camera station. This value was summed to determine juvenile species richness per zone.
rich_juvenile	Indicates the total number of juvenile palms recorded per camera station. This value was summed to calculate juvenile palm abundance per zone.
abun_juvenile	Indicates the total number of juvenile palms recorded per camera station. This value was summed to calculate juvenile palm abundance per zone.

rich_seedlings	Indicates the number of seedling palm species recorded in all the plots per camera station. This value was summed to determine seedling species richness per zone.
abun_seedlings	Indicates the total number of palm seedlings recorded per camera station. This value was summed to calculate seedling abundance per zone.
rich_animals	Indicates the number of animal species recorded by each camera station. This value was summed to determine total animal species richness per zone.
abun_animals	Indicates the total number of animal records (individuals) captured per camera station. This value was summed to calculate animal abundance per zone.
rich_carnivore	Indicates the number of carnivorous species recorded per camera station. This value was summed to determine carnivore species richness per zone.
abun_carnivore	Indicates the total number of carnivorous individuals recorded per camera station. This value was summed to calculate carnivore abundance per zone.
rich_predator	Indicates the number of seed predator species recorded per camera station. This value was summed to determine predator species richness per zone.
abun_predator	Indicates the total number of seed predator individuals recorded per camera station. This value was summed to calculate predator abundance per zone.
rich_disperser	Indicates the number of potential seed disperser species recorded per camera station. This value was summed to determine disperser species richness per zone.
abun_disperser	Indicates the total number of potential seed disperser individuals recorded per camera station. This value was summed to calculate disperser abundance per zone.
rich_herbivore	Indicates the number of herbivorous species recorded per camera station. This value was summed to determine herbivore species richness per zone.
abun_herbivore	Indicates the total number of herbivorous individuals recorded per camera station. This value was summed to calculate herbivore abundance per zone.
rich_insectivore	Indicates the number of insectivorous species recorded per camera station. This value was summed to determine insectivore species richness per zone.
abun_insectivore	Indicates the total number of insectivorous individuals recorded per camera station. This value was summed to calculate insectivore abundance per zone.

Table 2. List of palm species recorded in disturbed and undisturbed zones of the Secoya territory, including their forest stratum and total abundance.

Species	**Stratum**	**Perturbed**	**Undisturbed**	**Total**
Iriartea deltoidea	Canopy	81	54	135
Phytelephas macrocarpa	Canopy	63	13	76
Geonoma macrostachys	Understory	33	43	76
Astrocaryum sp.	Canopy	46	5	51
Prestoea schultzeana	Understory	25	8	33
Oenocarpus bataua	Canopy	1	21	22
Euterpe precatoria	Canopy	12	–	12
Aiphanes ulei	Understory	–	4	4
Astrocaryum chambira	Canopy	4	–	4
Aphandra natalia	Understory	3	–	3
Mauritia flexuosa	Canopy	1	–	1
Wettinia maynensis	Understory	–	1	1

Table 3. Animal species recorded in both zones with different levels of disturbance in the Secoya territory, organized by functional group and total abundance.

Group	Species	Disturbed	Undisturbed	Total
Disperser	*Dasyprocta fuliginosa*	111	59	170
	Cuniculus paca	35	72	107
	Dasypus novemcinctus	21	9	30
	Nasua nasua	10	1	11
	Tinamus major	8	2	10
	Psophia crepitans	3	5	8
	Cebus yuracus	7	–	7
	Philander andersoni	7	–	7
	Nothocrax urumutum	–	5	5
	Penelope jacquacu	1	4	5
	Myoprocta pratti	2	2	4
	Crypturellus soui	–	3	3
	Didelphis marsupialis	–	2	2
	Metachirus nudicaudatus	2	–	2
	Mitu salvini	–	1	1
	Ramphastos tucanus	1	–	1
	Saimiri cassiquiarensis	–	1	1
Carnivore	*Canis familiaris*	5	2	7
	Eira barbara	4	1	5
	Panthera onca	1	3	4
	Atelocynus microtis	–	3	3
	Buteogallus schistaceus	1	1	2
	Leopardus pardalis	2	–	2
	Puma concolor	–	1	1
Herbivore	*Mazama americana*	66	43	109
	Mazama nemorivaga	2	11	13
	Mazama sp.	1	7	8
	Hydrochoerus hydrochaeris	1	3	4
Insectivore	*Myrmecophaga tridactyla*	4	–	4
	Priodontes maximus	1	2	3
	Procyon cancrivorus	2	1	3
	Tamandua tetradactyla	1	–	1
Predator	*Dicotyles tajacu*	17	24	41

