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RESEARCH ARTICLE

Confronting forest-dweller local ecological knowledge and environmental DNA measurements of biodiversity

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Abstract

1. In the face of global changes and the biodiversity crisis, Local Ecological Knowledge of Indigenous communities is increasingly valued for aligning conservation policies with the needs of local communities and enriching conservation strategies through the synergy of diverse knowledge systems.
2. To assess whether conservation policies relying on biodiversity metrics integrate the interconnectedness between nature and Indigenous communities, we evaluated the congruence between standardised biodiversity measurements obtained through environmental DNA (eDNA) and Indigenous Local Ecological Knowledge (LEK).
3. We selected 19 sampling sites along the upper Oyapock River in French Guiana. We collected eDNA from the water to inventory fish and game species, and we conducted biodiversity perception surveys with anglers and hunters from the Wayãpi Indigenous group to collect LEK associated with each site.
4. Across the studied area, Wayãpi LEK presented different pictures of biodiversity compared to standardised biodiversity assessments. This comparative analysis demonstrates that Wayãpi LEK not only reflects species distribution but also encompasses diverse place-based obligations and relationships.
5. This underscores the need to integrate LEK into conservation policies to promote equitable and sustainable environmental decision-making. This can be achieved by encouraging participatory processes that incorporate diverse knowledge systems, enabling the identification of local conservation challenges and the determination of the most suitable compromises.

KEYWORDS
comparative analysis, eDNA metabarcoding, fish, freelist surveys, game species, indigenous communities, indigenous LEK

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1 | INTRODUCTION

There is an overwhelming consensus that global biodiversity loss is and will decrease ecosystem functioning and nature's contributions to people (West et al., 2020). Since the 1980s, this global crisis has sparked an interest in the knowledge, values and practices of people living in close contact with nature, as a means to better understand and address regional and global issues (Ainsworth et al., 2020; Brondízio et al., 2021).

Local Ecological Knowledge (LEK)—the cumulative body of knowledge, practice and belief, evolving by adaptive processes and passed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment—is being increasingly valued (Brondízio et al., 2021; Díaz et al., 2015). For example, Indigenous LEK has been used as a reliable method to collect information on species distribution (Braga-Pereira et al., 2022, 2024; Camino et al., 2020; Madsen et al., 2020). In these studies, the recognition of Indigenous LEK as a support to biodiversity assessment not only enhances biodiversity monitoring but holds significant potential to empower local stakeholders to manage their own environments (Bennett et al., 2017; Braga-Pereira et al., 2022). Furthermore, LEK is also shaped by feeding practices, habits, and beliefs (Chaves et al., 2020; Martin et al., 2013; Toledo, 2013) and this knowledge may vary in time, space, and with social and economic contexts (Ali et al., 2022; Brondízio et al., 2021). Hence, Indigenous LEK also plays a significant role in advancing sustainability goals through practices in territorial management, nature conservation, and restoration efforts (Ainsworth et al., 2020; Brondízio et al., 2021; McElwee et al., 2020). However, to better capture the complexity of the human-nature connection, there has been a paradigm shift in the way nature's value is conceptualised (Chan et al., 2016, 2018; Himes et al., 2024; West et al., 2020). Scientists are increasingly engaging with research associated with relational values, which include preferences, principles, and virtues about human-nature relationships (Chan et al., 2018). In this context, LEK offers alternative perspectives on nature-human relationships, emphasising values such as reciprocity, care, learning, and adaptiveness, expanding the concept of sustainability beyond social, economic, and environmental boundaries (Brondízio et al., 2021; Díaz et al., 2015; Lam et al., 2020; West et al., 2018).

Integrating interdisciplinary knowledge in conservation policies is challenging because Indigenous knowledge faces loss of authenticity when confronted with scientific knowledge, which tends to remove essential local characteristics in the process of generalising (Ainsworth et al., 2020). This can result in conservation conflicts, where two or more parties with strongly held opinions clash over conservation objectives and when one party is perceived to assert its interests at the expense of another (Ainsworth et al., 2020; Brondízio et al., 2021; Redpath et al., 2013). This is a challenge encountered in French Guiana, which presents poorly fragmented and preserved rainforests and freshwaters, but faces increasing threats due to gold exploitation and rapid population growth (Cantera, Coutant, et al., 2022). French Guiana is home to various ethnic groups that differ drastically in their use of natural resources, but also in their relationship with nature (Tritsch, 2013; Tritsch et al., 2011, 2015). The inland areas are inhabited by the Teko, the Wayana, and the Wayãpi as well as by the afro-descendant Maroons (Bushinengués). Inland Indigenous communities, who do not practice animal farming, depend on fishing and hunting for protein, with rivers and forests serving as their pantry. However, gold mining, particularly its impact on water quality and biodiversity, severely threatens their livelihoods (Ouhoud-Renoux, 1998; Tritsch, 2013). In this context, their worldviews embedded in relational values with nature, knowledge of the natural world and sustainable practices of resource management would play a key role in local environmental governance, which is currently based mostly on objectives related to scientific ecological knowledge of species and ecosystems.

In this study, we compared LEK and standardised eDNA biodiversity measurements along the upper Oyapock River in French Guiana, under varying levels of anthropogenic pressure. We assessed fish and mammal biodiversity at 19 locations using eDNA and conducted freelist surveys with Wayãpi participants at the same locations to gather LEK. The goal was to evaluate the congruence between species distributions from eDNA and Wayãpi LEK. A strong congruence suggests that current conservation policies integrate the Wayãpi's interconnectedness with nature, while a mismatch suggests that data-driven approaches aimed at safeguarding nature's intrinsic values overlook the realities of the Wayãpi.

2 | MATERIALS AND METHODS

2.1 | Study area

The Oyapock River, 404 km long, forms the border between Brazil and French Guiana. Our study focused on the upper 160 km of the river (Figure 1), where 19 evenly spaced sites were selected between the Wayãpi villages of Camopi (*kampi* in Wayãpi) and Trois-Sauts (*itu wasu* in Wayãpi) to include variations in anthropogenic pressure and environmental conditions while avoiding spatial autocorrelation. This section, protected by the Tumucumaque National Park (Brazil) and the Guianese Amazonian Park (France), allows only subsistence fishing and hunting but is affected by illegal gold mining near Camopi along the downstream section of the Camopi River (Figure 1). Around 2000 Indigenous people, mainly Wayãpi and Teko, inhabit the area, practicing slash-and-burn agriculture, hunting, and fishing for subsistence. These Tupi-Guaraní groups share extensive knowledge even though each has its own specificities (Davy et al., 2012; Grenand et al., 2017). Their knowledge of the fauna and flora has been documented in numerous studies in anthropology, ethnobotany, and ethnozoology, reporting fish and tree vernacular names and territorial management (Grenand, 1980; Grenand et al., 2015, 2017; Molino et al., 2022; Tritsch et al., 2011, 2015).

