Exploring the relationships between zoochory and the ecosystem service potentials of both birding and bushmeat provisioning across a successional gradient in former plantations in Suriname.

MSc. thesis

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Abstract

It is often assumed that biodiversity and ecosystem services (ES; direct or indirect benefits from ecosystems that humans rely on like food and carbon sequestration) are positively linked and can contribute to conservation measures. However, it is unclear to what extent this is true for specific relationships in neotropical forests. Considering how such biodiversity – ES relationships lie across a successional gradient is also important, because regenerating forests can be considered homologous to different biogeographical strata due to being dynamic systems on a temporal scale, which can obscure positive relationships. This study explores the relationships between animal-dispersed woody species (i.e., zoochorous trees and arborescent palms) and both birding and bushmeat provisioning across a successional gradient in a regenerating Surinamese forest on former plantations. Zoochory was used as a proxy to measure the theoretical potentials of birding and bushmeat to be ES in a 28-year-, a 50-year-, and an over 200-year-old forest. A vertebrate-fruit interaction dataset linked specific bird and bushmeat species to the woody species. It was hypothesized that the ES potentials would increase across succession due to an increase in zoochorous interactions. In contrast with the hypothesis, birding potential did not change, while bushmeat provisioning potential increased with forest age. It is encouraged to include earlier forest stages in future research, as it could influence the results. Additionally, future studies should directly measure the relationships between zoochory and both birding and bushmeat provisioning. This also clarifies to what extent zoochory can be used to measure birding potential and bushmeat provisioning potential. For, in a rapidly changing world, insights into how forests recover themselves could be key to ensuring their future – and ours.

Plain language summary

Scientists are uncovering relationships between biodiversity and ecosystem services (ES; beneficial services of nature to humans, like food and clean air), where it is assumed that they mostly empower each other. If true, protecting ES could be an effective way of protecting nature. However, it is also important to understand how positive relationships could change over time in forests that regrow after human disturbance, because it could impact the possibility to use the ES over time and therefore also its power in nature conservation. That is why this research aimed to explore the potential for a Surinamese regrowing forest on old plantations to provide birding activities (i.e. the hobby of spotting wild birds) and bushmeat availability (i.e. wild animals hunted for food). Changes in fruit-producing tree species presence were used as a sign for how birding and bushmeat provisioning changed over time, as they were assumed to empower each other. It was expected that forests would provide more fruit-interactions over time for the bird and bushmeat animals between a 28-year, a 50-year, and an over 200-year-old forest. However, Surinamese forests on old plantations did not become more or less attractive for birds regarding fruit-interactions, meaning its potential to be practised remained the same. In line with the expectations, interactions with fruit-producing trees did become more available for bushmeat animals and so the potential for bushmeat provisioning to exist in Surinamese forests on old plantations increased over time. Younger forests are encouraged to be included in future research, because they could show changes that were not observed in this study. Future research should also directly measure the relationships between fruit-producing trees and both birding and bushmeat provisioning. This clarifies whether fruit-producing trees can really be a sign of how birding and bushmeat provisioning change over time. For, in a rapidly changing world, insights into how forests recover themselves could be key to ensuring their future – and ours.

1. Introduction

Although there is increasing attention for relationships between biodiversity and ecosystem services, much remains unknown for specific relationships in tropical forests. The increased attention stems from the assumption posed by a group of ecologists that biodiversity – ecosystem service (BES-) relationships are positively linked and can contribute to conservation measures (Cimon-Morin et al., 2013; Mace, 2014). Ecosystem services (ES) are the ecological functions, processes, or characteristics of ecosystems that provide direct or indirect goods and benefits to human well-being (Costanza et al., 2017). Although raising debates addressing the ethics of the commodification of nature (McCauley, 2006; O'Neill & Spash, 2000), i.e. to put a price on nature, conserving biodiversity by protecting ES has become an increasing focus for new conservation measures (Cimon-Morin et al., 2013; Gómez-Baggethun & Ruiz-Pérez, 2011; Mace, 2014; Mace et al., 2012). In tropical forests such conservation measures are relevant, as they are under pressure from anthropogenic disturbances and unsustainable use of natural resources (Barlow et al., 2016; Giam, 2017), while also being among the most biodiverse ecosystems in the world (Cazzolla Gatti et al., 2022; Gentry & Dodson, 1987; Pillay et al., 2022). The assumption that BES are positively related is built upon the knowledge that biodiversity is an important component of all levels of ecosystem services; it regulates foundational ecosystem processes (e.g., pollination), functions as a final ES (e.g., food), and constitutes a good that can be valued, whether economic or other (Mace et al., 2012). Meta-analyses on relationships between all kinds of biodiversity have generally found positive relationships thus far, supporting the assumption that BES are positively related (Cardinale et al., 2012; Harrison et al., 2014; Quijas et al., 2010). However, it remains unknown for many specific BES-relationships, i.e. a relationship between a particular biodiversity component and a particular ecosystem service, how they lie.

One specific domain that lacks empirical research regards the relationships between plant diversity at the species level and ES in neotropical forests (Steur, 2022). Still, by showing that relationships between plant diversity and ES are complex and not exclusively positive (Steur et al., 2020, 2021, 2022), the work that has been done in this domain so far raises questions on how other ES may be affected by plant diversity in the tropics. For example, through a systematic analysis in Suriname, Steur et al. (2021) found that wild non-timber forest product (NTFP) abundance was negatively related to woody species richness (i.e., trees and arborescent palms). However, this relationship did vary with floristic vegetation types and the dominance of a few NTFP species that determined over 50% of NTFP abundance.

Within neotropical forests, little is also known on how specific BES-relationships lie in regenerating forests and questions also arise on how they may be affected. For instance, data from 1-ha plots across the Guiana Shield and Amazonia showed that the positive relationship between species richness and carbon stock became obscured by variation across biogeographical regions at the scale of Amazonia (Steur et al., 2022). Thus, environmental stratification is important in researching BES-relationships, since it can increase their detectability. Especially because similar studies had shown contrasting results (Aldana et al., 2017; Poorter et al., 2015; Steur et al., 2020; Sullivan et al., 2017). Different stages of forest succession (e.g. regenerating forests vs old-growth forests) can be considered homologous to different biogeographical strata due to being dynamic systems on a temporal scale. This is especially relevant given the large size of neotropical regenerating forests as a result of global environmental change (Williams et al., 2024). For instance, they covered 4.1% of land in the Amazon biome, or roughly the size of the United Kingdom (243,000 km^2), by 2017 (Smith et al., 2021).

To the best of my knowledge, birding activities and bushmeat provisioning are two such ES that have not been studied in regard to their relationships with plant diversity across a successional gradient in neotropical forests, yet can be expected to be positive, making them very relevant for tropical forest conservation. This will be explained further below and will be based on zoochorous interactions. Zoochory is the dispersal mechanism of plants by animals and is classified as endozoochory (i.e. fruit ingestion and dispersal by animals), synzoochory (i.e. seed dispersal by seed-caching animals), and epizoochory (i.e. dispersal by fruits that stick to the outside of animals). In this research, zoochory will only include endozoochory and synzoochory, as they require more active interactions from the animals.

Birding refers to the hobby of watching wild birds in their natural environment by so-called "birders". It is a fast-growing hobby, also referred to as avitourism within eco-tourism, and it provides potential for biodiversity conservation by having a low disturbance rate (Biggs et al., 2011; Schwoerer & Dawson, 2022). Zoochory is an important component between bird-plant interactions in old-growth tropical forests. For instance, it was found that certain frugivores such as toucans select habitats based on the availability of large-seeded zoochorous tree species in a multi-site forest restoration experiment in Costa Rica (Reid et al., 2021). That is in line with what can be expected from the mutualistic interaction; the plant provides food (fruits and seeds) that feeds the bird and the bird disperses the seeds elsewhere (Hammond et al., 1996; Velázquez-Escamilla et al., 2019). This is interesting in the neotropics, because nowhere else globally is the richness and proportion of frugivorous bird species higher than here (Daniel Kissling et al., 2009), which could indicate an important interacting relationship. However, much remains unknown about how this relationship behaves in regenerating neotropical forests and the potential for birding to be an ES.

A similar case can be made for bushmeat provisioning, which are wild animals hunted for food, and its relationship with zoochory. Bushmeat is crucial to rural food security and livelihoods across the tropics (Milner-Gulland & Bennett, 2003; Nasi et al., 2011) and higher zoochorous woody species richness and density appears to create a higher potential for bushmeat species to be present. For example, in a study that compared the impact of large fruit-eating primate hunting on large-seeded tree dispersal between a hunted site and two protected areas in Peru, it was found that tree species richness was 55% lower in the hunted sites and the density of trees that are dispersed by these primates was 60% lower (Nuñez-Iturri & Howe, 2007). That is also in line with the fact that bushmeat species are often frugivores. For instance, it was discovered that in Amazonian forests, frugivorous species showed steeper declines in heavily hunted sites than seed predators and browsers (Peres & Palacios, 2007). Research on the diets of bushmeat species in the neotropics is scarce, but studies in African tropical forests had similar findings to Peres & Palacios (2007) and showed that bushmeat species are often important mammalian seed dispersers (Fa et al., 2005; Poulsen et al., 2002). However, how this bushmeat-zoochory relationship behaves in regenerating neotropical forests is unknown.

Thus, understanding how zoochorous woody species composition changes across succession could illuminate how birding and bushmeat provisioning, when actively practised, are also affected over a temporal scale in regenerating forests. Additionally, their theoretical potentials, i.e. the possibility for the ES to exist and be practised somewhere, can also be measured then in regions where they may not be practised yet or when the ES cannot be evaluated directly. To start, zoochory is the most dominant dispersal mechanism in old-growth neotropical forests. An analysis of a comprehensive list of timber species from the Guianas found that 72% of the species were zoochorous (Hammond et al., 1996). From a series of transects covering the first 200 years of forest development on undisturbed riverbends in Peruvian lowland forest, it was found that the proportion of zoochorous species among trees and smaller woody plants is around 90% (Foster et al., 1986). Thus, zoochorous proportions in old-growth neotropical forests may lie somewhere between 72-90% and can, therefore, be considered rich in bird and bushmeat interactions. However, neotropical forest dispersal diversity proportions in earlier successional stages are poorly researched. Swaine & Hall (1983) did find that zoochory is also dominant in early succession at 64% in their research on early succession on cleared forest land in Ghana, Africa, but no other empirical data was found. In addition, these studies did not include specific animal-fruit interactions.

Therefore, this study aims to **explore the relationships between zoochory and the ecosystem service potentials of both birding and bushmeat provisioning across a successional gradient in former plantations in Suriname**. Based on the available literature and considering the mutualistic interactions between zoochory and both birds (Daniel Kissling et al., 2009; Hammond et al., 1996; Reid et al., 2021; Velázquez-Escamilla et al., 2019) and bushmeat animals (Fa et al., 2005; Nuñez-Iturri & Howe, 2007; Peres & Palacios, 2007; Poulsen et al., 2002), I assume that the potentials for birding and bushmeat provisioning to be ES are positively related to zoochory due to the reciprocal relationship that many birds and bushmeat species have with zoochorous plants. The working hypothesis is that birding potential and bushmeat potential increase across succession. This is based on the idea that early successional stages may be more susceptible to receive wind-dispersed seeds due to undeveloped stratification, i.e. the vertical layering of the habitat by plants and animals, and a possible higher reluctance for seed dispersers to approach early successional forests from a lack of hiding spots. Although research on zoochory across succession is scarce, preliminary results suggest a slight increase from 64% to 72-90% (Foster et al., 1986; Hammond et al., 1996; Swaine & Hall, 1983), in support of the hypothesis.