Table 4. Summary of the most significant GLMMs evaluating the effect of zone (disturbed vs. undisturbed) on palm community attributes.

N°	Model	Estimate	AIC
1	Juvenile palm richness ∼ zone	-1.09	114.32
2	Understory palm richness ∼ zone	-0.45	143.27
3	Palm richness ∼ zone	-0.38	184.81
4	Understory palm abundance ∼ zone	-0.67	230.62
5	Palm abundance ∼ zone	-0.63	289.07
6	Canopy palm abundance ∼ zone	-0.25	294.12
7	Seedlings palm abundance ∼ zone	-0.78	297.55

Table 5. Summary of the most significant GLMMs exploring the influence of animal-related variables on the structural attributes of the palm community

N°	Models	Estimate	AIC
1	rich_adults ∼ abun_predator	0.11	93.78
2	rich_adults ∼ rich_disperser	-0.03	99.12
3	rich_juvenile ∼ rich_herbivore	-0.52	108.94
4	rich_juvenile ∼ rich_predator	-0.85	111.82
5	rich_juvenile ∼ abun_disperser	0.008	114.13
6	abun_adults ∼ abun_predator	0.11	115.29
7	abun_adults ∼ abun_insectivore	0.29	118.76
8	abun_seedlings ∼ rich_carnivore	0.39	266.70
9	abun_canopy ∼ abun_carnivore	0.16	266.87
10	abun_seedlings ∼ abun_carnivore	0.15	267.19
11	abun_seedlings ∼ abun_herbivore	0.021	267.20