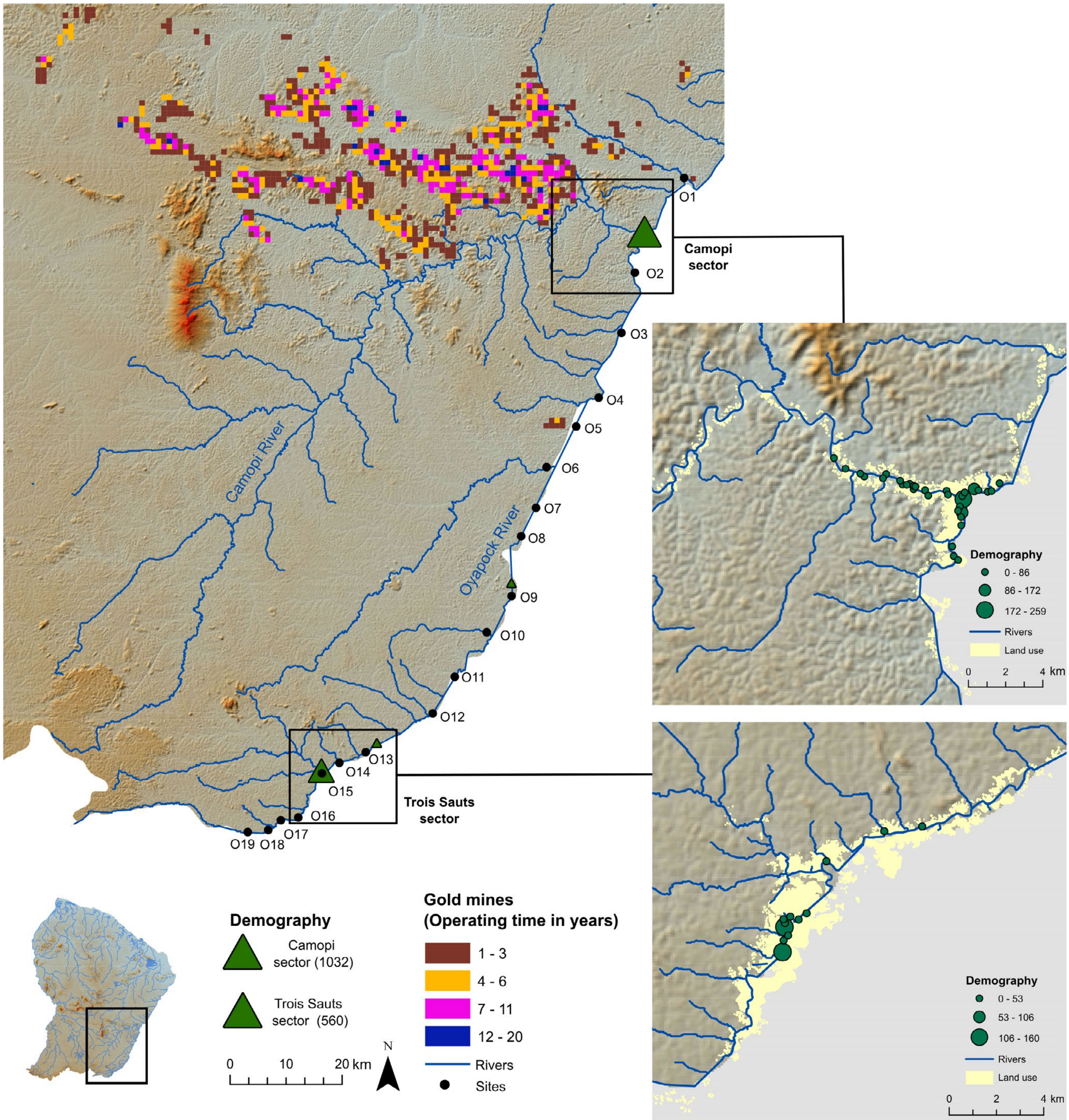

FIGURE 1 Study area and sampling sites. Each 1 km pixel contains a gold mine abandoned or still operating. Gold mine operating time (years) was shared by the Guinanese Amazonian Park (PAG) and the Mining Activity Observatory. The number of inhabitants was shared by the PAG. Right panels are highlights of Camopi and Trois-Sauts areas that are constituted of different villages. In these villages, the land use represented in yellow shows the agricultural areas (slash-and-burn agriculture). The territory located outside the two sectors (delimited by the black frames) is not exploited for agriculture.

2.2 | Environmental DNA

We collected eDNA from 19 sites during the wet season (April 2022), following the protocol of Cantera et al. (2019) and Cilleros et al. (2019). Two field replicates per site were collected by filtering water for 30 min with a peristaltic pump. Filtration capsules were filled with 80 mL of CL1 conservation buffer and stored in the dark before DNA extraction. For fish, we used the 'teleo' primer, and for other vertebrates, we used the 12S-V5 marker, both proven to effectively distinguish local species (Cantera et al., 2019; Cilleros et al., 2019; Kocher et al., 2017). Twelve PCR replicates per sample were performed (19 sites × 2 field replicates × 12 PCR replicates,

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456 in total). Before sequencing, purified PCR products were quantified via capillary electrophoresis and pooled in equal volumes to target a sequencing depth of 500,000 reads per sample for DNA library preparation. Five libraries for fish and two for vertebrates were prepared using the TruSeq nano-PCR Free Illumina protocol and sequenced with a MiSeq (2×125 bp) Flow Cell Kit Version 3. Sequences were analysed with OBITools (Boyer et al., 2016). Fish analysis was based on an updated reference database from Cilleros et al. (2019) with 368 species, while the game species database included 164 mammal species from Kocher et al. (2017) and GenBank. Full details on the eDNA protocol are provided in Method S1.

2.3 | Local ecological knowledge

We conducted the surveys directly at the sites to collect Wayãpi LEK that is the most representative of the community feeding practices, techniques, habits and beliefs, and more generally interrelationships with nature. Although the Wayãpi territory benefits from a detailed cartography and toponymy that could have been useful for remote surveys (Grenand et al., 2017), being on the sites ensures the spatial congruence of biodiversity measurements and LEK. Moreover, Wayãpi people interact within their territory on a local scale, with specific knowledge, experiences, beliefs, and resource acquisition associated with each site (Grenand et al., 2017; Tritsch et al., 2015). Therefore, conducting surveys at sites also allows the collection of LEK that is influenced by the specific relationships with each site. This choice prioritises the quality of the surveys over the quantity of people involved, as bringing participants to sites presents many challenges associated with cost and availability.

Seven Wayãpi participants answered the surveys in total. All participants were voluntary and aware of the interest of the study (see Section 2.5). Participants were anglers and hunters from Camopi and Trois-Sauts villages and possessed in-depth and localised knowledge of the upper Oyapock biodiversity. Two participants were also local agents of the Guianese Amazonian Park. Participants are recognised by their community for their traditional ecological/environmental knowledge, their hunting/fishing skills, and their knowledge of their ethnic group's customs and traditions. All participants were males, as fishing, hunting, and territory exploration activities are predominantly undertaken by men among Wayãpi people (Grenand, 1980). The participants were 40–60 years old, ensuring a comprehensive knowledge of the historical context and the environmental changes that have occurred in the region. Given the challenge of bringing more participants to the sites, we consider the LEK shared by the participants to be representative of the Wayãpi community.

At each site, one or two participants familiar with the area were interviewed by D.D. or O.C. Freelists were used because they reflect participants' familiarity with and the prominence of items within their local context (Quinlan, 2005). Hence, the responses and their sequence reflect the relationships between individuals and each item and are, therefore, not decontextualised. The freelist surveys were conducted during casual discussions allowing participants, especially in pairs, to interact while answering. Conversations about species and places were held using Wayãpi vernacular names and toponymy. During the conversations, we asked open-ended questions on different themes that allowed respondents to answer based on their complete knowledge, feelings, and understanding. There were therefore no expectations regarding the responses and respondents were not limited to a set of options. Themes included fish and game species diversity, gold mining threats, and slash-and-burn agriculture. For fish and game species themes, participants were asked several questions about the general quality of the sites for fishing, and hunting, and then asked which species can be encountered at the sites. The survey frame is provided in Figure S1.

2.4 | Data analyses

Species by site matrices were built from both eDNA and survey approaches (Tables S2A,B and S3A,B). Comparative analyses were conducted only based on the species mentioned in the surveys. We categorised sites based on the categorisation determined by the participants for fish and for games species diversity. Sites were referred to as 'good' or 'medium' for fish, and as 'good' or 'poor' for game species (Table S4). These categories were not based on explicit criteria, and the sites may be categorised for various reasons that are subject to change depending on the area. These are intended solely to reflect how the different sites are valued by the Wayãpi.

We conducted a comparative analysis between eDNA and surveys, but also between the site categories determined by the participants, for each approach. We compared the (i) site species richness, (ii) species detection/mention frequencies, and (iii) site species composition. For site species richness and species detection/mention frequencies, pairwise comparisons were realised with Kruskal–Wallis ('good' vs. 'medium'/'poor' sites) and Mann–Whitney *U*-tests (eDNA vs. surveys) for nonparametric and unpaired samples. For comparisons of site species composition, we built distance matrices using the Raup-crick metric (β_{rc}) to determine whether pairs of sites were more or less similar than expected under stochastic effects (Chase et al., 2011). We then used permutational analysis of variance (PERMANOVA) to test for differences in species composition between eDNA and surveys, ensuring homogeneous dispersion between compared groups with a permutation dispersion test (PERMDISP) (Anderson et al., 2006).

Finally, we investigated whether various factors known to impact species distribution were also embodied in Wayãpi LEK. The variables included physicochemical characteristics of water, watercourse types, land use, and deforestation (Tables S4 and S5 for detailed information on the explanatory variables). To standardise all variables, continuous variables were centered around their mean and scaled to a standard deviation of 1. Variables were fitted onto a PCoA for fish and game species, both for eDNA and surveys. We did not fit the variables for each site category because there were too few sites in the 'medium' and 'poor' categories. Fitting was done using the envfit function from the vegan package to identify correlations between variables and ordination axes. R^2 values were calculated to assess the strength of correlations between axes and variables. p-values were determined by comparing observed and simulated R^2 from 9999 random permutations. Continuous variables were transformed into vectors based on their correlation with the axes, with vector lengths proportional to R^2 values. For categorical variables, average ordination scores were calculated for species in each factor level to position categories within functional spaces.

2.5 | Ethics statement

In accordance with the guidelines detailed in Buppert and Adrienne (2013), we followed the rules for applying free, prior, and informed consent. Information, verbal consents, and coordination with communal authorities were carried out before the field campaign. The survey campaign was approved by the Camopi village chef (Denis Laprière) and the Trois-Sauts village chefs (Jacky Pawey and Thomas Palassissi). The participants were briefed on the mission during gatherings held in their respective villages, following their customary way of exchanging information during casual discussions. The discussions and surveys did not require local translators, as both interviewers and interviewees were fluent in French, and one interviewer, D.D., knows all the game and fish species names and toponymy in Wayãpi language. During the surveys, participants could provide as many responses as they wished, limit their responses, or choose not to respond at all. The surveys were conducted in a way that respected the taboos and practices associated with each location. Internationally Recognised Certificates of Compliance are accessible under ABSCH-IRCC-FR-246820-1 for fish and under ABSCH-IRCC-FR-245902-1 for all other aquatic organisms.

