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Understanding local pig hunter values and practices as a means toward co-management of feral pigs (*Sus scrofa*; pua'a) in the Hawaiian Islands

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ABSTRACT. Differing values between communities and government resource managers may lead to conflict, particularly when community members are not involved in decision making. Increasingly, co-management arrangements have become an important tool to increase local capacity for resource management, increase trust between diverse community groups, and foster effective stewardship. However, co-management depends upon collaboration between users and managers and the ability to understand relationships between a given resource and those who use it, even when these communities are often viewed as contravening conservation efforts. Invasive species, such as feral pigs (*Sus scrofa*), present particular management challenges because they damage island ecosystems but are also integral to community life ways and food systems. Based on interviews with local pig hunters in the Hawaiian Islands, we explored the social-cultural values and practices of local pig hunters, their reasons for hunting, and possibilities for greater collaboration in feral pig management. Results highlight the importance of hunting for both food and other forms of well-being and cultural perpetuation, along with opportunities for (1) expanding mechanisms of access to improve hunting opportunities for invasive species; (2) integrating rights and responsibilities to meet management objectives; and (3) improving communication to enhance collaborative arrangements. Considering the context of managing community use of an ecologically detrimental invasive species, this study offers insights to guide co-management partnerships with community groups that are sometimes perceived as opposed to invasive species control efforts.

Key Words: *access; collaboration; community engagement; feral pigs; hunting; natural resource management*

INTRODUCTION

Natural resource management conflict is often rooted in differing values amongst government agencies and local communities, particularly when that resource is an invasive species. For example, community members may value invasive species for food and recreation, even as these species are detrimental to native species and ecosystems, thus conflicting with other cultural values such as the use of medicinal plants (Crowley et al. 2017, Shackleton et al. 2019). Management conflicts with invasive species are exacerbated when local communities who rely upon and manage those species are not included in agency planning and conservation efforts (Smith et al. 1999, Schuett et al. 2001).

To improve natural resource management outcomes, natural resource managers (e.g., forestry and wildlife managers) and communities using a given resource may engage in co-management arrangements (Schuett et al. 2001, Folke et al. 2005, Berkes 2009). Co-management is “the sharing of power and responsibilities between the government and local resource users” (Berkes et al. 1991:12). However, co-management arrangements can take a variety of forms, and include a wide spectrum of power sharing (Pomeroy and Berkes 1997). Co-management outcomes may lead to increased capacity at the local level (e.g., resource users) to manage their own resources, as well as increased trust between government agencies and community members (local resource users; Plummer and Fitzgibbon 2004), for example in local stewardship of fisheries (Pinkerton 1999). Selected co-management agreements between Indigenous groups and governments have been shown to address conflicts in natural resource management (Castro and Nielsen 2001). In this study, Indigenous peoples are defined as, “populations of people who had ancestral relationships to Place that were already several centuries if not several millennia old at the point of contact with Euro-American colonisers” (Price et al. 2021:310).

Co-management arrangements may contribute a range of positive functions to natural resource management, including the integration of different knowledge systems such as Indigenous knowledge, traditional ecological knowledge, and local ecological knowledge. In this study we utilize the definition of Indigenous knowledge (IK) provided by Warren et al. (1995) as knowledge held by Indigenous people, or knowledge unique to a society or culture. Traditional ecological knowledge (TEK) is a body of knowledge, practices, and beliefs, developed through adaptive processes and passed down through generations by cultural transmission, about human relationships with each other and the environment (Berkes et al. 2000). A related body of knowledge that may overlap with IK and TEK is local ecological knowledge (LEK), held by a group of people about their local ecosystems, which includes the interplay between organisms and the environment (Olsson and Folke 2001). Acknowledging that cultures are dynamic and constantly evolving, we also engage with the integrated term Indigenous and local knowledge (ILK) to describe knowledge systems held by both Indigenous and local peoples (Williams et al. 2020). In this study, we recognize the knowledge held by hunters in Hawai'i, not all of whom are native Hawaiian, as a form of ILK. Many hunters possess valuable ecological knowledge about the places where they hunt (Peterson et al. 2011, Young et al. 2016a). In addition, hunting, along with fishing, and other related biocultural practices, such as preparation, preservation, and sharing of meat are recognized for their value in maintaining connections between humans and the environment through the gathering of food (Vaughan and Vitousek 2013, Garibaldi and Turner 2004).

In some places co-management of invasive species includes Indigenous and local communities who value and utilize these resources. In Kakadu National Park, Jawoyn elders and park rangers engaged with Indigenous knowledge to co-manage feral pigs, for example. In this case, they were able to quantify the

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impacts of feral pigs across habitats and over time, as well as articulate Indigenous relationships with feral pigs (Robinson and Wallington 2012). In Sweden, innovative co-management programs for moose helped transition hunters and landowners to a role of ecosystem stewards, which increased hunter participation in management efforts (Lindqvist et al. 2014). Despite these successful outcomes, both studies documented challenges with establishing co-management arrangements, such as gaining government support for local-level management initiatives, ensuring Indigenous knowledge is integrated equitably into co-management arrangements, and maintaining adequate funding to support local monitoring efforts. To improve management outcomes for culturally valued invasive species, hunters and managers must understand the challenges of past co-management arrangements, particularly when culturally important invasive species are perceived differently by various community members.

Feral pigs (*Sus scrofa*) are a common game species. Originally native to Eurasia, feral pigs inhabit many islands throughout Oceania, as well as every major continent except Antarctica (Barrios Garcia and Ballari 2012). Many government agencies around the world classify feral pigs as invasive species that pose major threats to the natural and agricultural environment, economy, and human health (Barrios-Garcia and Ballari 2012, Wehr et al. 2018, Risch et al. 2020, 2021). Feral pigs cause extensive environmental damage to island ecosystems because of trampling and uprooting of native plants, spreading invasive plant propagules through consumption, foraging on native birds and eggs, and altering soil fertility and nutrient cycling through rooting behavior (Diong 1982, Stone 1985, Browning et al. 2008). To enable many other species and ecosystem services valued by Indigenous people to persist, reducing the abundance of feral pig populations in sensitive ecosystems is extremely important.