The study area for this research is in Peperpot Nature Park (PNP), Suriname. It is a regenerating coastal tropical swamp forest that became a voluntary nature park in 2009 on former coffee and cacao plantations. It contains areas differing in successional age and some are accessible for tourism and birding activities, while illegal hunting in other areas is known to occur as well (Schuttler et al., 2021). The local community and PNP could benefit from knowledge about these BES-relationships, because the potentials for birding and bushmeat practices may be affected by the succession of PNP over time.

2. Methods

2.1 Study area

The study area involves the regenerating tropical swamp forest Peperpot Nature Park (PNP), formerly encompassing parts of five plantations (Peperpot, La Liberté, Puttenzorg, ‘t Eyland, and Mopentibo), where mostly cacao and coffee plants were cultivated (Fig. 2.1). PNP, Peperpot Nature Forest Foundation, and Utrecht University Botanic Garden’s Quantitative Biodiversity Dynamics research unit (QBD) established the long-term Project Peperpot to provide the needed information to protect PNP’s cultural heritage of the former plantations together with its biodiversity (*Project Peperpot, Suriname - Quantitative Biodiversity Dynamics - Utrecht University*, n.d.). The project involves creating a vegetation map of the forest and establishing permanent sampling plots to study the changes in biodiversity.

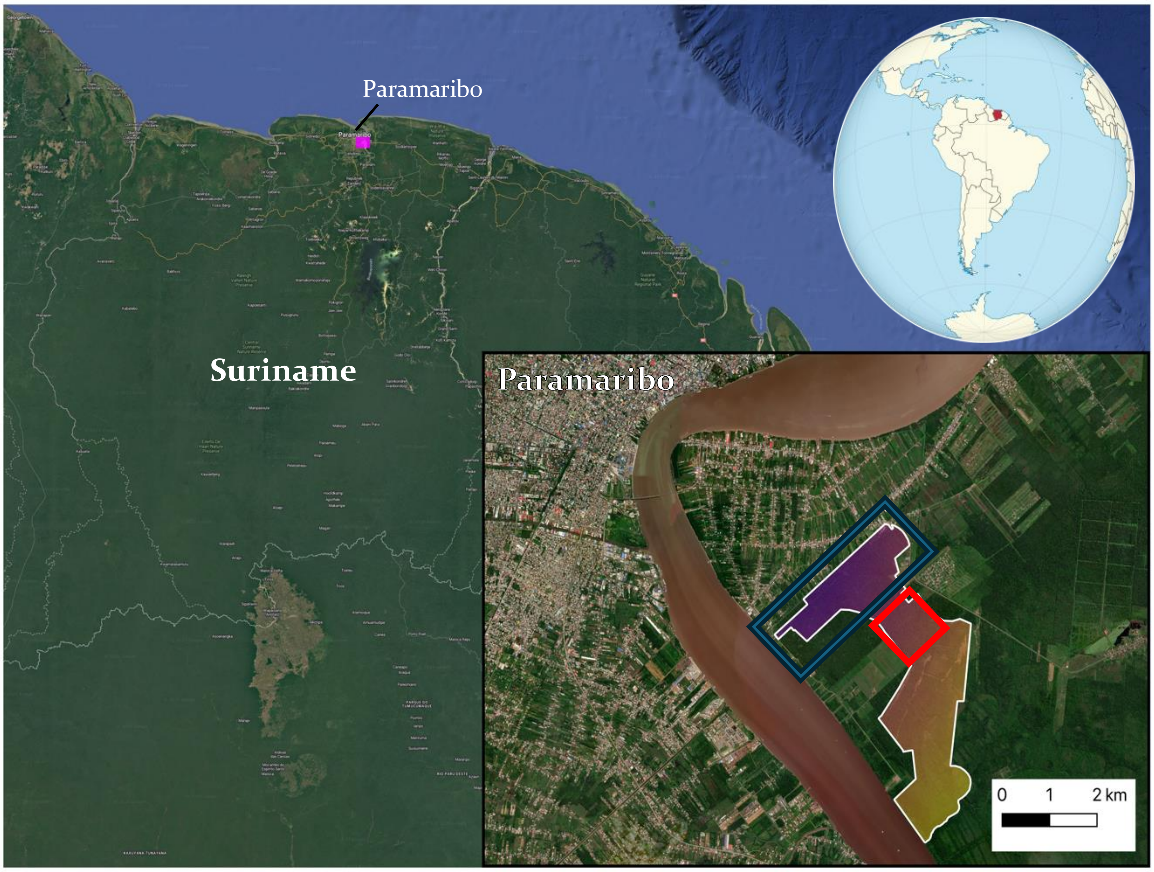

Figure 2.1. The study area of the current research. The small, highlighted area in pink is zoomed-in on the bottom right. The white-outlined area encloses Peperpot Nature Park and the purple-to-yellow gradient indicates the regenerating forest’s successional gradient where the purple part is the youngest in age. the red box confines the fieldwork area of the present study. The blue box confines a previous data collection area by Julia Blok and Sanne Poortman (Blok, 2024). The images were created in QGIS (QGIS.org, 2025), except for the globe (TUBS, 2011). Outline of PNP by Gijs Steur.

PNP spans 800 ha and is situated in the Commewijne District near the capital city of Suriname: Paramaribo (5°80’N, 55°12’W). On its Western side, PNP is separated from Paramaribo by the Suriname river and on the other sides it is surrounded by human-occupied rural areas, except for the section that connects PNP with largely undisturbed tropical forest through other former plantations in its Southern region. In 2023, Julia Blok and Sanne Poortman, mapped around 30%

(~240 ha) of the park (Fig. 2.1) starting in the area accessible for tourists, comprising a large segment of the former Peperpot (PP) plantation, in 2023 (Blok, 2024). A further 100 ha was mapped out during the present study, close-to but separated from the accessible part for tourists, comprising segments of the former PP and La Liberté (LL) plantations (Fig 2.1).

2.2 Determining the successional gradient

Data was collected of swamp forest of three different ages: ~28 years-old, ~50 years-old, and ≥200 years-old. The data for the youngest two were censused from PNP. PNP's successional gradient was youngest in its northwestern part and ages toward the southeast (Fig. 2.1). The area of the former PP plantation was abandoned after cacao and coffee farming stopped around 1997 (Blok, 2024; Schuttler et al., 2021). The accessible part of PNP for tourists and birders who practise birding, only includes the former PP plantation. Data collection in this study covered the remaining area of PP, but also the former LL plantation (Fig. 2.2). An employee who had been working in PNP since at least the 1970s noted that LL had probably been abandoned somewhere in the 1970s, but he was unaware of the exact year. For this study, 1975 was taken as the year that succession had started in LL, because it was the most neutral option in the 10-year span of the 1970s. Old-growth forest data was collected by Pieter Teunissen in Surinamese old-growth coastal swamp forests (Teunissen, 1980) in areas outside of PNP. Although this data collection took place in the 1970s, re-visits by Steur et al. (2021) of ten plots in 2018 and other floristic fieldwork in 2017-2019 confirmed that the current climax vegetation of the coastal area in Suriname is still well-characterized by climax vegetation data captured by Teunissen. Thus, in 2025 there was a 28-year-old Peperpot forest stage ("28-yr-forest"), a 50-year-old La Liberté forest stage ("50-yr-forest"), and an old-growth forest that is at least 200 years old ("200-yr-forest").

2.3 Vegetation survey and dataset

Four transects were walked to determine the vegetation types in the fieldwork area (Fig. 2.2). The transects routes were placed parallel to each other and divided the fieldwork area into 4 even parts. Identified vegetation types were based on P. Teunissen's (1980) classification of the old-growth Surinamese coastal plain forests. Plots were established and the woody (i.e. trees and arborescent palms) species composition and abundance was measured by identifying the woody individuals that inhabited these plots. Complying with previous data collection (Blok, 2024; Teunissen, 1980), plots of 0.04 ha were sampled in PNP and only individuals with a diameter at breast height (DBH) ≥ 5 cm were identified. DBH measurements followed The Rainfor manual for tropical forest plot establishment (Phillips et al., 2021). To reduce bias, plots were placed using a stratified random sampling method.

A total of 17 plots were sampled: 9 plots in PP and 8 plots in LL. Combined with Blok's (2024) data collection this resulted in 33 plots for the 28-yr-forest stage and 8 plots for the 50-yr-forest stage. Teunissen's 200-yr-forest data derived from 11 plots.

Figure 2.2. Fieldwork area of active data collection in PNP. The area is divided in a part of the former Peperpot (PP) plantation, where agricultural activities were abandoned around 1997, and a part of the former La Liberté plantation, where activities halted in the 1970s. The map is based on previous work by Blok (2024) and van Kollenburg (2025).

2.4 Data analysis

To understand how dissimilar the three successional stages were in community composition, a Bray-Curtis dissimilarity NMDS ordination was visualized. It quantified the dissimilarity in species composition between the different sites.

To attain information on the dispersal mechanisms of the woody plants in the study area, dispersal modes for each species was taken from a tree dispersal modes dataset (Correa et al., 2023). This dataset includes information on the scientific species name, family, genus, estimated overall population size, seed mass, and main dispersal mechanism, for more than 5400 tree species in the lowland rainforests of the Amazon River basin and the Guiana Shield. The dispersal modes were assigned by observation of diaspore morphology in herbaria exsiccates (virtual herbaria) and scientific literature. The taxonomy of the dataset was updated to match the scientific names used in the present study.

Bushmeat provisioning

Bushmeat provisioning potential, i.e. the potential that wild animals can be hunted for food in PNP, was based on a list of 31 of the most commonly hunted and traded bushmeat species in Suriname (Andel et al., 2003). The list was created by assimilating data from scientific literature and reports on wildlife trade in the Guianas. Despite the 22-year difference between this list and the current research, there was no reason to believe that hunting behaviour had changed. Thus, the bushmeat species that were known to occur in PNP in 2025 were taken from the list and used in statistical testing. To determine which bushmeat species occurred in PNP, camera trapping data (Ramcharan, 2017) and anecdotal records from conversations with current employees of the park were utilized.

Birds
For birding potential, i.e. the potential for birding to be an ES in PNP, a list of 305 bird species that were known to occur in PNP was used (*Plantage Peperpot (Hotspot)*, n.d.; Appendix D). The list was based on observations that were described on a website that was deemed trustworthy, because it has been used in other research (Ramcharan, 2017) and the creator of the list who assimilated all the records of bird observations (seen, heard, or caught), Jan Hein Ribot, has contributed to published bird research and field guides before (Ingels et al., 1984; Spaans et al., 2018).

Vertebrate-fruit interaction dataset
The animal and woody species datasets were combined with a vertebrate-fruit interactions dataset, which compiled recorded observations of interactions between vertebrates and the fruits of Guianan) tree species (i.e. Guyana, Suriname, and French Guiana (Vaessen et al., 2023; attachment excel file). Solely observations of interactions that have been described in scientific literature were compiled in this dataset.

As sometimes a number of species did not appear in the interaction dataset, it could potentially skew the results (zero-inflate the data). Therefore, these species were not considered. Ultimately, that meant that only 52 of the known 305 PNP bird species could be utilized, as well as only 16 of 23 PNP bushmeat species. Similarly, only 43 of 103 woody species that occurred in the three successional stages could be used.