2.6 | Positionality

This present research is part of a project ongoing for over 10 years in French Guiana, aiming to comprehensively understand the territory's freshwater ecology in the face of increasing environmental threats and to inform local environmental policies. Our team comprises several co-authors from France (S.B., J.M.), French Guiana (O.C., D.D.), and representatives from local environmental agencies and NGOs (A.J.O., G.Q., O.C.). D.D. has been collaborating on ethno-ecological research with the Wayãpi for over 20 years and has mediated this present study thanks to his familiarity with both Western and Wayãpi societies. This has ensured that the research is informed by and respectful of the cultural contexts of all parties involved. Indeed, Indigenous communities, whose livelihoods depend on subsistence economies rather than Western lifestyles, have specific nature needs. However, they are often marginalised, partly due to limited access to culturally appropriate education, which affects their representation in environmental institutions. In this context, we are committed to conducting research that is relevant, respectful, and reciprocal. This entails a long-term project that allows sufficient time to build collaborations adapted to different ways of sharing knowledge. In this long-term project, knowledge restitution and sharing are essential not only to keep Indigenous communities informed but also to gather their input and perspectives on the ongoing research. This approach fosters a deeper understanding of the needs and potential benefits for each collaborator, paving the way for more meaningful and inclusive conservation efforts.

3 | RESULTS

eDNA identified 115 fishes and 113 other vertebrate species across the 19 sites (Table S2A,B). Fish and game species mentioned in the surveys were a subset of those detected with eDNA. There were 18 fishes and 18 game species (mammals, birds, and reptiles) cited in the surveys (Table S3A,B). Two fish species (*Ancistrus aff. temminckii*, *Heros efasciatus*) and two game species (*Paleosuchus* spp. caimans, *green iguana*) were reported in surveys but not detected by eDNA, likely due to species discrimination issues and lower reptile DNA shedding rates (Nordstrom et al., 2022). Fourteen sites were classified as 'good' and five as 'medium' for fish, while 13 were 'good' and six 'poor' for game species. Comparative analyses focused on the 18 fishes and 18 game species mentioned in the surveys; other eDNA-detected species were excluded.

3.1 | Site species richness

For the surveys, the species richness ranged from 2 to 12 (median = 5.5) for fish and from 2 to 11 (median = 8) for game species at the sites categorised as 'good' (Figure 2a,b). At the sites categorised as 'medium' for fish, fish species richness ranged from 4 to 10 (median = 5) (Figure 2c) while the species richness of the game species ranged from 1 to 9 (median = 3.5) for sites considered as 'poor' (Figure 2d). There was no significant difference in the species richness of fish nor in the species richness of game species between the sites categorised as 'good' and 'medium'/'poor' (Table 1; Table S6).

With eDNA, the site species richness ranged from 9 to 17 (median = 14) for fish and from 7 to 15 (median = 13) for game species at the sites categorised as 'good' (Figure 2a,b). At the sites categorised as 'medium', the fish species richness ranged from 11 to 17 (median = 14) (Figure 2c) while the species richness of game species ranged from 10 to 15 (median = 13.5) for the sites considered as 'poor' (Figure 2d). There was no significant difference between the fish species richness of the 'good' and 'medium' sites. Similarly, no significant difference was reported for the species richness of game species between the 'good' and 'poor' sites (Table 1; Table S6).

The comparison of the species richness retrieved with eDNA and surveys for each site category showed that eDNA species richness was systematically significantly higher than the species richness of the surveys (Table 1; Table S6). At the 'good' sites, the eDNA species

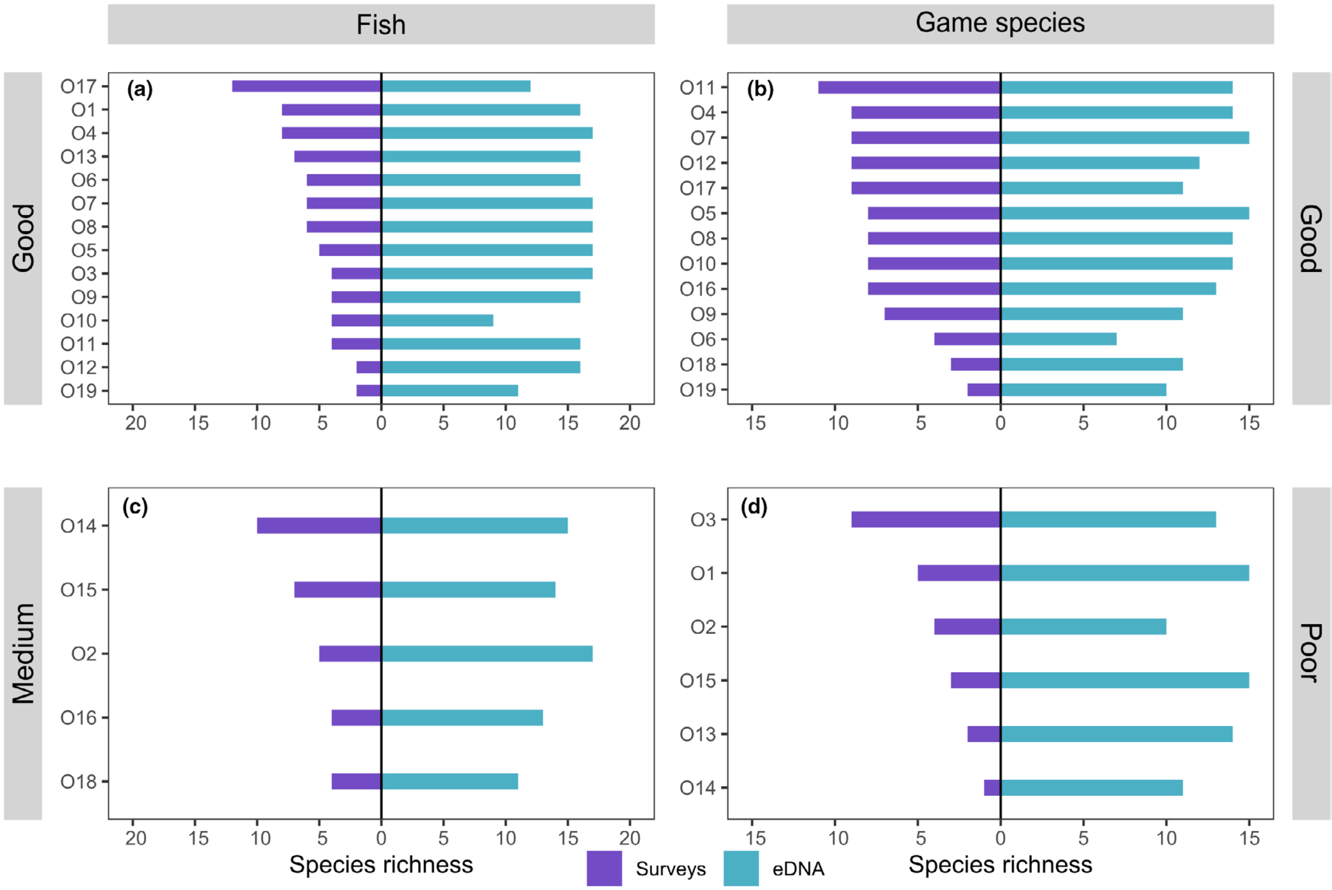

FIGURE 2 Site species richness obtained with environmental DNA (eDNA) and surveys for each site category. Results for the surveys are presented on the left side of each panel (purple color) and on the right side for eDNA (blue color). (a) Fish species richness in the 'good' sites for the surveys and eDNA, (b) Game species species richness in the 'good' sites for the surveys and eDNA, (c) Fish species richness in the 'medium' sites for the surveys and eDNA, (d) Game species species richness in the 'poor' sites for the surveys and eDNA.

TABLE 1 Species richness, species detection/mention frequencies, and site species composition comparisons between site categories ('good' vs. 'medium'/'poor') and between surveys and environmental DNA (eDNA). Kruskal–Wallis statistical tests were used to compare species richness and species detection/mention frequencies between site categories. Mann–Whitney *U*-tests were used to compare species richness and species detection/mention frequencies between site categories for eDNA and for the surveys. Site composition was compared using permutational analysis of variance after checking for homogeneous dispersion between compared groups with permutation dispersion tests.

Comparisons	Site categories	Species richness	Species detection/mention frequency	Composition
Fish				
Surveys	Good–medium	ns	ns	*
eDNA	Good–medium	ns	ns	ns
eDNA-surveys	Good	***	***	***
eDNA-surveys	Medium	*	***	**
Game species				
Surveys	Good–poor	ns	ns	*
eDNA	Good–poor	ns	ns	ns
eDNA-surveys	Good	***	*	***
eDNA-surveys	Poor	**	***	**

Note: See Tables S6 and S7 for statistical test details.
$^{*}p<0.05$. $^{**}p<0.01$. $^{***}p<0.001$.
$^{ns}p>0.05$.

richness of fish and game species was on average 2.73 times and 1.69 times greater than that obtained with the surveys, respectively (Figure 2a,b). Similarly, the eDNA species richness of fish and game species at the 'medium' and 'poor' sites was 2.33 times and 3.25 times higher than that obtained with the surveys, respectively (Figure 2c,d).