Indigenous Pacific Islanders traditionally placed substantial cultural value on pigs as food, as well as symbols of social, economic, and political power, while managing them in a way that minimized impacts to native ecosystems (Denning 1980, Schieffelin and Crittenden 1991, Kirch 2014, Luat-Hū'eu et al. 2021). Pigs have been a longstanding component of Hawai'i's social-ecological systems (Winter et al. 2018), following the arrival of Polynesians between 1000 and 1200 AD (Pearson et al. 1971, Kirch 2011), and were primarily domesticated and managed through husbandry practices, where Hawaiian families tended pigs in enclosures near their homesteads (Luat-Hū'eu et al. 2021). Pig hunting was not practiced in Hawai'i until the 1850s, driven by the introduction of novel tools and land use practices, change in governance and land tenure, and changes in resource abundance (Luat-Hū'eu et al. 2021). Foreigners brought with them different breeds of pigs that interbred with Hawaiian pigs, increasing their size and reproductive output. Further, as the Hawaiian land tenure system diminished following the diversion of water for plantation agriculture, loss of 90% of Hawaiian people from introduced diseases, and changes in land management practices, pigs became feral across the landscape. Today, most pig populations in Hawai'i are identified as feral, meaning that they originated from domestic stock, but have reverted from domesticity to become free-living, no longer depending on husbandry for sustenance or breeding (Pullar 1950, Kruska and Röhrs 1974). As a result, today feral pigs threaten

Hawai'i's ecosystems, yet are also highly valued as a culturally important food source among Hawaiians and local communities (Lohr et al. 2014).

The State of Hawai'i Department of Land and Natural Resources (DLNR) is the main agency managing feral pigs on land owned by the state. The Division of Forestry and Wildlife (DOFAW) under DLNR is mandated to manage feral pigs as both a game species for public hunting and as an invasive species that threatens ecosystems and biodiversity. All nonnative bird and mammal game species in the Hawaiian Islands were intentionally introduced for food and hunting purposes (Duffy and Lepczyk 2021). Game hunters wishing to hunt on state-owned lands and private lands (with permission) in Hawai'i are required to obtain a hunting license from DLNR, which is achieved by passing a hunter safety education course. Hunting on private lands without permission and/or a hunting license is designated as hunting and is subject to legal prosecution by the landowner. The Division of Conservation and Resource Enforcement (DOCARE) is the subsidiary agency mandated to enforce game hunting regulations set by the state.

DLNR is legally mandated to protect and conserve natural and cultural resources in the Hawaiian Islands while simultaneously providing public hunting opportunities to local residents and U. S. citizens for recreation (Ikagawa 2013). However, natural resource management planning regarding feral pigs has often failed to fully integrate the social-cultural values and practices of Hawaiians and local communities associated with feral pigs, leading to conflicts between pig hunters and agency resource managers (Adler 1995, Lohr et al. 2014). For example, in the 1990s when resource managers installed pig exclusion fences in a natural area reserve with minimal community input, hunters cut the fences to allow feral pigs into the reserve area (Burdick 2006, Warner and Kinslow 2013).

The majority of research relating to feral pigs in the Hawaiian Islands has focused on the ecological component, with little attention to the social and cultural values associated with feral pigs and other game mammals. Qualitative research methods such as interviews are extremely valuable for exploring the views, beliefs, and motivations of individuals on a specific matter, in this case the hunting of feral pigs (Gill et al. 2008). However, few studies have used oral interviews to directly solicit local pig hunter perspectives. By conducting interviews with local pig hunters we aimed to answer two main research questions: (1) what are social-cultural values and practices of local pig hunters on O'ahu and Maui; and (2) how can knowing hunter values and practices aid to improve policies and collaboration for feral pig management? Understanding the values and practices of local pig hunters may reduce conflicts and help establish effective co-management practices that respect diverse values of community members.

METHODS

Study site

Interviews took place with hunters who resided on the islands of O'ahu and Maui. Game mammals on the island of O'ahu include feral pigs and feral goats, while the island of Maui has feral pigs, feral goats, and Axis deer (*Axis axis*). DOFAW provides public hunting opportunities through "public hunting areas" characterized as (1) game management areas; (2) forest reserves

and surrendered lands; (3) natural area reserves; (4) restricted watersheds; (5) cooperative game management areas; (6) military training areas; (7) unencumbered state lands; (8) designated sanctuaries; and (9) other lands designated by the Board of Land and Natural Resources (DOFAW Hawai'i Administrative Rules §13-123-2). Rules and regulations such as bag limits, hunting method, and permitted days to hunt vary among public hunting areas, depending on factors like proximity to residences, time of year, and other land uses. Hunters also access game species on private lands by owning private land, obtaining permission from private landowners, or creating formal agreements through hunting clubs. The exact number of hunting clubs and associations in the Hawaiian Islands is not known. Cattle ranches and large agricultural regions often have their own hunting access lists that are largely restricted to employees and family members of employees, or may have required fees and waivers to limit liability.

Data collection

We conducted semi-structured interviews with local pig hunters on the islands of O'ahu and Maui who identified as "local" and/or "Hawaiian," consistent with our intent to explore Indigenous and local knowledge regarding hunting in the Hawaiian Islands. Semi-structured interviews are usually conversational between the interviewer and interviewee and include several main open-ended questions to be explored (Longhurst 2003). Open-ended questions are valuable because they allow the interviewee to elaborate on a certain idea or topic, potentially revealing information that was not thought of as relevant to the interviewers (Britten 1999, Gill et al. 2008). We selected interview participants from this study primarily using the snowball sampling method, meaning that we spoke to one hunter, who referred us to another and so on, until saturation of information was reached (Noy 2008). To ensure a diverse interview pool, we also interviewed hunters from across the islands geographically for both O'ahu and Maui, and contacted pig hunters through personal connections recommended by family and friends. With permission from participants, we audio recorded interviews to allow for transcription and coding.

Interviews covered questions about hunter values and practices, preferred areas to hunt, issues with hunting and/or management, and recommendations to improve hunting and/or management. Questions were not asked in a specific order. Instead, we let the interviewees guide the interview and asked certain questions when it fit within the flow of the conversation, or for clarification.

Data analysis

Each interview recording was transcribed, and a memorandum was written that noted important comments and key takeaways discussed with the interviewee. We used MAXQDA Analytics Pro 2020 (qualitative data analysis software) for analyzing interviews. We took a grounded theory approach, where theories evolved during the research process with interplay between data analysis and data collection (Charmaz and Belgrave 2007). Other studies conducted in the Hawaiian Islands have used similar methodologies to help develop new policies for resource management (Montgomery and Vaughan 2018). We read through interview transcripts to identify main themes and interview codes based on our questions. Given that this article was aimed toward understanding Indigenous and local values as well as the cultural

importance of pigs for the Hawaiian Islands, we acknowledge that two of the three authors from this study identify as Native Hawaiian (KKL, MBV).

