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Improve Long-Term Biodiversity Management and Monitoring on Certified Oil Palm Plantations in Colombia by Centralizing Efforts at the Sector Level

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Commodity crop expansion remains a leading driver of deforestation and defaunation in the tropics. Voluntary certification standards are the primary mechanism for making commodity production more sustainable and rely on the High Conservation Value (HCV) framework for protecting biodiversity on farms. In the oil palm sector, the HCV approach requires producers to create a management and monitoring plan for on-farm species and habitat, but many companies struggle with interpreting and implementing recommendations from HCV reports. In this study, we explore the challenges to effective biodiversity monitoring on oil palm plantations by consulting recommendations from twenty-one HCV reports for RSPO-certified projects in Latin America, and conducting semi-structured interviews with eight RSPO-certified palm oil mills in Colombia to understand how companies adopt recommendations. We identified several shortcomings under the HCV management-monitoring process including lack of indicators and guidance in HCV reports, emphasis on operational (i.e., procedural) over strategic (i.e., effectiveness) monitoring, over-reliance on incidental wildlife encounters for monitoring populations, and significant technical and financial barriers facing companies. We provide recommendations for improving these aspects including the adoption of Essential Biodiversity Variables (EBV)—population state variables that bridge raw data with global indicators for policymakers—to guide and standardize monitoring on plantations. We conclude by proposing a strategy for biodiversity monitoring that is long-term, driven by EBVs, and centralized at the sector level in Colombia to improve standardization and reduce costs. Current company efforts track drivers of biodiversity trends that complement EBVs, and should continue to encourage staff buy-in and awareness of biodiversity conservation importance.

Keywords: Colombia, eco-label, essential biodiversity variables (EBVs), high conservation value, Latin America, RSPO, voluntary certification schemes

INTRODUCTION

Voluntary certification schemes have become the most salient strategy for making tropical commodity supply chains more sustainable, reflecting a shift toward private-sector sustainability governance (Byerlee and Rueda, 2015). In voluntary certifications, biodiversity conservation can be addressed both directly, through the creation of on-farm habitat (e.g., conservation set-asides), or indirectly, through implementation of better agronomic practices (e.g., reduced chemical inputs) (Tayleur et al., 2016). A recent review of 14 voluntary supply chain initiatives in 11 major agricultural commodity markets found that biodiversity conservation is rarely addressed explicitly in sustainability standards; instead standards aim to address biodiversity through enhanced habitat conservation (Potts et al., 2017). Spatially targeted habitat conservation is predominantly established through the High Conservation Value (HCV) approach, which deems areas ecologically valuable if they contain viable populations of rare, threatened, or endangered (RTE) species (HCV 1), contain habitat fragments that are rare or critical to the larger landscape (HCV 2 and 3), or provide ecosystem services (HCV 4) (Brown et al., 2013). The HCV framework has become a mainstream strategy for biodiversity conservation in supply chain initiatives, yet even on certified farms where natural habitat may be better protected, biodiversity conservation remains uncertain (Yu Ting et al., 2016).

In the oil palm sector, a study in Southeast Asia found that HCV areas in RSPO-certified concessions are highly degraded and require active management (i.e., restoration) to support biodiversity (Scriven et al., 2017). Effective management of HCV areas requires monitoring to match strategies with empirical evidence that informs plantation managers whether conservation actions are working. This process is captured in the management and monitoring (m&m) plans that certified companies must develop after completing the HCV assessment (Brown and Senior, 2014). The goal of management is to "maintain or enhance" HCVs over time and companies are expected to translate recommendations from HCV reports into *management prescriptions*—specific objectives, targets, and strategies (Brown and Senior, 2014). A monitoring protocol is then established to evaluate and inform management strategies in an adaptive way. This process is not straightforward for palm oil companies. A study commissioned by the RSPO Biodiversity and High Conservation Value Working Group surveying 16 companies across 10 countries found that companies face significant technical and financial challenges in the design and implementation of HCV m&m (Lyons-White et al., 2017). Plans consisted of a list of standard operating procedures but lacked specific objectives, targets, or indicators, and monitoring activities were generic and not conducted in a systematic fashion.

