

RESEARCH ARTICLE

Increased utilitarian value of invasive species in regions with long invasion history may limit public engagement for invasion control

Laurel Mael Philpott¹  | Orou G. Gaoue^{1,2,3} 

¹Department of Ecology and Evolutionary Biology, University of Tennessee, Knoxville, Tennessee, USA

²Laboratory for Population Dynamics (PopDYN), Faculty of Agronomy, University of Parakou, Parakou, BP, Benin

³African Centre for DNA Barcoding, Department of Botany and Plant Biotechnology, University of Johannesburg, APK Campus, Johannesburg, South Africa

Correspondence

Laurel Philpott, Department of Ecology and Evolutionary Biology, University of Tennessee, Knoxville, TN 37996, USA.

Email: lphilpo1@vols.utk.edu

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Societal Impact Statement

Positive perceptions of invasive species can hinder effective management, especially if management efforts that are rooted in scientific theories are misaligned with local ecological knowledge. We documented local ecological knowledge about land invasibility as predicted by invasion biology theories. Participants with greater local ecological knowledge were more likely to support management, contrary to those who use invasive plants as food or medicine. Our findings emphasize the importance of promoting awareness of the threats of even culturally important invasive species while also drawing upon local stakeholder knowledge to generate effective management.

Summary

- Misaligned management goals between scientists and local people can complicate the management of invasive plants, particularly if invaders are locally positively perceived. Management efforts that integrate local ecological knowledge with scientific knowledge are often particularly effective. We explored the relationship between local ecological knowledge, use, and management of an invasive plant in Benin.
- We interviewed 242 farmers across the northward invasional gradient of *Chromolaena odorata*, presenting participants with questions representing five invasion biology hypotheses that predict potential drivers of *C. odorata* invasion.
- First, we used the Kullback–Liebler divergence to show that local ecological knowledge on *C. odorata*'s invasion converged with scientific predictions. Second, we analyzed how demographics and distance from the invasional front shaped the use, knowledge, and management of *C. odorata*. Participants in regions with longer invasion history were more likely to use *C. odorata* as food or medicine than those near the invasional front. Third, we showed that participants who used *C. odorata* as food or medicine were less likely to support invasion management. Inversely, participants with higher local ecological knowledge were more likely to agree that managing *C. odorata* was important.

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- Our results emphasize that by promoting awareness of the ecological contexts of invasion and integrating local ecological knowledge into management, we may encourage public involvement in managing even culturally important invasive species.

KEYWORDS

biological invasions, biotic resistance, enemy release, evolution of increased competitive ability, invasional meltdown, local ecological knowledge, management, West Africa

1 | INTRODUCTION

In the Anthropocene, expanding global trade networks and an increasing rate of anthropogenic disturbance are facilitating the introduction of nonnative species, which pose a threat to natural ecosystems. Gaining insights into potential risk species and vulnerable lands can help land managers design proactive invasive species management strategies. Here, invasive species management refers to the actions and strategies taken to remove, control, or suppress invasive species populations. However, because humans are central to every stage of biological invasion (Mack & Lonsdale, 2001; Shackleton et al., 2019), insights gained from such predictions may be limited if they do not consider the role of humans in driving and managing invasions. While a growing area of research is focused on the role human activities play in driving invasions in environments (Dalmazzone & Giaccaria, 2014; Essl et al., 2019; Pyšek et al., 2010), an underrepresented aspect in the field of invasion biology is how human knowledge and opinions of invasive species underline behavior relating to invasive species introductions and management. Kapitza et al. (2019) described the current state of invasion biology on how humans perceive invasive species as being in its infancy, with few papers that include the human dimensions published each year. The number of invasion biology studies including human knowledge and perceptions that are based outside of North America or Europe is even fewer (Kapitza et al., 2019). It is therefore critical that invasion biologists draw upon the efforts of other disciplines (Gawel et al., 2024; Prinbeck et al., 2011; Robbins, 2004; van Riper et al., 2019), highlighting human interactions with invasive species so that we can produce a more complete understanding of how people shape global biological invasions.