8. FIGURES

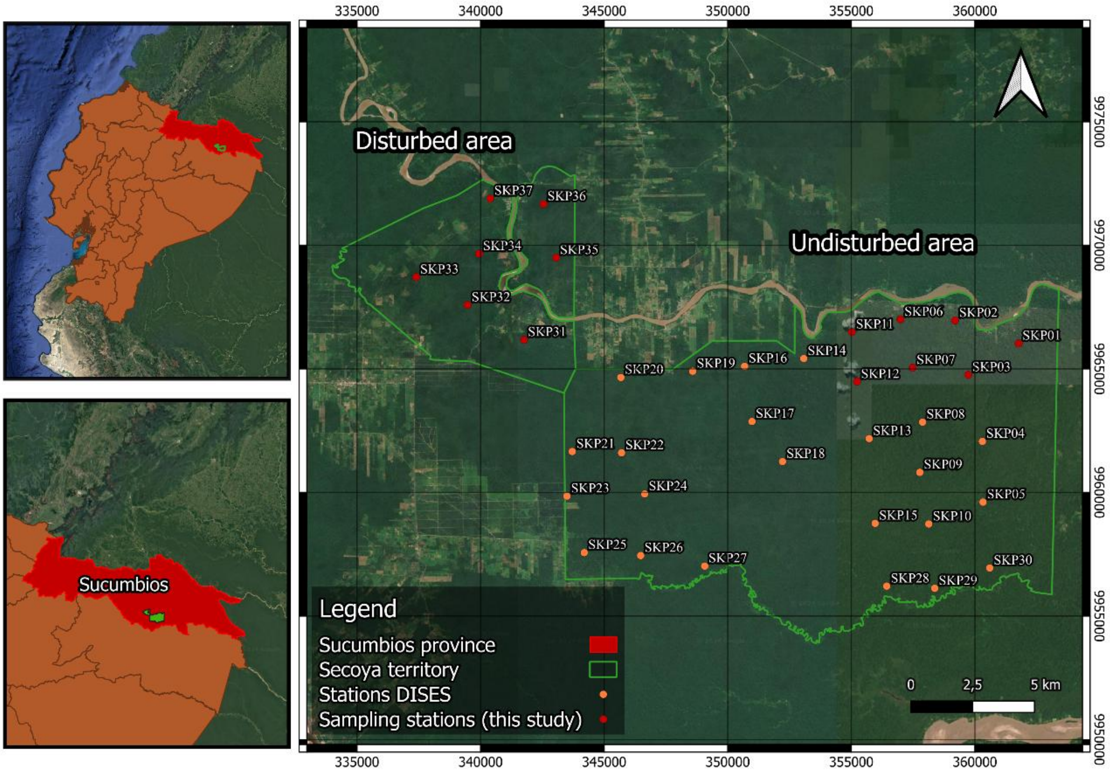

Figure 1. Study zone and station locations. Top left: Ecuador; bottom: Sucumbíos Province; right: the Secoya zone with sampling points. Red points indicate the stations used in this study (SKP01–SKP37), while orange points indicate stations that were not used.

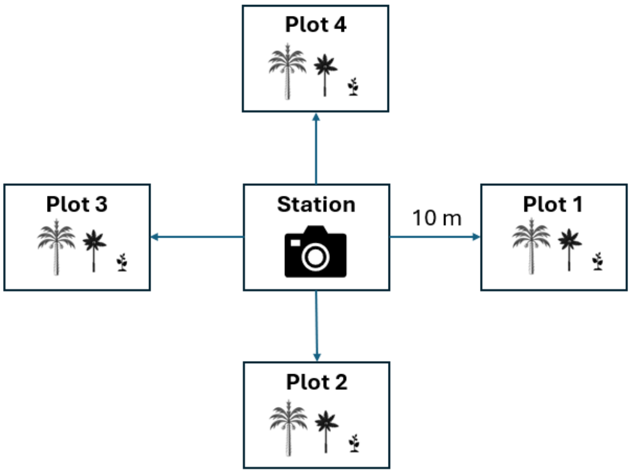

Figure 2. Diagram illustrating the layout of sampling plots at each station. Each plot contains data on the number of palms at different life stages—seedlings, juveniles, and adults. A total of four plots were established per station.

