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The Commons of Conservation Technology? Examining the Social Dimensions of an Open Source Insect Monitor

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Abstract

1. With increased calls for open science practices in wildlife conservation and ecological research, open source technologies (e.g., acoustic monitors, environmental sensors, and satellite tags) are emerging in the field. In this article, we describe the social and

ecological dimensions of open source conservation technologies by analysing how they embody relationships among people, technologies, and nature through the sharing of common resources.

2. Using multi-sited ethnographic fieldwork, we studied how the Mothbox, an open source nocturnal insect monitor, is used in restoration projects in Panama and at an international conference on digital technologies for field biology in Indonesia. This research adopted a descriptive and interpretive approach, drawing on participant observation, interviews, and the lead author's experience fabricating open source instruments for ecological research.
3. By analysing the Mothbox project as a network, rather than a static technical object, we identified relationships among technologists, researchers, hobbyists, community organisers, communities of practice, development methodologies, and environmental conditions that were crucial to the establishment and continuation of the open source project.
4. We discuss how material practices rooted in observational data collection, shared customs and norms from the hacker movement, and the Mothbox's open source design negotiate power and govern resource exchange within the network. The intermingling of these material, craft, and social practices produces a moral economy in which knowledge, skills and physical goods are circulated as both commodities and gifts. We demonstrate how nuanced gift-commodity exchanges mediate relationships within the network and support the collective governance of shared resources as the commons.
5. Based on our empirical analysis, we argue that the methods of field biologists, the social practices of hackers, and the open source design of the device sustain the commons in the Mothbox network. These research findings broaden our understanding of how open

source and “common” technologies for ecological research are developed and used. Furthermore, we posit that examining technical objects in conservation projects allows for critical analysis of social and technical relations in ecological research.

1. Introduction

In October of 2022, a flurry of open source scientific instruments arrived in Panama as part of a four-day gathering of the global open science hardware community. Pipetting robots, 3D-printed microscopes, air-quality monitors, and modified camera traps were scattered throughout the conference as the group convened in person for the first time in four years. In the field of open science hardware, communities rally around a shared goal: making open source instruments ubiquitous in scientific research (Gathering for Open Science Hardware, 2018). Two years later, the open science hardware movement continues its journey across the isthmus, with a new open source insect monitor emerging in the conservation technology scene. This device, known as the Mothbox, was created by a team of hardware developers and ecologists in Panama for landscape-scale insect monitoring.

The adoption of the UNESCO Recommendation on Open Science (United Nations Educational, Scientific and Cultural Organisation, 2021) reflects the growing popularity and global reach of the open science movement. Today, many researchers are familiar with open science practices throughout the research lifecycle, from open-access journals to open source statistical software (e.g., R) (Hampton et al., 2015). The recommendation was a pivotal moment for the open hardware community, as it explicitly mentions the need for open science infrastructure, that is, open source research instruments, tools, and technologies (both hardware and software alike). Scientific instruments, such as environmental monitors, sensors, microscopes, or even biological reagents, are considered to be open source when their design is made publicly available so that anyone can study, modify, distribute, make, and sell the design or object (Gathering for Open Science Hardware, 2018; Open Source Hardware Association, n.d.). Open source hardware is often described as a cost-effective replacement for proprietary scientific tools, with reported high returns on investment (Pearce, 2015) and economic cost savings of up to 87% (Pearce, 2020).

The low cost and accessibility of open source hardware benefit field biologists by increasing adaptability, reducing upfront and maintenance costs, and improving transparency and reproducibility (Hill et al., 2019; Hsing et al., 2024). There are several examples of open hardware for ecology and wildlife conservation, including acoustic monitors (Hill et al., 2018), satellite tags (Beuchert et al., 2023) and environmental sensors for remote fieldwork (Fieldkit, n.d.). Fine-tuned automated species detection is on the rise due to advancements in computer vision, and we are witnessing the emergence of automated monitoring technologies (Bjerge et al., 2021; Möglich et al., 2023) for insects. Despite being the most diverse class of animals (Stork, 2018), insects are significantly understudied and underrepresented in biodiversity datasets, protected area coverage, and conservation assessments (Chowdhury, Jennions, et al., 2023; Chowdhury, Zalucki, et al., 2023; Troudet et al., 2017) and an estimated 80% of all insect species remain undescribed (Stork, 2018). To address these knowledge gaps, entomologists and conservationists are calling for the use of novel technologies, including computer vision and camera trapping, to improve the collection of insect biodiversity data (Van Klink et al., 2022; Van Klink et al., 2024).

The Mothbox is a nocturnal insect monitor that uses light to attract and photograph nocturnal insects (Szczygieł et al., 2026). In this study, we examined the do-it-yourself (DIY)

Mothbox version, which is made with off-the-shelf materials that are easy to source and cost roughly 375 USD to assemble. The entire device weighs 2.5 kilograms, making it lightweight and portable for field deployments. Its core electronic components consist of a light attractant (the Mothbeam), a Raspberry Pi, an Arducam 64MP camera, LED microscope ring lights for camera flash, and 12V batteries and regulators (Figures 1 and 2). A Plano 1460-00 box houses the internal components, with two laser-cut acrylic arms and a target attached to the housing, providing a surface for insects to land on for photography (Figure 2). To assist users with data processing, project developers created ‘Mothbot’, a series of Python scripts that enable taxonomic identification of organisms in photos taken by the Mothbox (Szczygieł et al., 2026). These scripts rely on the Ultralytics YOLOv11 (Redmon et al., 2016) computer vision model for object identification and BioCLIP (Stevens et al., 2024) for taxonomic prediction. All software, firmware, and hardware are licensed under the open MIT and CERN-OHL-W licenses (Digital Naturalism Laboratories, n.d.-b; n.d.-c), and project documentation is publicly available on GitHub under a Creative Commons Attribution (CC BY 4.0) license (Digital Naturalism Laboratories, n.d.-a).

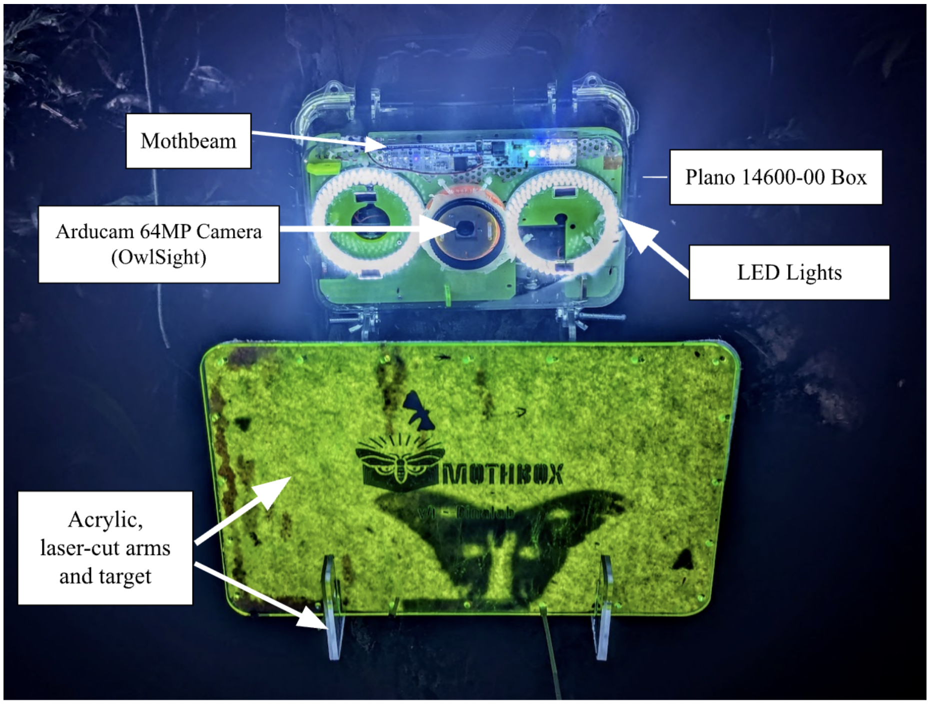

Figure 1. Photo of a deployed Mothbox (DIY version) with labelled external components. Components include the Mothbeam light attractant and the Arducam 64MP Camera, which takes photos of insects that land on the acrylic laser-cut arms and target, which are illuminated by the LED lights on either side of the camera. All electronic components are housed in a weatherproof Plano 1400-00 box. Credit: Digital Naturalism Laboratories CC BY 4.0