Indices to measure ES potentials
The proportions of zoochorous woody plants across the three successional stages were examined using a linear model to determine whether zoochory increases, decreases, or remains the same among the communities. 3 indices were made for both bushmeat and birding to investigate how their potentials would change by differences of fruit interactions over a successional gradient:

1. An index of relevant **species richness**. The proportion of woody species that were known to have at least one interaction with an animal from the datasets were calculated here.
2. An index of relevant species abundance. The second index examined the abundance of interacting **individuals**. Here, the proportion of woody individuals that had at least one interaction was calculated and compared.
3. An index that summed the total number of possible interactions of the relevant species abundance. The last index measured the **sum of interactions**. This index calculated the average number of interactions per woody individual.

Index 1 is relevant, because it clarifies how interacting species richness fluctuates over succession and therefore whether zoochorous species become more or less prevalent. Similarly, indices 2 and 3 are important, because the former shows how the relative abundance of interacting species changes over succession in comparison to non-interacting species, while the latter defines whether the actual number of interactions per individual increases, decreases or remains the same with forest age. On their own, these indices do not reflect a complete picture. For example, the proportion of interacting individuals may be very high, evoking the speculation that many interactions exist as well, but the sum of interactions can be low if those species have only few interactions with frugivores. Thus, together, these indices reveal how woody species richness, species composition, and number of interactions, may influence the potentials for both bushmeat provisioning and birding to be ES across succession more completely.

In line with the working hypothesis, it is expected that all three indices will increase across succession, which would indicate that both birding potential and bushmeat provisioning potential increase with forest age due to increased zoochorous interactions and interacting species richness. To measure their differences across the three successional stages, linear models were performed on the 3 indices. All assumptions for the statistical tests were met. All statistical tests were performed in R-studio (version 2025.05.1+513; Posit team, 2025), using R version 4.5.0 (2025-04-11) "How About a Twenty-Six" (R Core Team, 2025).

2.5 Validation of ecosystem service potentials

To find support for zoochory being a good proxy for birding potential in PNP, online interviews were conducted with two expert birder tour guides in PNP. One interviewee operated for Flora & Fauna Tours (*Flora & Fauna Tours*, n.d.), and there was another independent tour guide. No interviews were conducted regarding bushmeat provisioning, as this proved difficult given the illegality of hunting in PNP.

3. Results

3.1 Vegetation types and woody species composition across succession

The vegetation types among the three successional stages were based on the classification of old-growth Surinamese lowland ecosystems made by Teunissen (1980). The three successional stages all had a dominance of *Euterpe oleracea* palms and along with the rest of their species compositions, they were best described as E46 and E89 vegetation types (number E46 and E89 in the Teunissen classification), i.e. hydrophytic swamp forests with *Virola surinamensis*, *Symphonia globulifera* with a dominance of *Euterpe oleracea*. (Table 3.1; a more comprehensive overview can be found in Appendix C). However, Number E46 are young swamp ecosystems, which pertain to the 28-yr-forest and the 50-yr-forest, while number E89 are old swamp ecosystems and pertain to the 200-yr-forest. Number E89 is generally more diverse in species composition than E46.

Despite that the 28-yr-forest and 50-yr-forest shared many of the same woody species, they were markedly different in structure. For example, the 50-yr-forest was more open and less crowded with small trees than the 28-yr forest. Historically, Land use has also differed. Employees in the park mentioned that crops such as coffee and cacao were cultivated in the former PP plantation (i.e. 28-year-forest stage), and the canals between the fields that were observed during fieldwork (see: Fig. 2.2) were visual remnants of it. PNP employees also speculated that cattle roamed in the former LL plantation before commercial activities were halted. This was plausible, given that LL was mostly flat and without canals, but this alternative land-use was not officially proven.

Table 3.1. The five most abundant woody species across succession (percentage of total stems). For every successional stage, the percentages of the five most common woody species were calculated from their pooled plots (28-yr-forest = 33 plots; 50-yr-forest = 8 plots; 200-yr-forest = 11 plots). The age for every successional stage is also given, in addition to their vegetation type (see Appendix C for a more comprehensive overview).

Peperpot (Young;~28 yrs; E46)		**La Liberté: (Intermediate; ~50 yrs; E46)**		**Various Old-growth (~200 yrs; E89)**	
Euterpe oleracea	(40.4%)	*Euterpe oleracea*	(69.2%)	*Euterpe oleracea*	(61.9%)
Virola surinamensis	(9.9%)	*Triplaris weigeltiana*	(3.9%)	*Diospyros guianensis*	(4.2%)
Inga ingoides	(7.4%)	*Diospyros guianensis*	(3.8%)	*Symphonia globulifera*	(3.9%)
Triplaris weigeltiana	(7.0%)	*Virola surinamensis*	(3.8%)	*Myrcia neomontana*	(3.7%)
Casearia mariquitensis	(4.9%)	*Tabebuia fluviatilis*	(3.4%)	*Carapa guianensis*	(2.4%)

The visual representation of the Bray-Curtis dissimilarity NMDS ordination showed a dissimilarity in species composition among the three stages. Stress-values are generally acceptable between 0.1-0.2, with values below 0.1 indicating better values, and this NMDS ordination had an acceptable stress-value of 0.1704841 (Fig. 3.1). The compositional difference between the studied forest in PNP and the old-growth forests was also supported by the lack of overlap in the ordination (i.e. 28-yr-forest + 50-yr-forest vs. ≥200-yr-forest). The study sites closer in age had a more similar species composition (i.e. 28-yr-forest + 50-yr-forest).

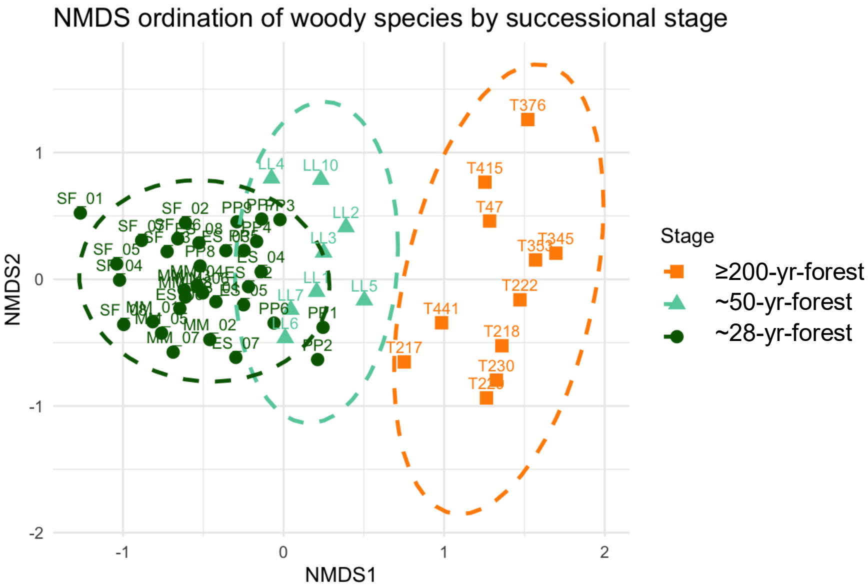

Figure 3.1. Bray-Curtis dissimilarity NMDS ordination plot. The three successional stages are distinguished by differing colors and shapes for every stage. The 28-yr-forest contains plots sampled from the former Peperpot plantation (n = 33), the 50-yr-forest was sampled from the former La Liberté plantation (n = 8), while the 200-yr-forest was sampled in coastal Northern Suriname (n = 11). All plots had different plot codes (e.g. LL1 or T376) to distinguish them from each other.

3.2 Zoochory proportions across succession

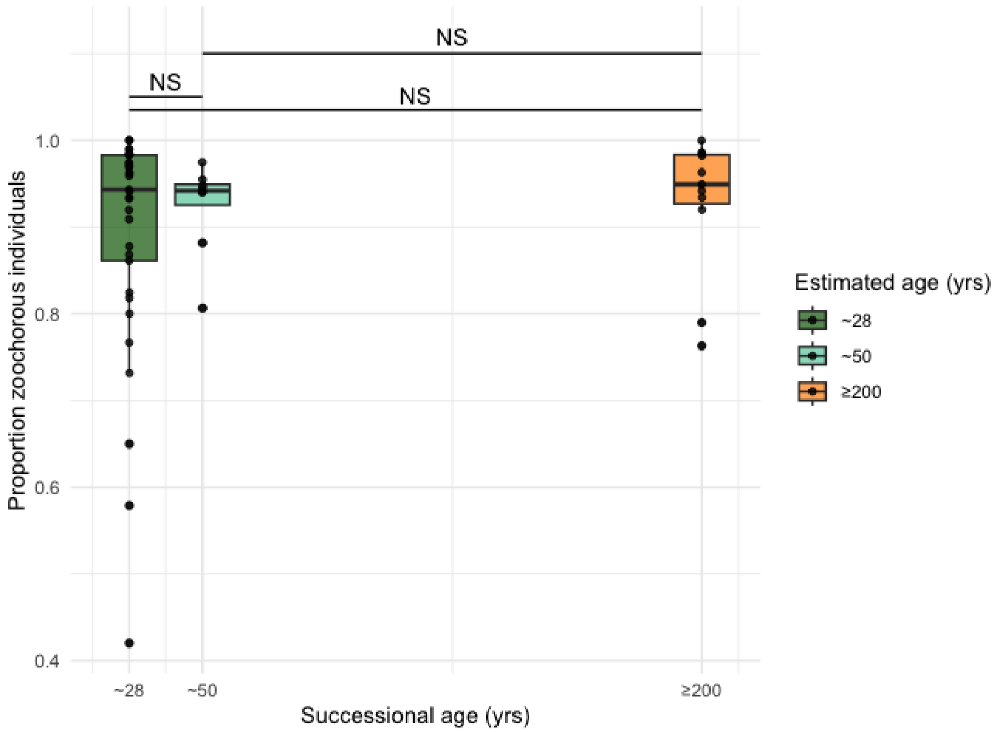

Figure 3.2. Boxplots for the zoochory proportions across the study sites. Indicated p-values: $p > 0.05$ (NS). Significant differences were measured by Tukey-adjusted comparisons based on the linear model. "~28" pertains to the 28-yr-forest plots (n = 33), "~50" pertains to the 50-yr-forest plots (n = 8), and "≥200" pertains to Teunissen's 200-yr-forest plots (n = 11).

Regarding the proportions of zoochory among the woody species communities across succession, no significant differences in the means and no significant linear relationship were detected (all pairwise comparisons Tukey-adjusted $p > 0.05$; Fig. 3.2, and regression $p = 0.41$, Appendix A (Fig. A.1)). Zoochory was high and similar across the successional stages (median 94.3, 94.2 and 94.9% for 28-yr, 50-yr and 200-yr-forest, respectively; 83 of all 103 woody species across succession were zoochorous).

3.3 Bird-fruit interactions across succession

Regarding the richness of woody species that have interactions with the identified relevant bird species (index 1), no significant differences were found between the mean richness of each successional stage (Tukey-adjusted, $p > 0.05$, Fig. 3.3.A). In addition, no significant linear relationship between aforementioned richness and the successional stage could be detected ($p = 0.17$, Appendix A; Fig. A.2A), nor could any visual pattern be observed in the median richness across successional stages (28-yr-forest = 30%, 50-yr-forest = 27.6%, 200-yr-forest = 25%).

Concerning the abundance of woody individuals that have interactions with the identified relevant bird species (index 2), both the 50-yr-forest and 200-yr-forest had a significantly higher mean abundance than the 28-yr-forest, while no difference was found between the 50-yr-forest and the 200-yr-forest (Tukey-adjusted, $p < 0.01$, $p < 0.05$, $p = 0.68$, Fig. 3.3.B). However, no significant linear relationship between abundance and successional stage could be detected ($p = 0.085$, Appendix A; Fig. A.2B). A visual pattern was observed in the median abundance across successional stages, where the 50-yr-forest was highest, followed by the 200-yr-forest and then the 28-yr-forest (28-yr-forest = 53%, 50-yr-forest = 78%, 200-yr-forest = 66%).