RESULTS

Overview

We conducted 30 semi-structured interviews with local pig hunters on the islands of O'ahu and Maui (16 on O'ahu and 14 on Maui) primarily in English. Twenty interviews were done in-person at locations that included the homes of participants, the University of Hawai'i at Mānoa Campus, and the personal residence of the lead author. Because of concerns following the emergence of the COVID-19 pandemic in March 2020 that shut down inter-island travel and required social distancing, we completed the remaining interviews by phone, or with social distancing protocols. The duration of interviews ranged from 30 to 90 minutes with an average duration of 58 minutes. We determined key background information regarding interviewees, including age group, place of residence (home zip code), preferred method of hunting, and ethnic group. For our analysis, we grouped results based on five main interview themes: (1) reasons for hunting; (2) Indigenous and local knowledge; (3) responsibilities and values of being a hunter and hunting; (4) current issues and concerns with hunting and/or management; and (5) recommendations to improve hunting and/or management.

Demographics

All participants were males. While women do hunt pigs in Hawai'i, there are far fewer female pig hunters than males. Interview participants ranged in age from 21 to 77 years old, with a mean age of 42 years (Fig. 1). All participants were born and raised in the Hawaiian Islands, with 21 of 30 participants identifying as Native Hawaiian (70%).

Fig. 1. Age groups of participants (n = 30). Each age group ranges 10 years, except for the oldest age group, which was for participants age 58 years and older. Mean age of participants was 41.6 years old.

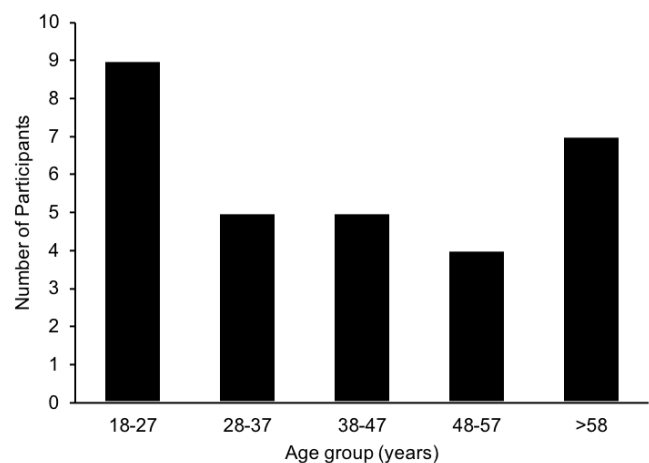
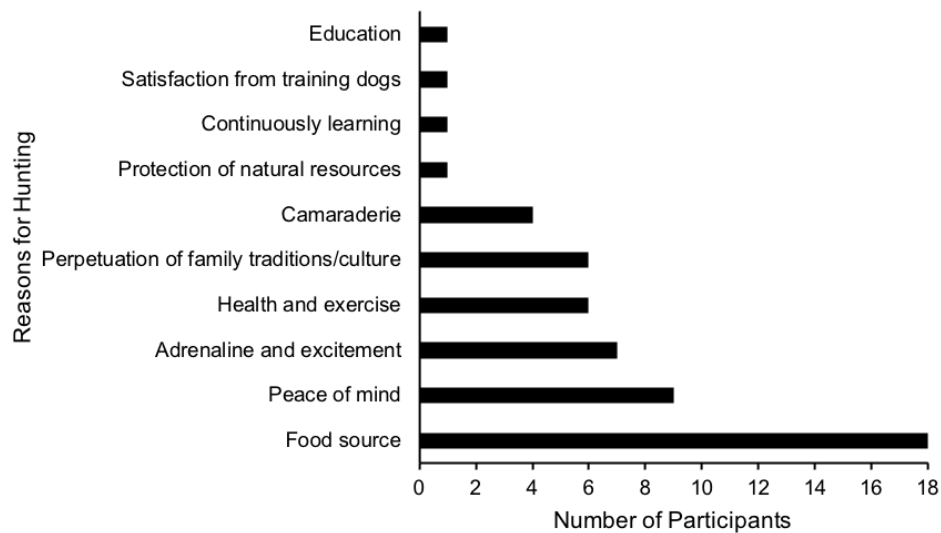


Fig. 2. Reasons for hunting mentioned by participants. Participants often gave more than one reason for hunting. The most common reason for hunting was for a “food source” (n = 18).



Hunting Methods

The most common hunting method for feral pigs was dog and knife (n = 21), although some participants preferred other methods including bow and arrow (n = 4), rifle (n = 3), and traps (n = 3). Two participants preferred a combination of methods. With the dog and knife method, trained hunting dogs are utilized to track down feral pigs and corner or physically hold the pig until the hunter is able to slice the throat of the pig with a knife, resulting in a relatively quick death that preserves the meat for consumption. In contrast, other methods like guns or bows can damage the meat if hunters do not hit the pig in head, throat, or lungs. Participants stated that dog and knife is one of the most efficient methods for hunting pigs in the Hawaiian Islands, because of the dense vegetation as well as steep and rugged terrain.