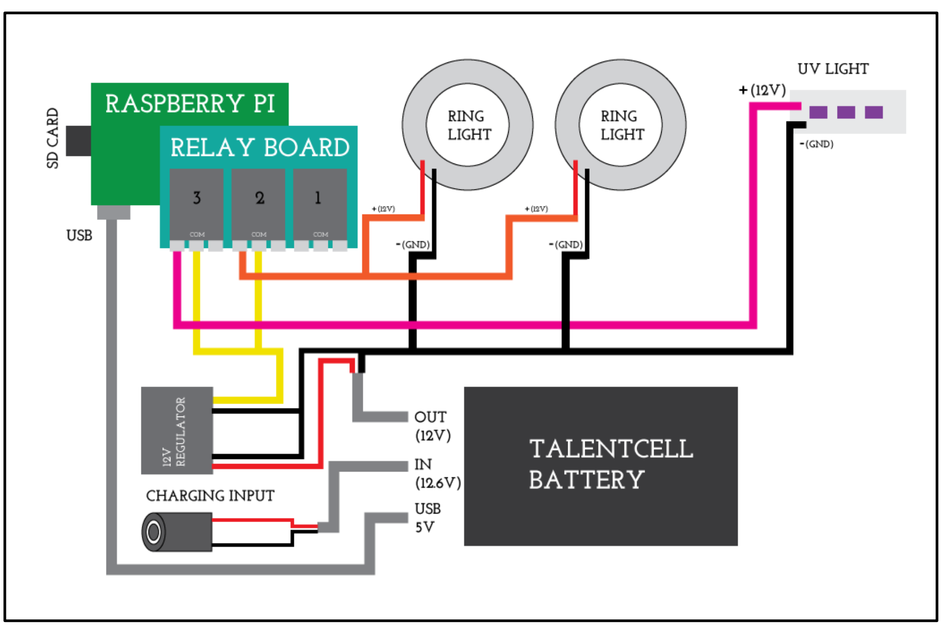

Figure 2. Circuit diagram of the internal electronic components for the Mothbox (DIY version). The circuit diagram shows key technical components critical to device functionality, including the Talentcell battery, Raspberry Pi (and accompanying relay boards), Mothbeam (represented by UV light in this diagram), regulator, and charging input. Credit: Digital Naturalism Laboratories CC BY 4.0

Our research provides an empirical account of the development of open technologies (namely, hardware) for ecological research, drawing on Actor–Network Theory approaches in science and technology studies that explicitly focus on technosocial and socioenvironmental relations. Using qualitative methods, we describe a "heterogeneous assemblage" of human and nonhuman "actors" that constitute the Mothbox network (Akrich, 1992; Callon, 1984; Latour, 2005; Law, 2011). The lead author of this study conducted ethnographic fieldwork for 10 months in Panama and Indonesia, utilising participant observation, field interviews, and autoethnography to examine how open source technologies for insect monitoring are used in wildlife conservation and biodiversity monitoring. Through careful analysis of human and nonhuman actors in an open source conservation technology network (the Mothbox project), we unpack how a "technical object" (the Mothbox) is not a static, physical object but rather an assemblage of social, ecological, and technical relationships.

We begin our discussion by identifying a typology of human actors in the network based on disciplinary boundaries, including researchers, technologists, hobbyists, and community organisers. We describe non-human actors such as communities of practice, development methodologies, environmental conditions, insects, and components of the technical object itself. We then argue that the Mothbox is a *de facto* standardised instrument (or a technology that negotiates power) (Busch, 2011) due to the existence of a moral economy in the network, where the exchange of services and goods is mediated by shared norms and obligations (i.e., fairness) rather than material gain (Thompson, 1971). The moral economy of the Mothbox network is the result of the methods, or "craft practices" (Kohler, 1994), of field biologists, the social practices of hacker culture, and the Mothbox's open source design. From here, we delve further into the network's varied modes of resource exchange and describe the presence of both commodities and gifts. We conclude that social obligations, carried out through acts of gift-giving in the Mothbox network, sustain the collective governance of resources (knowledge, skills, and physical objects) outside the market and the state, as part of the commons (Ostrom, 1990).

2. Methods and Positionality

This paper is the result of years of community organising within the open science hardware movement. Several of the coauthors on this paper are actively involved in the free and open source software and hardware movement and in communities of practice such as the Gathering for Open Science Hardware (GOSH) and the Open Source Hardware Association (OSHWA). The authors also reflect the varied disciplinary realms present in this research project: interdisciplinary researchers, anthropologists, hardware developers and ecologists, many of whom were co-participants in the research project itself. To examine the Mothbox network, the lead author of this study conducted multi-sited ethnographic fieldwork from November 2024 to September 2025, following the Mothbox project across Panama and Indonesia as well as online spaces. Field sites included a prototyping studio in Panama, where hardware developers were building Mothboxes, restoration projects on the Azuero Peninsula of Panama, where field biologists used Mothboxes to assess nocturnal insect diversity, and a month-long conference in the northeast of Bali, Indonesia, focused on developing technologies in nature. Online spaces included meetings with the core Mothbox team and project funders, user testing sessions, and meetings with open science hardware vendors seeking to establish a distributed manufacturing network for the Mothbox.

While studying (and actively participating in) the Mothbox network, the lead author conducted online and in-person interviews in English with 5 co-participants between April and September of 2025, including ecologists, hobbyists, technologists, and community organisers. Countries of origin (Australia, Costa Rica, India, the Philippines, and the United States) and residence (Australia, Cambodia, Indonesia, and Panama) varied amongst co-participants, reflecting the globally distributed nature of the network. Although several co-participants were residing in the countries where fieldwork was conducted (Panama and Indonesia) and had long-established networks, they were not born there. Rather than following a formal recruitment process, interviews arose from serendipitous interactions with co-participants. This approach reflects the lead author's *embeddedness* in the community, and we supplemented interviews with participant observation, analysis of physical and digital artefacts, and autoethnography.

As an active participant in the Mothbox network, the lead author utilised autoethnography to connect personal experiences as a technician to broader patterns that emerged from participant observation and interviews with other actors in the network. Historical accounts of scientific research often overlook the technician's perspective (Shapin, 1989), and incorporating this perspective is key to uncovering invisible relations within the network. Ethnography of technical systems ultimately requires an ethnography of the infrastructure surrounding the technical object of study. These elements of communication, workflow, and physical structures are often “behind the scenes” and may otherwise reveal invisible relationships not immediately apparent to the ethnographer or through participant observation alone (Star, 1999). In this ethnography of infrastructure, we analysed GitHub repositories of software code, documentation, design files, schematics, meeting notes, and individual components of the technical object. We used the data visualisation and network analysis tool Gephi to create a map of the institutional linkages surrounding the Mothbox (Figure 3). Network nodes included key organisations and individuals selected using an ego-centric network mapping approach that prioritised actors crucial to the development of the Mothbox (LeCompte et al., 1999).