As for the sum of all known interactions with the identified relevant bird species for the abundance of woody individuals (index 3), no significant differences were found between the mean interactions per woody individual of each successional stage (Tukey-adjusted, $p > 0.05$, Fig 3.3.C). Additionally, no significant linear relationship between aforementioned interactions per woody individual and successional stage could be found ($p = 0.75$, Appendix A; Fig. A.2C), nor could any visual pattern be observed in the median interactions per individual across successional stages (28-yr-forest = 2.11, 50-yr-forest = 2.64, 200-yr-forest = 1.96).

Together, these results show that 1) bird-associated woody species richness remains between 25-30% across succession, 2) the proportion of bird-interacting individuals is higher in later successional stages, increasing their relative abundance, and 3) the number of interactions per woody individual does not change across succession.

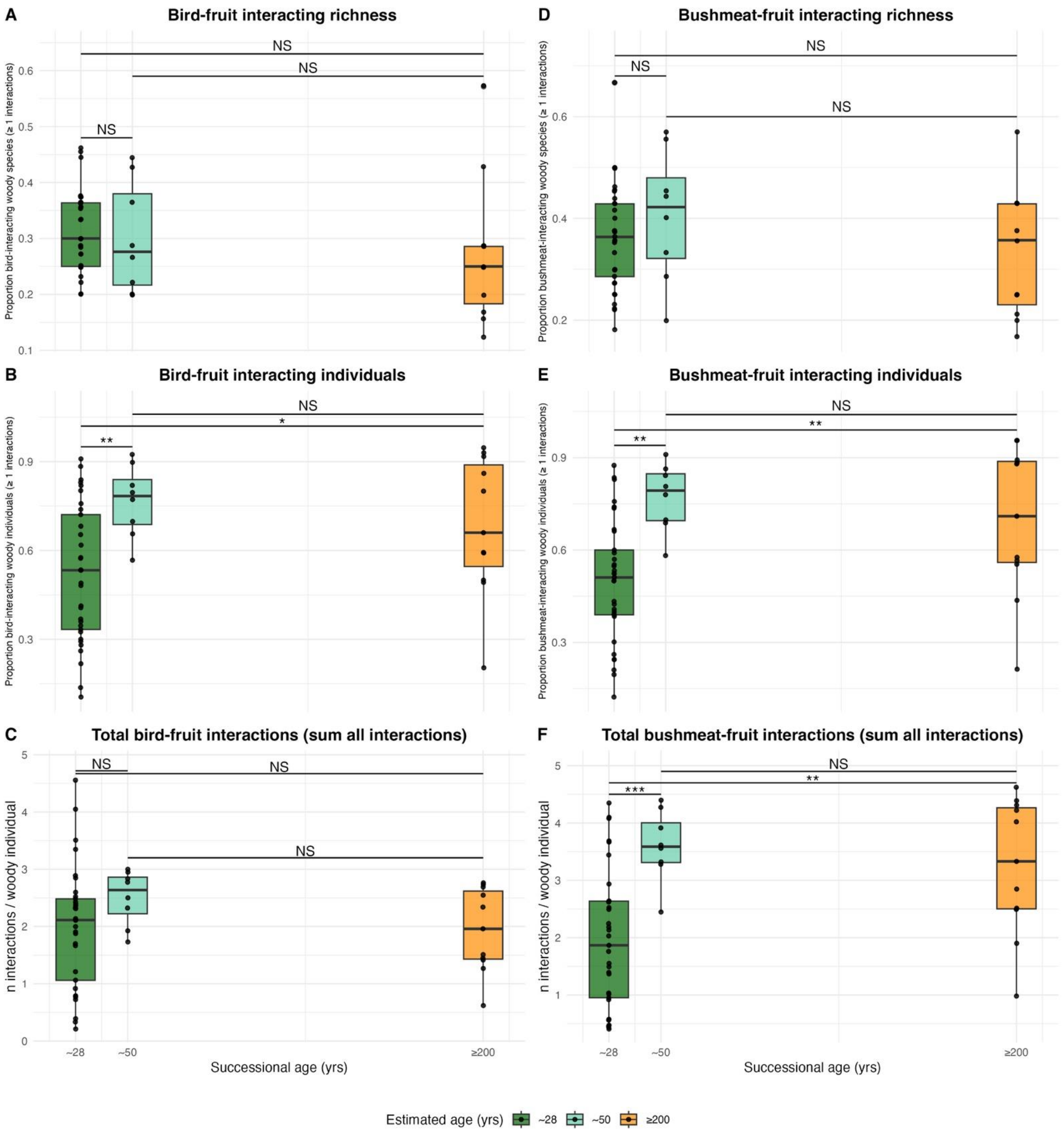

Figure 3.3. Boxplots of bird- and bushmeat-interacting woody indices across three successional stages. Significant differences were measured by Tukey-adjusted comparisons on linear models. "~28" pertains to the 28-yr-forest plots (n=33), "~50" pertains to the 50-yr-forest plots (n=8), and "≥200" pertains to the 200-yr-forest plots (n=11). The p-values are indicated by the following ranks: $p < 0.001$ (***), $p < 0.01$ (**), $p < 0.05$ (*), $p > 0.05$ (NS).

3.4 Bushmeat-fruit interactions across succession

Concerning the richness of woody species that have interactions with the identified relevant bushmeat species (i.e. index 1), no significant differences were found between the mean richness of each successional stage (Tukey-adjusted, $p > 0.05$, Fig. 3.3.D). In addition, no significant linear relationship between aforementioned richness and the successional stage could be detected ($p = 0.38$, Appendix A; Fig. A.3A), nor could any visual pattern be observed in the median richness across successional stages (28-yr-forest = 36.4%, 50-yr-forest = 42%, 200-yr-forest = 35.7%).

In regard to the abundance of woody individuals that have interactions with the identified relevant bushmeat species (i.e. index 2), both the 50-yr-forest and 200-yr-forest had a significantly higher mean abundance that the 28-yr-forest, while no differences was found between the 50-yr-forest and the 200-yr-forest (Tukey-adjusted, $p < 0.01$, $p < 0.01$, $p = 0.67$, Fig. 3.3.E). Furthermore, a significant positive linear relationship was found (slope = 0.00099, $R^2 = 0.094$, $p < 0.05$, Appendix A; Fig. A.3B). A visual pattern was observed in the median abundance across successional stages, where the 50-yr-forest was highest, followed by the 200-yr-forest, and then the 28-yr-forest (28-yr-forest = 51%, 50-yr-forest = 79%, 200-yr-forest = 71%).

As for the sum of all known interactions with the identified relevant bushmeat species for the abundance of woody individuals (i.e. index 3), both the 50-yr-forest and 200-yr-forest had a significantly higher mean number of interactions per woody individual than the 28-yr-forest stage, while no difference was found between the 50-yr-forest and the 200-yr-forest (Tukey-adjusted, $p < 0.001$, $p < 0.01$, $p = 0.77$, Fig. 3.3.F). Additionally, a positive linear relationship was found (slope = 0.0066, $R^2 = 0.12$, $p < 0.05$, Appendix A; Fig. A.3C). A visual pattern was observed in the median interactions per individual across successional stages, where the 50-yr-forest was highest, followed by the 200-yr-forest, and then the 28-yr-forest (28-yr-forest = 1.87, 50-yr-forest = 3.59, 200-yr-forest = 3.33).

Together, these results show that 1) bushmeat-associated species richness remains between 35.7-42% across succession, 2) the proportion of bushmeat-interacting individuals is higher in later successional stages, increasing their relative abundance, and 3) the number of interactions per woody individual is higher in later successional stages.

3.5 Birding interviews and bushmeat anecdotal records

Regarding support for zoochory being a good proxy for the potential for birding, the two expert birder tour guides in the interviews shared the opinion that, although birding is practiced in PNP, “special” birds that birders specifically look for in Suriname do not occur here. The birds that can be found in PNP are typical Surinamese coastal plain birds which are not considered “special” birds (i.e. birds that are major tourist attractors). Such “special birds” are more common in the interior of Suriname. The experts did not know of any specific relationship between zoochorous trees and birds in PNP, while they believed that such relationships did exist for birds found in the interior. In Surinamese inland forests, it was said that the high woody species richness causes frequent blossoms and fruit availability that attracts birds. One of the experts stated that birds are mostly attracted to the insects in PNP, rather than the fruits. In the 8 and 17 years that both tour guides were active in PNP until present, they did not notice any change in bird species composition and abundance.

More support for zoochory being a good proxy for the potential for bushmeat provisioning was not attained during fieldwork. However, more evidence for the occurrence of illegal hunting in PNP was attained. First, in the park it was known that illegal hunting occasionally occurs, as employees hear gun shots emanating from the park every month. Second, two açai-berry harvesters (berries from the *Euterpe oleracea* palm) were encountered during fieldwork. It is illegal to harvest açai-berries in PNP, which indicated that it is reasonable to suggest that illegal hunters could also enter the park. Last, someone who grew up close to PNP shared that their father used to hunt in PNP, decades ago, and that he mainly hunted for Red-rumped agoutis (*Dasyprocta leporina*).

4. Discussion

This research investigated the relationships between woody plant diversity and the ecosystem services of birding and bushmeat provisioning across a successional gradient from former plantations to old-growth of swamp forests in Suriname. Birding and bushmeat provisioning were approximated as a service by their potential, i.e. the ecosystem's capacity to provide the ES, where interactions with zoochorous species were utilized as proxies to measure their potentials. Data on woody species richness and abundance of three successional stages were used (a 28-yr-forest, 50-yr-forest, and a 200-yr-forest). From regenerating former plantations to old-growth stands, birding potential did not change while bushmeat provisioning potential increased across succession.

4.1 Birding potential

In the working hypothesis, it was stated that all three birding potential indices were expected to increase across succession due to a higher possibility of zoochorous interactions taking place as a forest develops. Across the successional gradient from former plantation vegetation to old-growth stands, the abundance of bird-interacting species increased, but both interacting species richness and number of interactions per woody individual did not. This partly contrasts with the hypothesis. In line with the hypothesis, the relative abundance of interacting species increased and thus interacting species became more dominant with forest age. In contrast with the hypothesis, both interacting species richness and number of interactions per woody individual remained the same, indicating that despite interacting species becoming more dominant, it does not lead to more potential interactions in the communities. Perhaps the results could be different if the successional gradient included data on forest ages younger than 28 years-old, which was the youngest stage used in this study. In a multisite analysis for the neotropics where tree species richness and composition recovery was studied across successional gradients in anthropogenic disturbance and environmental conditions, for example, it was found that it takes a neotropical forest only 20 years of succession to recover 80% of tree species richness after disturbance, while species composition recovery is slower at 34% after 20 years (Rozendaal et al., 2019). It shows that vegetation develops rapidly in secondary succession and perhaps bird-interacting species richness does as well and saturates before 28 years of succession after a former coffee- and cacao plantation in a Surinamese coastal swamp area has been abandoned. However, on specific bird-interactions across a successional gradient, no literature was found to either support or contrast the results. Thus, based on these results and calculations, birding potential does not change across succession on former plantations in Suriname.