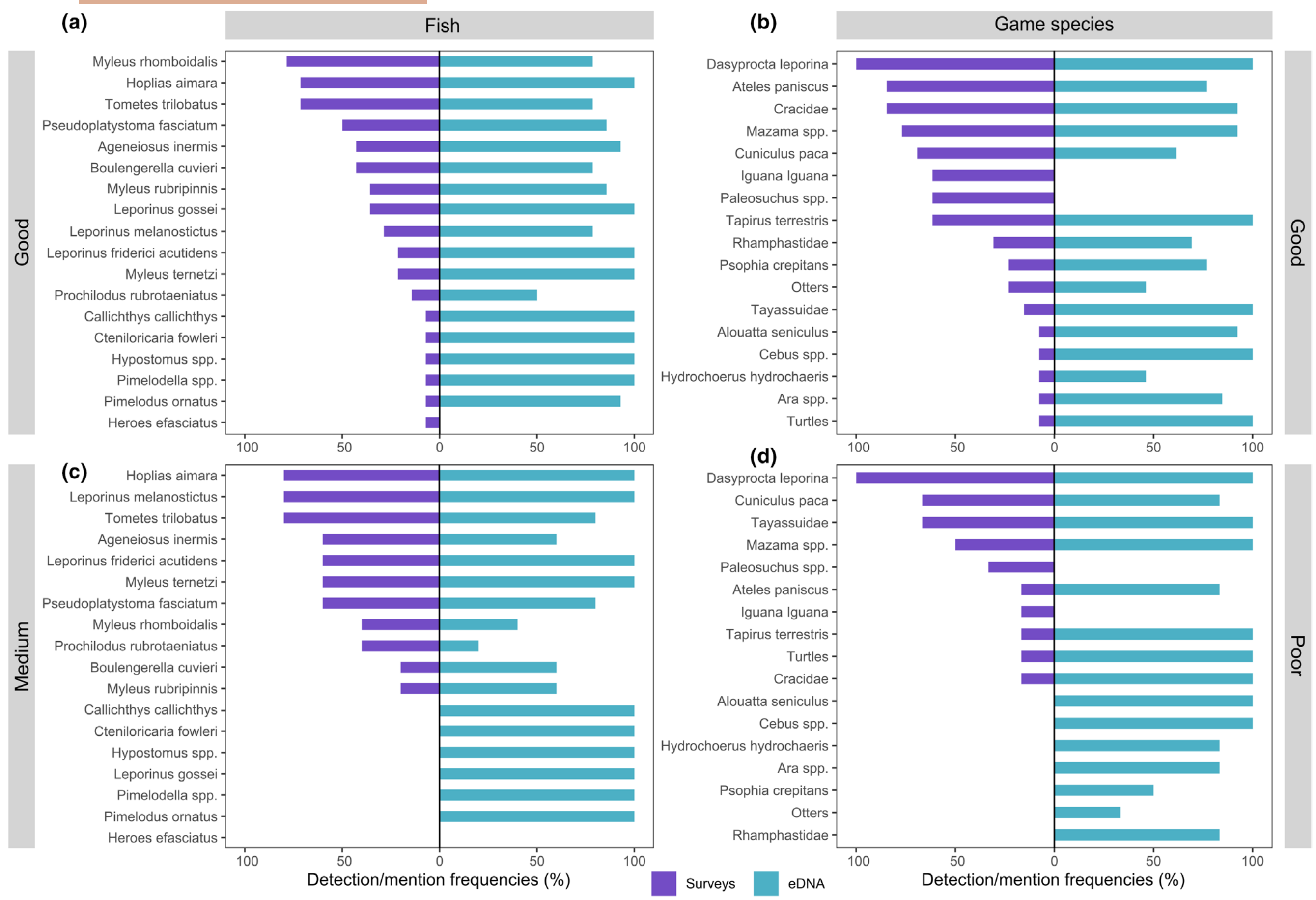

FIGURE 3 Species detection/mention frequencies obtained with environmental DNA (eDNA) and surveys for each site category. Results for the surveys are presented on the left side of each panel (purple color) and on the right side for eDNA (blue color). (a) Fish species detection/mention frequency in the 'good' sites for the surveys and eDNA, (b) Game species detection/mention frequency in the 'good' sites for the surveys and eDNA, (c) Fish detection/mention frequency in the 'medium' sites for the surveys and eDNA, (d) Game species detection/mention frequency in the 'poor' sites for the surveys and eDNA.

3.2 | Species detection/mention frequencies

With the surveys, the mention frequency of fish ranged from 7.14% to 78.57% (median = 25) while it ranged from 7.69% to 100% (median = 30.77) for game species at the 'good' sites (Figure 3a,b). At the 'medium' and 'poor' sites, fish and game species mention frequencies ranged from 0% to 80% (median = 30) and from 0% to 100% (median = 16.67), respectively (Figure 3c,d). There was no significant difference in the fish mention frequencies obtained with the surveys between the sites categorised as 'good' and 'medium' (Figure 3a,c; Table 1; Table S6) and in the game species mention frequencies between the sites categorised as 'good' and 'poor' (Figure 3b,d; Table 1; Table S6).

With eDNA, the fish and game species detection frequencies ranged from 0% to 100% at the 'good' sites (median = 92.86 and 84.62, respectively) (Figure 3a,b). At the 'medium' and 'poor' sites, the detection frequencies of fish and game species also ranged from 0% to 100% (median = 100 and 83.33, respectively) (Figure 3c,d). There was no significant difference between the fish detection frequencies obtained with eDNA between the sites categorised as 'good' and 'medium' (Figure 3a,c; Table 1; Table S6) nor between the sites categorised as 'good' and 'poor' for game species (Figure 3b,d; Table 1; Table S6).

Contrasting trends were reported for the detection/mention frequency comparisons between surveys and eDNA. At the 'good' and 'medium' sites, the mean fish detection frequencies obtained with eDNA were 2.73 and 2.33 times significantly higher than the mean mention frequencies obtained with the surveys, respectively (Figure 3a,c; Table 1; Table S6). Similarly, the mean game species detection frequencies retrieved with eDNA were 1.69 and 3.25 times significantly higher than the mean mention frequencies obtained with the surveys for the 'good' and 'poor' sites, respectively (Figure 3b,d; Table 1; Table S6).

3.3 | Site species composition

The PERMDISP tests validated the homogeneity of site dispersion between all groups compared (eDNA vs. surveys and 'good' vs. 'medium'/'poor') (Table S7; see Table S8 for PCoA coordinates). With the surveys, the site composition between the 'good' and 'medium'

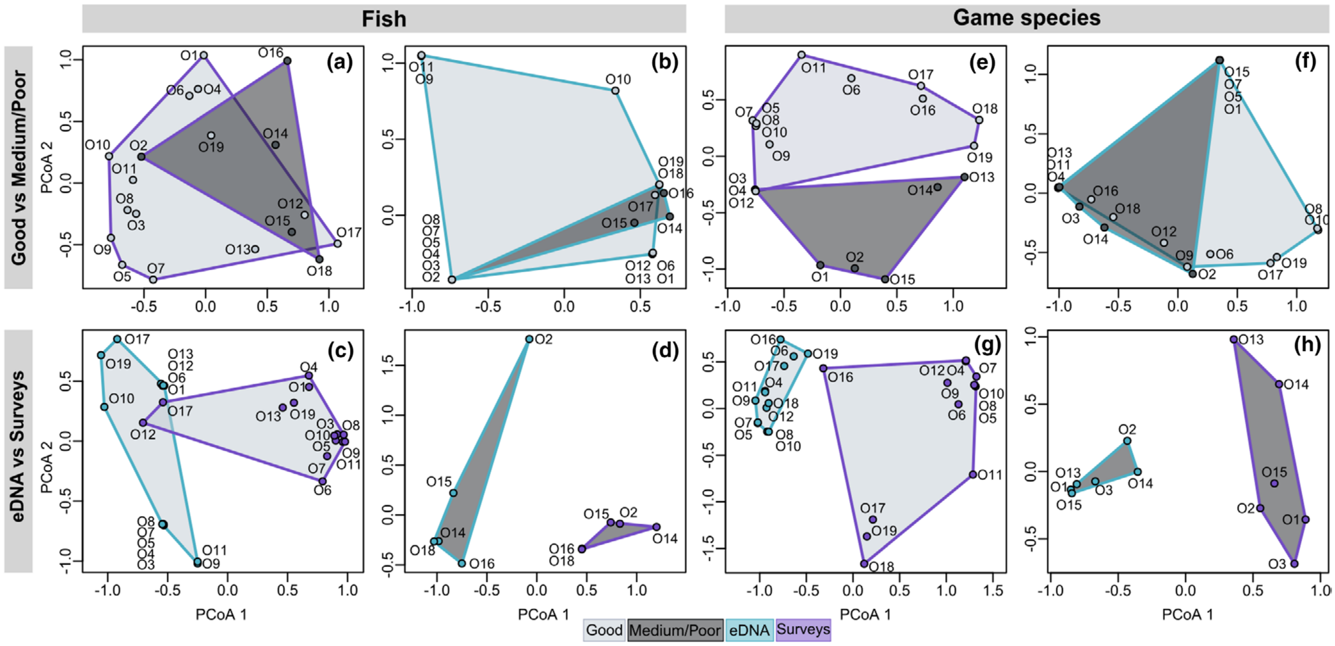

FIGURE 4 Site species composition for each site category and for eDNA and surveys based on the β_{rc} index. (a) Fish site composition of 'good' and 'medium' sites with the surveys, (b) Fish site composition of 'good' and 'medium' sites with environmental DNA (eDNA), (c) Fish site composition of 'good' sites obtained with surveys and eDNA, (d) Fish site composition of 'medium' sites retrieved with the surveys and eDNA, (e) Game species site composition of 'good' and 'poor' sites with the surveys, (f) Game species site composition of 'good' and 'poor' sites with eDNA, (g) Game species site composition of 'good' sites obtained with the surveys and eDNA, (h) Game species site composition of 'poor' sites obtained with the surveys and eDNA.

sites for fish and between the 'good' and 'poor' sites for game species was significantly different as supported by the PERMANOVA tests (Figure 4a,e; Table 1; Table S7). Conversely, with eDNA, there was no significant difference in site species composition between the 'good' and 'medium' sites for fish and between the 'good' and 'poor' sites for game species (Figure 4b,f; Table 1; Table S7). The comparisons between eDNA and survey site composition revealed significant differences for both fish and game species and for both site categories ('good' and 'medium'/'poor') (Figure 4c,d,g,h; Table 1; Table S7).