Previous studies have demonstrated that despite adverse ecological and economic consequences associated with nonnative species, these effects may not be perceived similarly across communities (Dos Santos et al., 2014; Jarić et al., 2025; Maldonado & Voeks, 2021; Nuñez & Simberloff, 2005). Local people's engagement in invasive species management efforts may be affected by their perception of invasive species. Occasionally, invasive plants or animals are adopted into the cultural milieu of a community becoming so economically, aesthetically, or culturally useful that their loss would be harmful to community identity (Camou-Guerrero et al., 2008; Nuñez & Simberloff, 2005). For example, despite ecological risks associated with eucalyptus trees in San Francisco, local citizens developed the organization POET ("Preserve our Eucalyptus Trees") in a public effort

to resist management of invasive eucalyptus trees on Angel Island (Nuñez & Simberloff, 2005). Although the eucalyptus trees are highly flammable and contribute to wildfires, people were willing to resist control efforts because the ornamental trees had become iconic symbols of the Bay Area. Water hyacinth (*Eichhornia crassipes*) is another example of an invasive species that contributes to local livelihood and economy, particularly in southern Africa. Although there are no documented cases of people actively protesting its removal as with the POET movement, water hyacinth is widely used in basket weaving, as feed for animals, and even to produce biofuels (Ilo et al., 2020; Keawmanee, 2015). Another potential reason invasive species may be valued is because of their availability; common species may be used or valued more because they are widespread and therefore accessible (Albuquerque, 2006; Gaoue et al., 2017). For example, nonnative bluegrass in Kentucky, United States is so widespread that its ornamental properties are now synonymous with the cultural landscape of the "Bluegrass State" (Nuñez & Simberloff, 2005). Bluegrass also exemplifies the versatility hypothesis: when a species has high use value, people will protect it to retain its useful properties (Alencar et al., 2014; Gaoue et al., 2017). Availability, therefore, influences usage, and people may be less willing to support the removal of useful species—especially if removal is time-intensive and expensive.

Because strong community attachment can affect the effective management of useful invasive species, promoting local ecological knowledge (LEK) may be critical to controlling invasive plant populations. Local ecological knowledge includes the beliefs, traditions, and knowledge a group of people holds about their local ecosystems that are derived from human–environmental interactions (Berkes, 1999; Cebrián-Piqueras et al., 2020). Previous studies have demonstrated that knowledge, perception, and beliefs can shape practices and behavior toward invasive alien species (Ajzen, 1991; Novoa et al., 2017; Prinbeck et al., 2011; Shackleton et al., 2019). Thus, public willingness to support invasive species management hinges on their perception and local understanding of the ecological (e.g., changing nutrient or fire regimes and competition with native species) (Brooks et al., 2004; Von Holle et al., 2006), economic (e.g., lower crop yield, increased herbicide costs) (Cook et al., 2007; Paini et al., 2016; Pimentel et al., 2000), and cultural (e.g., damage to historical sites and displacement of useful or valuable native species) (Celesti-Grapow & Ricotta, 2021; Maldonado & Voeks, 2021) damage caused by invasive species. In this study, we primarily focus on how understanding of the ecological impacts of invasive species shapes public management

opinion. Previous research has demonstrated that outside of invasion contexts, individuals with higher LEK scores (i.e., their knowledge of the environment matches the traditions and beliefs of their community about the local environment) were more likely to support management of protected areas (Braga et al., 2017; Cebrián-Piqueras et al., 2020). Perpetuating LEK about the consequences of the invasive plant, highlighting the threats to biodiversity and farmland, could therefore help garner public support for removal efforts even when communities attribute a high use value to the invasive species.