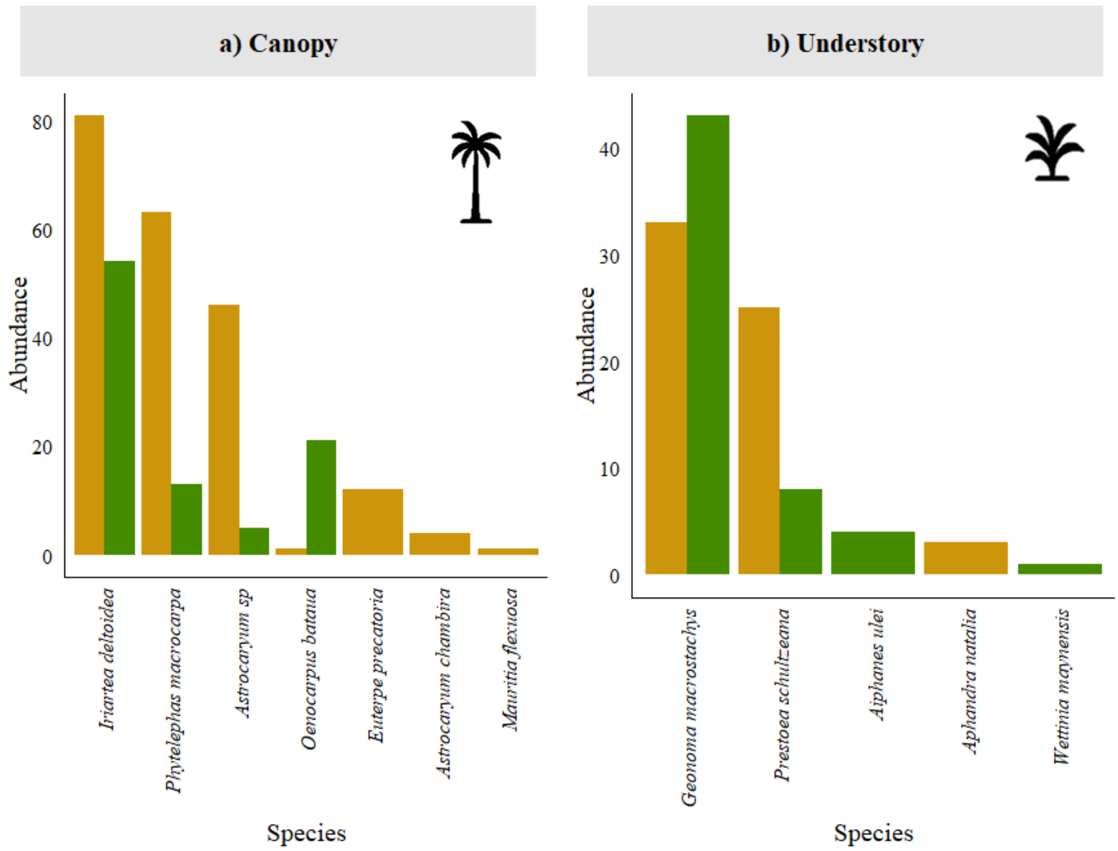

Figure 3. Abundance of palm species by forest stratum in the Secoya territory, Shushufindi, Sucumbíos. Graph (a) displays canopy species and graph (b) displays understory species, comparing disturbed (yellow) and undisturbed (green) areas. Bars represent total individual counts per species across all sampled plots.