Interview themes

Reasons for hunting

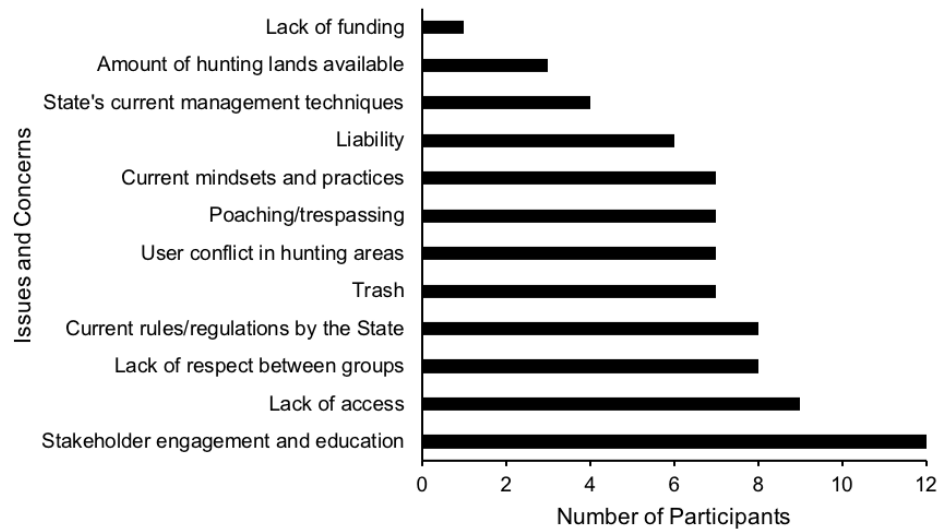
One of the core questions asked across interviews was “Why do you hunt?” Participants primarily hunted feral pigs as a food source, with answers related to food by far the largest category of response (n = 18; Fig. 2); “Providing food for the table” was important for many of the participants, both for their own families, and to share. One participant mentioned that sometimes he traded the pork he caught with friends in exchange for fish. Similarly, a participant stated that he hunted “mainly just help people out or [if] someone needs meat, we’ll go out and get meat for them.” Another participant talked about benefits of the meat, “feels like that’s [feral pigs] a more healthier source of meat, as far as pork goes than one farm raised one.” Together, these results suggest hunters maintain important roles within their communities in increasing food security.

A second category of reasons for hunting centered on individual well-being, through peace of mind, excitement, and health. The second most frequent response overall, after food, was that

hunting offered peace of mind (n = 9). One participant explained how hunting helped to reduce his stress by stating, “At the end of a hunt, whatever problems you have going into the mountain, you tend to just forget while you’re doing it.” Another participant with a similar view on hunting explained it as “...almost like church. You go out there and lose yourself to nature... it’s a good stress reliever.” Another participant described hunting as his escape from town and people. Motivation to hunt pigs also included adrenaline and excitement, especially with the dog and knife method (n = 7). Some words that participants used to describe hunting included a rush, exciting, adrenaline, a fever. One participant stated that “I like hearing the pigs making noise and the dogs making some noise. That’s my adrenaline.” Participants also mentioned that they hunt feral pigs for exercise and a means to maintain their physical health (n = 6). Four of the six participants who hunted for exercise were above 50 years old. One participant shared, “Today I just there [hunting] for exercise ... I just go for exercise because my partner is 60 and I’m 58, but we can handle like the younger guys.” Often times, those participants stated that catching a pig was not their main focus, instead it was a bonus.

Some participants hunted to perpetuate family tradition and culture (n = 6), the practice being rooted in their family across generations, including their parents, grandparents, and great-grandparents. Some interviewees suggested that they felt separated from culture, so hunting pigs has been one means to regain that connection. One participant believed hunting was one of the many components people used to make a connection with Hawaiian culture by stating, “There’s a disconnect. Hunting, just like surfing or fishing, is their [Hawaiian] way being a part of that culture and perpetuating it.” The camaraderie aspect of hunting was also brought up by participants as a reason for hunting (n = 4). One of the older participants had been hunting with the same group of people for nearly his whole life and expressed a desire to continue hunting together as long as possible. A younger

Fig. 3. Current issues and concerns with hunting and/or management mentioned by participants. Participants often mentioned multiple issues and concerns. The most common issue brought up was “community engagement and education” (n = 12).



participant (18–27 age category) hunted because “it brings everyone together. It’s family and friends. It’s a good feeling all getting together and taking part in that.” Other less common reasons for hunting that emerged from the interviews included the protection of natural resources, continuously learning, satisfaction from training hunting dogs, and education (teaching others). One participant assisted with pig eradication efforts in neighborhoods and for golf courses, areas where pigs can cause damage if not removed. He stated about he and his friends, “We’re just doing it [hunting] out of love to save the forest ...” Hunting was an important food source, and also source of peace, adrenaline, and exercise, while offering participants means to connect to Hawaiian culture, to family practice across generations, to friends who were also hunters, and with nature, as well as to a lesser degree, protecting forests, training, learning, and teaching.

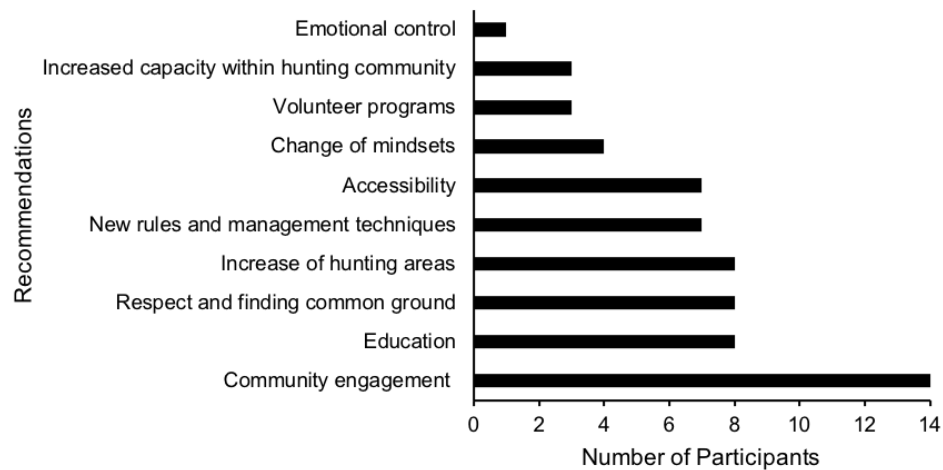
Indigenous and local knowledge of hunters

We asked various questions about hunter preferences such as “how do you select hunting areas?,” “where do you like to hunt?,” and “what does it take to be an efficient hunter?” Asking these types of questions revealed some of the ILK that hunters acquired from hunting feral pigs. Participants mentioned that they selected their hunting areas depending on ecological variables including weather (e.g., rain, wind, heat), food availability for the pigs (e.g., fruiting guava trees), seasons, presence of water, terrain, moon phase, along with the ability to access the area. One participant stated, “When we go hunting, we’ll look for a food source and a lot of times, the *waiwi* [strawberry guava] is pretty much our main [food] source down here, or the yellow [common] guava. Mountains that don’t have food like that, there will be purple plums, so you’ll need to find the source.” Food availability depended on the different seasons of the year, so the health and size of the pigs were likely to vary as well. Another participant stated, “Certain times of the year, you see skinny, real sick [pigs].