Several environmental and anthropic variables significantly correlated the species site compositions. With fish surveys, turbidity, conductivity, and elevation were the most strongly correlated with the ordination (r^2 = 0.55, 0.55, and 0.50, respectively). The distance to the nearest settlement, the temperature, the Strahler order, and the pH were the least correlated with the ordination (r^2 = 0.46, 0.43, 0.36, and 0.34, respectively; Figure 5a; Table S9). With the game species surveys, the distance to the nearest settlement, the turbidity, the elevation, and the conductivity had the highest correlation coefficients, superior to 0.5 (r^2 = 0.68, 0.67, 0.61, and 0.57, respectively). River width, temperature, and deforestation were less strongly correlated with the ordination (r^2 = 0.44, 0.44 and 0.31, respectively). Two categorical variables were also significantly correlated with the ordination, the site categories for fish (obtained from the surveys), and the presence of slash-and-burn areas (r^2 = 0.22 and 0.17, respectively; Figure 5b; Table S9). With eDNA for fish, the two most strongly correlated variables were the Strahler order and the temperature (r^2 = 0.88 and 0.85, respectively). Elevation, river width, and turbidity had weaker correlation coefficients (r^2 = 0.62, 0.54, and 0.42, respectively; Figure 5c; Table S9). With eDNA for game species, the presence of gold mines was the only significant variable correlating the ordination (r^2 = 0.18; Figure 5d; Table S9).

4 | DISCUSSION

An increasing body of literature recognises Indigenous LEK for enriching our understanding of species distribution and enhancing biodiversity assessments. However, Indigenous LEK also embodies a holistic view of both the material and immaterial dimensions of nature, adapted to specific economic, ecological, and cultural environments (Ali et al., 2022; Brondízio et al., 2021; McElwee et al., 2020). Here, we compared species distributions obtained from Indigenous LEK and eDNA measurements at different sites distributed across the Wayãpi lands. While we anticipate LEK to depict fauna reflecting how people are connected to and exploit the region at each site, eDNA offers an objective and standardised assessment of biodiversity across the study area (Cantera et al., 2019; Cantera, Decotte, et al., 2022; Coutant et al., 2021).

4.1 | LEK reflects species distribution similar to standardised assessments

Sites consistently exhibited greater species richness and higher detection frequencies for fish and game species with eDNA compared

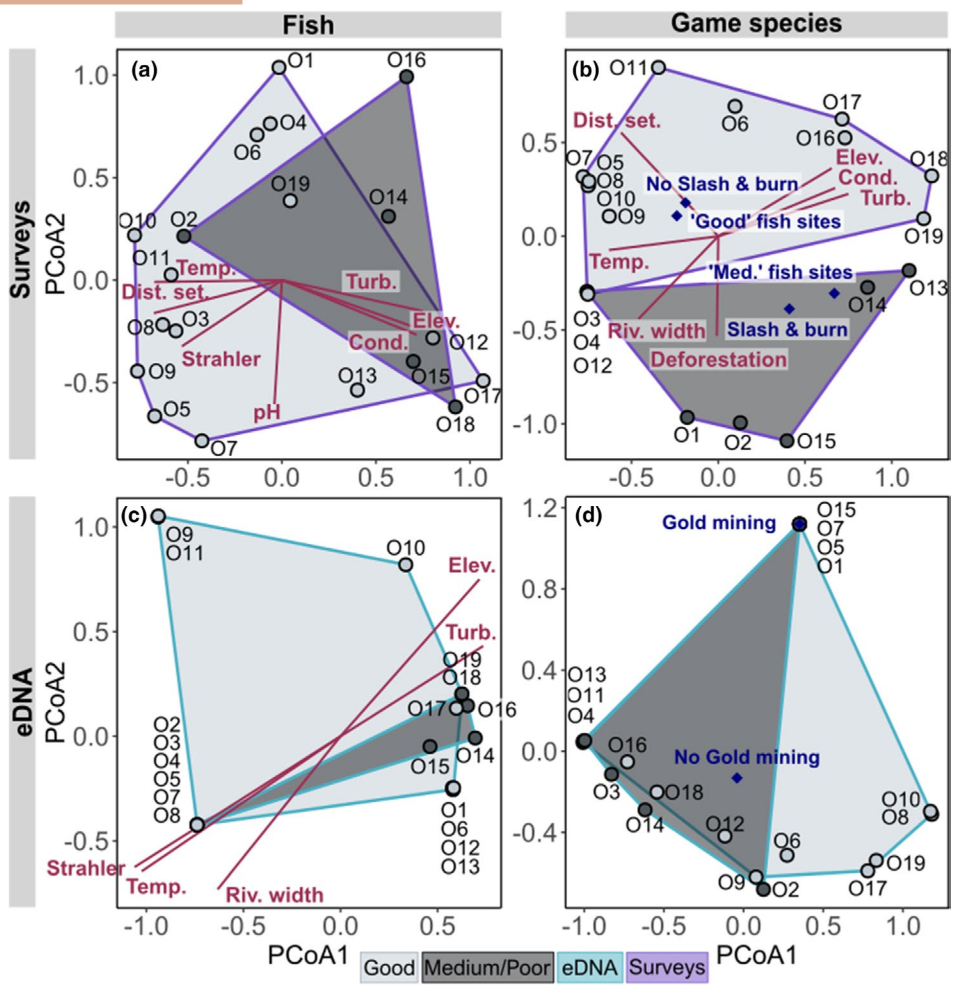

FIGURE 5 PCoA ordinations of fish and game species site composition based on the β_{rc} index for eDNA and surveys. Significant correlated continuous (red lines) and categorical (blue diamond symbols) environmental variables are displayed on the ordinations. 'good' and 'medium/poor' site compositions are presented in the top panels for fish (a) and for game species (b) and in the bottom panels for eDNA (c), Fish and (d), Game species. Dist. Set. refers to the distance to the nearest settlement, Elev. refers to elevation, Temp. refers to temperature, 'Good' fish sites refers to category 'good' sites for fish, 'Med.' fish sites refers to category 'medium' sites for fish, Cond. refers to conductivity, Turb. refers to turbidity, Riv. width refers to river width, Slash & burn refers to the presence of slash-and-burn areas around the sites (<1 km), and No Slash & burn refers to the absence of slash-and-burn areas around the sites.

to surveys. The species composition for fish and game species was also consistently significantly different between the two methods, with surveys providing a subset of eDNA-inventoried species. Despite these differences, both approaches provided similar insights into changes in species distribution due to environmental variability and anthropogenic activities. This congruence between the two methods has already been evidenced in previous studies (Braga-Pereira et al., 2022, 2024; Brondízio et al., 2021; Camino et al., 2020). For example, participants mentioned that *Tometes trilobatus*, *Myleus rhomboidalis*, and *Boulangerella cuvieri* never occur upstream of the Mutaquere confluence (Mitake in Wayãpi), corroborating eDNA findings and existing literature (Le Bail et al., 2012). This was also evidenced by the correlation between LEK of fish/game species distribution and environmental factors like turbidity, elevation, conductivity, river width, and water temperature, which are important drivers of fish diversity along the upstream-downstream continuum (Carvalho & Tejerina-Garro, 2015). Locally, the Wayãpi associated specific habitats with distinct species compositions; for instance, site O2 was deemed 'poor' for game species due to the absence of nearby hill forests, reflecting known species composition differences linked to forest types in French Guiana. Several species valued by the Wayãpi, such as the red brocket deer (*Mazama americana*), collared peccary (*Pecari tajacu*), or spider monkey (*Ateles paniscus*), are characteristic of hill forests (Richard-Hansen et al., 2015). For fish, the rapids at site O8 were noted as particularly suitable for rheophilic species from the Loricariidae family (Le Bail et al., 2012).