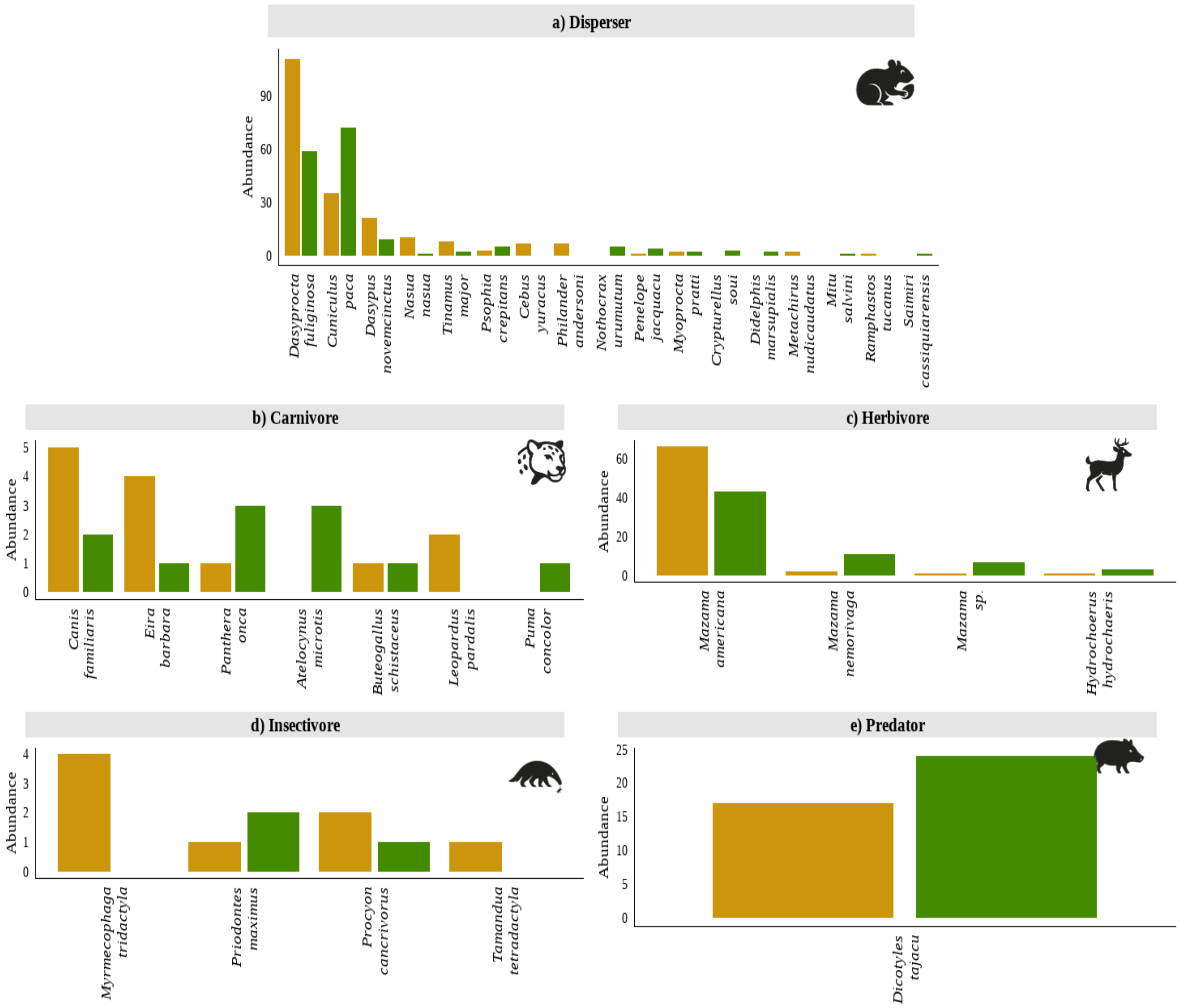

Figure 4. Vertebrate abundance by functional group (a–e) in disturbed (orange) and undisturbed (green) zones of the Secoya territory. The functional groups represented are: a) Potential seed dispersers, b) Carnivores, c) Herbivores, d) Insectivores, and e) Seed predators.