The two interviews with expert birder tour guides revealed that no relationships between birds and zoochorous trees were observed in Surinamese regenerating coastal forests on former plantations and no "special" birds (birds that birders specifically look for) occur there either. However, such relationships were observed in the interior of Suriname, where it was said that the high woody species richness causes frequent blossoming and fruits that attract birds. This partly contrasts with the assumption that zoochory can be a good proxy for birding potential. Thus, deducing from the two interviews, the use of this proxy depends on the geographic location and can be good in interior forests of Suriname, but not in Surinamese regenerating coastal forests on former plantations.

4.2 Bushmeat provisioning potential

In the working hypothesis, it was stated that all three bushmeat provisioning potential indices were expected to increase across succession due to a higher possibility of zoochorous interactions taking place as a forest develops. Across the successional gradient from former plantation to old-growth stands, both the abundance of bushmeat-interacting woody individuals and the average number of interactions per individual increased, while interacting species richness stayed the same. This is mostly supported by the hypothesis. In line with the hypothesis, the relative abundance of interacting woody species and sum of interactions increased across succession. In contrast with the hypothesis, interacting species richness did not change with forest age. Despite interacting species richness remaining the same over succession, interacting species did become more dominant in abundance and had more interactions with bushmeat animals. Similar to the argument for birding potential, perhaps interacting species richness changes in earlier stages of forest succession and saturates before they reach 28 years of succession, which was the youngest stage used in this research. Again, research has found that it takes a neotropical forest only 20 years of succession to recover 80% of tree species richness after disturbance, while species composition recovery is slower at 34% after 20 years (Rozendaal et al., 2019). Thus, perhaps interacting species richness still increases across succession on former cacao- and coffee plantations in Suriname coastal swamps, but saturates quicker than expected. However, no additional literature could be found that either supports or contrasts the present results. This, along with the fact that interacting species became more abundant and provided more potential interactions with forest age, it was deduced that bushmeat potential increases across succession on former plantations in Surinamese coastal swamps, based on these results and calculations.

The abundance of interacting individuals and the average number of interactions per individual peaked at the 50-yr-forest stage and did not change over succession, indicating that the highest bushmeat potential is already reached after 50 years of Surinamese forest succession.

Perhaps the contrast to the bird results could be explained by the diets and body size of the animals included in the research. Many of the bushmeat animals, such as the lowland tapir (*Tapirus terrestris*), the white-lipped peccary (*Tayassu pecari*), and the capybara (*Hydrochoerus hydrochaeris*), have a greater body size than most PNP birds and may sustain more intricate relationships with zoochorous woody species due to a greater need for nutritional sustenance, causing zoochory to possibly be a better indicator for bushmeat presence potential than bird presence potential.

4.3 Zoochory across succession

the working hypothesis expected an increase in zoochory across succession from the idea of a high susceptibility of early forests to receive wind-dispersed seeds and seed dispersing animals being more reluctant to traverse undeveloped forests with few hiding spots. Proportions of zoochory as a dispersal mode among woody individuals were around 90% and did not change with forest age. This contrasts the hypothesis. The scarce literature suggested a slight increase in zoochory, from 64% in early succession of cleared land in Ghana (Swaine & Hall, 1983), to between 72-90% in old-growth neotropical forests (Foster et al., 1986; Hammond et al., 1996). The present results indicate that at the 28-yr-old forest stage, regenerating Surinamese swamp forests on former plantations have zoochory levels similar to old-growth neotropical forests.

Perhaps changes in proportions of zoochory were not detected in the present results because old-growth zoochory proportions are reached earlier than expected in regenerating forests.

4.4 Limitations and suggestions

The current research focused on the theoretical potentials for birding and bushmeat provisioning under the assumption that they are positively linked with zoochory, but more definitive conclusions can be drawn on whether zoochory can actually be a good proxy for both birding potential and bushmeat potential when the ES are measured directly. Hence, future research is encouraged to measure these ES directly to better understand how birding and bushmeat provisioning are related to zoochory. For example, more interviews can be done with birding tourists and experts or surveys can be performed on the specific frugivorous diets of both birding and bushmeat animals, and how their geographic distribution relates to the geographic distribution of the vegetation that provides the fruits in their diets. This will also clarify to what extent zoochory can be used as a proxy for both birding potential and bushmeat potential.

Another caveat of this research is that the vertebrate-fruit interaction dataset that was used to measure the ES potentials is not complete. Despite the dataset covering over 2000 interactions between animals and tree species, it can be expected that many more interactions exist in the Guianas. This is also evident from the data analysis, as only 43 out of 103 (41%) woody species across the three successional stages occurred in the interaction dataset, while 83 of the 103 (80%) species were found to be zoochorous from the dispersal mode dataset. Similarly, some PNP birds and bushmeat species did not occur in the interaction dataset, while they are known to be frugivorous. For example, the lowland paca (*Cuniculus paca*, sometimes also referred to as *Agouti paca*) does not occur in the dataset, but is known to be frugivorous in French Guiana (Dubost & Henry, 2017) and occurs in PNP. As a substantial number of species were omitted from the data analysis, it is reasonable to expect that the outcomes of the present research could be different if a more complete dataset was used. Perhaps some woody species only occurring in one of the successional stages have interactions with many birding and bushmeat animals, but they might not be described by the interaction dataset. This could influence the significance of the results.

Regenerating forests are also encouraged to be included in future studies that research how ES potentials could change. Regenerating forests can be considered homologous to different biogeographical strata due to being dynamic systems on a temporal scale. This also applies to regenerating forests on former cacao- and coffee plantations included in this research. The variation in floristic species richness and composition that arises on the temporal scale can cause an ecosystem's capacity to provide an ES, like bushmeat potential, to change and is therefore important to consider.

4.5 Societal relevance

For PNP, through 2 interviews in this study, it was shown that in the park and the surrounding coastal area of Suriname no "special" birds occur. Thus, regardless of succession, it will never lead to more "special" birds in PNP. As birding continues to be practised in the park, it does not appear to be having an effect on the casual birder who also enjoys spotting common birds. They could consider modifying the vegetation along the tourist trails to possibly increase the chance of spotting certain common birds that are considered relatively more "special".

Based on these results, bushmeat provisioning potential increases with forest age in PNP, or at least until they are at 50 years in succession. If poachers notice such a potential increase in bushmeat presence, it could arise speculation that poaching activities become more prevalent due to an increased supply of bushmeat, depending on the current poaching pressure. Given the illegality of hunting activities in the park, this could be a point of careful consideration. The park could consider monitoring the boarders of the park, as they appeared relatively easy to cross.

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GenAI statement

Generative Artificial Intelligence was solely used to help write code for the data analysis in R and to conceptualize ideas. This included interpretations of code and advice on how to translate an idea into code. For example, how to interpret the output of a linear model or how to change a value in a column This was done using ChatGPT version GPT-4 (OpenAI, 2025). All output of the prompts were checked upon using them in the data analysis for accuracy and validity of the proposed method. Although it provided suggestions on elements to consider in writing, no parts of this report were written by GenAI. The prompts can be found in the attachment. However, I must admit that some of the prompts have been lost over time as they could not be found in the prompt history bar.

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Appendix

A. Linear regression plots

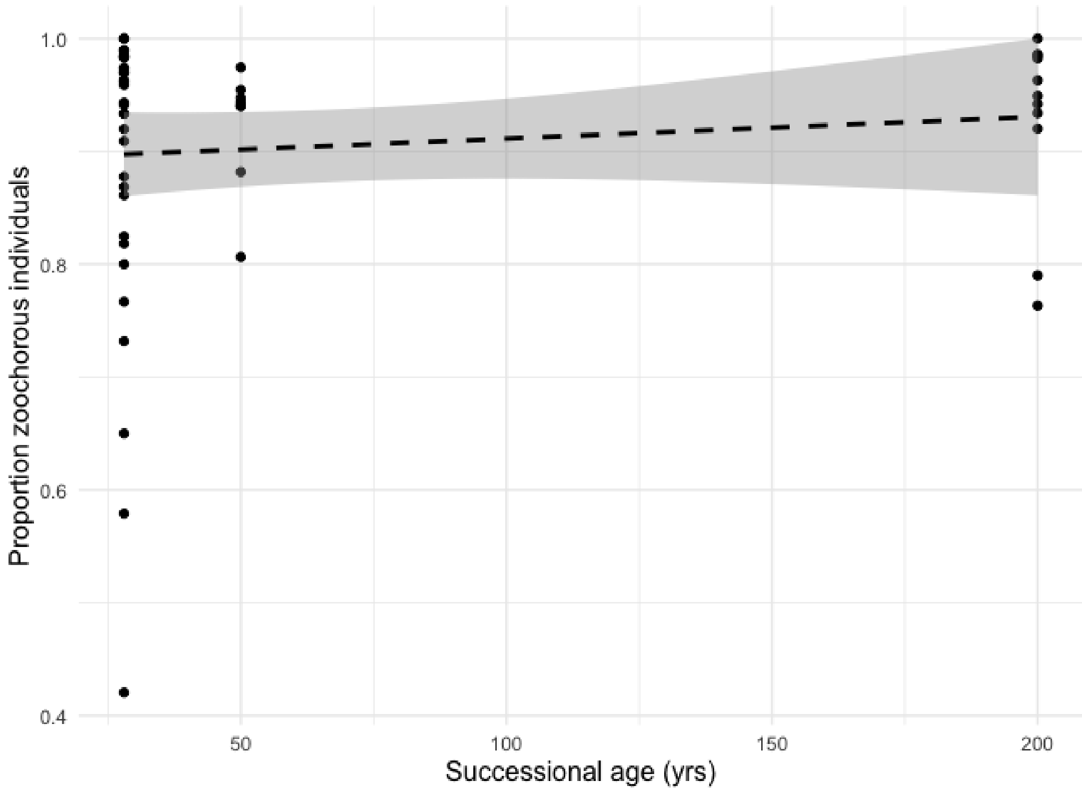

Figure A.1. Linear relationship of woody zoochory proportions among individuals across three successional ages. Dashed regression lines indicate non-significane. Linear models were made to measure the relationships.