Misalignment of goals and values between stakeholders can deter invasive species management (Estévez et al., 2015; García-Díaz et al., 2021). Community stakeholders often have values and goals defined by their traditional knowledge of their land and the needs of their community. In contrast, researchers often view invasions from a scientific lens, in which their knowledge is based upon systematically tested understanding of ecological processes (Whitham et al., 2015). This is referred to as scientific ecological knowledge (SEK). If, by promoting LEK about invasion dynamics, people begin to consider invasive species management efforts to be more important, we may also alleviate tensions between land managers and local individuals (Butler et al., 2012; Charnley et al., 2007; Rist et al., 2016). There has also been a push in the field to integrate LEK with scientific theory (Raymond et al., 2010; Ruiz-Mallén et al., 2009). Such an approach could unite invasion biologists and the local people who live with invasive species, encouraging more successful collaborative management. Misalignment between LEK and SEK can lead to culturally inappropriate invasion management, as in Hawaii, where local people have strongly opposed management of invasive pigs because pig hunting has been adopted into the culture as a form of celebration (Estévez et al., 2015). Although removal may be ecologically advantageous, invasive species management also needs to consider the cultural and societal implications of removal. It is therefore critical to investigate if predictions of what factors make a species a successful invader and what factors make land more susceptible to invasions are consistent with, and respectful of, LEK. In turn, integrating LEK with scientific theory may improve scientific understanding of the mechanisms behind biological invasions.

Here, we investigate how use, LEK, and SEK shape public management of the culturally important invasive plant, *Chromolaena odorata* (Asteraceae), in Benin (West Africa). Our first step was to investigate the convergence between LEK and SEK to identify which mechanisms underlie the invasion dynamics of *C. odorata* according to local farmers. We then leveraged existing historical data on the invasional gradient of *C. odorata* in Benin to investigate how LEK and usage of invasive species are shaped by invasion history and sociodemographic attributes. We were also interested in seeing how knowledge, use, and management shifted with varying ethnic diversity of the villages, as different compositions of cultural groups likely had unique perspectives and experiences with *C. odorata*. We analyzed the impact of *C. odorata*'s invasional gradient on the development of knowledge and plant use. We hypothesized that the knowledge of participants in regions with longer invasion history would more consistently match others in their community since there has been more

time to develop a widespread and uniform understanding of the invasion dynamics of *C. odorata*. We also hypothesized that participants in long-invaded regions would report using the plant for a higher number of applications than those near the invasional front (Albuquerque, 2006; Gaoue et al., 2017). Similarly, we explored whether local names reflected knowledge and use of *C. odorata* and analyzed how names shifted with distance from the invasional front. Finally, we examined whether participants who reported many uses for *C. odorata* would be less likely to consider management to be important due to their desire to retain the plant for its practical applications. We hypothesized that individuals with higher LEK and SEK scores would be more likely to find *C. odorata* management efforts to be important since they have a greater understanding of the ecological consequences of the invasive plant.

2 | MATERIALS AND METHODS

2.1 | Study system

We interviewed 242 participants in eight villages across the northward invasional gradient of *C. odorata* (Asteraceae) in Benin, West Africa. The invasional gradient of *C. odorata* follows the climatic gradient of Benin, which has three distinct zones: the southernmost, wet Guineo-Congolian zone (6°25'–7°30' N), the intermediate Sudano-Guinean zone (7°30'–9°30' N), and the northernmost, semi-arid Sudanian zone (9°30'–12° N). *Chromolaena odorata* is well established near the coast in the Guineo-Congolian zone (southern Benin) and is expanding its range toward the Sudanian zone (northernmost Benin), which represent the invasional front (Dandjlessa et al., 2021; Fandohan et al., 2015). This established invasional gradient makes *C. odorata* an ideal study system for testing how knowledge, use, and management practices shift based upon local availability of the plant. In the southern Guineo-Congolian zone, many of the coastal mangroves and moist woodlands have been replaced with oil palm plantations and agricultural fields (Wren-Lewis et al., 2020). Dry forests remain in the Sudano-Guinean zone (Idrissou et al., 2020). The Sudanian zone is characterized by a savannah mosaic, floodplains, gallery forests, and thorny scrubs (Sogbohossou & Aglissi, 2017).