Here, we argue the need for improved biodiversity monitoring for effective conservation in oil palm landscapes, focusing on the capacity of large-scale, commercial plantations. We draw on HCV reports available online and semi-structured interviews with commercial RSPO-certified oil palm growers in Colombia to understand how companies interpret m&m recommendations contained in HCV reports, and explore the challenges and shortcomings of implementation in practice (see **Supplementary Information** for detailed methodology). We give particular attention to the actions for monitoring fauna to assess how effectively these might inform management strategies. The paper is divided into sections that address shortcomings under the current system and provide recommendations for improvement, drawing on the Essential Biodiversity Variable (EBV) framework as a way to standardize indicators and methodologies (Pereira et al., 2013). The EBV concept seeks to distill the complexity of biodiversity into a list of priority measurements to coordinate monitoring and bridge gaps from the local to global scale (Geijzendorffer et al., 2016; Brummitt et al., 2017). EBVs serve as an intermediate layer between primary data observed in the field and more derived indicators for policymakers; they underlie an effort to harmonize and integrate biodiversity monitoring into a global system that informs initiatives such as the Aichi Targets of the Convention on Biological Diversity, and the UNEP Intergovernmental Science Policy Platform on Biodiversity and Ecosystem Services (Pereira et al., 2013). We conclude by proposing an alternative approach that centralizes monitoring efforts at the sector-level.

CHALLENGES AND RECOMMENDATIONS

Lack of Monitoring Indicators and Guidance in HCV Reports

Biodiversity m&m recommendations from 21 HCV reports for companies seeking RSPO certification in Latin America are summarized in **Table 1** (see also **Table S2**). In general, these can be divided into activities for fauna (HCV 1) and flora (HCV 2–4). In order to assess the effectiveness of management activities, monitoring plans must determine species population metrics, or biological state variables, of plant and animal communities on plantations so that they can be compared over time (Schmeller et al., 2017). Nonetheless, monitoring recommendations from HCV reports are vague and lack specific indicators or sampling methods, leaving this open to interpretation by companies. For instance, the level of detail included for fauna monitoring calls for assessments that can "determine population status" or "species abundance" but offers no sampling protocol or methodology. Importantly, no target or threshold is outlined for specific indicators.

One explanation for the lack of specific outcome indicators in m&m plans may be the way certification standards are designed, relying primarily on *practice*-based instead of *performance*-based requirements (Potts et al., 2017). For instance, in regulating chemical inputs, the RSPO says that pesticide use should be minimized, instead of outlining a permissible limit per unit area. Similarly, hunting or extraction of resources from forests is prohibited in practice, but standards contain little criteria that require the explicit measurement, management, and protection of populations (Potts et al., 2017). Less rigid, practice-based requirements have advantages for accommodating different local contexts when applying a standard over a larger geographic area, but risk legitimizing unsustainable practices

TABLE 1 | Essential biodiversity variable (EBV) classes and candidate variables most relevant to monitoring of HCVs on RSPO-certified plantations, adopted from Pereira et al. (2013) (Note "genetic composition" and "species traits" EBV classes are excluded).

EBV class	EBV candidate	HCV	M&M recommendations (*on paper*)	M&M Activities (*in practice*)
Species populations			"Photograph incidental encounters (sightings, tracks, scat, body parts, hunted/roadkill animals)"	
	Species distribution	1	"Assess & determine population status of fauna using oil palm and HCV areas"	*Incidental encounters *Visual encounter surveys *Walking transects *Camera traps
			"Biannual monitoring of flora and fauna (winter and summer), esp. migratory birds"	
			"Determine wildlife transit and travel routes between natural vegetation"	
	Population abundance	1	"Monitor presence of RTE species and their abundance"	*Visual encounter surveys *Camera traps
	Population structure by age/size class	–	–	–
			"Assess & determine population status of fauna using oil palm and HCV areas"	*Visual encounter surveys *Walking transects *Camera traps
Community composition	Taxonomic diversity	1	"Biannual monitoring of flora and fauna (winter and summer), esp. migratory birds"	
	Species interactions	–	–	–
			"Conduct transects to evaluate the status of vegetation cover"	
	Habitat structure	3, 4	"Establish permanent vegetation plots in riparian forests to verify restoration and recovery efforts"	Vegetation plots/transects
			"Monitor the area, quality, and dynamics of natural ecosystems (e.g., forest remnants, wetlands) on the plantation, including increase or decrease of regeneration areas"	
Ecosystem structure	Ecosystem extent and fragmentation	2, 3, 4	"Information on poaching, illegal logging and land conversion should be collected and analyzed at least quarterly	–
			"Include restoration status of riparian zones"	
	Ecosystem composition by functional type	3	"Include restoration status of riparian zones"	Vegetation plots/transects
	Net primary productivity	–	–	–
Ecosystem function	Secondary productivity	–	–	–
	Nutrient retention	4	–	–
	Disturbance regime	4	–	–