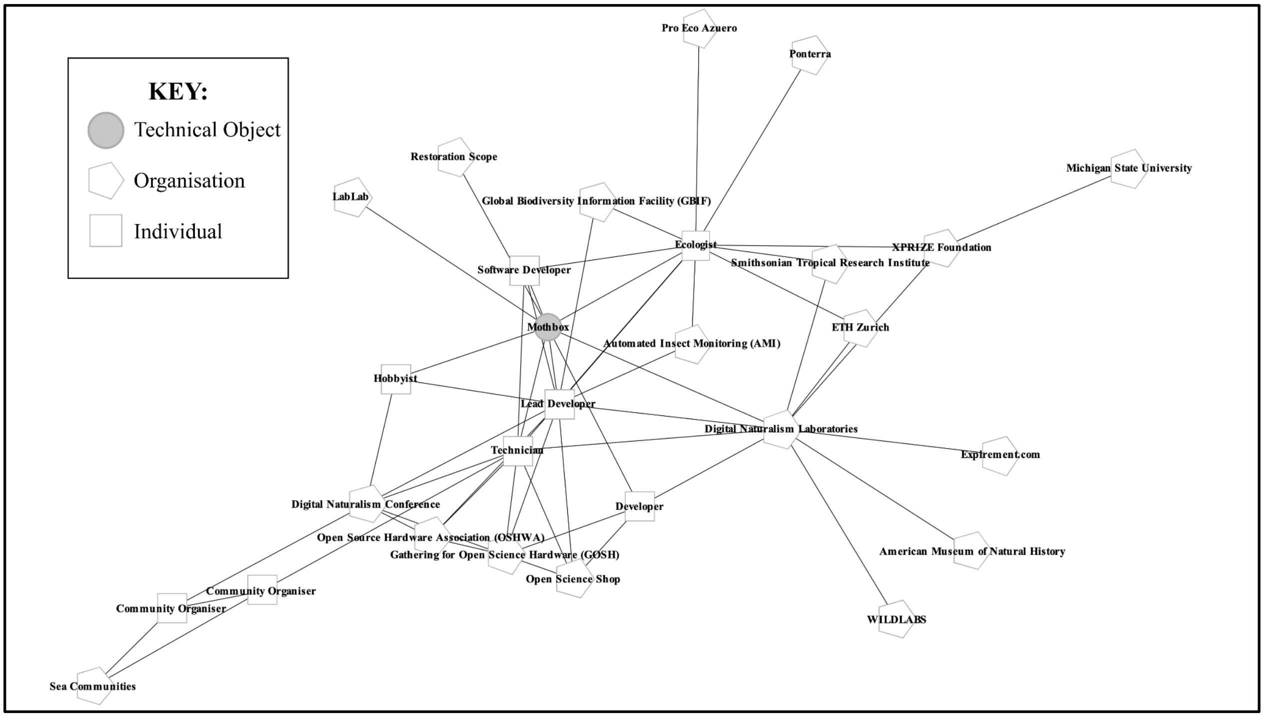

Figure 3. Network map of individuals and organisations involved in the development of the Mothbox project. Actors were selected from the empirical material based on their relevance to the Mothbox project, including funding, deployment, and device development. The figure represents the Mothbox network during the data collection period (November 2024-September, 2025) and does not reflect the full network of actors. Its purpose is to illustrate the institutional connections present in the Mothbox project.

3. Description of the Mothbox network

3.1 Origins of the Mothbox project

The initial development of the Mothbox resulted from a close working relationship between two actors: an ecologist and a hardware developer, and their goal to adapt existing technologies for insect monitoring for scalable use in tropical ecosystems. These two actors became the central nodes of the Mothbox network (Figure 3). The ecologist conducted the earliest prototyping of the Mothbox while designing scalable monitoring systems for reforestation projects in the Azuero Peninsula of Panama. He was eager to develop a scalable solution for nocturnal insect monitoring and used an automated light trap he found in an academic article as a launching point: "[...], and then I found this paper published in 2021, [author name], that outlined an automated light trap for moths, basically, like an automated camera trap-moth sheet type deal. And I thought, perfect. Well, great. Well, that's my solution. " However, technical limitations led the ecologist to ask a developer at Digital Naturalism Laboratories for help constructing the device's electronic components, who became the lead developer of the Mothbox project: " [...] and he [lead developer] helped me with electronics, I had no clue about anything to do with Raspberry Pi, so [lead developer] solidly helped me with getting a basic operating system going." This was the moment when the core Mothbox team emerged, comprising the ecologist and two developers from Digital Naturalism Laboratories.

The subject of Digital Naturalism and the location of Digital Naturalism Laboratories are crucial to establishing the Mothbox project. Digital Naturalism is a design framework for developing field biology tools where they will be used (in the field), rather than in a controlled laboratory elsewhere (Quitmeyer, 2017). Digital Naturalism Laboratories is a prototyping studio and field station nestled in a small town on the Panama Canal. The studio's location is strategic;

this town is home to one of the Smithsonian Tropical Research Institute's (STRI) main facilities, as well as the docks researchers use to reach another STRI research facility on Barro Colorado Island. The research institute attracts hundreds of researchers from across the globe to Panama each year, including the ecologist working on the Mothbox project. A meta-analysis by Boyle et al. (2025) found that 40.5% of publicly available datasets on tropical insect population trends are from Barro Colorado Island, and although STRI does not directly contribute to the development of the Mothbox, its sphere of influence on tropical insect monitoring undoubtedly shaped the device's development through researcher collaborations and permits (Figure 3).

In the early days of Mothbox development, funding for the project was piecemeal, often coming from small grants (ranging from 1,000 to 10,000 USD) and from research labs, NGOs, and start-up businesses connected to the ecologist. While these sources of funding supported the early prototypes of the Mothbox, the stable, field-ready version used today depended on sustained, long-term funding. This came to the Mothbox project in April of 2024, when the team received a 60,000 USD grant from WILDLABS, a global conservation technology network. This was succeeded by a second 50,000 USD grant from WILDLABS in 2025. Funding from WILDLABS was a pivotal moment in the project's chronology, enabling the network to expand and bring in new collaborators and additional funding, as the ecologist describes:

> [...] with this WILDLABS Grant as a core piece of money to keep the project alive, it allowed us to get more money from other sources. I think that was another kind of important bit where if we hadn't had that, [employer] wouldn't have chipped in, we wouldn't have had the pile on.

It is worth mentioning the role of the environment and non-human (but still living) actors, such as the insects themselves. For instance, the relationship between nocturnal insect behaviour (attraction to light) and the Mothbox imposes design choices on the technical object, such as incorporating light attractants (Figures 1 and 2). The environmental conditions of the Azuero Peninsula in Panama, where the Mothbox project was first developed, further influenced the design of the device, so that it could be "[...] weatherproof, work in the tropics, lightweight, where [...] I [ecologist] throw a bunch of them in a backpack and go somewhere remote." The Peninsula is marked by rolling crestlines and fragments of tropical dry forest interspersed with cattle ranches. It is a popular tourist destination and is rife with environmental restoration projects aimed at undoing the negative impacts of expansive agricultural practices. The lead author witnessed firsthand the relationship between the technical object and the natural terrain when deploying Mothboxes with field crews in the southeastern tip of the Peninsula. She found herself traversing steep hills, at times crawling on her hands for balance, listening to Mothboxes tossing around in her backpack. The clunking of plastic cases evoked an understanding of the rugged design of these devices and their relationship to a certain environmental landscape.

3.2 Expansion of the Mothbox network and inclusion of new human actors

The expansion of the Mothbox network led to the emergence of human actors with relatively stable identities, namely technologists, hobbyists, researchers, and community organisers. These identifications were established based on descriptions participants provided of themselves in interviews and field observations, in which interlocutors shared information regarding their occupational background and/or disciplinary expertise. This typology of human actors can be divided into two defining roles: *the development* and *use* of the technical object, with technologists and hobbyists working in the former realm, and researchers and community organisers focusing on the latter. It is important to note that many of the human actors selfidentified as more than one of the above typologies (e.g., identifying as both a technologist *and* a community organiser). Nonetheless, this typology reflects our interpretive analytical approach to the ethnographic material.

Technologists include hardware and software developers, as well as technicians who provide paid or volunteer labour for the project. These actors provide development work that extends beyond device functionality, addressing higher-level organisational concerns such as project scaling, deployment, and device manufacturing. We describe these actors as involved in the development of the Mothbox project as a *whole,* rather than just the device itself. We provide an example of this approach when the lead developer, the ecologist, and a volunteer software developer created a new software platform to classify Mothbox data. The software developer described the importance of not only creating a platform that works, but that has broad applicability across a variety of users:

> Because for [the] Mothbox to be useful, it needs to be used by others, people other than [the ecologist], right? So we need to think about when [ecologist] is not around, and he's not piloting, and a person is starting from scratch, how will they learn? How will they use these tools?