When get ginger, the fruits like *waiwi* [strawberry guava] ... That’s when they get healthy. But usually from August to ending of October, that’s when get the feed and the pigs [are] more healthy and fat.” Some participants mentioned that they looked for other signs when popular fruiting plants were not in season, “That’s one way that I use to find those guys, by looking at the destruction that they’ve done, so the diggings, all that stuff and they tear up a lot of stuff in the mountains.” One participant valued the presence of water to determine whether or not pigs were in the area: “I always told my boys, wherever you find water, that’s where the pig going be ... you gotta think like the pig yeah. Why you going far when you can live close to the water yeah? ... Guarantee every time we find water, the pigs stay in that area.” To find pigs, hunters need to know and, in many ways, study ecological factors, including those that change with the time of year and within lunar months.

One participant talked about how pig activity changed with the moon: “When get full moon, they [pigs] up all night usually. So when you go hunt in the morning, they sleeping already, so the scent going [to] be faint I guess ... the dogs going [to] have [a] hard time finding them.” Understanding the different variables that affect pigs’ activity and presence can greatly improve a hunter’s ability to catch pigs. An older participant (> 58 years old) talked about the importance of taking notes to catch pigs, “I had a notebook when I first moved up here [Maui] in [the] 1980s. Wherever I caught a pig, I would put down the location and the time of the year. And pigs, they habitual. If they was born here and feeding here. Certain times of the year, get certain kind of feed. They [pigs] come back. And that’s what I used to do. It used to pay off.” An older participant from O’ahu (> 58 years old) also took similar notes, “It was a eight and a half by eleven sheet that I cut in half. I had two forms per page. And I filled one out every time I caught a pig. I marked date, time, location, the weather conditions. I marked boar or sow, weight. I put down the shape of the hoof. Pointed or really rounded, whether they’re walking

Fig. 4. Recommendations to improve hunting and management of feral pigs mentioned by participants. Participants often gave multiple recommendations. The most common recommendation was “community engagement” (n = 14).



on really hard or soft stuff. I marked down how much hair the pig had ... I always cut the stomach to look to see what it was eating ...” Over time, this record keeping and observation builds Indigenous and local knowledge within individual hunters and, if shared, within families and across hunting communities.

Responsibilities and values of hunting

Interviewees indicated that a lot of responsibilities come with being a hunter. One of the main responsibilities that participants were taught or learned to value about hunting was respect (n = 16). Participants described respect as having multiple aspects, including respect for the land (n = 9), respect for each other (other user groups such as hikers; n = 7), respect for the animal (n = 7), and respect for property (i.e., not poaching, asking permission to hunt; n = 3). Respect for the land consisted of not cutting too much vegetation for trails, making little to no noise when possible, and being mindful of good intentions while hunting. Participants also stressed the need to respect the animal (feral pigs) they were hunting, whether it was appreciating the process it took to get the animal, not wasting animals that are caught, killing the animal in the most humane way possible, or staying alert if a pig rushed toward the hunter. Safety was especially important when hunting with dogs and targeting the boars (males), who have large sharp tusks that can cut through skin with ease and cause injuries to the dogs or the hunters.

Taking care of hunting dogs was also an important responsibility of being a hunter (n = 13). Participants described taking care of the dogs as raising and training the dogs properly, feeding the dogs, giving the necessary medicine, sewing up cuts and wounds, and treating dogs with respect, because the dogs were one of the main ways hunters were able to catch pigs efficiently. When hunters lost their dogs in the mountain while pursuing pigs, some participants mentioned they would search as long as they could throughout the day until dark. If unable to find their dog that same day, “Put a shirt on the ground ... that’s the smell of your clothes ... come back the next day, the dog stay [is] right around, on top [of] your shirt laying down.”

Safety was another responsibility of hunting mentioned among participants (n = 13). There were a lot of safety precautions to consider when hunting and most of them were taught in hunter education courses by DLNR required for hunters to obtain their hunting license. One participant stressed the importance of gun safety, “because once you pull that trigger, you cannot call that bullet back.” Some specific gun safety practices included, “never be running around with a loaded weapon until you [are] ready” and, “point that muzzle in the right direction always.” Participants noted that hunting incidents usually occurred because of a lack of attention to important safety measures. Other than gun safety, knowing the hunting area was important in terms of, “remember where you’re coming in from, your main trail. That way, on your way back out, you come out the same way.” Hunting was noted to be unpredictable, so some participants mentioned how important it was to always pack necessary gear such as water, snacks, waterproof clothing (e.g., jackets, boots), knives, and ropes in case they got lost in the mountain and had to stay overnight, or were hunting for an extended period of time. Less common responsibilities brought up by participants included taking care of each other [other hunters], sustainable harvesting practices, proper processing of the meat, promotion of hunting culture, and education.

Current issues and concerns with hunting and/or management

Participants felt that a lack of community engagement and education by the state resulted in problems with the current management of feral pigs for hunting (n = 12), more specifically that voices and concerns of hunters were not included in decision-making processes regarding certain management efforts related to feral pigs (Fig. 3). Some participants expressed that “they [DLNR] come after the fact or they come with an agenda, knowing that they’re going to do it anyway ...” Participants felt that agencies consulted them for opinions instead of inviting them to actively participate in decision making. Participants were concerned that the state offered public meetings at times and locations inconvenient for hunters and their families to attend, such as during the day, when most hunters work, so the meetings ended up being a waste of time.

Interview participants noted the lack of access to hunting areas and pigs as a current issue ($n = 9$). Hunter etiquette required hunters to “give people right of way. If someone is over there [parked at a hunting area entry point], people don’t like to be hunted [from] behind ... There is a mutual respect that people have for each other.” Most of the public hunting areas were noted to have one entry point and “it’s just tradition that whoever [is] there first, gets the spot first.” In some cases, the entry point into the hunting area was such a great distance away from the area permitted to hunt, that “half (of) the day is spent trying to get [back] there [to the hunting area] ... It’s why a lot of hunters start early.” One participant mentioned the impact of development on access. “Access to land is going to get harder and harder. Land is developing. I can tell you when I was a kid and I was hunting, there are houses where there used to not be.” Another participant mentioned that some of the public hunting areas in Central O’ahu were located just outside of neighborhoods without a designated parking lot for hunters, which worried some hunters about parking their vehicle along the side of the road throughout the day. One participant mentioned that he had his truck burglarized while hunting.