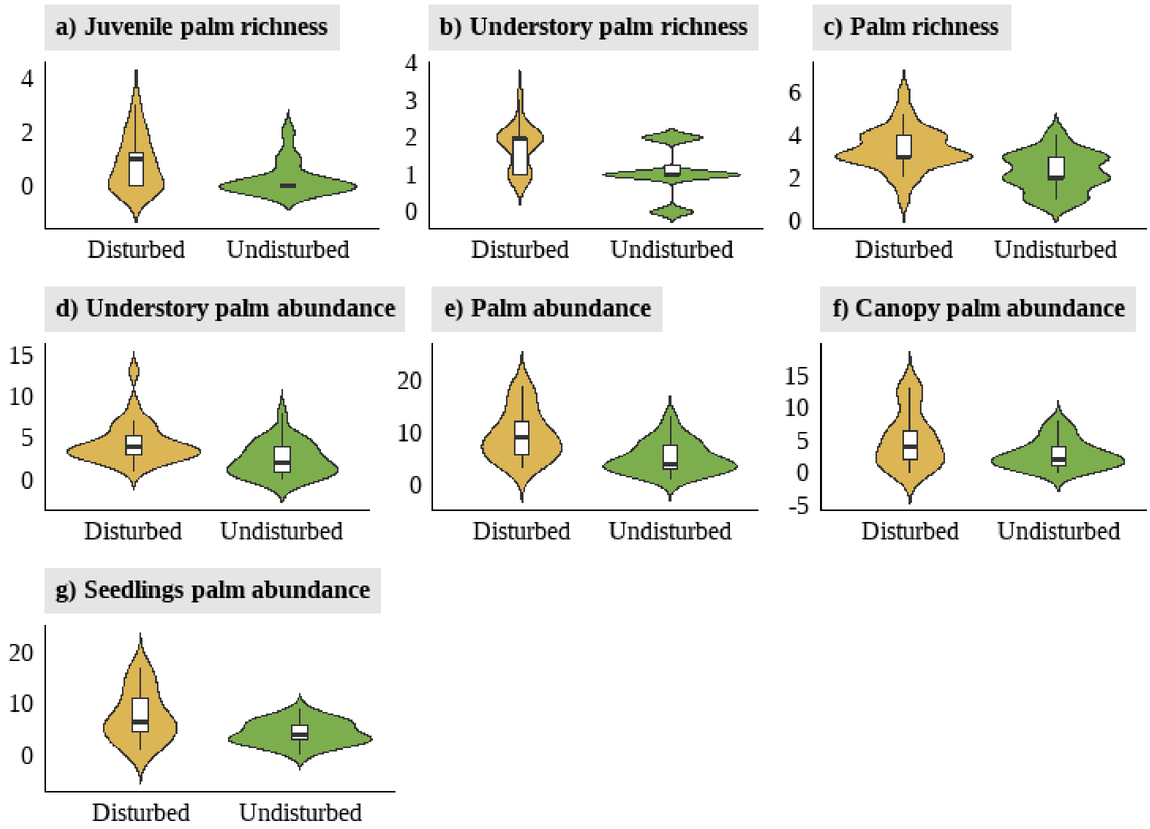

Figure 5. Violin plots (a–g) showing the distribution of palm richness and abundance variables in the seven most significant GLMMs, selected based on their lowest AIC values and statistical significance. Each plot compares disturbed (orange) and undisturbed (green) zones within the Secoya community territory, Shushufindi – Sucumbíos. The shape of each plot reflects data density, highlighting greater variability and, in some cases, higher palm richness or abundance in disturbed zones.

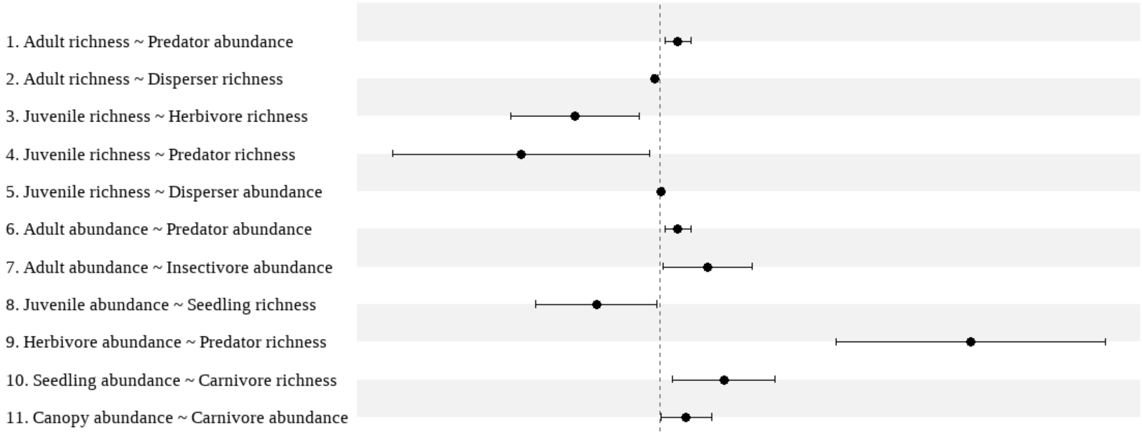

Figure 6. Forest plot of GLMMs evaluating the effect of faunal variables on structural attributes of palms and on other faunal variables, based on the 11 most significant models.

SUPPLEMENTARY MATERIAL

Table of palm species and their abundances in disturbed and undisturbed areas of the Secoya community.