This statement brings to the surface the relationship between the technical object and the technologist: the technologist reshapes the object in response to an ever-expanding web of users. Thus, technologists frequently act as an interface between users and the technical object, as demonstrated by a conversation had between the software and hardware developers and the ecologist during a recurring user testing meeting for a new application the software developer was building:

> [Ecologist] chimed in to say that one technical challenge is how to go from the field to uploading data. He says that "it's impractical to do data input electronically in the field" and that they need to rely on field sheets in order to collect the data they need. [Lead developer] adds, "The hardest part is getting field technicians to write down data." [Ecologist] continues by saying, "You go from the paper sheet to going to sit down and add it to a form. And sometimes, this doesn't happen." [Software developer] then discusses how it's crucial to make inputting metadata the first step in this process and ensuring that you can't continue the process until you've done this step. That it should be mandatory and first in the workflow.
>
> - Lead author's fieldnotes, September 4th, 2025

These minor frustrations in user workflow (from deployment to data management) reveal how the technologist's work often lies at the nexus of the user and the device.

However, technologists are not the only human actors involved in Mothbox development. The hobbyist is another developer identity in the Mothbox network, and, in contrast to the technologist's work, the hobbyist tends only to be involved in developing the technical object itself, on a volunteer basis. They are enthusiastic about developing open technologies and describe working on technologies as a leisurely activity rather than an occupation:

> I've done a number of international projects helping people out. People pop up on Discord in some of the channels and say, "Hey, anyone know electronics, and you know, want to help?" I'm doing this…. anyone want to help us out? But then, I helped a guy who was living in Arkansas, [...] and he wanted to build an open source metal printer. [...] he was using a prototype board… and I'm going - prototype PCB… Let's make a specific board. And it was beautiful. So I made this PCB. It was quite large, nearly a foot in size,

> but you break off each section and you build a stack of PCBs. There'd be the tank on the top, and then underneath would be two nozzle plates, and you'd lay the [...] filament in between all the nozzles, line it all up, and I had dotted lines for everything, and then you'd bolt it all tightly together. And then I designed a driver, with really high current, to ignite everything. And I spent about six months on it. And I'm retired, so I could just work on it.

In the Mothbox network, the collaboration between hobbyists and technologists is crucial to improving device functionality. While travelling with the Mothbox to the Digital Naturalism Conference (Dinacon) in Bali, Indonesia, the hobbyist emerged as a key identity in the Mothbox network. Dinacon is a month-long gathering of engineers, makers, artists, and activists using digital technologies to interact with nature, and the Mothbox was one of nearly a hundred projects that found their way to Dinacon. The Mothbox's arrival at Dinacon coincided with a new phase for the project. The core Mothbox team was now determined to make the Mothbox mass-manufacturable; however, this meant developing a version with a new printed circuit board (PCB) that would significantly reduce assembly time, effort, and cost. The lead Mothbox developer sought help designing the PCB, and that help came from a hobbyist attending Dinacon. Dinacon serves as both a physical event and a community of practice, and was instrumental in connecting these two actors. In the beginning, the process of creating this new PCB was serendipitous, emerging from passing moments throughout the conference, where the developer would ask the hobbyist a question about a particular element in the new PCB design whenever they bumped into each other (often before a quick swim in the nearby ocean). The lead ethnographer’s fieldnotes capture the convivial nature of these interactions during an open day at Dinacon, where participants (and the general public) could learn more about the projects at the conference:

> I sat down at our Mothbox booth with [lead developer], where we had one Mothbox (with arms and a target attached) resting on the table, accompanied by a small sign that read, "Learn more about the Mothbox." Soon after, [hobbyist] walked up and asked us how things were going with the new Mothbox PCB. [lead developer] jumped up to grab the new PCB from HQ [conference headquarters] and brought it back to show [hobbyist]. [Lead developer] explained that there have been a few malfunctions so far with the PCB, mainly a few capacitors and transistors exploding and burning out on the board. When [lead developer] was explaining this, [hobbyist] began providing [lead developer] with advice regarding why these parts were malfunctioning, and said, "We can look through the diagrams together."
>
> - Lead author's fieldnotes, June 29th, 2025

The collaboration between the two deepened, and they began working together for extended periods, with the hobbyist explaining to the lead developer why specific changes were needed for the PCB to work. After the event ended, the hobbyist continued working remotely on new PCB designs, committing modifications to the Mothbox project's GitHub repository. They continued to build prototypes together until January the following year, and distributed over 100 PCBs worldwide. The involvement of the hobbyist in the Mothbox network was a crucial step towards developing a mass-manufacturable device and defining the relationship among the technologist, the hobbyist, and the technical object.

We identified researchers as the core user audience for the Mothbox. Researchers who used Mothboxes were often ecologists or field biologists interested in collecting insect data. In the Mothbox network, users frequently impose design choices on the device. For the researcher, these choices are rooted in scientific inquiry, as indicated by the ecologist's rationale for designing the initial Mothbox prototype:

> Okay. So I was designing a system for scalable biodiversity monitoring. This is before [employer] even existed in the tropics. So that is kind of the goal. I want to measure biodiversity in a scientifically accurate way, but a way that can be scaled across a landscape and can be applied to other regions of the world pretty similarly without major changes.

Researchers use scientific instruments to answer particular research questions. The scientific method relies on systematic results, and researchers' desire for rigorous data further influences design choices. When discussing the challenges of implementing open source hardware, the ecologist said, "it needs to be valid, [...] scientifically valid and tested", indicating the researcher's desire to use a technology that provides value in the form of viable scientific outputs.

There is, however, another type of user whose relationship with the technical object reassigns meaning within the network: the community organiser. While the developer and the hobbyist physically reshaped the Mothbox's electronic infrastructure at Dinacon, the community organiser was busy reshaping its meaning. Many Dinacon participants are longtime activists in the open source movement, and the event was co-organised with Sea Communities. This organisation delivers community-based education programmes in the northeast of Bali. Sea Communities' flagship project is a coral reef restoration initiative that is led by a conservationist and scuba diver who was formerly a cyanide fisherman in the community. The convergence of community organisations and activists at Dinacon allowed for the technical object to extend into community organising networks. Community organisers' use of open technologies and relationship to scientific endeavours differed from that of researchers, as they establish clear political and economic uses alongside scientific inquiry, as described by one of the conference co-organisers from Sea Communities:

> Our model is to look for a community with very rich experience tackling a problem and have something to show for it already. Here, in this case, we have [conservationist] who decimated their reef and then changed their ways and started experimenting on different kinds of structures to resuscitate their coral reef. Our work is to allow that experience, that knowledge, to be shared to a wider community, also to add science to it, then use that to generate livelihood opportunities for the village by creating tourism activities and also sometimes they network directly, and set up projects that are not tourism-based, but are livelihood-based.

The same co-organiser took a particular interest in the Mothbox during Dinacon, and the lead author would often venture into nearby forests with him to deploy Mothboxes together with other conference attendees and translators from Sea Communities. When describing his experiences working with open science projects such as the Mothbox, he emphasised that "citizen science" projects need to be integrated into the local community and provide value, stating that “the Mothbox is not just a research tool. It's an educational, market, and tourism tool.” At the end of the conference, the lead developer left behind two Mothboxes for Sea Communities to use, asking only that they regularly field test them. The community organiser shared that he wishes to incorporate Mothboxes into educational tourism projects and plans to connect with local universities to explore potential citizen science projects involving the Mothbox.

During its travels, the technical object revealed its fluidity, that is, it showed that there is no definitive way for someone to develop or use the Mothbox: it exists in constant flux (de Laet & Mol, 2000). On the Azuero Peninsula in Panama, the device was a sensor that detected landscape-scale changes in insect diversity. In Bali, the device reconstituted itself as a tool for educational tourism. The Mothbox manifests as a physical representation of how network actors constitute themselves and how meaning is translated at a particular moment in time, demonstrating the "process of reciprocal definition" (Akrich, 1992, p. 222) between technical objects, the environment, and human actors.