Another issue that participants mentioned was a lack of respect among groups ($n = 8$), primarily between hunters and managers, but also between hunters and private landowners and among hunters. One participant believed that relationships between DLNR and hunters were better when he was younger and management was flexible, whereas “Now, we get DLNR trying to control ... Not too much hunters get along with DLNR.” With limited access to public hunting lands, some hunters have resorted to hunting on private lands with and without permission, i.e., poaching. Poaching has led to issues between landowners and hunters. One participant gave his input as to why there is a lack of respect stating, “I think a lot of those large landowners, they have this problem. Whether [it is] theft on their ag [agriculture] land, whether it be vehicles, tractors, whatever is related to the hunting activity.” Participants did acknowledge disrespectful behaviors by some hunters: “They don’t care ... They want to catch their pig, take their picture or not ... There’s no way to change these people’s minds.” Interview participants also highlighted lack of communication between hunters and the general public where, “A lot of people look [at] hunters as bad people because they [are] killing pigs and utilizing dogs, but really it is not even like that ...” Participants were concerned that social media and local news stations had the ability to spread false representations of hunters that the public believed, while it was actually only a small group of hunters responsible for negative behaviors.

Participants noted an increase in hiker use of trails in Hawai’i, especially in public hunting areas of state forest reserves managed by DLNR, leading to an increased potential for user conflict between hunters and hikers ($n = 7$). One participant voiced his concerns from a personal experience with hikers stating, “There are [hikers] in there [public hunting areas] walking dogs and then your dog hurts their dog, it costs you money. And their dog starts growling and barking at your dog.” Hikers moving through the same areas as hunters may also reduce the likelihood of catching a pig. One participant described his past experiences where “Plenty times we see hikers and the dogs [are] out tracking pigs ... we just ask them to keep it [the noise] down ... then around the corner, they [hikers] start screaming their head off.”

The increased presence of trash was another important issue among interview participants ($n = 7$). Participants noted that with the influence of social media and tourism, human presence (not only hunters) in Hawai’i’s mountains and forest areas was larger than ever before, increasing the amount of trash within these areas. Some participants noted that they often have to pick up candy wrappers, plastic bottles, beer bottles, and other trash, particularly in forest reserves frequented by hikers. One participant pointed out that hunters also leave trash, especially in areas far from the main hiking trails. Other issues and concerns raised by participants included current attitudes and practices, liability, current management techniques by the State of Hawai’i (DLNR), the lack of available hunting areas, and lack of funding (Fig. 3).

Recommendations to improve hunting and management of feral pigs

Nearly half of the interview participants recommended the need for increased community engagement and interactions by the state (e.g., DLNR) with hunters and local communities ($n = 14$; Fig. 4). Participants noted they would like to see resource managers show a concerted effort to reach out to different communities, including hunters. Some specific options of community engagement that participants recommended were outreach to local communities about potential decisions, recreation days for hunters and managers to interact, and arranging for hunters to help with damage control and/or eradication of feral pigs from ecologically sensitive areas.

Education was the next most common recommendation among participants ($n = 8$). Some participants felt that education could be improved by adding more literature onto the DLNR website, using social media to provide updates on rule changes, and learning more about native vegetation and ecosystems. One participant shared that “it’s never one side. There’s so many things that come into play.” Education will not succeed without relationships between community members and different user groups. Participants also provided recommendations for new rules and management techniques ($n = 7$), including increasing seasonal hunting areas, restricting hikers and their dogs in hunting areas to avoid conflict, increasing trash cans in hunting areas to decrease trash, issuing permits to allow nighttime hunting (currently illegal), and improving call-in or internet-based systems to reserve road access for hunting areas.

Respect and finding common ground were both important suggestions from participants to improve hunting and management of feral pigs ($n = 8$). One participant talked about how DOCARE (Division of Conservation and Resource Enforcement) officers were often negatively portrayed by hunters without personally knowing the officer. Participants felt that hunters needed to work extra hard to gain public support. As one participant pointed out, “If the hunters can start respecting the people around us then those people can start respecting us.” Suggestions to improve public meetings included “Sometimes [managers] just sit and listen to folks *mana’o* [thoughts], and issues and questions. Try not to make it like [managers are] higher than anybody else ... Be respectful of each other’s opinions.” Increasing the number of hunting areas ($n = 8$) and improved access to hunting areas ($n = 7$) were also recommendations among interview participants. Interviewees talked about access and

expanding hunting areas simultaneously. One participant recommended, “Make more check-in stations ... we [hunters] usually have to park on the side of the road. Make one area where we can park inside ... Get plenty spots that I feel get [have] plenty pigs.” Two participants brought up the idea of a lottery system similar to that on the island of Lānaʻi for Axis deer hunts, stating, “It would be cool if they did open up another region on the island or section on the island to hunt ... Every hunter could have their number submitted and it’s just a random pool. Whoever gets pulled up (in the lottery), those groups of hunters can go hunt in this section this week.” Participants would like more official access to the mountain because they already hunt many areas, so it would help if those areas were legally approved by the state.

Similar to respect and finding common ground, changing mindsets was also a recommendation among some participants ($n = 4$), more specifically changing the mindsets of hunters. As one participant stated, “The hunters have to get on board and the hunters have to recognize [that] if we’re going to save hunting, if we’re going to save fishing, we have to practice conservation and we have to support it.” Another recommendation was for hunters to self-reflect, “[it is] a lot harder to ask yourself ... what part do I have to play [to improve management]? That’s just the first step ... The acceptance is often the first step of these processes.” Less common recommendations from the interviews included volunteer programs, increased capacity within the hunting community, and better communal coordination on an interpersonal level (not allowing emotions to hinder ability to work with others). Participants recommended expanding access to hunting areas, along with education, enhanced respect and communication between managers and hunters, more agency engagement of hunters in decision making and hunters changing their mindsets to become participants in conservation.

DISCUSSION

With this study we aimed to understand the social-cultural values and practices of pig hunters and how those values and practices can aid in improving co-management of feral pigs for hunting and conservation. The majority of hunters interviewed for this study identified as being Native Hawaiian. Participants primarily hunted feral pigs as a food source, but also mentioned a range of additional motivations for hunting that included peace of mind, perpetuating family traditions and culture, maintaining physical health and exercise. They also described responsibilities inherent to hunting, as well as recommendations for improving pig management. We will draw upon all of these results to describe three emerging themes that may improve co-management of feral pigs and other culturally important invasive species in Hawaiʻi and beyond: (1) expanding mechanisms of access to hunt or gather invasive resources such as feral pigs, (2) integrating rights and responsibilities to meet management objectives, and (3) improving means of communication to enhance collaborative arrangements.