Wayãpi LEK is also influenced by anthropogenic activities. The correlation between Wayãpi LEK of fish and game species distribution with deforestation, water turbidity, and gold mining indicates that the Wayãpi observe changes in species distribution linked to these activities, leading to environmental alterations such as increased turbidity and deforestation (Hammond et al., 2007). For instance, at site O1, previously exploited for gold, a participant noted that fish were afraid of the mining engines. Although mining ceased before 2020, the participant believed that the water remains contaminated and undrinkable. Additionally, the Wayãpi identified poaching by people settled along the Brazilian riverbank as a driver of local depletion of game species like the black curassow (*Crax alector*), spider monkey, and marail guan (*Penelope marail*). This was particularly stated for O7, which was considered to have one of the lowest species richness among the 'good' game species sites. These results are concerning because gold mining and poaching are less prevalent in the upper Oyapock River than in the Maroni River (Cantera, Coutant, et al., 2022), but it is sufficient to significantly impact biodiversity and the Wayãpi's livelihoods.

4.2 | LEK is inseparable from place-based relations and obligations

Wayãpi LEK is embedded within a worldview inseparable from place-based obligations and relations evidenced in this study by foraging practices and spiritual beliefs (Latulippe & Klenk, 2020). This was reflected by the several inconsistencies between the mentioned species richnesses and the site categorisation, as well as by the different site categorisation for fish and game species. For example, sites O12 and O19 had the lowest reported fish species richness but were categorised as 'good' sites for fish. Site O2, despite a reported low fish species richness, has been historically and continues to be used for traditional fish poisoning, a method using a substance derived from lianas. Another example is O1, which was considered as 'good' for fish but 'poor' for game species. These examples, along with the significant difference in fish and game species composition between 'good' and 'medium'/'poor' sites in surveys (but not with eDNA), illustrate that species diversity is not the only factor influencing the site values, which depend on the species considered. In general, these observations reflect foraging practices shaped by trade-offs between various factors such as targeted species, species occupancy probability, and abundance, costs of hunting/fishing excursions, as demonstrated by Richard-Hansen et al. (2019). The correlation between the sites' composition based on surveys and variables such as the distance to the nearest village suggests that site valuations vary depending on village proximity and the presence of specific species. For instance, site O13 and O14 located near Trois-Saut villages were considered as 'poor' sites for game species with the lowest species richnesses. At these sites, the participants stated that primates such as spider monkeys, red howler monkeys (*Alouatta macconnelli*), capuchins (*Cebus* spp.), or birds such as Cracidae including black curassows were absent. These species are highly valued by the Wayãpi but sensitive to human harvest and tend to decline in hunted and residential areas due to their low reproductive rates (Richard-Hansen et al., 2019). These observations suggest that the Wayãpi notice a depletion of specific and valued species around villages, which affects the quality of the site according to their own definition of site quality. Wayãpi LEK also reflected spiritual beliefs. For instance, participants recognised one site as 'good' for fish and game species but reported that establishing camps and hunting in this site was prohibited as it was once inhabited by a dark shaman (shaman who likes to kill people). Beyond species distribution, these differential perceptions of sites and species underscore the intricate practices and nature relationships of hunters/anglers, which are shaped by sociological, cultural, economic, and geographical constraints (Levi et al., 2011).

4.3 | Integrating LEK into conservation frameworks for greater equity

Confronting LEK and standardised measurements of biodiversity revealed that the Wayãpi have their own representation of species distribution (Ali et al., 2022; Brondízio et al., 2021; Grenand, 1980; West et al., 2018). This divergent picture of the fauna illustrates that conservation strategies may not integrate the interconnectedness of the Wayãpi with their lands if they are solely based on objective assessments of species distribution and metrics such as local species richness.

In French Guiana, conservation frameworks primarily focus on the protection of vulnerable species, or specific natural reserves where hunting is regulated. In recent years, however, environmental policies have become more inclusive with the development of a national protected area (Guianese Amazonian Park), dedicated to promoting the natural and cultural richness of the area and committed to developing co-constructed management rules (Richard-Hansen et al., 2019). As demonstrated by a growing body of literature, integrating LEK and involving Indigenous communities in environmental governance has significant potential to manage ecosystem health, generate knowledge rooted in diverse values of nature, and address environmental challenges (Brondízio et al., 2021; Lam et al., 2020). This can be achieved by promoting participatory processes in environmental decision-making, which have proven effective in resolving conservation conflicts (Ainsworth et al., 2020; Latulippe & Klenk, 2020; Redpath et al., 2013). Developed within an appropriate framework that ensures the integration of different knowledge systems, these participatory processes can prevent Indigenous knowledge from being reduced to filling gaps in datasets (Ainsworth et al., 2020). Instead, it could contribute to the creation of culturally relevant spaces for Indigenous scientific research embedded in different relational values (Brondízio et al., 2021; Latulippe & Klenk, 2020).

In French Guiana, LEK-based research has already demonstrated the values behind Indigenous LEK, providing important information on how Indigenous communities interact with nature and how they are affected by growing nature changes (Longin et al., 2021; Richard-Hansen et al., 2019). For instance, Richard-Hansen et al. (2019) showed that the species depletion in the studied area generated changes in reported hunting trends, with a shift from primates, deer, and peccaries to more resilient rodent species. These observations underscore the necessity of transitioning to conservation strategies that are both more effective and equitable. Our study demonstrates that LEK must not be disconnected from its spatial context as it can fail to depict local communities' livelihoods and the diversity of nature relationships within a territory. Furthermore, combining Indigenous LEK and standardised biodiversity assessments may help identify local conservation challenges and determine the optimal compromise for designing equitable environmental policies.

4.4 | Study limitations

While LEK reflected how people are connected to and exploit the region at various locations, eDNA provides an objective and standardised assessment of biodiversity across the study area. In the context of this study, however, one major limitation of eDNA is its limited ability to effectively measure species abundance. Species abundance is a crucial metric for interpreting and comparing species distribution patterns obtained through LEK and eDNA, as it likely influences foraging practices. These socioecological comparisons could be enhanced by combining eDNA with traditional inventory methods, such as net fishing or line transects, which provide data on species abundance. Nonetheless, compared to some traditional inventory methods, the non-invasive nature of eDNA makes it an efficient tool for rapid multi-taxa biological inventories, allowing data collection on Indigenous lands without impacting biodiversity or depleting resources.

Our approach to LEK collection also has several limitations. First, conducting on-site surveys restricted the number of participants, which may have resulted in a partial representation of Wayãpi LEK. Additionally, because we focused on collecting LEK outside the villages, only men participated in the surveys. To more accurately capture how local populations interact with their environment, it is crucial to include a wider range of socio-demographic groups, such as women and youth, who can offer complementary perspectives on human-nature relationships. Lastly, the interviewer's socio-cultural identity can influence how participants share their knowledge. Participants may tailor their responses based on their perception of the interviewer or adjust their answers to align with the interviewer's expectations (Schaeffer et al., 2010). In our study, we minimised this bias by using Wayãpi-specific vocabulary related to species and by ensuring one interviewer was familiar with the Wayãpi community. However, to collect more representative LEK, surveys would be more effective if conducted by members of the local community.

5 | CONCLUSIONS

This initial socioecological study demonstrates that the current French data-centric conservation frameworks do not adequately embody the diverse ways the Wayãpi interact with their territory in French Guiana. It shows that comparing standardised biodiversity assessments with LEK, when considered in its full context, can lead to a more comprehensive understanding of human-nature relationships, which are shaped by socioeconomic, cultural, and resource availability factors. While the benefits of this study for the community involved may not be immediate, its value lies in contributing to a broader discussion on how to effectively integrate diverse stakeholders in conservation efforts. This could help better address local and regional biodiversity challenges for Wayãpi people. Extending it to other Indigenous communities closely dependent on natural resources would help design more equitable policies bridging biodiversity conservation and Indigenous communities well-being.

AUTHOR CONTRIBUTIONS

Opale Coutant, Damien Davy, Sébastien Brosse, and Jérôme Murienne conceived the ideas and designed the methodology. Opale Coutant, Sébastien Brosse, Arnaud Jahn-Oyac, Grégory Quartarollo, Jérôme Murienne, and Damien Davy collected the data. Alice Valentini and Tony Dejean supervised the laboratory work and conducted the bioinformatic analyses. Opale Coutant analysed the data. Opale Coutant led the writing of the manuscript. All authors critically contributed to the manuscript.

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CONFLICT OF INTEREST STATEMENT

Teleo primers and the use of the amplified fragment for identifying fish species from environmental samples are patented by the CNRS and the Université Grenoble Alpes. This patent only restricts commercial applications and has no implications for the use of this method by academic researchers. SPYGEN owns a licence to this patent. AV and TD are research scientists at a private company specialising in the use of eDNA for species detection (SPYGEN).

DATA AVAILABILITY STATEMENT

The Illumina raw sequence data used in this study are available under accession code https://doi.org/10.6084/m9.figshare.27232593.v1. The runs used for this study can be extracted using the Sequencing Metadata file and Table S1.