3.3 Exclusion and identity in sociotechnical networks

While the expansion of the Mothbox network led to the inclusion of several new actors, there were also moments when exclusionary aspects came to the fore. One interlocutor shared the risks of travelling with Mothboxes as we packed up Mothboxes before his trip home from Dinacon, saying, "This is the barrier to open source hardware." When the lead author asked him to clarify, he explained that having to carry these devices (whose wires and internal electronics are visible) in checked baggage when crossing borders is a limitation of open source devices. He expressed anxiety about being racially profiled by airport security when travelling across borders with so many loose electronics.

The typology we created captures the array of human actors in the Mothbox network as it expanded. It is crucial to note that this typology clusters around disciplinary boundaries and technical expertise, rather than around identifications such as race, gender, and class (although many participants discussed their country of origin and residence with the lead author). This reflects that these self-identifications were not prominently featured in the ethnographic material, an analytical point that links our empirical findings to existing discourse on diversity advocacy in hacker movements. The work of Christina Dunbar-Hester in *Hacking Diversity: The Politics of Inclusion in Open Technology Cultures* (2020) captures the tensions that arise when the political actions of diversity advocates confront open technology spaces that are dominated by a white, cis-male, English-speaking technical elite. Dunbar-Hester provides a detailed account of the dissonant approaches to recruiting and retaining women in hackerspaces, ultimately arguing that neither technological solutions nor diversity activism is sufficient to enact societal change. If diversity advocates seek justice within the hacker movement, they must seriously grapple with the discernments surrounding identity, labour, and the workplace. Representation is not a sufficient tool for assessing power relations, and a critical approach to redistributing geopolitical power within the hacker movement is needed.

While discussions of identities such as class, gender, or race were rare, that does not mean the ethnographic material was devoid of politics. Openness and sharing, as means of egalitarianism (discussed in more detail in the sections below), emerged prominently throughout the ethnography. However, idealised notions of sharing and openness as emancipatory practices stand in contrast to a reality in which technical expertise is a limitation. An autoethnographic excerpt from the lead author’s fieldnotes, whose first hands-on experience fabricating open hardware was with the Mothbox project, demonstrates this tension:

> [Developer] included non-technical folks [referring to those with limited knowledge of electrical engineering], such as [interlocutor] and me, in the process of creating a PCB, giving us a glimpse into the inner workings of the design process for an open hardware tool. While I looked at the program and understood the basics, there was only so far I could go without a technical background. For instance, when looking at [developer]

working on KiCad, I often wondered - why a resistor there in the circuit? Why a certain voltage for the whole system? Clearly indicating I didn't have the same background knowledge as the technologist/engineer.

- Lead author's fieldnotes, June 5th, 2025

3.4 Components as nonhuman actors

The Mothbox is not a static device but rather an assemblage of several technical objects. Some components of the Mothbox, such as regulators, batteries, and LED lights (Figures 1 and 2), are interchangeable, so no single *type* is required for it to work. One could walk into their local hardware store and purchase a 12V battery from one brand to power their Mothbox, or order a battery from a different brand online. Other components, such as the Raspberry Pi and an Arducam 64MP camera, are harder to substitute, and their relationships with other network actors can impose hefty design changes on the technical object. For example, when the project's data curation platform caused significant delays in data processing, the ecologist and lead developer had to reach out to a software developer to help design an entirely new platform.

Examining this network of technical components reveals the inherent ambiguity in open science hardware devices. Open hardware differs from software in that it can embody both hardware and software components simultaneously. Additionally, an open hardware device can consist of open source or proprietary components, leading to challenges in defining (and ultimately licensing) open science hardware (Figure 4). However, there are opportunities for networks to establish clear boundaries through communities of practice. One afternoon at Dinacon, community organisers from the Open Source Hardware Association ran a session on open source hardware certification and licensing. The organisers did not shy away from the difficulties of defining open source hardware, emphasising that you cannot control every component within an open source device. However, it is more important to “open up what you can control” in your project and to license its documentation appropriately. The relationship between these technical (components) and organisational (communities of practice) actors sets norms and shared definitions of open hardware, establishing the foundation for a standardised open source scientific instrument.

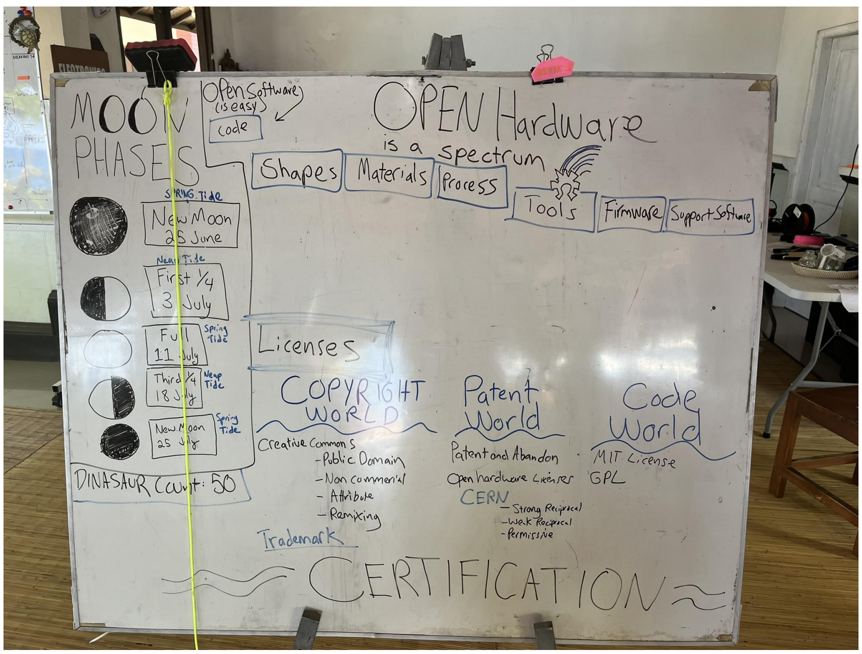

Figure 4. Photo of whiteboard display from Dinacon of different definitions and licensing schemes for open hardware. The whiteboard presents a multifaceted definition of open hardware, noting that it exists on a spectrum: it encompasses tangible objects such as materials and tools, as well as intangible properties like processes. The whiteboard also highlights the complexities of licensing open hardware by listing various schemes related to copyright, patents, trademarks, and software code that can aid open hardware projects. Credit: Brianna Johns CC BY 4.0

When we take into account all the sociotechnical actors in the Mothbox network, they are not separate entities but rather a heterogeneous assemblage of relations that constantly influence one another (Akrich, 1992; Callon, 1984; Latour, 2005; Law, 2011). For instance, a budding collaboration between a hobbyist and the lead developer results in a new Mothbox PCB design; however, these actors may not have crossed paths were it not for their shared membership in a community of practice. Platforms such as GitHub enable hobbyists and hardware developers to share PCB schematics, granting them access to the technical object via open source design files. It is through this heterogeneous assemblage that a standardised form of the technical object is created.