Expanding mechanisms of access to increase hunting opportunities for invasive species

Lack of access to hunting areas emerged as a key concern for hunters in this study. Interview participants talked most directly about physical access, discussing the number of entry points into hunting areas, physical distance needed to travel, impacts of residential development, and areas landlocked by private lands.

People also had limited time to hunt because of work and family schedules, making efficient physical access more critical. In Hawaiʻi, feral pigs are increasingly seen along highways and in residential areas, possibly because of decreasing access to mountain areas (Vaughan 2018). Access conflicts with hunting are well documented in the literature. A study that surveyed big game hunters in the continental U.S. identified access to private and public land as one of the top constraints for people to continue hunting (Montgomery and Blalock 2010). Both landowners and state governments have increased their efforts to restrict access to private lands for hunting (Sigmon 2004). One reason for decreasing access to private lands is in response to poaching or trespassing by hunters (Wright and Kaiser 1986). Another study that surveyed elk hunters in Montana determined that access to hunting on private lands decreased because of increased commercialization of wildlife (e.g., hunting tours) and that most of the state hunting lands were inaccessible because they were landlocked by surrounding private lands (Eliason 2016). Other contributing factors to the lack of access to private lands include changing land ownership, increasing development, and changing public values and perceptions of hunting (Miller 2002).

Beyond physical access to resources, access can also be defined as “the ability to benefit from things” (Ribot and Peluso 2003:155). Using this broader framework, Ribot and Peluso (2003) offer multiple mechanisms of access, which allow people to benefit from a natural resource including technology, authority, markets, labor, capital, knowledge, identities, and social relations. The mechanisms of access articulated by interviewees in this study offer a range of potential solutions for increasing access to hunt and manage invasive species.

Following the guidance of Ribot and Peluso (2003) to extend our analysis beyond problems of physical access, we found that barriers to hunting in this case could include gaining access to technology, e.g., four-wheel drive vehicles to reach remote locations, GPS to map areas of high pig activity, and GPS collars to track locations of hunting dogs during hunts. Another access issue of concern is knowledge. This includes having the knowledge required for properly training hunting dogs to effectively track down feral pigs, and acquiring knowledge about specific characteristics of hunting areas like weather variables, seasons, food availability for feral pigs, and moon phases that shape access to the resource. Transmission of this Indigenous and local knowledge between hunters from a given area and across generations, is also a challenge as has been shown with ILK of fishers and other practitioner groups in Hawaiʻi and beyond (Vaughan 2018, Winter et al. 2023).

Further, we see access to authority being important to the co-management efforts considered in our study. Most issues of public hunting are embedded in law, suggesting the need to reevaluate laws concerning hunter access to wildlife in the U.S. (Eliason 2016). Changes in law and policy require more hunters to be involved with DLNR, the legislature, and in decision-making positions. One example of increased access to authority implemented in the last few years is the Game Management Advisory Commission. In this recently created institution, elected members across the Hawaiian Islands serve in an advisory capacity to the Board of Land and Natural Resources, and help shape management decisions and actions related to public hunting.

This is also an instance of hunters contributing their labor to management. The mechanism of labor might also expand access through cases in which hunters engage in stewardship opportunities with private landowners, such as restoration of invasive species and control of feral pig populations, and thus are permitted to hunt in those areas, providing food for their families. Working collectively, hunting associations could offer large landowners like ranches and farms work-trade deals, providing a steady volunteer labor force in exchange for permission to hunt on their lands. Some ranches in Hawai'i already offer work-trades that have increased hunter access to feral pigs. Given recent impacts from exponentially growing Axis deer populations on the islands of Maui and Moloka'i (Akutagawa et al. 2016), private landowners may be more willing to develop agreements with hunters to reduce deer populations on their lands.

Social relations are a key mechanism of access that could be enhanced to expand hunting of invasive species. Participants in this study described the need to enhance relationships with management agencies, as well as public perceptions of hunters, through embracing responsibility and decreasing negative practices such as trespassing, leaving trash, and opposing conservation efforts that would decrease pig populations. Management agencies can map existing public hunting areas, and how they overlap with hiking and other uses, then partner with private landowners to increase areas exclusively for hunting as well as entry points into currently designated public hunting areas. This may be dependent on the availability of funding to purchase or lease more state hunting areas. Hunter access programs are state-developed agreements with private landowners to allow public hunting on private lands in the continental U.S. (Montgomery and Blalock 2010). Relationship building with private landowners has enhanced hunting access in other locales (Miller and Vaske 2003). Landowners who perceive hunting to be low risk from a liability perspective, and see benefits from a reduction of negative impacts of ungulates on their lands, may be more likely to allow hunting on their properties (Burke et al. 2019). Our study offers examples of how considering mechanisms of access more broadly, can offer means to potentially expand opportunities to hunt and engage in management of invasive species.

Integrating rights and responsibilities to meet management objectives

One mechanism of access not articulated by Ribot and Peluso which is critical within Indigenous settings and articulated by participants in this study, is access through responsibility (Vaughan 2018, Diver et al. 2019). The Hawaiian value of *kuleana* can be defined as rights as well as responsibilities (Vaughan 2018). In Hawai'i, pig hunting was affirmed as a traditional and customary right under Hawai'i's State Constitution, Article XII, Section 7 in the State v. Palama 2016 court case, involving a Hawaiian farmer and hunter as the defendant and DLNR as the plaintiff (Akutagawa et al. 2016). The court ruled that since hunting existed in Hawai'i before 1892, the act of hunting pigs on private property was constitutionally protected. Although pig hunting developed primarily as a biocultural practice in the mid-19th century when domestic pigs became feral on the landscape (Luat-Hū'eu et al. 2021), the relative modernity of practice does not invalidate its legal protection as a customary right nor its importance to local and Hawaiian culture today, as

cultural practices evolve over time. Yet, participants in our study recognized the integration of protected rights with responsibilities. The Akutagawa et al. (2016) study utilized interviews on the island of Moloka'i regarding resident perceptions of hunting as a traditional and customary right and their opinions on a potential fencing project that would exclude ungulates from one area of the island (Akutagawa et al. 2016). One participant in that study recommended building small fencing units that were easier to manage because large fences may fall into disrepair. Other residents recommended lowering the elevation of the fence lines, enlarging the size of the protected areas to better protect the health of each *ahupua'a*. It is noteworthy that hunters recommended modifications to improve fencing because fences as a means to control invasive species may be controversial for hunters and certain cultural practitioners (Warner and Kinslow 2013). Though not all participants in the Moloka'i study believed fencing was the best management solution, all acknowledged their responsibility to *mālama 'āina* (care for the land). Respect for the land was also the most common responsibility articulated by hunters in our study.