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REFERENCES

Ainsworth, G. B., Redpath, S. M., Wilson, M., Wernham, C., & Young, J. C. (2020). Integrating scientific and local knowledge to address conservation conflicts: Towards a practical framework based on lessons learned from a Scottish case study. *Environmental Science & Policy*, *107*, 46–55. https://doi.org/10.1016/j.envsci.2020.02.017

Ali, T., Buergelt, P. T., Maypilama, E. L., Paton, D., Smith, J. A., & Jehan, N. (2022). Synergy of systems theory and symbolic interactionism: A passageway for non-indigenous researchers that facilitates better understanding indigenous worldviews and knowledges. *International Journal of Social Research Methodology*, *25*(2), 197–212. https://doi.org/10.1080/13645579.2021.1876300

Anderson, M. J., Ellingsen, K. E., & McArdle, B. H. (2006). Multivariate dispersion as a measure of beta diversity. *Ecology Letters*, *9*(6), 683–693. https://doi.org/10.1111/j.1461-0248.2006.00926.x

Bennett, N. J., Roth, R., Klain, S. C., Chan, K., Christie, P., Clark, D. A., Cullman, G., Curran, D., Durbin, T. J., Epstein, G., Greenberg, A., Nelson, M. P., Sandlos, J., Stedman, R., Teel, T. L., Thomas, R., Veríssimo, D., & Wyborn, C. (2017). Conservation social science: Understanding and integrating human dimensions to improve conservation. *Biological Conservation*, *205*, 93–108. https://doi.org/10.1016/j.biocon.2016.10.006

Boyer, F., Mercier, C., Bonin, A., Le Bras, Y., Taberlet, P., & Coissac, E. (2016). Obitools: A unix-inspired software package for DNA metabarcoding. *Molecular Ecology Resources*, *16*(1), 176–182. https://doi.org/10.1111/1755-0998.12428

Braga-Pereira, F., Mayor, P., Morcatty, T. Q., Pérez-Peña, P. E., Bowler, M. T., De Mattos Vieira, M. A. R., Alves, R. R. D. N., Fa, J. E., Peres, C. A., Tavares, A. S., Mere-Roncal, C., González-Crespo, C., Bertsch, C., Rodriguez, C. R., Bardales-Alvites, C., Von Muhlen, E., Paim, F. P., Tamayo, J. S., Valsecchi, J., … El Bizri, H. R. (2024). Predicting animal abundance through local ecological knowledge: An internal validation using consensus analysis. *People and Nature*, *6*(2), 535–547. https://doi.org/10.1002/pan3.10587

Braga-Pereira, F., Morcatty, T. Q., El Bizri, H. R., Tavares, A. S., Mere-Roncal, C., González-Crespo, C., Bertsch, C., Rodriguez, C. R., Bardales-Alvites, C., von Mühlen, E. M., Bernárdez-Rodríguez, G. F., Paim, F. P., Tamayo, J. S., Valsecchi, J., Gonçalves, J., Torres-Oyarce, L., Lemos, L. P., de Mattos Vieira, M. A. R., Bowler, M., … Mayor, P. (2022). Congruence of local ecological knowledge (LEK)-based methods and line-transect surveys in estimating wildlife abundance in tropical forests. *Methods in Ecology and Evolution*, *13*(3), 743–756. https://doi.org/10.1111/2041-210X.13773

Brondízio, E. S., Aumeeruddy-Thomas, Y., Bates, P., Carino, J., Fernández-Llamazares, Á., Ferrari, M. F., Galvin, K., Reyes-García, V., McElwee, P., Molnár, Z., Samakov, A., & Shrestha, U. B. (2021). Locally based, regionally manifested, and globally relevant: Indigenous and local knowledge, values, and practices for nature. *Annual Review of Environment and Resources*, *46*(1), 481–509. https://doi.org/10.1146/annurev-environ-012220-012127

Buppert, T., & Adrienne, M. (2013). *Guidelines for applying free, prior and informed consent: A manual for Conservation International*. Conservation International.

Camino, M., Thompson, J., Andrade, L., Cortez, S., Matteucci, S. D., & Altrichter, M. (2020). Using local ecological knowledge to improve large terrestrial mammal surveys, build local capacity and increase conservation opportunities. *Biological Conservation*, *244*, 108450. https://doi.org/10.1016/j.biocon.2020.108450

Cantera, I., Cilleros, K., Valentini, A., Cerdan, A., Dejean, T., Iribar, A., Taberlet, P., Vigouroux, R., & Brosse, S. (2019). Optimizing environmental DNA sampling effort for fish inventories in tropical streams and rivers. *Scientific Reports*, *9*(1), 1–11. https://doi.org/10.1038/s41598-019-39399-5

Cantera, I., Coutant, O., Jézéquel, C., Decotte, J.-B., Dejean, T., Iribar, A., Vigouroux, R., Valentini, A., Murienne, J., & Brosse, S. (2022). Low level of anthropization linked to harsh vertebrate biodiversity declines in Amazonia. *Nature Communications*, *13*(1), 3290. https://doi.org/10.1038/s41467-022-30842-2

Cantera, I., Decotte, J., Dejean, T., Murienne, J., Vigouroux, R., Valentini, A., & Brosse, S. (2022). Characterizing the spatial signal of environmental DNA in river systems using a community ecology approach. *Molecular Ecology Resources*, *22*(4), 1274–1283. https://doi.org/10.1111/1755-0998.13544

Carvalho, R. A., & Tejerina-Garro, F. L. (2015). The influence of environmental variables on the functional structure of headwater stream fish assemblages: A study of two tropical basins in Central Brazil. *Neotropical Ichthyology*, *13*(2), 349–360. https://doi.org/10.1590/1982-0224-20130148

Chan, K. M. A., Balvanera, P., Benessaiah, K., Chapman, M., Díaz, S., Gómez-Baggethun, E., Gould, R., Hannahs, N., Jax, K., Klain, S., Luck, G. W., Martín-López, B., Muraca, B., Norton, B., Ott, K., Pascual, U., Satterfield, T., Tadaki, M., Taggart, J., & Turner, N. (2016). Why protect nature? Rethinking values and the environment. *Proceedings of the National Academy of Sciences of the United States of America*, *113*(6), 1462–1465. https://doi.org/10.1073/pnas.1525002113

Chan, K. M. A., Gould, R. K., & Pascual, U. (2018). Editorial overview: Relational values: What are they, and what's the fuss about? *Current Opinion in Environmental Sustainability*, *35*, A1–A7. https://doi.org/10.1016/j.cosust.2018.11.003

Chase, J. M., Kraft, N. J. B., Smith, K. G., Vellend, M., & Inouye, B. D. (2011). Using null models to disentangle variation in community dissimilarity from variation in α-diversity. *Ecosphere*, *2*(2), 1–11. https://doi.org/10.1890/ES10-00117.1

Chaves, L. S., Alves, R. R. N., & Albuquerque, U. P. (2020). Hunters' preferences and perceptions as hunting predictors in a semiarid ecosystem. *Science of the Total Environment*, *726*, 138494. https://doi.org/10.1016/j.scitotenv.2020.138494

Cilleros, K., Valentini, A., Allard, L., Dejean, T., Etienne, R., Grenouillet, G., Iribar, A., Taberlet, P., Vigouroux, R., & Brosse, S. (2019). Unlocking biodiversity and conservation studies in high-diversity environments using environmental DNA (eDNA): A test with Guianese freshwater fishes. *Molecular Ecology Resources*, *19*(1), 27–46. https://doi.org/10.1111/1755-0998.12900

Coutant, O., Richard-Hansen, C., de Thoisy, B., Decotte, J.-B., Valentini, A., Dejean, T., Vigouroux, R., Murienne, J., & Brosse, S. (2021). Amazonian mammal monitoring using aquatic environmental DNA. *Molecular Ecology Resources*, *21*(6), 1875–1888. https://doi.org/10.1111/1755-0998.13393

Davy, D., Tritsch, I., & Grenand, P. (2012). Construction et restructuration territoriale chez les Wayãpi et Teko de la commune de Camopi, Guyane française. *Confins. Revue Franco-brésilienne de géographie / Revista Franco-Brasilera de Geografia*, *16*, 16. https://doi.org/10.4000/confins.7964

Díaz, S., Demissew, S., Carabias, J., Joly, C., Lonsdale, M., Ash, N., Larigauderie, A., Adhikari, J. R., Arico, S., Báldi, A., Bartuska, A., Baste, I. A., Bilgin, A., Brondizio, E., Chan, K. M., Figueroa, V. E., Duraiappah, A., Fischer, M., Hill, R., … Zlatanova, D. (2015). The IPBES conceptual framework—Connecting nature and people. *Current Opinion in Environmental Sustainability*, *14*, 1–16. https://doi.org/10.1016/j.cosust.2014.11.002

Grenand, P. (1980). *Introduction à l'étude de l'univers Wayãpi. Ethnoécologie des Indiens du Haut-Oyapock (Guyane française) (Langues et Civilisations à Tradition Orale; 40)*. SELAF.

Grenand, P., Chapuis, J., André, C., Antonia, C., Damien, D., Françoise, G., Jégu, M., Keith, P., Martin, E., François, N., Hélène, P., & Le Bail, P.-Y. (2015). Revision of vernacular names for the freshwater fish of French Guiana. *Cybium*, *39*(4), 279–300.