4. The "craft" practices of field biologists and the emergence of a standardised instrument

In the early 1900s, a group of geneticists at Columbia University began conducting experiments with the common fruit fly, *Drosophila melanogaster*. The use of *D. melanogaster* in their lab established the fly as a standard laboratory organism, and it remains commonplace in biological experiments today. In Kohler's (1994) book *Lords of the Fly: Drosophila Genetics and the Experimental Life,* he uses the experimental practices involving *Drosophila* to demonstrate the material and social conditions that give rise to a standardised organism in scientific research. He illustrates how the material culture, or "craft practices", of these early geneticists favoured the fly's cosmopolitan evolutionary traits, resulting in the fly becoming the model organism for laboratory experiments. Over a century later, we are following the Mothbox on its journey through the tropical forests of Panama and Indonesia as it becomes a standardised tool for ecological research. At the turn of the 20th century, a particular craft practice established itself as a mainstay in genetic scientific laboratories: experimentation. The succession of experimental practice in the laboratory created a need for the ideal experimental creature, which is how *D. melanogaster* found its niche. The material culture of field biologists and wildlife conservationists is primarily observational rather than experimental. Their craft practice exists in an age of mass species extinction (IPBES, 2019), where data availability determines conservation area designation (Farooq et al., 2026), and market-based mechanisms quantify biodiversity in economic terms (Miles et al., 2025). Researchers are seeking technologies that can collect high volumes of data across large spatial and temporal scales, placing selection pressure on the technologies they choose to use (or, in the case of the Mothbox, develop). When interlocutors were asked about their experiences with open science technologies, nearly all emphasised the importance of meaningful data collection and stewardship. What interlocutors describe as meaningful data is context-dependent, whether it be for data-driven conservation projects, as is the case for the ecologist:

> The idea is you can save time, you can save time, tons of time in monitoring whole insect communities relative to… things where you need to trap and pin them. Like, if you have physical samples, it's a whole level of complexity, and you need to spend a lot of time pinning and identifying things. So, photos are great because you now have the photo, and that's your voucher, basically. And now with the rise of, like, computer vision and things like that, we have ways of processing these huge amounts of data. If you had a Mothbox without the AI, it would still take tons and tons of time, maybe less than pinning, but at that point, like, you're still losing data.

Data collection could have an explicit political goal as well, as one technologist describes:

> So I'm finding tools like MothBox, which [...] should bring scientific data collection into the fold of this participatory practice without extractiveness. Like [...], there is something

> called data sovereignty. So we [...] have this highly engaged community of Indigenous guardians. They have the tools, mobile phone-based tools that [do] data collection that is manual, right? You enter, you take a picture, you say, Oh, this is a new deforestation, and you click it. And then the next logical step is automation. So you know, they can't be there everywhere, so we can have a little AudioMoth, yeah, collecting gunshot things, and they'll say, Oh, I heard the gunshot now, and record it or log it. It's always going to be difficult to do data sovereignty without access to local storage, without some kind of notarization or like decentralised web technologies.

Questions about data stewardship in the Mothbox project arose repeatedly throughout the lead ethnographer's fieldwork. The following autoethnographic passage from her fieldnotes captures her grappling with varied understandings of *what kinds* of data the Mothbox gathers, and for *whom,* when deploying devices with the Dinacon co-organiser in Indonesia*:*

> While walking, [community organiser] asked me a couple questions regarding how to use the data from the Mothboxes; as in what research we are using it for (or should be using it for). This felt tricky for me to answer. I explained to [community organiser] that the Mothbox team is more concerned with building the device (or technical object) and less so with what's being done with the data afterwards. I felt, internally, as if it is easiest to just say "it's up to the user (or researcher) to decide what is done with that data," but in all honesty, I felt as if this conversation opened me up to a whole new grey area regarding the responsibility hardware has to data management, curation, presentation, and, in some regards, sovereignty.
>
> - Lead author's fieldnotes, July 8, 2025

This excerpt highlights the interrelatedness of technical objects and the data they collect, demonstrating that the meaning of "use" remains in constant flux in the network. The Mothbox network will have to contend with serious questions about governance and decision-making as it travels across the globe.

Towards the end of Dinacon, participants deployed a Mothbox on the ocean floor (Figure 5), to monitor the vibrant coral reefs that the Sea Communities is rehabilitating. While seemingly playful, it provided a glimpse into how meaning and decision-making are shaped by observational data collection within the Mothbox network. The Mothbox, originally designed for terrestrial use, now sits stationary underwater, photographing corals, fish, and other sea creatures. It demonstrates that the use of this technology is not solely dictated by field biologists but also by other actors, such as the community organiser and Sea Communities, who are seeking ways in which the Mothbox project can support community-based educational programs.

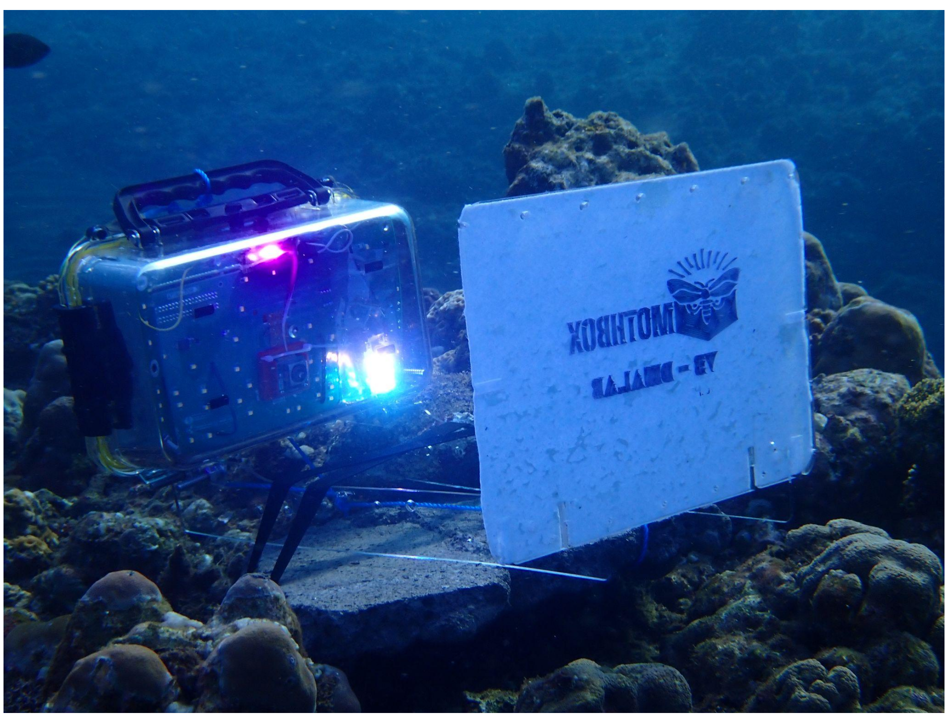

Figure 5. Photo of Mothbox being deployed on the ocean floor in Bali, Indonesia. Since

Mothboxes were initially designed to document nocturnal insect biodiversity, this photo demonstrates the ever-shifting use cases and meanings ascribed to the technical object. Credit: Paula Te

However, despite this alternative future for the Mothbox in Bali, the craft practices of field biologists are the dominant use case in the network, exerting the most influence over the design and understanding of the project itself. Take, for example, the welcoming description of the Mothbox project on its website:

> The Mothbox is a low-cost, high-performance insect monitor. It features a power efficient and lightweight design that helps field biologists deploy it in the depths of the jungle. Its low cost means you can deploy many devices to study a landscape or build one to study the biodiversity at your home!
>
> - Mothbox project description listed on the Mothbox website (Digital Naturalism Laboratories, n.d.-a, retrieved April 30, 2025)

The first sentence explicitly states that field biologists are the target user audience for the device, exerting influence over its “power efficient” and “lightweight design.” However, the second sentence states that the low cost of the technical object enables anyone, not just field biologists, to monitor biodiversity, a demonstration of hacker-aligned values of “radical openness” (Murillo, 2025) in the network. The presence of these values, alongside the craft practices of field biologists, is foundational to the moral economy we discuss in the next section.

To meet the craft practices of researchers in the Mothbox network, technologies must be capable of collecting vast amounts of data across large spatiotemporal scales. The Mothbox's ability to become a standardised instrument for ecological research is intricately tied to its open source design. The lower costs associated with open source hardware and its hands-on, modular nature can, in theory, make it easier for users to deploy more devices. However, the creation of a standardised open source instrument also depends on communities of practice that establish boundaries for what constitutes open source hardware, with organisations such as the Open Source Hardware Association issuing certifications to projects that meet documentation standards (Open Source Hardware Association, n.d.).