Recognizing informal codes of hunting conduct and standards of respect and responsibility can help to reverse negative perceptions of hunters by the public or by natural resource managers based upon the actions of a small group of unethical hunters (Adler 1995). Examples of unethical hunting include leaving trash (e.g., plastic bottles, food, unburied carcasses), poaching, being loud and rowdy, mistreating hunting dogs, or wasting meat. Participants in this study articulated responsibilities of ethical hunting including taking care of hunting dogs, prioritizing safety, respect for the animals being hunted, respecting other hunters by not following them on a trail, sharing meat with the community, and respecting the mountains in which one hunts by going quietly, minimizing trails and impact, and cleaning up after oneself and others. Articulating often unspoken codes of conduct for ethical harvest, and emphasizing responsibilities over rights, may enhance public and government support for indigenous and local resource users, strengthening their role in co-management.

Reciprocal relations are another important component of Hawaiian culture that may also help to balance rights and responsibilities, while restoring community access to resources. This is a concept that "recognizes the social norms that encourage individuals to pursue environmental caretaking, and the sociopolitical factors that lead people to abdicate such responsibilities" (Diver et al. 2019:402). Eddie Ka'anana, respected elder and cultural practitioner, noted that *kuleana* (responsibility) is rooted in relationships with the land and how well people care for it (Vaughan 2018). Scholars have begun to understand reciprocal relations as a solution to increase and restore community access to resources.

As more hunters deepen their cultural understanding of native ecosystems and formalize responsibilities to steward areas, they may increase both hunting opportunities and public support for hunting. Local communities across the Hawaiian Islands have already begun to formalize reciprocal relations for fisheries into law through formal co-management agreements with state agencies, including four different community subsistence fishing areas, which shift rule-making responsibilities to the local level and base law on indigenous and local practice (Vaughan et al.

2017). Establishing collaborative management arrangements in the form of Indigenous agency, the ability and capacity of Indigenous people to self-govern in their best self-interest (UN 2007) through ancestral values such as *mālama 'āina*, may increase Indigenous and community participation in stewardship efforts of place while also fulfilling conservation and management goals (Winter et al. 2021).

Improving means of communication to enhance collaboration

The need for better communication between hunters, managers, and the broader community was a key recommendation that emerged from this study. Recommendations include a suggestion for agencies to conduct public meetings at times and places convenient for community members to attend (e.g., after work hours, weekends), engage hunters to assist with outreach, and employ outside entities who specialize in mediation and facilitation. For example, mediators in the 1990s helped to organize meetings on Hawai'i Island with community members including hunters, environmentalists, and forestry managers that facilitated recommendations to resolve long-standing conflicts in feral pig management (Adler 1995). By their last meeting, community members had built strong relationships that enabled them to make collective agreements. Nonetheless, studies about successful collaboration and co-management among community members in Hawai'i are still lacking, and conflicts continue to re-emerge.

Open interpersonal communication is a critical component for successful collaboration (Schuett et al. 2001), and will more likely lead to co-management (Schusler et al. 2003). Specifically, small working groups may help to familiarize people with one another and build positive relationships (Schusler et al. 2003). Most meetings between resource managers and hunters in Hawai'i are held at times when most community members work, and include one person speaking in front of a large panel of state employees. Some participants from our study suggested this type of meeting deters people from speaking. Crowley et al. (2017) emphasize that communication strategies in invasive species management are often simplistic and one-sided. They recommended communication strategies that promote dialogue between groups and address concerns, for instance mentioning both the positive and negative impacts of a potential invasive species management effort (Crowley et al. 2017). Similarly, some participants from our study wanted DLNR to also consider and recognize the potential for unintended negative impacts of proposed management actions, rather than solely promoting the intended benefits. Participants also suggested building long-term steady communication with hunters, including to assess effects of existing management, rather than only holding meetings to propose a new intervention. Another study found that unclear communication of environmental assessments by government agencies was a key constraint to building trust among community members; and in response, community members called for more consistent and honest communication by the agency (Davenport et al. 2007).

Identifying how to improve communication is crucial because it leads to other benefits for management like increased trust (Davenport et al. 2007). Lack of trust has been identified as a reason for past resource management conflicts between agencies or decision makers and resource users (Young et al. 2016b). Hunters in our study suggested that they need to continue to self-

organize within their hunting communities to demonstrate their ability and commitment to co-management with the state. Our study identified multiple layered reasons that hunters value invasive species, besides just for food. Helping managers and the public to understand these values is vital to enhancing trust and collaboration for invasive species management.

CONCLUSIONS AND FUTURE RESEARCH

This study aimed to identify social-cultural values and practices of hunters and how understanding their values and practices can aid in improving policies and collaboration for feral pig management. Although interviews cannot fully represent all hunters in Hawai'i, they provide a rich source of information to inform improved management and relationships, as well as a baseline for comparison with future studies. Future studies should expand our understanding of natural resource co-management by exploring gender diversity, geography, and the range of relationships among diverse community members (e.g., hunters, large private landowners, NGOs, cultural practitioners, hikers, and other user groups) that will be critical to meeting community needs regarding feral pigs.

Results from this study demonstrate that hunters value pig hunting for numerous reasons, vary in their perceptions of the current state of hunting and management of hunting, and recommend solutions that enhance management while expanding hunting opportunities. Incorporating forms of Indigenous agency, like the Indigenous and local knowledge that hunters possess of feral pig behavior and distribution, can increase the effectiveness of management actions, along with using place-based approaches to management. This study suggests engagement with local hunters may create pathways toward co-management that help to reduce past conflicts between government agencies and local resource users while improving community participation in management of invasive species.

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Data Availability:

The data that support the findings of this study are available on request from the corresponding author, KKL. None of the data are publicly available because they contain information that could compromise the privacy of the research participants. Ethical approval for this research study was granted by The University of Hawai'i Human Studies Program Institutional Review Board (CHS #24086).

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