Grenand, P., Grenand, F., Joubert, P., & Davy, D. (2017). Pour une histoire de la cartographie des territoires teko et wayãpi (Commune de Camopi, Guyane française). *Revue d'ethnoécologie*. https://doi.org/10.4000/ethnoecologie.3007

Hammond, D. S., Gond, V., Thoisy, B. D., Forget, P.-M., & DeDijn, B. P. E. (2007). Causes and consequences of a tropical forest gold rush in the Guiana Shield, South America. *Ambio: A Journal of the Human Environment*, *36*(8), 661–670. https://doi.org/10.1579/0044-7447(2007)36[661:CACOAT]2.0.CO;2

Himes, A., Muraca, B., Anderson, C. B., Athayde, S., Beery, T., Cantú-Fernández, M., González-Jiménez, D., Gould, R. K., Hejnowicz, A. P., Kenter, J., Lenzi, D., Murali, R., Pascual, U., Raymond, C., Ring, A., Russo, K., Samakov, A., Stålhammar, S., Thorén, H., & Zent, E. (2024). Why nature matters: A systematic review of intrinsic, instrumental, and relational values. *Bioscience*, *74*(1), 25–43. https://doi.org/10.1093/biosci/biad109

Kocher, A., De Thoisy, B., Catzeflis, F., Huguin, M., Valière, S., Zinger, L., Bañuls, A., & Murienne, J. (2017). Evaluation of short mitochondrial metabarcodes for the identification of Amazonian mammals. *Methods in Ecology and Evolution*, *8*(10), 1276–1283. https://doi.org/10.1111/2041-210X.12729

Lam, D. P. M., Hinz, E., Lang, D. J., Tengö, M., Wehrden, H. V., & Martín-López, B. (2020). Indigenous and local knowledge in sustainability transformations research: A literature review. *Ecology and Society*, *25*(1), art3. https://doi.org/10.5751/ES-11305-250103

Latulippe, N., & Klenk, N. (2020). Making room and moving over: Knowledge co-production, indigenous knowledge sovereignty and the politics of global environmental change decision-making. *Current Opinion in Environmental Sustainability*, *42*, 7–14. https://doi.org/10.1016/j.cosust.2019.10.010

Le Bail, P.-Y., Covain, R., Jégu, M., Fisch-Muller, S., Vigouroux, R., & Keith, P. (2012). Updated checklist of the freshwater and estuarine fishes of French Guiana. *Cybium*, *36*(1), 293–319. https://doi.org/10.26028/cybium/2012-361-016

Levi, T., Lu, F., Yu, D., & Mangel, M. (2011). The behaviour and diet breadth of central-place foragers: An application to human hunters and neotropical game management. *Evolutionary Ecology Research*, *13*, 171–185.

Longin, G., Beaufort, L., Fontenelle, G., Rinaldo, R., Roussel, J.-M., & Le Bail, P.-Y. (2021). Fishers' perceptions of river resources: Case study of French Guiana native populations using contextual cognitive mapping. *Cybium: International Journal of Ichthyology*, *45*, 5–20. https://doi.org/10.26028/cybium/2021-451-001

Madsen, E. K., Elliot, N. B., Mjingo, E. E., Masenga, E. H., Jackson, C. R., May, R. F., Røskaft, E., & Broekhuis, F. (2020). Evaluating the use of local ecological knowledge (LEK) in determining habitat preference and occurrence of multiple large carnivores. *Ecological Indicators*, *118*, 106737. https://doi.org/10.1016/j.ecolind.2020.106737

Martin, A., Caro, T., & Kiffner, C. (2013). Prey preferences of bushmeat hunters in an East African savannah ecosystem. *European Journal of Wildlife Research*, *59*(2), 137–145. https://doi.org/10.1007/s10344-012-0657-8

McElwee, P., Fernández-Llamazares, Á., Aumeeruddy-Thomas, Y., Babai, D., Bates, P., Galvin, K., Guèze, M., Liu, J., Molnár, Z., Ngo, H. T., Reyes-García, V., Roy Chowdhury, R., Samakov, A., Shrestha, U. B., Díaz, S., & Brondízio, E. S. (2020). Working with indigenous and local knowledge (ILK) in large-scale ecological assessments: Reviewing the experience of the IPBES Global Assessment. *Journal of Applied Ecology*, *57*(9), 1666–1676. https://doi.org/10.1111/1365-2664.13705

Molino, J.-F., Sabatier, D., Grenand, P., Engel, J., Frame, D., Delprete, P. G., Fleury, M., Odonne, G., Davy, D., Lucas, E. J., & Martin, C. A. (2022). An annotated checklist of the tree species of French Guiana, including vernacular nomenclature. *Adansonia*, *44*(26). https://doi.org/10.5252/adansonia2022v44a26

Nordstrom, B., Mitchell, N., Byrne, M., & Jarman, S. (2022). A review of applications of environmental DNA for reptile conservation and management. *Ecology and Evolution*, *12*(6), e8995. https://doi.org/10.1002/ece3.8995

Ouhoud-Renoux, F. (1998). *De l'outil à la prédation: Technologie culturelle et ethno-écologie chez les Wayapi du Haut Oyapock (Guyane française)* (Paris, Paris X, Thèse de Doctorat).

Quinlan, M. (2005). Considerations for collecting freelists in the field: Examples from ethobotany. *Field Methods*, *17*, 219–234. https://doi.org/10.1177/1525822X05277460

Redpath, S. M., Young, J., Evely, A., Adams, W. M., Sutherland, W. J., Whitehouse, A., Amar, A., Lambert, R. A., Linnell, J. D. C., Watt, A., & Gutiérrez, R. J. (2013). Understanding and managing conservation conflicts. *Trends in Ecology & Evolution*, *28*(2), 100–109. https://doi.org/10.1016/j.tree.2012.08.021

Richard-Hansen, C., Davy, D., Longin, G., Gaillard, L., Renoux, F., Grenand, P., & Rinaldo, R. (2019). Hunting in French Guiana across time, space and livelihoods. *Frontiers in Ecology and Evolution*, *7*, 289. https://doi.org/10.3389/fevo.2019.00289

Richard-Hansen, C., Jaouen, G., Denis, T., Brunaux, O., Marcon, E., & Guitet, S. (2015). Landscape patterns influence communities of medium-to large-bodied vertebrates in undisturbed terra firme forests of French Guiana. *Journal of Tropical Ecology*, *31*(5), 423–436. https://doi.org/10.1017/S0266467415000255

Schaeffer, N., Dykema, J., & Maynard, D. (2010). Interviewers and Interviewing. In P. V. Marsden & J. D. Wright (Eds.), *Handbook of survey research* (2nd ed., pp. 437–470). Emerald Group Publishing.

Toledo, V. M. (2013). Indigenous peoples and biodiversity. In *Encyclopedia of biodiversity* (pp. 269–278). Elsevier. https://doi.org/10.1016/B978-0-12-384719-5.00299-9

Tritsch, I. (2013). *Territorial dynamic and identity of the Wayãpi and Téko indigenous people of the municipality of Camopi (French Guiana)* [PhD thesis, Université de Guyane].

Tritsch, I., Gond, V., Oszwald, J., Davy, D., & Grenand, P. (2011). Occupation du territoire et gestion des ressources naturelles en contexte Amérindiens: Le cas des Wayãpi et Teko de Camopi en Guyane Française. In C. Farcy, J.-L. Peyron, & Y. Poss (Eds.), *Forêt et foresterie: Mutations et décloisonnements* (p. 348). Harmattan.

Tritsch, I., Marmoex, C., Davy, D., Thibaut, B., & Gond, V. (2015). Towards a revival of indigenous mobility in French Guiana? Contemporary transformations of the Wayãpi and Teko Territories. *Bulletin of Latin American Research*, *34*(1), 19–34. https://doi.org/10.1111/blar.12204

West, S., Haider, L. J., Masterson, V., Enqvist, J. P., Svedin, U., & Tengö, M. (2018). Stewardship, care and relational values. *Current Opinion in Environmental Sustainability*, *35*, 30–38. https://doi.org/10.1016/j.cosust.2018.10.008

West, S., Haider, L. J., Stålhammar, S., & Woroniecki, S. (2020). A relational turn for sustainability science? Relational thinking, leverage points and transformations. *Ecosystems and People*, *16*(1), 304–325. https://doi.org/10.1080/26395916.2020.1814417

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

Figure S1. The survey frame.

Table S1. Sequencing information for fish, game species, and controls.

Table S2. Species by site matrices obtained from eDNA (A) for fish species and (B) for vertebrate species other than fish.

Table S3. Species by site matrices obtained with the surveys (A) for fish species and (B) game species.

Table S4. Site variables fitted onto the eDNA and survey PCoA ordinations for fish and game species.

Table S5. Description of the environmental and survey-based variables fitted onto the eDNA and survey ordinations for fish and game species.

Table S6. Results of the statistical tests of the comparative analyses for the site species richness and the species detection/mention frequencies.

Table S7. Results of the statistical tests of the comparative analyses for the site species composition.

Table S8. PCoA coordinates of the two first axes for the different comparisons (eDNA vs. surveys and 'good' vs. 'medium'/'poor').

Table S9. PCoA scores, correlations (r^2), and statistical significance (p) of environmental variables fitted on the surveys and eDNA ordinations obtained with the envfit function (9999 permutations).

Method S1. Detailed protocol for eDNA metabarcoding.

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