Examining a technical object as a *de facto* standard reveals interwoven relations, reframing it as a manifestation of material, economic, political, and social conditions (Busch, 2011). A definitive characteristic of standards is that they are often obscured or overlooked while simultaneously consigning power relations. Take, for example, the Corbett Tiger Reserve (CTR) in northern India, where camera traps serve a dual purpose: tracking animals and surveilling women's activities in the forest (Simlai & Sandbrook, 2024). In these forests, the camera trap transforms into a new form of monitoring technology, one that records species observations while simultaneously mediating gendered power relations through surveillance. Reframing the technical object as a standard raises the question of how power relations are delegated in the sociotechnical network. For the Mothbox network, power is negotiated through a moral economy where ideas, information (data), techniques, and technical objects are exchanged as both gifts and commodities.

5. Hacker values and moral economy of the network

The early geneticists working with *D. melanogaster* forged a collective identity around their use of the fly in their labs, contributing to a culture of sharing resources (ideas, practices, and flies). The process of sharing resources in the lab was governed by shared values and norms, creating a moral economy that exists at the nexus of material conditions and lived experience

(Fassin, 2009; Thompson, 1971) For these early geneticists, the fly moulded their moral economy: the value they placed on their craft practice (experimentation) was their currency, and they established social norms around resource sharing under the guise that it would continue to make laboratory experimentation as productive as possible. The very circulation of fly stocks animated ties across labs, forming a vibrant experimentalist network.

The Mothbox network, operating under its own craft practice of observational data collection, finds itself guided by a similar ethos. As mentioned before, material and historical conditions that create a sense of urgency to collect large amounts of biodiversity data situate the craft practices of field biologists. The ethos in the Mothbox network represents a convergence of these conditions with values tied to a particular lineage of hacking that supports "common technologies" and experiments with "radical openness" (Murillo, 2025). Studying alongside developers and technologists in the Mothbox network reveals long-standing values related to non-hierarchical, *ad hoc* community structuring (often referred to as a "do-ocracy" by members of the open hardware movement) that have existed within the hacker-aligned open source movement for decades. One technologist who has spent years working in open communities highlighted the importance of these do-ocratic values when describing existing open hardware communities of practice:

> [...] it was driven by shared values and has, like, let's get things done first. Forget about writing papers. Papers will come later. So setting up that environment is the key. It's a safe space for everyone, irrespective of their thing [...].

The closing sentence in the above quote demonstrates a belief that do-ocratic values equate to egalitarian actions.

In the Mothbox network, experiments with radical openness manifest as moral imperatives that open technologies must be documented and shared, to the point that human actors are frequently obliged to do so. The lead author witnessed the salience of radical openness during her orientation at Dinacon, when organisers introduced her to the only three rules of the conference: You must 1) complete something, 2) document it openly, and 3) get feedback from two other participants on what you made. One interlocutor described the imperative to share during the conference: “A lot of people in my area are [..] super burnt out from the world, you know, work, and life, and people don't want to document. And that's very frustrating, yeah…yeah, very frustrating.” Radical openness becomes actualised in physical and communal spaces, such as hackerspaces. During Dinacon, participants would regularly leave tools, electronics, notebooks, and other project materials in outdoor common areas, largely unsupervised. There were no fences or gates enclosing these common areas from the rest of the world, and the only threat was the occasional thunderstorm. Under the sheltered common areas, our belongings were safe from impending storms.

6. Moments of the gift (and the commodity)

The ethos of the Mothbox network comprises customs and norms governing the exchange of knowledge, skills, and technical objects. Communities of practice, such as the Open Source Hardware Association, formalise sharing and documentation customs through established certifications (Open Source Hardware Association, n.d.). Furthermore, archival documents such as open source licenses reveal how the network codifies these customs:

> Permission is hereby granted, free of charge, to any person obtaining a copy of this software and associated documentation files (the "Software"), to deal in the Software

> without restriction, including without limitation the rights to use, copy, modify, merge, publish, distribute, sublicense, and/or sell copies of the Software, and to permit persons to whom the Software is furnished to do so, subject to the following conditions…
>
> -Excerpt from the MIT software license located in the Mothbox GitHub repository (Digital Naturalism Laboratories, n.d.-b, retrieved January 10, 2026)

The ethos is also influenced by informal customs and norms shared by network actors. One interlocutor described how he not only openly shares a design but also his experiences when constructing a device. He explained that he often shares his processes for making open source hardware on his personal blog to make information publicly accessible. Technologists in the network expressed their desire to help out by bringing their expertise to the project: “I will say that some people [...] have been asking, hey, I have some knowledge of machine learning. Could I use my engineering skills to help with data collection to make it easier?” Many of the network actors resonate with a fast-paced culture of sharing and conviviality as a way to get meaningful work done. While the Mothbox team was reconstructing a new data-processing platform, the software developer described the differences between working collaboratively with the Mothbox team compared to other research-based collaborations:

> So far, I think you all have been- you've reminded me a lot of the days where I was building software in a little startup, and people were like, always eager to do things better and share ideas, and [...] there were no weird political shenanigans or like it was pure, how do we create something good for others? And that's always extremely refreshing. And I've had a lot of fun, yeah, and the availability, the availability that you have to be like - okay, let's jump on a call tomorrow - and it's giving you, the four of us… and it will take whatever it takes, and we keep trying new things, and like thinking about ideas and

> adding more complexities and everything has been very positive and with a spirit of doing better. And I think that's amazing. I would say it's…I bet it's rare, but I don't know. I hope it's not, but I think it's rare.

The above quote expresses a common pattern in which the network's values reflect lived sociotechnical experience, and conviviality creates relations between actors through shared work around the technical object. Principles of sharing govern the exchange of knowledge, skills, and technical objects in the Mothbox network, and it is when these objects of exchange become personal relations that the gift emerges (Godbout & Caille, 1998; Gregory, 2015; Mauss, 1990). When the exchange centres on negotiating social relationships, as in the case of a software developer volunteering time to a project where he experiences a sense of belonging, it becomes a moment of the gift. Though a gift exchange entails a social obligation (the technologist is expected to help the core Mothbox team develop a new data platform), the object (the data platform) cannot be disentangled from the social ties among actors in the exchange, thereby transforming it into a gift. The same pattern of gift exchange resurfaces throughout the Mothbox's journey, from the collaboration between the lead developer and a hobbyist to create a new PCB to the Mothboxes that the lead developer gave to Sea Communities.

It is important to note that while there are moments of gift exchange in the Mothbox network, there are also moments of commodity exchange. The Mothbox device itself is a manifestation of this: nearly all of the hardware components are bought on the market; however, much of the software it uses for data processing is open source, which is free for anyone to use, study, modify or distribute. Thus, examining the technical components of the Mothbox reveals a hybrid economy at work, in which both gift and commodity exchanges occur. Throughout its life cycle, the Mothbox frequently shifts between gift and commodity, and with each shift, social relations are either bound or cut. The construction of a Mothbox begins with components that are purchased from an online store, in which the consumer bears no social obligation to give, receive, or reciprocate (Mauss, 1990) to the workers who built that component, alienating them from their labour and reducing the gift to a commodity (Tsing, 2013). Yet the PCB one purchases from an overseas manufacturer would not exist were it not for the exchange of knowledge, skills and time as gifts between the hobbyist and the lead developer. Once constructed, Mothboxes entered the register of the gift at the end of Dinacon, where the lead developer gave Sea Communities Mothboxes, with a social obligation for Sea Communities to collect data for the project's benefit. Thus, the Mothbox is frequently situated on the register of the gift and the commodity, as demonstrated by other open hardware networks such as the Chaihuo Makerspace in Shenzhen, China (Murillo, 2025).

The maturity of the Mothbox project coincided with increasing demand for Mothboxes from research labs across the globe. This presents an opportunity for the Mothbox to become a research instrument sold on the market and traded as a commodity, in contrast to its early development, which depended on the exchange of knowledge, skills, and technical objects as gifts. The Mothbox team now faces a dilemma: How can the Mothbox exist as a product while maintaining the gift economy that was so crucial to the device's creation? While serving as a technician on the Mothbox project, the lead author participated in several meetings with a novel community of practice focused on the distributed manufacturing of open science hardware (Pearce, 2017; Weinberg et al., 2021). The community is experimenting with ways to decentralise the manufacturing and sale of open source instruments, while maintaining the underlying ethos of radical openness of the hacker movement. The sharing of knowledge and skills during these meetings showcases the underlying threads of social connectivity that sustain these market-based exchanges, allowing open hardware to circulate across the globe as a product that is "not yet fully private" (Tsing, 2013, p. 34).