EBV categories are shown alongside a summary of biodiversity monitoring recommendations from HCV reports in Latin America and actual monitoring activities being implemented on RSPO certified companies in Colombia to show the gap between systems. On paper, "Species populations" and "Ecosystem structure" EBVs are relatively well-represented by monitoring recommendations. In practice, actual monitoring activities underperform. Asterisk (*) indicates monitoring activities that provide only partial or incomplete information toward EBV, either "presence-only" data or methods limited to one or few taxa.

as certified since companies have more room to interpret requirements (Potts et al., 2017).

Recommendation 1*: Management and monitoring recommendations in HCV reports could move from practice-to performance-based actions by being more prescriptive with indicators and methodologies. The HCV assessment team spends several weeks on plantations and in surrounding communities conducting field surveys, gaining a good sense of the local context* *(e.g. community conflicts). Instead of leaving companies to interpret the findings of m&m recommendations in HCV reports, a critical final stage of the HCV assessment should include a short workshop at the plantation to properly disseminate the HCV findings and capacitate plantation managers to design their m&m plan. The final HCV report should then summarize the results of the workshop, necessary next steps for m&m by the company, and the resources needed to implement the m&m plan.*

EMPHASIS ON OPERATIONAL OVER STRATEGIC MONITORING

Management and monitoring recommendations from HCV reports tend to focus on actions that are most feasible for the mill, relying on plantation workers to implement m&m plans. In a sample of eight palm oil mills interviewed in Colombia, companies performed better *operational monitoring*, or documenting the implementation of management activities, than *strategic monitoring*, collecting data on the ecological outcomes of management activities (Brown and Senior, 2014) (**Table 1**). For fauna, management recommendations are mainly centered around the threat of illegal hunting and try to deter this behavior through patrols, seizures, and posting signs. The main strategy to monitor the effectiveness of these activities on populations is through a photo-registry of incidental wildlife encounters (**Table S3**). Plantation workers and supervisors document animal sightings or unfamiliar plants during labor activities, and photos are uploaded to an application for consultants to identify species. Incidental encounters offer a creative way of empowering workers to contribute to biodiversity monitoring while raising awareness about HCVs on the plantation and may be sufficient for monitoring charismatic or common species (Jetz et al., 2019), but do not provide information on cryptic or less identifiable species. Importantly, these opportunistic data are unvalidated and do not provide reliable information on species absence, which is necessary for detecting local emigration and extirpation events, as well as immigrations and introduction, including invasive species (Jetz et al., 2019).

Only half of the oil palm producers interviewed in Colombia used some form of standardized and strategic monitoring, limited to surveillance rather than targeted monitoring of particular RTE species (Pereira et al., 2017). In addition to incidental encounters, three mills conducted periodic, active visual field surveys or walking transects. Transects were established in HCV areas (e.g., forest patches, riparian corridors) and conducted by trained surveyors—contracted field biologists, environmental engineers, or university students. One mill also hired former hunters from the local community for their ability to spot and identify animals. During walking transects, surveyors rely on visual detection or signs of animal activity (e.g., tracks, scat). The frequency of surveys varied from weekly, bi-weekly, or monthly (**Table S3**). Three mills also reported passive monitoring using camera traps in HCV areas on the plantation. While camera traps add a standardized and repeatable element to the sampling protocol, detection is limited to larger-bodied mammals and ground birds. Only one mill had its camera trap network in place long enough to track the presence-absence of species from year to year. Systematic biodiversity inventories, like those conducted for the initial HCV assessment, are not required unless there is a major change to the scope of the project (i.e., new plantings). This raises the risk that for companies who have no plans to expand and only monitor biodiversity through incidental encounters, there is virtually no strategic monitoring of management activities based on long-term biodiversity trends.