Benin has high deforestation rates, mainly driven by local farming (Wren-Lewis et al., 2020), which occupies approximately 80% of the country's population (FAO, 2026). Subsistence agriculture is the dominant farming type, with workers using traditional methods to produce staple food crops like yams and corn primarily for personal household consumption (FAO, 2026; International Trade Administration, 2023). Commercial agriculture is also a critical part of the economy, with cash crops like cotton contributing to nearly 35% of Benin's GDP (FAO, 2026). For pastoralist groups in Benin, such as the Fulani, raising cattle is an essential part of their cultural and economic livelihoods. While many Fulani are sedentary, living and working on small-scale farms, there are transhumant groups that migrate their livestock seasonally to access resources for their cattle (Gaoue & Ticktin, 2009). Our study focused on farmers because they constitute the majority of

the population, and they are directly and disproportionately affected by the invasion of *C. odorata*.

Benin has approximately 50 sociolinguistic groups, with Fon, Nagot, Yoruba, Bariba, and Fulani representing the major ethnic groups in addition to other important groups such as the Adja, Dendi, Wama, Idatcha, and Lopka. We selected our study districts to include major sociolinguistic and ecological regions of the country across the invasional gradient. We sampled the Fon in the south (Allada), the Nagot–Yoruba in the Center (Tchaourou), the Bariba in the mid-northern region (Bembereke), and the Wama–Berba in the upper-north (Tanguieta). We also sought to account for the diversity of agro-ecological regions with the Guineo–Congolian zone (Allada), the Sudano–Guinean zone (Tchaourou), and the Sudanian zone (Tanguieta), with Bembereke situated at the border of the Sudanian and Sudano–Guinean zones. All the participants in this study were farmers living in small rural villages. Additionally, by sampling across the invasional gradient, we were able to represent many of the different major ethnic groups of Benin.

Chromolaena odorata is a culturally important species recognized not only as an invasive weed but also as a medicinal plant, fungicide, and contributor to soil fertility (Uyi et al., 2014). *Chromolaena odorata* is native to the Americas but is invasive in many parts of Asia and Africa. It was introduced to Nigeria in the 1930s through the importation of contaminated forestry seeds and has since spread throughout West Africa (Uyi & Igbinosa, 2013). The first sightings of *C. odorata* in Benin were in the southern portion of the country in the 1970s–1980s, and the plant has since spread northward (Uyi & Igbinosa, 2013). *Chromolaena odorata* is fast-growing and allelopathic (Vaisakh & Pandey, 2012). Attempts to manage *C. odorata* in Nigeria in the 1980s with the moth *Pareuchaetes pssuedoinsulata* ultimately failed (Muniappan & Bamba, 2000). While herbicide application can be effective, widespread use is costly and therefore not always practical (Uyi et al., 2014). Mixed cultural perceptions of the plant in nearby Nigeria have led to minimal public support for trying new methods of management (Uyi et al., 2014).

2.2 | Semistructured interviews and focus group discussions

To investigate the alignment between LEK and SEK regarding the invasion dynamics of *C. odorata*, as well as to explore how the plant is used and managed, we conducted in-person interviews across four districts in Benin: Allada, Tchaourou, Bembèrèkè, and Tanguieta (Figure 1). We conducted interviews in two villages per district with the help of four enumerators who received 2 days of training on the research topics and the questionnaire. The four field assistants were selected based on their mastery of the local languages in the study villages. After drafting an initial questionnaire, we consulted three local experts in rural sociology to finalize the instrument, ensuring that all questions were culturally appropriate as required by the University of Tennessee Knoxville Institutional Review Board (IRB #23-07799-XP). Even though the interviews were guided by the core questionnaire,