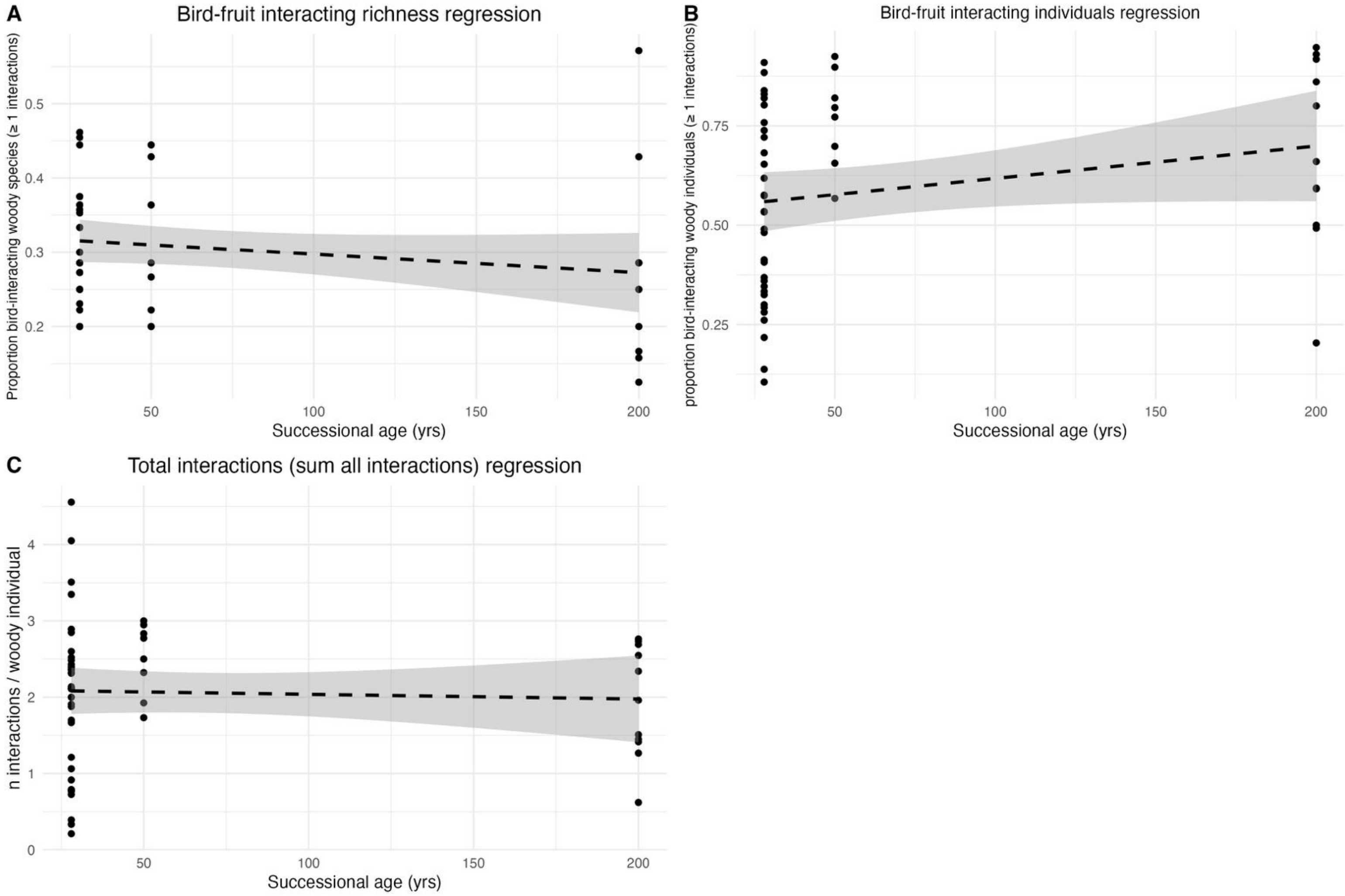

Figure A.2. Linear relationships of bird-interacting woody indices across three successional ages. Dashed regression lines indicate non-significane. Linear models were made to measure the relationships.

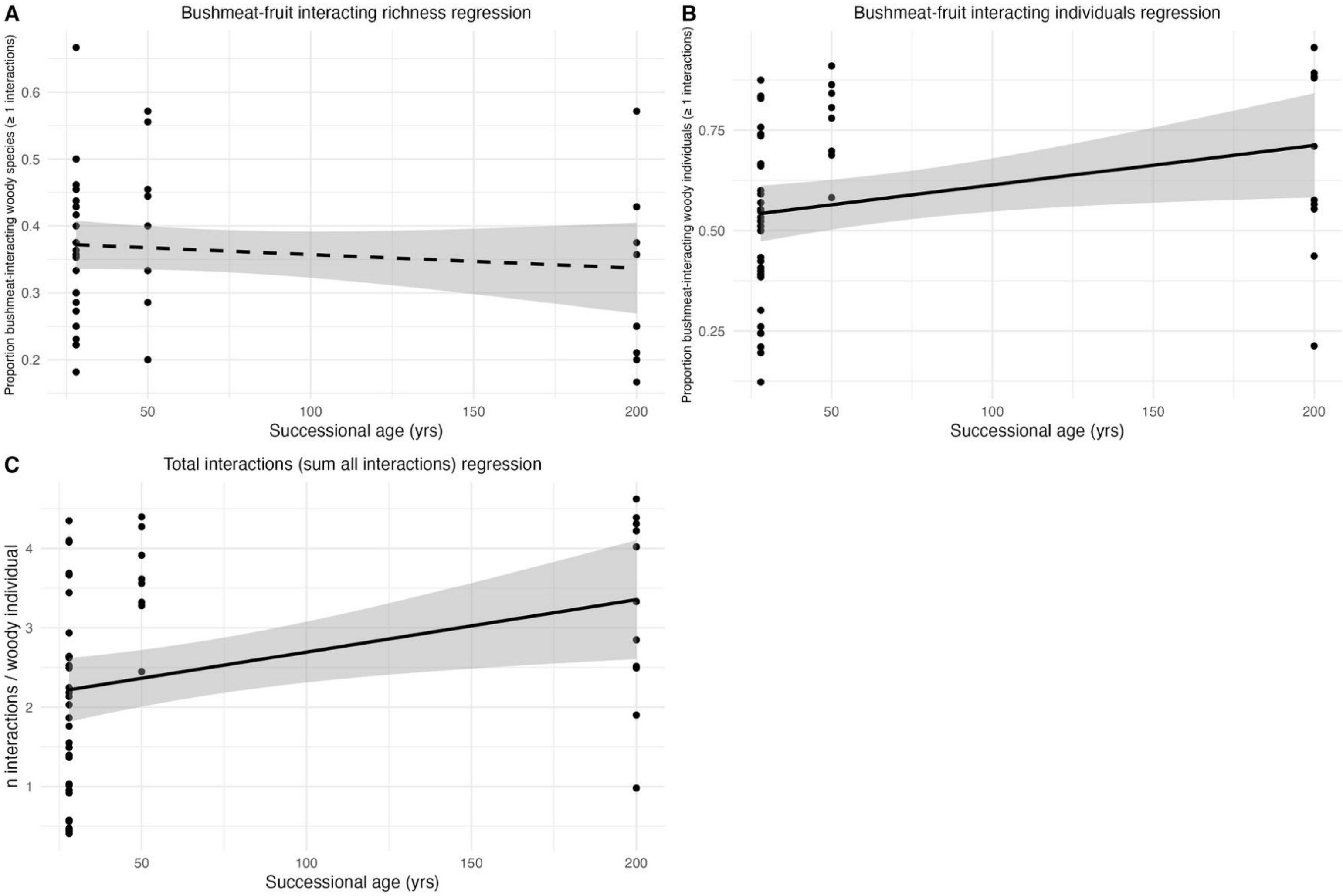

Figure A.3. Linear relationships of bushmeat-interacting woody indices across three successional ages. Solid lines indicate significant linear relationships and dashed regression lines indicate non-significane. Linear models were made to measure the relationships.

B. *Interviews*

Birding

Interviews were conducted with two expert birder tour guides who are familiar with the birds that reside in PNP, to determine which bird species are relevant for birding in the park and which can be used for the data analysis. From the answers of a tour guide that operates for Flora & Fauna Tours (*Flora & Fauna Tours*, n.d.) in Suriname, it became apparent that bird species composition and abundance did not appear to have changed over the last 8-10 years that they have been active in the park. There are also no "special" birds that birders specifically look for in PNP when they visit the park, because such birds do not occur in the area. The bird diversity is relatively low in this area compared to inland areas. Relatively big birds that do occur in PNP and which are frequently spotted include:

Hawks (not specified)
Crested Oropendola (*Psarocolius decumanus*)
Green Oropendola (*Psarocolius viridis*)
Yellow-rumped Cacique (*Cacicus cela*)
Snail Kite (*Rostrhamus sociabilis*)

The tour guide answered that *Euterpe oleracea* palms are important for the birds that occur in PNP. However, they do not notice any relationship between the occurrence of specific bird species and woody species. In elaboration, they remark that the flowering periods of specific plants do appear to attract differing birds. Furthermore, it was mentioned that PNP can be classified as having low vegetation and that in the area of PNP, only 4% of the woody plants produce fruits that attract birds. Further elaboration on the latter point was not attained. Rather than fruit availability, it was noted that PNP does harbour numerous insects that attract birds.

The second interview was conducted with another expert birder tour guide who has been active in PNP since 2008. In the period 2008-2025, he noticed no difference in bird species composition and abundance in the park. The birds that occur in PNP are characteristic of Surinamese coastal swamp birds, although they also occur in different ecosystems in Suriname. Similar to the first interviewee, the independent expert stated that "special" birds are only observed inland, and he accredited that to the higher diversity of woody species, which causes more frequent blossoming and fruits throughout the year and attracts more birds. The frequently spotted birds in PNP include:

Arrowhead Picculet (*Picumnus minutissimus*)
Blood-colored Woodpecker (*Veniliornis sanguineus*)
Crimson-hooded Manakin (*Pipra aureola*)
Spotted Puffbird (*Bucco tamatia*)
Green-throated Mango (*Anthracothorax viridigula*)
Tanagers (not specified)

The interviews showed that specific bird species of particular impact on birding do not occur in PNP despite the park's popularity among birders, and no specific relationships were observed by the expert birder tour guides between woody plant diversity and the occurrence of specific bird species in the park, except for how woody species composition may play a role in bird presence.

Bushmeat

Acquiring interviews with people that may be able to share valuable information regarding bushmeat proved complex. An anonymous source did share that their father used to hunt in PNP, decades ago, and that he mainly hunted for Red-rumped agoutis (*Dasyprocta leporina*). Additionally, it is known in the park that illegal hunting occasionally occurs, as employees hear gun shots emanating from the park every month. Lastly, during data collection in the field, two illegal açai-berry harvesters (from the *Euterpe oleracea* palm) were encountered in separate occasions and were asked whether they were willing to answer a question. They accepted and to the question whether they know about any hunting occurring in the park, they replied in similar fashion by stating "No" and that hunting in the park is now illegal. Based on the possible refrainment of the harvesters to share such sensitive information and the fact that gun shots were heard every month, it was deduced that hunting probably still occurs in the park.

C. *Species composition change across succession*

Below is a table that shows the woody species composition change over the three successional stages expressed in percentages to the total number of individuals per species for every stage. "Eriotheca globosa / Pachira nervosa" could not be specified to the exact species, but they share the same dispersal mechanism. The total number of species that were encountered across the three stages is 103.