Essential Biodiversity Variables (EBVs) can be used to guide more standardized biodiversity monitoring on oil palm plantations by serving as an intermediate layer between primary data observed in the field and more derived indicators for policymakers (**Table 1**; **Figure 1**). EBVs should be biological state variables of wildlife populations with spatiotemporal dimensions (Schmeller et al., 2017); they can be derived directly from field observations or by aggregating multiple data sources using modeling or other computational techniques. These variables then offer points of comparison with other sites, species, or communities and allow data integration with other EBVs and information on change drivers to indicate system-level biodiversity trends. Drivers of change, or *what* drives populational trends, are not captured very well by EBVs (Geijzendorffer et al., 2016), but companies are relatively good at tracking these variables with operational monitoring (e.g., poaching or deforestation events, experimental crop management). Thus, both tiers of monitoring (i.e., strategic and operational) are complementary for effective long-term biodiversity management and monitoring.

The goal of HCV m&m is to determine species abundance and distribution on oil palm plantations, particularly as it relates to habitat quality of HCV areas. Thus, the EBV classes most relevant to HCV m&m are species populations, community composition, ecosystem structure, and ecosystem function (Pereira et al., 2013; Jetz et al., 2019) (**Table 1**). Specific variables from these classes might include species distribution and abundance, taxonomic diversity, habitat structure, and nutrient retention. However, there is currently a gap between these EBVs and actual HCV m&m recommendations and activities (**Table 1**). Furthermore, current fauna monitoring strategies in place on certified plantations in Colombia produce "presence-only" data for charismatic or common species, and do not provide a complete picture of species distribution and abundance (**Figure 1**). Assessing species population EBVs requires periodic (1–2 years) species inventories at the plantation and landscape scale that provide information for multiple taxa and can target cryptic and RTE species as well (Jetz et al., 2019). Cost-effective methods that meet these requirements are needed. Acoustic monitoring provides a useful approach for understanding the population dynamics of a target species (Campos-Cerqueira and Aide, 2016) or can be used to compare entire acoustic communities based on soundscapes (Furumo and Aide, 2019), creating an opportunity to link species population and habitat structure EBVs. Acoustic surveys are a good complement to camera traps that some companies are already using, and together these methods capture a greater variety of taxa.

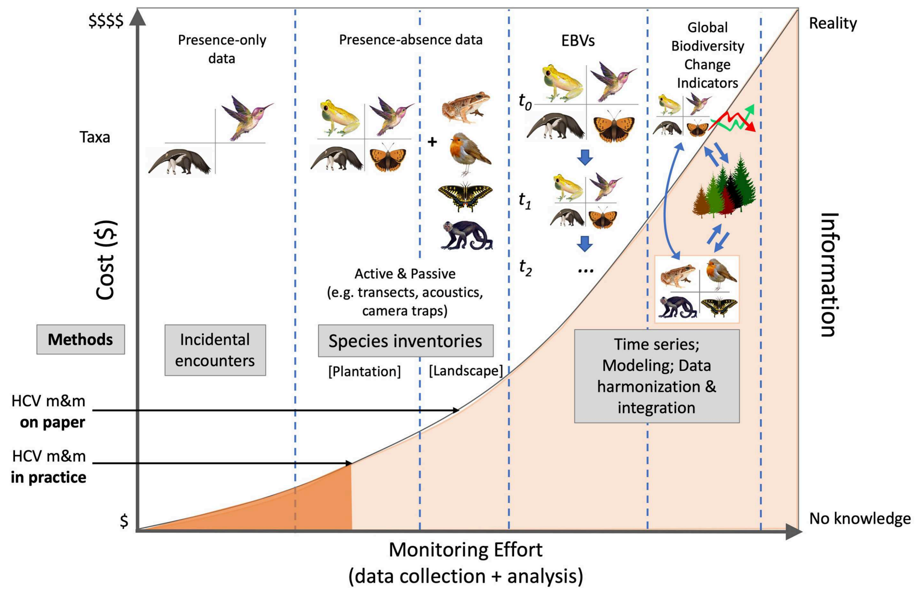

FIGURE 1 | Projected tradeoffs between improved biodiversity monitoring in oil palm landscapes and higher costs, mainly associated with analysis and interpretation of data. Area under the curve estimates the amount or quality of biodiversity monitoring acquired with different monitoring methods, and the taxa captured. Current monitoring efforts on certified plantations in Colombia are shaded in dark orange based on interviews with palm oil mills. Companies could standardize monitoring plans by utilizing EBVs (essential biodiversity variables), which can then be linked with global biodiversity change indicators across oil palm production regions.