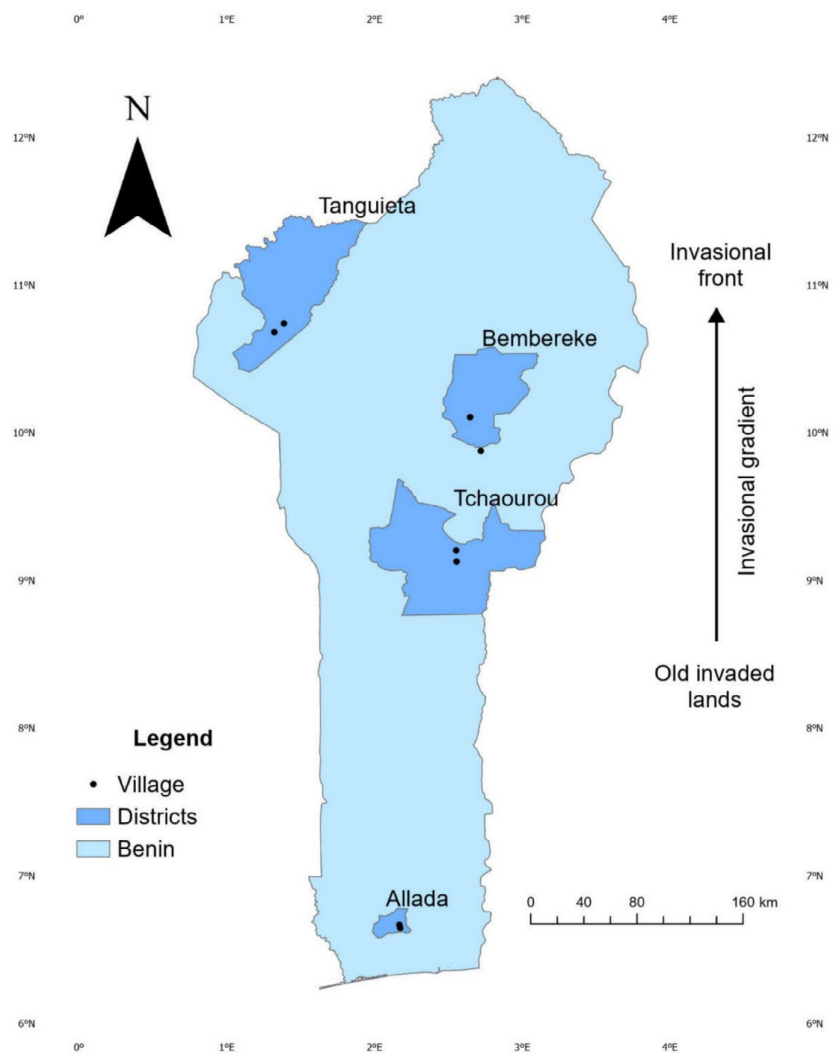
we chose to use a semistructured approach because the delivery of the questions needed to vary across languages and cultural contexts. We therefore selected four field assistants, who, while translating from French to local languages, needed to convey the original intent of the investigators. The field assistants were from the four districts represented in this study and were therefore familiar with the local dialects and customs, which eased the translation process.

In each of the eight villages, our initial step was to receive verbal permission to conduct interviews from the village chief and hold initial short focus group discussions. For the focus group discussions, we included participants selected randomly in the village via informal interviews and after discussions with local farmers organizations who recommended additional farmers. These focus group discussions served as a pilot test to confirm that participants understood the questions and also helped the field assistants practice the ways and order to ask the questions. The participants included in the focus groups were not included in the final analysis. Each of the focus group discussions included between five and 10 people in total, including both men and women. Beyond allowing field assistants to practice asking questions in the field before collecting data, the focus group discussions also helped us learn about participants' collective knowledge of invasion biology, natural history of *C. odorata*, and to recruit initial survey participants (outside of those included in the focus group discussion) via snowball sampling. Snowball sampling is a nonrandom sampling technique in which one participant recommends a list of other participants who fit the attributes necessary to participate in the study (in this case, men or women farmers over the age of 18). To limit homophily originating from participants recommending people who have similar demographic attributes and knowledge to themselves, after interviewing five participants, we selected a new independent participant to snowball from. The snowball method is a commonly used sampling technique in ethnobiology (Bernard, 2006; Tongco, 2007).

Aside from the initial focus group discussions, each interview was one-on-one, with a single interviewer and participant. At the beginning of each individual interview, we began by explaining our research purpose, interview procedures, and we asked participants if they had any questions or concerns. Once we acquired verbal consent from each of the participants and ensured they were farmers above the age of 18, we began the interviews. Only participants who recognized *C. odorata* were eligible to participate. In regions with longer invasion history, most of the participants we approached were familiar with *C. odorata*. Interview responses were recorded using Kobocollect software (<https://www.kobotoolbox.org/>) using a smartphone in the field (Galvis-Tarazona et al., 2022; Gangopadhyay et al., 2024; van Vliet et al., 2023).