	Disturbed	Undisturbed	Total
SKP01			
Geonoma macrostachys	-	2	2
Iriartea deltoidea	-	12	12
Phytelephas macrocarpa	-	10	10
Prestoea schultzeana	-	8	8
SKP02			
Astrocaryum sp	-	5	5
Geonoma macrostachys	-	8	8
Iriartea deltoidea		11	11
Phytelephas macrocarpa	-	3	3
Wettinia maynensis	-	1	1
SKP03			
Geonoma macrostachys	-	2	2
Iriartea deltoidea	-	1	1
Oenocarpus bataua	-	11	11
SKP06			
Aiphanes ulei	-	3	3
Geonoma macrostachys	-	2	2
Iriartea deltoidea	-	8	8
Oenocarpus bataua	-	4	4
SKP07			
Geonoma macrostachys	-	4	4
Iriartea deltoidea	-	6	6
Oenocarpus bataua	-	2	2
SKP11			
Aiphanes ulei	-	1	1
Geonoma macrostachys	-	6	6
Iriartea deltoidea	-	3	3
Oenocarpus bataua	-	4	4
SKP12			
Geonoma macrostachys	-	19	19
Iriartea deltoidea	-	13	13
SKP31			
Astrocaryum sp	10	-	10
Euterpe precatoria	12	-	12
Iriartea deltoidea	13	-	13
Mauritia flexuosa	1	-	1
Phytelephas macrocarpa	2	-	2
Prestoea schultzeana	12	-	12

SKP32			
Astrocayum sp	1	-	1
Geonoma macrostachys	8	-	8
Iriartea deltoidea	6	-	6
Phytelephas macrocarpa	4	-	4
Prestoea schultzeana	4	-	4
SKP33			
Aphandra natalia	2	-	2
Astrocaryum chambira	2	-	2
Astrocaryum sp	2	-	2
Geonoma macrostachys	1	-	1
Iriartea deltoidea	14	-	14
Phytelephas macrocarpa	24	-	24
SKP34			
Aphandra natalia	1	-	1
Astrocaryum chambira	2	-	2
Astrocaryum sp	5	-	5
Geonoma macrostachys	1	-	1
Iriartea deltoidea	6	-	6
Phytelephas macrocarpa	10	-	10
SKP35			
Astrocaryum sp	1	-	1
Geonoma macrostachys	6	-	6
Iriartea deltoidea	8	-	8
Oenocarpus bataua	1	-	1
Phytelephas macrocarpa	6	-	6
Prestoea schultzeana	2	-	2
SKP36			
Astrocaryum sp	5	-	5
Geonoma macrostachys	10	-	10
Iriartea deltoidea	24	-	24
Phytelephas macrocarpa	15	-	15
Prestoea schultzeana	1	-	1
SKP37			
Astrocaryum sp	22	-	22
Geonoma macrostachys	7	-	7
Iriartea deltoidea	10	-	10
Phytelephas macrocarpa	2	-	2
Prestoea schultzeana	6	-	6

Table of animal species and their abundances in disturbed and undisturbed areas of the Secoya community.

	Disturbed	**Undisturbed**	**Total**
SKP01			
Atelocynus microtis	-	3	3
Crypturellus soui	-	1	1
Cuniculus paca	-	8	8
Dasyprocta fuliginosa	-	14	14
Dasypus novemcinctus	-	1	1
Dicotyles tajacu	-	5	5
Mazama americana	-	2	2
Psophia crepitans	-	1	1
Tinamus major	-	1	1
SKP11			
Cuniculus paca	-	1	1
Dasyprocta fuliginosa	-	6	6
Dasypus novemcinctus	-	1	1
Dicotyles tajacu	-	3	3
Didelphis marsupialis	-	1	1
Mazama americana	-	1	1
Mazama nemorivaga	-	1	1
Myoprocta pratti	-	2	2
Nothocrax urumutum	-	2	2
SKP12			
Cuniculus paca	-	5	5
Dasyprocta fuliginosa	-	5	5
Dasypus novemcinctus	-	4	4
Dicotyles tajacu	-	10	10
Mazama americana	-	9	9
Mazama sp.	-	1	1
Nothocrax urumutum	-	3	3
Penelope jacquacu	-	3	3
Priodontes maximus	-	1	1
SKP02			
Cuniculus paca	-	4	4
Dasyprocta fuliginosa	-	4	4
Dasypus novemcinctus	-	1	1
Dicotyles tajacu	-	1	1
Hydrochoerus hydrochaeris	-	3	3
Mazama americana	-	17	17
Mazama nemorivaga	-	1	1
Mazama sp.	-	1	1
Mitu salvini	-	1	1
Psophia crepitans	-	1	1