Recommendation 2*: Strategic monitoring should be improved by introducing methods that capture 'presence-absence' data able to assess species population and community composition EBVs. These can be combined with ecosystem structure EBVs through vegetation surveys in HCV areas and operational monitoring of drivers of change (e.g. poaching, logging, reforestation projects) that companies are better at carrying out. Cost-effective species inventories can be obtained using passive monitoring (i.e. camera traps, acoustic recorders) complemented with incidental encounters of more common fauna. Sampling should be conducted in all parts of the plantation (e.g. crops, HCV, water courses, and forest fragments) and at the landscape level to understand how species move through the agricultural matrix.*

TECHNICAL AND FINANCIAL BARRIERS TO EFFECTIVE DATA COLLECTION AND INTERPRETATION

Lack of Experts

None of the companies interviewed in Colombia had any permanent biologists or technical experts on staff, and this lack of experts appears consistent across regions (Lyons-White et al., 2017). Only one mill had a full-time worker dedicated to the implementation of the m&m plan; others relied on administrators, supervisors, and workers to dedicate part of their time to m&m, and occasionally contracted experts for field surveys. After raw field data is collected, analysis and interpretation are key to understand if management activities are actually working. One company explicitly described their struggle with understanding how to utilize the information gathered from incidental wildlife encounters and field surveys. Beyond updating species lists, they were unsure how to extract meaningful ecological inferences from this data to inform and update their management strategies. With a lack of ecological experts on staff, companies will remain limited in their capacity for adaptive management and the continued need to consult experts will keep m&m costs high.

High Costs of Monitoring

Multiple companies initially intended to repeat flora and fauna surveys of HCV assessments every 2 years using hired consultants, but costs became prohibitive and management turned to the worker-based observation protocol. For instance, one company began with a budget of $25,000 USD for bi-annual surveys but instead opted for an application service that identifies species in uploaded photos and costs the company less than $10,000 USD per year. The recent drop in palm oil prices since 2016 was reported as a major barrier to allocating funds for m&m activities (Federación Nacional de Cultivadores de Palma de Aceite (Fedepalma), 2019). Costs associated with HCV monitoring were difficult to obtain, due to the conflated activities between m&m activities. Companies reported an annual m&m operational budget of between $0.70–2.15 USD per hectare of oil palm when standardized according to area planted (median = $1.16 USD/ha). Thus, an average-sized plantation in Colombia is allocating approximately $8,000 USD per year to m&m activities. These estimates should be interpreted with caution as they only represent direct costs (e.g., tree nurseries, equipment, consultants) and do not take into account the partial salaries of supervisors and workers that support m&m plans in addition to their labor duties.

***Recommendation 3**: Commercial plantations should staff at least one full-time biologist to coordinate m&m activities and interpret data. Agronomic engineers with a background in ecological principles may represent good candidates to provide further training for m&m capacity. University students provide a potential resource for cost-effective data collection, but professional experts are needed to synthesize monitoring data and update management activities accordingly. Offsetting the costs of monitoring may be the best approach for convincing companies to invest in better strategies, and there is much potential for increasing appeal by linking biodiversity with ecosystem services (e.g. pest control, soil fertility, pollination) that increase productivity and profitability.*

A NEW STRATEGY—CENTRALIZED, SECTOR-LED BIODIVERSITY MONITORING ON OIL PALM PLANTATIONS

Given the significant technical and financial barriers companies are facing, it is unlikely that the current HCV system underlying RSPO certification will result in meaningful biodiversity management and monitoring given the disproportionate burden placed on producers throughout this process. Though monitoring tools are becoming more affordable, increased data collection alone will have limited ability to characterize species distributions and abundance without a corresponding increase in data analysis and integration (**Figure 1**). If scientists and industry experts have not figured out how to lower the cost of monitoring while producing robust information that can inform management and policy, it would be unrealistic to expect companies to find this solution. Instead, we propose an alternative approach that centralizes biodiversity m&m at the sector level and we discuss how this could work in Colombia.