This research took place in the summer of 2023, spanning 14 days and including 242 participants. The four field assistants worked simultaneously in their respective districts, spending 7 days per village. There were 28–32 participants from each of the eight villages. We collected sociodemographic data from each of the participants, including age, gender, how long they resided in their current village (residence time), education level, ethnicity, and whether they owned or rented their farmland (Table S1). We aimed to interview an

FIGURE 1 A map showing the distribution of all eight villages in each of the four districts of Benin represented in this study. Black points represent villages, and the dark blue represents the districts the villages are located within. The village names have been deidentified to preserve anonymity as required by our IRB guidelines.



equivalent number of men and women from each village, since they tend to have different farming practices and constraints (Aboudou & Fok, 2019; Alidou & Niehof, 2013). Men are typically associated with larger-scale agronomy (cash crop production like cotton, etc.), whereas women are responsible for smaller scale, more specialized farming (medicinal crops, etc.). Although it was not always possible to find an even proportion of men and women to interview in each village, our study included 131 men (54.13%) and 111 women (45.87%).

The interview questionnaire included 18 Likert-scale and free-response questions and was validated through several rounds of expert review (Table 1). The interview was divided into three primary sections. The first part of the instrument included questions pertaining to participant familiarity with and use of *C. odorata*. We showed participants photographs of *C. odorata* and asked if they recognized the plant. Once we established that each participant was familiar with *C. odorata*, we asked if they knew the plant's name and, if so, what its name meant in their local dialect. We also asked whether *C. odorata* was present and when they first noticed *C. odorata* in their area, and

for each participant to list the beneficial uses of *C. odorata* that they used the plant for.

The second part of the interview focused on participant knowledge of the natural history of *C. odorata*. The interview was divided into sections representing predictions of five invasion biology hypotheses: biotic resistance hypothesis, Darwin's naturalization hypothesis, aspects of the evolution of increased competitive ability (EICA) hypothesis, enemy release hypothesis, and invasional meltdown hypothesis (Table S2). It is important to note that the statement representing EICA does not perfectly capture the entirety of the hypothesis's predictions that, in the absence of native enemies, nonnative plants can put more energy into growth and reproduction instead of defense. Given the difficulties in translating the concept of evolutionary trade-offs to local languages, we chose to focus on the tangible evidence of EICA (increased growth and reproduction in invaded lands) that participants could have witnessed (Table 1). Therefore, principles of EICA inspired the development of the statements we presented to the participants of this study, but we do not claim to

TABLE 1 The IRB-approved questionnaire (in English) that was used for this study. This questionnaire includes the Likert-style statements representing predictions of biotic resistance hypothesis, Darwin's naturalization hypothesis, part of evolution of increased competitive ability (EICA), enemy release hypothesis, and invasional meltdown. The questionnaire also asked about participant knowledge and use of the plant, their management techniques and success, and their sociodemographic information.