Woody species	**young**	**intermediate**	**old_growth**
Euterpe oleracea	40.4%	69.1%	61.9%
Virola surinamensis	9.92%	3.77%	2.39%
Inga ingoides	7.37%	1.62%	0%
Triplaris weigeltiana	6.96%	3.95%	0%
Casearia mariquitensis	4.88%	0.718%	0%
Faramea occidentalis	4.52%	0.359%	0%
Guarea guidonia	3.79%	0%	0%
Cordia tetrandra	2.75%	0.18%	0%
Trichilia pallida	2.28%	0.718%	0%
Spondias mombin	1.92%	1.08%	0%
Eugenia wullschlaegeliana	1.87%	1.8%	0%
Coffea liberica	1.82%	0%	0%
Coccoloba latifolia	1.3%	1.08%	0%
Neea spruceana	1.14%	0%	0%
Erythrina fusca	1.09%	0%	0%
Castilla elastica	0.779%	0%	0%
Protium heptaphyllum	0.779%	1.44%	0%
Ficus maxima	0.727%	0.718%	0%
Cecropia peltata	0.675%	0%	0%
Inga acrocephala	0.519%	0.718%	0%
Margaritaria nobilis	0.415%	0%	0%

Elaeis guineensis	0.363%	0%	0%
Tabebuia fluviatilis	0.363%	3.41%	0%
Didymopanax morototoni	0.312%	0%	0%
Ocotea leptobotra	0.312%	0%	0%
Tapirira guianensis	0.312%	1.26%	0.104%
Pterocarpus officinalis	0.26%	0.359%	1.25%
Genipa americana	0.208%	0%	0%
Naucleopsis glabra	0.208%	0%	0%
Andira inermis	0.156%	0%	0%
Ceiba pentandra	0.156%	0%	0%
Duroia eriopila	0.156%	0.18%	0.312%
Guapira eggersiana	0.156%	0%	0%
Sapium glandulosum	0.156%	0%	0%
Theobroma cacao	0.156%	0%	0%
Carapa guianensis	0.104%	0.539%	2.39%
Crateva tapia	0.104%	0%	0%
Garcinia madruno	0.104%	0%	0%
Nectandra sanguinea	0.104%	0%	0%
Tabernaemontana heterophylla	0.104%	0%	0%
Astrocaryum vulgare	0.052%	0%	0%
Diospyros guianensis	0.052%	3.77%	4.15%
Ficus nymphaeifolia	0.052%	0%	0%
Ficus pertusa	0.052%	0%	0%
Vitex triflora	0.052%	0.18%	0%
Bactris maraja	0%	0.18%	0%
Brosimum guianense	0%	0.18%	0%
Cedrela odorata	0%	0.18%	0%
Copaifera guianensis	0%	0.18%	0%
Couratari multiflora	0%	0.18%	0%
Couroupita guianensis	0%	0.359%	0%
Inga bourgonii	0%	0.539%	0.104%
Machaerium kegelii	0%	0.18%	0%
Myrcia amazonica	0%	0.18%	0%
Pachira aquatica	0%	0.18%	0%
Tabernaemontana siphilitica	0%	0.539%	0%
Terminalia amazonia	0%	0.18%	0%
Alchorneopsis floribunda	0%	0%	0.104%
Astrocaryum paramaca	0%	0%	0.104%
Caraipa densifolia	0%	0%	0.312%
Caryocar microcarpum	0%	0%	0.208%
Cassipourea guianensis	0%	0%	0.415%
Catostemma fragrans	0%	0%	0.104%
Copaifera guyanensis	0%	0%	0.312%
Couma guianensis	0%	0%	0.831%
Cybianthus surinamensis	0%	0%	0.519%
Cynometra marginata	0%	0%	0.727%

Drypetes variabilis	0%	0%	0.104%
Elvasia elvasioides	0%	0%	0.312%
Eriotheca globosa / Pachira nervosa	0%	0%	0.208%
Eschweilera subglandulosa	0%	0%	0.208%
Goupia glabra	0%	0%	0.104%
Gustavia augusta	0%	0%	0.208%
Hirtella racemosa	0%	0%	0.415%
Hymenopus divaricatus	0%	0%	0.104%
Hymenopus macrophyllus	0%	0%	1.35%
Ilex guianensis	0%	0%	0.312%
Ilex martiniana	0%	0%	0.104%
Inga edulis	0%	0%	0.104%
Iryanthera hostmannii	0%	0%	0.727%
Lecythis corrugata	0%	0%	1.35%
Licania heteromorpha	0%	0%	1.25%
Macrolobium acaciifolium	0%	0%	0.208%
Macrolobium angustifolium	0%	0%	0.312%
Macrosamanea discolor	0%	0%	0.623%
Malouetia tamaquarina	0%	0%	0.208%
Manilkara huberi	0%	0%	0.104%
Mauritia flexuosa	0%	0%	1.45%
Mora excelsa	0%	0%	0.831%
Mouriri grandiflora	0%	0%	0.208%
Mouriri nigra	0%	0%	0.104%
Myrcia neomontana	0%	0%	3.74%
Parahancornia fasciculata	0%	0%	0.104%
Parinari campestris	0%	0%	1.35%
Posoqueria latifolia	0%	0%	0.208%
Protium tenuifolium	0%	0%	0.104%
Simarouba amara	0%	0%	0.104%
Symphonia globulifera	0%	0%	3.95%
Tabebuia insignis	0%	0%	1.56%
Terminalia dichotoma	0%	0%	0.415%
Trichilia micrantha	0%	0%	0.104%
Unonopsis guatterioides	0%	0%	0.623%
Zygia latifolia	0%	0%	0.623%

D. List of bushmeat species

The most commonly hunted and traded bushmeat species in Suriname (Andel et al., 2003) and their recorded presence in PNP, based on camera trapping data (Ramcharan, 2017) and anecdotal records from people who work in PNP.

Original name in list (2003)	Scientific name (2025)	Common name	Data presence PNP
Ara ararauna	Ara ararauna	blue and yellow macaw	TRUE
Ara chlorptera	Ara chloropterus	red and green macaw	TRUE
Ara macao	Ara macao	scarlet macaw	TRUE
Cairina moschata	Cairina moschata	muscovy duck	FALSE
Crax alector	Crax alector	black curassow	FALSE
Penelope marail	Penelope marail	marail guan	TRUE
Psophira crepitans	Psophia crepitans	grey winged trumpeter	TRUE
Ramphastos spp.	Ramphastos tucanus	White-throated Toucan	TRUE
Ramphastos spp.	Ramphastos vitellinus	Channel-billed Toucan	TRUE
Ramphastos spp.	Ramphastos toco	Toco Toucan	TRUE
Tinamus major	Tinamus major	greater tinamou	FALSE
agouti paca	Cuniculus paca	paca	TRUE
Ateles paniscus	Ateles paniscus	black spider monkey	TRUE
Alouatta seniculus	Alouatta seniculus	red howler monkey	TRUE
Cebus apella	Sapajus apella	tufted capuchin	TRUE
Cebus olivaceus	Cebus olivaceus	weeper capuchin	FALSE
Dasyprocta spp.	Dasyprocta leporina	red-rumped agouti	TRUE
Dasypus kappleri	Dasypus kappleri	greater long-nosed armadillo	FALSE
Dasypus novemcinctus	Dasypus novemcinctus	9-banded armadillo	TRUE
Hydrochoerus hydrochaeris	Hydrochoerus hydrochaeris	capybara	TRUE
Mazama spp.	Mazama americana	red brocket deer	TRUE
Mazama spp.	Mazama gouazoubira	gray brocket deer	TRUE
Myoprocta exilis	Myoprocta acouchy	acouchi	FALSE
Tapirus terrestris	Tapirus terrestris	lowland tapir	TRUE
Tayassu pecari	Tayassu pecari	white-lipped peccary	TRUE
Tayassu tajacu	Pecari tajacu	collared peccary	TRUE
Saimiri sciureus	Saimiri sciureus	squirrel monkey	TRUE
Caiman crocodilus	Caiman crocodilus	spectacled caiman	FALSE
Iguana iguana	Iguana iguana	common iguana	TRUE
Geochelone carbonaria	Chelonoidis carbonarius	red-footed tortoise	FALSE
Geochelone denticulata	Chelonoidis denticulata	yellow-footed tortoise	TRUE

E. List of bird species

List of bird species that have been recorded (seen, heard, caught) in PNP as of 2025. The table is derived from the website surinamebirds.nl and was assimilated by Jan Hein Ribot (*Plantage Peperpot (Hotspot)*, n.d.).

scientific_name	common_name
Tinamus major	Great Tinamou
Crypturellus cinereus	Cinereous Tinamou
Crypturellus soui	Little Tinamou
Crypturellus variegatus	Variegated Tinamou
Dendrocygna autumnalis	Black-bellied Whistling-Duck
Cairina moschata	Muscovy Duck
Ortalis motmot	Variable Chachalaca
Phalacrocorax brasilianus	Neotropic Cormorant
Anhinga anhinga	Anhinga
Tigrisoma lineatum	Rufescent Tiger-Heron
Agamia agami	Agami Heron
Cochlearius cochlearius	Boat-billed Heron
Ixobrychus exilis	Least Bittern
Ixobrychus involucris	Stripe-backed Bittern
Nycticorax nycticorax	Black-crowned Night-Heron
Butorides striata	Striated Heron
Bubulcus ibis	Cattle Egret
Ardea cocoi	Cocoi Heron
Ardea alba	Great Egret
Pilherodius pileatus	Capped Heron
Egretta tricolor	Tricolored Heron
Egretta thula	Snowy Egret
Egretta caerulea	Little Blue Heron
Eudocimus ruber	Scarlet Ibis
Mesembrinibis cayennensis	Green Ibis
Mycteria americana	Wood Stork
Cathartes aura	Turkey Vulture
Cathartes burrovianus	Lesser Yellow-headed Vulture
Cathartes melambrotus	Greater Yellow-headed Vulture
Coragyps atratus	Black Vulture
Sarcoramphus papa	King Vulture
Pandion haliaetus	Osprey
Elanus leucurus	White-tailed Kite
Chondrohierax uncinatus	Hook-billed Kite
Leptodon cayanensis	Gray-headed Kite
Morphnus guianensis	Crested Eagle
Spizaetus tyrannus	Black Hawk-Eagle
Spizaetus melanoleucus	Black-and-white Hawk-Eagle
Spizaetus ornatus	Ornate Hawk-Eagle
Busarellus nigricollis	Black-collared Hawk
Rostrhamus sociabilis	Snail Kite
Helicolestes hamatus	Slender-billed Kite
Ictinia plumbea	Plumbeous Kite
Circus buffoni	Long-winged Harrier
Geranospiza caerulescens	Crane Hawk
Buteogallus aequinoctialis	Rufous Crab-Hawk
Buteogallus meridionalis	Savanna Hawk
Buteogallus urubitinga	Great Black-Hawk
Rupornis magnirostris	Roadside Hawk
Pseudastur albicollis	White Hawk
Buteo nitidus	Gray-lined Hawk
Buteo brachyurus	Short-tailed Hawk
Herpetotheres cachinnans	Laughing Falcon
Micrastur semitorquatus	Collared Forest-Falcon
Daptrius ater	Black Caracara
Milvago chimachima	Yellow-headed Caracara
Falco rufigularis	Bat Falcon
Falco deiroleucus	Orange-breasted Falcon
Falco femoralis	Aplomado Falcon
Falco peregrinus	Peregrine Falcon
Aramus guarauna	Limpkin
Aramides cajaneus	Gray-necked Wood-Rail
Anurolimnas viridis	Russet-crowned Crake
Laterallus melanophaius	Rufous-sided Crake
Laterallus exilis	Gray-breasted Crake
Mustelirallus albicollis	Ash-throated Crake
Mustelirallus erythrops	Paint-billed Crake
Porphyrio martinicus	Purple Gallinule
Porphyrio flavirostris	Azure Gallinule