SKP03			
Dasyprocta fuliginosa	-	2	2
Dicotyles tajacu	-	1	1
Mazama americana	-	2	2
SKP31			
Dasyprocta fuliginosa	8	-	8
Dicotyles tajacu	1	-	1
Hydrochoerus hydrochaeris	1	-	1
Mazama americana	2	-	2
Myrmecophaga tridactyla	1	-	1
Tamandua tetradactyla	1	-	1
Tinamus major	4	-	4
SKP32			
Cuniculus paca	1	-	1
Dasyprocta fuliginosa	50	-	50
Dasypus novemcinctus	9	-	9
Metachirus nudicaudatus	2	-	2
Nasua nasua	3	-	3
Penelope jacquacu	1	-	1
Philander andersoni	7	-	7
Tinamus major	2	-	2
SKP33			
Dicotyles tajacu	1	-	1
Mazama americana	37	-	37
Mazama nemorivaga	1	-	1
SKP34			
Cebus yuracus	1	-	1
Cuniculus paca	12	-	12
Dasyprocta fuliginosa	15	-	15
Dasypus novemcinctus	4	-	4
Eira barbara	1	-	1
Mazama americana	4	-	4
Mazama nemorivaga	1	-	1
Myrmecophaga tridactyla	1	-	1
Nasua nasua	3	-	3
Ramphastos tucanus	1	-	1
SKP35			
Cebus yuracus	3	-	3
Cuniculus paca	9	-	9
Dasyprocta fuliginosa	24	-	24
Dasypus novemcinctus	6	-	6
Dicotyles tajacu	12	-	12
Mazama americana	1	-	1
Myoprocta pratti	2	-	2
Myrmecophaga tridactyla	2	-	2
Nasua nasua	2	-	2

Priodontes maximus	1	-	1
Procyon cancrivorus	1	-	1
Psophia crepitans	3	-	3
SKP37			
Cebus yuracus	3	-	3
Cuniculus paca	13	-	13
Dasyprocta fuliginosa	14	-	14
Dasypus novemcinctus	2	-	2
Dicotyles tajacu	3	-	3
Eira barbara	3	-	3
Mazama americana	22	-	22
Mazama sp.	1	-	1
Nasua nasua	2	-	2
Procyon cancrivorus	1	-	1
Tinamus major	2	-	2
SKP06			
Crypturellus soui	-	1	1
Cuniculus paca	-	2	2
Dasyprocta fuliginosa	-	10	10
Dasypus novemcinctus	-	1	1
Dicotyles tajacu	-	1	1
Didelphis marsupialis	-	1	1
Mazama americana	-	9	9
Mazama nemorivaga	-	5	5
Mazama sp.	-	5	5
Nasua nasua	-	1	1
Penelope jacquacu	-	1	1
Priodontes maximus	-	1	1
Psophia crepitans	-	1	1
Saimiri cassiquiarensis	-	1	1
SKP07			
Crypturellus soui	-	1	1
Cuniculus paca	-	52	52
Dasyprocta fuliginosa	-	18	18
Dasypus novemcinctus	-	1	1
Dicotyles tajacu	-	3	3
Eira barbara	-	1	1
Mazama americana	-	3	3
Mazama nemorivaga	-	4	4
Procyon cancrivorus	-	1	1
Psophia crepitans	-	2	2
Puma concolor	-	1	1
Tinamus major	-	1	1