Consent to participate in research

a.	Do you have questions about the research?	Yes/no, address questions
b.	Are you 18 years of age or older?	Yes/no
c.	Having said that, do you agree to participate in this study?	Yes/no
1.	Utilization history	
a.	Do you know this plant?	Yes/no
b.	What do you call this plant in your local language?	Free-list
c.	Is <i>Chromolaena odorata</i> a local plant?	Yes/no/uncertain
d.	When did you first see this invasive plant, <i>Chromolaena odorata</i> , in your area or on your land?	Free-list
e.	What beneficial uses do use <i>Chromolaena odorata</i> for in your area?	
f.	Rank the different uses you make of <i>Chromolaena odorata</i> in order of importance.	Free-list
2.	Elton's biotic resistance hypothesis	
a.	<i>Chromolaena odorata</i> tends to occupy land where there are more plant species than elsewhere.	Likert scale
3.	Darwin naturalization hypothesis	
a.	<i>Chromolaena odorata</i> tends to occupy lands that have more native plant species with traits like <i>Chromolaena odorata</i> .	Likert scale
4.	Statements inspired by evolution of increased competitive ability (EICA) hypothesis	
a.	<i>Chromolaena odorata</i> tends to occupy more land because it grows faster and faster and reproduces better (produces more seeds and fruits) than local plants in the same area.	Likert scale
b.	<i>Chromolaena odorata</i> tends to grow less and establish less outside of its native area.	Likert scale
5.	Enemy release hypothesis	
a.	<i>Chromolaena odorata</i> will dominate the land because it is eaten less by animals than native plants.	Likert scale
6.	Invasional meltdown hypothesis	
a.	<i>Chromolaena odorata</i> tends to occupy lands where other nonnative species are abundant.	Likert scale
b.	The invasion of <i>Chromolaena odorata</i> on these lands is facilitated by other nonnative species	Likert scale
c.	List any invasive plants or animals you know of in your area	Free-list
7.	Management	
a.	How do you manage the problem of <i>Chromolaena odorata</i> on your land?	Free-list
b.	The fight against <i>Chromolaena odorata</i> on my land is important to me.	Likert scale
c.	I manage to control <i>Chromolaena odorata</i> on my land	Likert scale
d.	What are ways we can successfully control <i>Chromolaena odorata</i> on our land?	Free-list
8.	Personal information	
a.	Region:	Free-list
b.	Village:	Free-list
c.	How long have you lived in this village or region?	Free-list
d.	Place of origin:	Free-list
e.	Age:	Free-list
f.	Sex:	Male/female
g.	Ethnic group:	Free-list
h.	Level of education:	Multiple choice
	1. None	
	2. Primary	
	3. Secondary	
	4. Superior (post-high school)	
	5. Alphabetize (refers to home schooling in local language)	

TABLE 1 (Continued)

i.	Do you own or rent your land?	Multiple choice
	1. Owner	
	2. Tenant	
	3. Owner and tenant	
j.	How much land do you own?	Free-list
k.	How much land do you rent?	Free-list
l.	Save your current location (instruction to field assistant to record coordinates of the village)	Free-list
m.	What is the size of your farm in hectares?	Free-list
n.	How many hectares of cash crops do you have?	Free-list
o.	How many hectares of food crops do you have?	Free-list

fully capture the entire essence of the hypothesis. These hypotheses were selected because they predict either why some environments are more invasible than others or the organismal functional traits that may help species successfully invade (Table S2). Participants ranked their level of agreement with statements representing the predictions of each hypothesis on a scale from strongly disagree to strongly agree. For instance, participants were presented with two Likert statements pertaining to the invasional meltdown hypothesis, which predicts that alien species facilitate the spread of other alien species. One of the Likert statements representing invasional meltdown was “*C. odorata* tends to occupy lands where other non-native species are abundant.”

The third part of the interview featured management of *C. odorata*. Participants were asked to list the management strategies they used to manage *C. odorata* on their land. The farmers then indicated their level of agreement with the statement “The fight against *Chromolaena odorata* on my land is important to me.” We also asked them to rank their level of agreement with the statement: “I manage to control *Chromolaena odorata* on my land.”

2.3 | Estimating use, management, and local ecological knowledge scores

We first calculated a relative use score for each participant by counting the number of ways each person reported using *C. odorata* and divided it by the number of unique uses mentioned across all responses. In this method, someone who used the plant for five applications would have a higher use score than someone who only used it for one purpose. Management scores were the ratio of the number of management strategies an individual used compared with the total number of management strategies reported across all participants. Individuals with high management scores, therefore, reported using a greater number of management techniques than those with lower scores.