Heliornis fulica	Sungrebe	Coccyzus melacoryphus	Dark-billed Cuckoo
Eurypyga helias	Sunbittern	Coccyzus americanus	Yellow-billed Cuckoo
Pluvialis dominica	American Golden-Plover	Crotophaga major	Greater Ani
Vanellus chilensis	Southern Lapwing	Crotophaga ani	Smooth-billed Ani
Charadrius semipalmatus	Semipalmated Plover	Tapera naevia	Striped Cuckoo
Gallinago paraguaiae	South American Snipe	Tyto alba	Barn Owl
Bartramia longicauda	Upland Sandpiper	Megascops choliba	Tropical Screech-Owl
Actitis macularius	Spotted Sandpiper	Pulsatrix perspicillata	Spectacled Owl
Tringa flavipes	Lesser Yellowlegs	Asio clamator	Striped Owl
Tringa solitaria	Solitary Sandpiper	Nyctibius grandis	Great Potoo
Calidris pusilla	Semipalmated Sandpiper	Nyctibius griseus	Common Potoo
Calidris melanotos	Pectoral Sandpiper	Nyctidromus albicollis	Common Pauraque
Calidris subruficollis	Buff-breasted Sandpiper	Chaetura spinicaudus	Band-rumped Swift
Jacana jacana	Wattled Jacana	Chaetura brachyura	Short-tailed Swift
Leucophaeus atricilla	Laughing Gull	Panyptila cayennensis	Fork-tailed Palm-Swift
Sternula superciliaris	Yellow-billed Tern	Phaethornis squalidus	Lesser Swallow-tailed Swift
Phaetusa simplex	Large-billed Tern	Florisuga mellivora	White-necked Jacobin
Patagioenas cayennensis	Pale-vented Pigeon	Phaethornis ruber	Rufous-breasted Hermit
Patagioenas plumbea	Plumbeous Pigeon	Phaethornis longuemareus	Pale-tailed Barbthroat
Patagioenas subvinacea	Ruddy Pigeon	Phaethornis longuemareus	Little Hermit
Leptotila verreauxi	White-tipped Dove	Phaethornis subochraceus	Reddish Hermit
Leptotila rufaxilla	Gray-fronted Dove	Phaethornis bourcieri	Straight-billed Hermit
Columbina passerina	Common Ground-Dove	Phaethornis superciliosus	Long-tailed Hermit
Columbina minuta	Plain-breasted Ground-Dove	Polytmus theresiae	Green-tailed Goldenthroat
Columbina talpacoti	Ruddy Ground-Dove	Chrysolampis mosquitus	Ruby-topaz Hummingbird
Forpus coelestis	Lilac-tailed Parrotlet	Anthracothorax viridigula	Green-throated Mango
Pyrrhura aurantiocephala	Golden-winged Parakeet	Anthracothorax nigricollis	Black-throated Mango
Pionus fuscus	Dusky Parrot	Lophornis ornata	Tufted Coquette
Pionus menstruus	Blue-headed Parrot	Heliomaster longirostris	Long-billed Starthroat
Amazona farinosa	Mealy Parrot	Chlorostilbon mellisugus	Blue-tailed Emerald
Amazona amazonica	Orange-winged Parrot	Chlorestes notata	Blue-chinned Sapphire
Forpus passerinus	Green-rumped Parrotlet	Campylopterus largipennis	Gray-breasted Sabrewing
Pionites melanocephalus	Black-headed Parrot	Thalurania furcata	Fork-tailed Woodnymph
Deroptyus accipitrinus	Red-fan Parrot	Amazilia leucogaster	Plain-bellied Emerald
Eupsittula pertinax	Brown-throated Parakeet	Amazilia fimbriata	Glittering-throated Emerald
Orthopsittaca manilata	Red-bellied Macaw	Hylocharis sapphirina	Rufous-throated Sapphire
Ara ararauna	Blue-and-yellow Macaw	Chlorestes cyanocephala	White-chinned Sapphire
Ara severus	Chestnut-fronted Macaw	Trogon viridis	Green-backed Trogon
Aratinga leucophthalma	White-eyed Parakeet	Trogon rufus	Guianan Trogon
Coccycua minuta	Little Cuckoo	Megaceryle torquata	Ringed Kingfisher
Piaya cayana	Squirrel Cuckoo		
Coccyzus melanogaster	Black-bellied Cuckoo		

Chloroceryle amazona	Amazon Kingfisher
Chloroceryle americana	Green Kingfisher
Chloroceryle inda	Green-and-rufous Kingfisher
Chloroceryle aenea	American Pygmy Kingfisher
Galbula galbula	Green-tailed Jacamar
Notharchus tectus	Pied Puffbird
Bucco tamatia	Spotted Puffbird
Chelidoptera tenebrosa	Swallow-winged Puffbird
Capito niger	Black-spotted Barbet
Ramphastos tucanus	White-throated Toucan
Ramphastos vitellinus	Channel-billed Toucan
Pteroglossus viridis	Green Aracari
Pteroglossus aracari	Black-necked Aracari
Picumnus exilis	Golden-spangled Piculet
Picumnus rufiventris	Arrowhead Piculet
Melanerpes rubricapillus	Red-crowned Woodpecker
Colaptes atricollis	Golden-collared Woodpecker
Dryobates sanguineus	Blood-colored Woodpecker
Colaptes punctigula	Spot-breasted Woodpecker
Celeus elegans	Chestnut Woodpecker
Celeus flavus	Cream-colored Woodpecker
Celeus torquatus	Ringed Woodpecker
Dryocopus lineatus	Lineated Woodpecker
Campylorhamphus trochilirostris	Red-necked Woodpecker
Campephilus melanoleucos	Crimson-crested Woodpecker
Dendrocincla longicauda	Long-tailed Woodcreeper
Dendrocincla fuliginosa	Plain-brown Woodcreeper
Dendrocincla merula	Cinnamon-throated Woodcreeper
Dendrocolaptes platyrostris	Black-banded Woodcreeper
Xiphorhynchus obsoletus	Striped Woodcreeper
Xiphorhynchus guttatus	Buff-throated Woodcreeper
Dendroplex picus	Straight-billed Woodcreeper
Xenops minutus	Plain Xenops
Synallaxis albigularis	Yellow-chinned Spinetail
Synallaxis albescens	Plain-crowned Spinetail
Synallaxis rutilans	Pale-breasted Spinetail
Thamnophilus nigrocinereus	Black-throated Antshrike
Taraba major	Great Antshrike
Sakesphorus canadensis	Black-crested Antshrike
Thamnophilus doliatus	Barred Antshrike
Thamnophilus punctatus	Northern Slaty-Antshrike
Thamnophilus amazonicus	Amazonian Antshrike
Thamnophilus nigrocinereus	Cinereous Antshrike
Myrmotherula surinamensis	Guianan Streaked-Antwren
Myrmotherula axillaris	White-flanked Antwren
Cercomacroides nigrescens	Blackish Antbird
Myrmoborus leucophrys	White-browed Antbird
Hypocnemoides melanopogon	Black-chinned Antbird
Sclateria naevia	Silvered Antbird
Percnostola rufifrons	Black-headed Antbird
Poliocrania exsul	Spot-winged Antbird
Formicarius analis	Black-throated Antbird
Grallaria ruficapilla	Rufous-capped Antthrush
Capsiempis flaveola	Yellow-crowned Tyrannulet
Myiopagis gaimardii	Forest Elaenia
Myiopagis flavivertex	Yellow-crowned Elaenia
Elaenia flavogaster	Yellow-bellied Elaenia
Phaeomyias murina	White-lored Tyrannulet
Camptostoma obsoletum	Southern Beardless-Tyrannulet
Pogonotriccus eximius	Mouse-colored Tyrannulet
Tyrannulus elatus	Guianan Tyrannulet
Mionectes oleagineus	Ochre-bellied Flycatcher
Phylloscartes flavovirens	Pale-tipped Tyrannulet
Myiornis ecaudatus	Short-tailed Pygmy-Tyrant
Lophotriccus galeatus	Helmeted Pygmy-Tyrant
Todirostrum maculatum	Spotted Tody-Flycatcher
Todirostrum cinereum	Common Tody-Flycatcher
Todirostrum pictum	Painted Tody-Flycatcher
Tolmomyias sulphurescens	Yellow-olive Flycatcher
Pogonotriccus leucopygius	Gray-crowned Flycatcher
Tolmomyias assimilis	Yellow-breasted Flycatcher
Onychorhynchus coronatus	Royal Flycatcher
Myiobius barbatus	Sulphur-rumped Flycatcher
Cnemotriccus fuscatus	Fuscous Flycatcher
Fluvicola pica	Pied Water-Tyrant
Arundinicola leucocephala	White-headed Marsh-Tyrant
Legatus leucophaius	Piratic Flycatcher
Myiozetetes cayanensis	Rusty-margined Flycatcher
Pitangus sulphuratus	Great Kiskadee

Philohydor lictor	Lesser Kiskadee	Tachyphonus rufus	Black-faced Tanager
Myiozetetes granadensis	Yellow-throated Flycatcher	Nemosia pileata	Hooded Tanager
Myiodynastes maculatus	Streaked Flycatcher	Tangara cayana	Gray-headed Tanager
Megarynchus pitangua	Boat-billed Flycatcher	Tachyphonus rufus	White-lined Tanager
Tyrannus melancholicus	Tropical Kingbird	Ramphocelus carbo	Silver-beaked Tanager
Tyrannus savana	Fork-tailed Flycatcher	Thraupis episcopus	Blue-gray Tanager
Tyrannus dominicensis	Gray Kingbird	Thraupis palmarum	Palm Tanager
Rhytipterna simplex	Grayish Mourner	Tangara mexicana	Turquoise Tanager
Myiarchus tuberculifer	Dusky-capped Flycatcher	Cyanerpes cyaneus	Red-legged Honeycreeper
Myiarchus ferox	Short-crested Flycatcher	Conirostrum speciosum	Chestnut-vented Conebill
Attila cinnamomeus	Cinnamon Attila	Volatinia jacarina	Blue-black Grassquit
Attila spadiceus	Bright-rumped Attila	Sporophila americana	Wing-barred Seedeater
Gymnoderus foetidus	Bare-necked Fruitcrow	Sporophila intermedia	Lesson's Seedeater
Chiroxiphia pareola	Blue-backed Manakin	Sporophila minuta	Ruddy-breasted Seedeater
Chiroxiphia coronata	Crimson-hooded Manakin	Oryzoborus angolensis	Chestnut-bellied Seed-Finch
Tityra cayana	Black-crowned Tityra	Coereba flaveola	Bananaquit
Tityra inquisitor	Black-tailed Tityra	Saltator maximus	Buff-throated Saltator
Iodopleura fusca	Dusky Purpletuft	Saltator coerulescens	Olive gray Saltator
Pachyramphus rufus	Cinereous Becard	Piranga rubra	Summer Tanager
Pachyramphus minor	White-winged Becard	Cyanocompsa cyanoides	Blue-black Grosbeak
Vireo olivaceus	Red-eyed Vireo	Parkesia noveboracensis	Northern Waterthrush
Hylophilus decurtatus	Ashy-headed Greenlet	Geothlypis aequinoctialis	Masked Yellowthroat
Stelgidopteryx ruficollis	Southern Rough-winged Swallow	Setophaga fusca	Hyp.: Blackburnian Warbler
Progne tapera	Brown-chested Martin	Setophaga petechia	Yellow Warbler
Progne chalybea	Gray-breasted Martin	Psarocolius decumanus	Crested Oropendola
Progne subis	Southern Martin	Cacicus cela	Yellow-rumped Cacique
Tachycineta albiventer	White-winged Swallow	Cacicus haemorrhous	Red-rumped Cacique
Riparia riparia	Bank Swallow	Icterus cayanensis	Epaulet Oriole
Hirundo rustica	Barn Swallow	Icterus nigrogularis	Yellow Oriole
Troglodytes aedon	House Wren	Chrysomus icterocephalus	Yellow-hooded Blackbird
Thryothorus coraya	Coraya Wren	Psarocolius guira	Giant Cowbird
Cyphorhinus arada	Buff-breasted Wren	Molothrus bonariensis	Shiny Cowbird
Polioptila plumbea	Tropical Gnatcatcher	Quiscalus lugubris	Carib Grackle
Donacobius atricapilla	Black-capped Donacobius	Sturnella militaris	Red-breasted Blackbird
Turdus leucomelas	Pale-breasted Thrush	Euphonia finschi	Finsch's Euphonia
Turdus fumigatus	Cocoa Thrush	Euphonia violacea	Violaceous Euphonia
Turdus nudigenis	Spectacled Thrush	Euphonia minuta	White-vented Euphonia
Mimus gilvus	Tropical Mockingbird		