The National Federation of Oil Palm Growers in Colombia (Fedepalma) provides strong institutional support and leadership to the national sector, including a research branch, Cenipalma, which focuses on increasing productivity and has four experimental field stations from which they provide extension services and support to palm oil companies in different production regions. This high level of organization, research capacity, and geographic coverage provides an opportunity to centralize biodiversity monitoring in the Colombian sector and move beyond the focus of individual plantations to entire oil palm landscapes in different ecosystems. By centralizing monitoring efforts, costs could be reduced, and data could be more easily standardized. Such a system could be financed by creating a fund similar to the *Fondo de Fomento Palmero,* which takes a small percent (1.5%) of all palm oil sales and establishes a national purse for stabilizing palm oil prices and compensating the cost of exports (Law 138, 1994). Alternatively, a "per-hectare" rate based on the HCV areas identified and plantation size could be charged by Cenipalma to establish and maintain the project, including several full-time staff positions at their experimental stations (potentially replacing the need for a staff biologist on smaller individual plantations). Our study suggests that this annual cost should be less than $3 USD per hectare to ensure company participation.

Partnerships with local institutions (e.g., Alexander von Humboldt Institute) could help build the initial capacity in Cenipalma and determine the minimum amount of data needed from each plantation to define EBVs and sampling protocols. Data collection could be conducted by different actors: (1) *Palm oil companies*—Cenipalma could organize workshops to capacitate plantation personnel (i.e., staff biologist) to conduct surveys and loan them monitoring equipment (e.g., camera traps, sound recorders); (2) *Consultants*—independent experts or researchers certified by a third-party group; or (3) *Institutions*—Cenipalma could outsource data collection and analysis to local universities or NGOs through a request for proposals. The costs shared by companies and Cenipalma would need to be projected in each of these scenarios to assess potential trade-offs. Buy-in from downstream supply chain actors (e.g., traders, manufacturers) should also be explored, since these actors benefit from certified palm oil, but do not adequately compensate producers for improved biodiversity monitoring in price premiums. Cenipalma would maintain an online platform where raw data from each plantation is uploaded, consolidated, and made transparent, allowing species population EBVs for plantations to be derived and synthesized with other EBVs for habitat structure, composition, and ecosystem function at landscape and regional levels. Ideally, companies would use these results to update their management strategies, with support provided through plantation visits or regional workshops. Through coordination with other countries in Latin America and other palm oil producing regions (e.g., Asia, Africa), a set of global indicators for biodiversity conservation in oil palm landscapes could eventually be defined for policymakers.

Orchestrating data collection and analysis at the sector level would alleviate pressure on companies, reduce costs, and greatly increase standardization and consistency of methods across different regions, making results directly comparable and allowing robust EBVs to be built. Instead of requiring smallholders to engage in the same level of monitoring as commercial producers, mills could engage smallholder suppliers collectively, using findings to create wildlife-friendly farm designs that contribute to more sustainable production landscapes (Tscharntke et al., 2015). Fedepalma has already gained experience toward this with the GEF-funded Biodiverse Oil Palm Landscapes project that made strides in linking farm-level HCV areas with landscape management tools and ecosystem services (Espinosa, 2019).

Ultimately, improving monitoring could lead to market differentiation for Colombian palm oil. The sector already has the advantage of relatively low deforestation compared to other regions (Furumo and Aide, 2017) and recently signed the first ever national-level oil palm zero deforestation agreement (Tropical Forest Alliance (TFA) 2020, 2017); enhancing biodiversity conservation on plantations through improved monitoring would position Colombia at the vanguard of sustainability. By adhering to a standardized level of rigor and consistency, these efforts could result in value-added palm oil products packaged under a "biodiversity smart" label similar to the Smithsonian's Bird-Friendly coffee, distinguishing products on the marketplace and potentially helping to offset monitoring costs through price premiums. Such a label could be integrated with more comprehensive standards like RSPO or Rainforest Alliance and communicate to consumers that companies are informed about the biodiversity on their plantations and are taking meaningful conservation action.

DATA AVAILABILITY

All datasets generated for this study are included in the manuscript and/or the **Supplementary Files**.

AUTHOR CONTRIBUTIONS

PF designed the study, collected and analyzed data, interpreted results, and wrote the manuscript. EB-G, JE, GG-Z, and TA assisted with data interpretation and contributed to the discussion of the manuscript.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/ffgc.2019.00046/full#supplementary-material

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Conflict of Interest Statement: TA is the founder of Sieve Analytics, an acoustic biodiversity monitoring company.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.