The continuous negotiation between gift and commodity exchanges illustrates the remarkable plasticity of the moral economy at work in the Mothbox network. The case of the Mothbox demonstrates that standardised open source scientific instruments do not operate within a single gift or market economy. Approaching open source hardware projects as nuanced gift-commodity economies allows us to understand these sociotechnical networks as complex, multidirectional systems in which starkly contrasting elements coexist, sustaining a commons in which the exchange of knowledge, skills, and technical objects maintains social relations.

7. The commons in conservation technology networks

In the book *The Serviceberry: Abundance and reciprocity in the natural world,* Kimmerer (2024) invites readers to conceptualise elements of the natural world as gifts to be held in common, rather than natural resources, restructuring exchange towards reciprocity rather than colonial, extractivist markets. The book was an instant *New York Times* bestseller, reflecting the presence of Indigenous, anti-colonial and anti-capitalist discourse in popular culture. In contrast, Hardin's (1968) paper "The Tragedy of the Commons" continues to influence ecological discourse, arguing that shared resources are inevitably degraded by unfettered access by rational individuals acting in self-interest. The pervasive idea of the downfall of the commons due to the rational, self-interested individual was later challenged by Ostrom (1990), who demonstrated the successes of collective self-governance of common-pool resources that operate alongside private markets and the state. In the 21st century, commons theory has broadened to include intangible resources, such as knowledge (Hess & Ostrom, 2007), while some scholars such as Caffentzis and Federici (2014), move beyond the institutionalist thought of Ostrom and provide a more radical political framing: an anti-capitalist commons that the market or the state cannot co-opt, allowing communities to govern resources in a nonhierarchal manner (more aligned with an understanding of reciprocity in Kimmerer and the example of the serviceberry).

Ostrom already demonstrated empirically that Hardin's universal truth was fundamentally wrong, but more contemporary examples can be provided. Private investment in biodiversity monitoring grapples with mismatches between market interests and broader conservation objectives that prioritise the preservation of ecologically relevant areas (Convention on Biological Diversity, 2022; zu Ermgassen et al., 2025; Miles et al., 2025; Myers et al., 2000). In the United States, decades of political attacks on scientific integrity demonstrate the limitations of relying on public policy alone to solve environmental problems (Berman & Carter, 2018). Forms of peer production, including the local manufacturing of open source devices, could be seen as a step away from mass production and towards the creation of commons-oriented technologies (Kostakis et al., 2018). The work of Murillo (2025) provides empirical evidence that hackerspaces are sites of commoning, where the development of common technologies is mediated by moral economies that share a lineage with the Mothbox. In the case of the Mothbox network, we witnessed how hacking and field biology collide, fusing the material practices of field biologists with the social practices of hackers. The following quote from the lead ecologist on the project demonstrates this amalgamation:

> Really open science hardware, [developer] introduced me to this idea. And its importance, and this whole kind of world of people that are creating things together. I never thought about that, like the PCR machine in the lab is some proprietary thing and like, I understood that this is a very expensive machine, and to fix it costs a lot of money,

> and it needs to go somewhere, you know, like, you need a skilled technician, or you need to send it to another country. All that stuff. I didn't consciously think of that as just like, oh, this is difficult technology for doing science. That's how it works. But I realised that that's not necessarily what the world has to be like.

Collaborative open source development demonstrates that the commons can thrive through widespread use without leading to what Hardin considered an inevitable ruin. However, we must use open source technologies for wildlife monitoring under the guise of social responsibility to, at a minimum, prevent harm, inequity, and injustice in places where these technologies are used, and, at best, foster community science practices and epistemic justice (Sandbrook et al., 2021). This is an ongoing question for the open source community concerning the uses and abuses of it, without return to the community.

Exclusion and homogeneity can exist in the commons (Caffentzis & Federici, 2014), and there is a need for continued research to understand power dynamics in open projects, including those focused on questions of diversity and representation regarding gender, race, ethnicity, nationality, and class (Dunbar-Hester, 2020). Digging deeper into the value systems and the nature of exchange in technosocial networks can reveal insights into power dynamics over time. For example, a hacker-aligned open community (such as the Mothbox project) guided by “do-ocratic” values can quickly slip into a form of meritocracy in which power is concentrated among those who work the most, leading to exclusionary effects down the road. The scientific literature has historically overlooked the technician’s role in scientific research (Shapin, 1989), and this was not an emergent theme for discussion in this paper, nor was there a more detailed analysis of how commodity exchanges produce an alienation of labour in the Mothbox network. Further analysis of labour relations in open technology networks, with an explicit focus on hardware and field technicians, is necessary to investigate power relations in these communities. Disciplinary identities in a heterogeneous open science and technology network, such as those elicited by this ethnography, are just one of many ways we can categorise actors in a network. Therefore, it is critical to conduct an expanded study of how networks constitute and reconstitute themselves over time in open source projects and how to portray “de-scriptions” (Akrich, 1992) of technical objects. It is important to clarify that this ethnography of the network of sociotechnical actors surrounding an open source insect monitor is not a call for technosolutionist approaches to environmental challenges. Rather, it serves as a partial perspective (Haraway, 1988) that encompasses a narrow slice of the multitude of lived experiences we encountered while following the Mothbox on its journeys throughout the world.

8. Conclusion

With theoretical grounding in Actor-Network Theory, this research relies on empirical evidence to describe open source conservation technologies, reconfiguring the Mothbox as a technical object within a heterogeneous assemblage of human and nonhuman actors. Our findings demonstrate how actors in open conservation technology networks produce not only physical objects but also varied meanings of what constitutes an open source conservation technology. Through an ethnographic account of the Mothbox network, we examine the Mothbox as a *de facto* standard for open source conservation technologies, operating within a moral economy that negotiates power among actors. Within this moral economy, we disentangle the values and customs ascribed to the Mothbox network through the lived experiences, craft practices, and radical openness of the human actors, as well as environmental conditions and the Mothbox's open source design. We argue that the synthesis of social practices from the hacker movement and field biology gives rise to a complex system of exchange in which goods and services are circulated as both commodities and gifts. Examining how goods and services circulate in the Mothbox project revealed the nuanced nature of exchange in the network, in which knowledge, skills, technical objects, and data can enter onto the register of the gift. The connective social threads throughout gift exchanges reinforce the Mothbox as a community-controlled technology, demonstrating the existence of the commons at the intersection of open technologies and field biology. However, further analysis of exclusionary dynamics and labour relations is needed to gain a holistic view of how power is continuously transformed throughout the network. This research offers numerous possibilities for understanding how open source devices, situated at the boundaries of market and gift economies, can be collectively governed, laying the groundwork for continued inquiry into how commoning occurs in conservation technology networks.

Authors contribution

Brianna Johns: Conceptualization, Methodology, Investigation, Formal Analysis, Visualization, Writing - original draft. **Hubert A. Szczygiel:** Funding acquisition, Resources, Writing - review & editing. **Andrew Quitmeyer:** Funding acquisition, Resources, Writing - review & editing. **Luis Felipe R. Murillo:** Supervision, Methodology, Writing - review & editing.

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Conflict of Interest Statement

The authors of this research have no conflicts of interest to declare.

Data Availability Statement

To protect participants' privacy, the dataset supporting the results of this study is not publicly available.

Ethics Committee Approval Statement

The Notre Dame Institutional Review Board (Protocol #23-09-8082) approved all fieldwork and interviews for this research project, which the lead author conducted as a fellow of the National Science Foundation (NSF) Socio-Environmental Knowledge Commons project, with written consent confirmed by all participants.

AI Usage Statement

The artificial intelligence tool Grammarly was used to assist in the grammatical review of the text.

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