We estimated two types of ecological knowledge in this study: SEK and LEK. Here, SEK was used to measure participant agreement with scientific predictions regarding biological invasions, specifically in the case of *C. odorata*'s invasion in Benin. SEK scores were assigned based upon whether the participant agreed with the predictions of each scientific hypothesis. For example, the biotic resistance hypothesis

predicts that in areas with high biodiversity, there are fewer introduced species because of increased competition, parasitism, and other biotic factors that resist the establishment of new species (Table S2). However, in the interview (Table 1), the statement presented to the participants stated, “*Chromolaena odorata* tends to occupy land where there are more plant species than elsewhere.” If the participant responded with *strongly disagree* they would be awarded two points. Those who answered *disagree* would earn one point, and any other response would be given zero points. In other words, if a participant responded in a way that matched scientific theory, they earned points. Therefore, participants whose knowledge of *C. odorata*'s invasion aligned with science predictions earned greater scientific knowledge scores.

Each participant received seven SEK scores, representing the seven Likert scale statements they responded to. The seven SEK scores were used in a principal component analysis (PCA) to calculate a composite SEK score, which is the score used in our structural equation models (Methods S1).

LEK scores were calculated by scoring each participant's answer against consensus from the broader community, or the most frequent answer provided by all participants. We scored participants' answers against the most frequently answered response across all participants for each of the seven Likert questions representing invasion biology hypotheses (Table S3). While SEK scores were based upon agreement with predictions of scientific theory, cultural consensus theory calculates scores based upon the culturally “correct” responses, or beliefs of the group (Weller, 2007). Using cultural consensus to estimate LEK or other knowledge types is a common method used in ethnobiological papers (Braga-Pereira et al., 2024; Van Holt et al., 2016). In this study, a participant with the highest possible LEK score would be in perfect agreement with the most common beliefs across all participants. The most common beliefs may or may not correspond with scientific predictions. As with SEK, each participant received seven LEK scores. We used PCA to calculate a composite LEK score, which was used in our structural equation models (Supporting Information, data analysis).

We did not intend to measure a holistic LEK score encapsulating total knowledge of environmental functioning. Instead, our objective was to document what local farmers tended to think about the invasion dynamics of *C. odorata*. While the farmers undoubtedly knew more about the invasion of *C. odorata* than what was captured in this

study, the advantage of asking them about specific, sometimes opposing, invasion biology hypotheses was that we could compare what farmers tended to know about *C. odorata*'s invasion with what was predicted. Knowing which hypotheses align with local observation points to which mechanisms may be ecologically relevant in this system and also identifies a shared foundation upon which to build management strategies.

2.4 | Estimating village ethnic diversity

Many districts in Benin are often dominated by a small number of ethnic groups. We estimated village ethnic diversity to account for how use, knowledge, and management of *C. odorata* shifted with unique cultures. This allowed us to gain insights into cross-cultural local knowledge sharing, and how this impacted overall management. To calculate the village-level ethnic diversity score, we used the self-reported ethnicity of each participant to construct a matrix representing all unique ethnicities. We used the Shannon index through the *diversity* function in the *vegan* package in R version 4.4.1 to estimate an ethnic diversity score for each village (Oksanen et al., 2001). With this diversity score, we estimated the effect of village ethnic diversity on use, knowledge, and management in the structural equation models (SEMs).

2.5 | Data analysis

To investigate the extent to which local knowledge converged with scientific theory, we used Kullback–Leibler (KL) divergence to measure the overlap in the distributions of SEK and LEK scores. We first found the probability distributions of the SEK and LEK scores and then used the *KL* function in the *philentropy* package in R version 4.4.1 (Drost, 2018). If the distribution of the SEK scores and the LEK scores were perfectly aligned, the resulting KL score would be 0. The higher the KL score, the greater the misalignment between SEK and LEK, demonstrating that most participant responses did not agree with scientific theory.

We used SEM with the *psem* function in the package *piecewiseSEM* to explore the direct and indirect links between use, composite SEK and LEK, and management scores. We chose SEM over generalized linear models (GLMs) because the hypothesized relationships between variables used mediation, which has as interdependent structure that required simultaneous estimation of all pathways. SEM integrates this within a single integrated framework, preventing us from having to use multiple GLMs and additional analyses. We originally had three candidate models showing hypothetical relationships between the following variables: management score, use score, residence time, distance to invasional front, and village diversity score. The model with the best fit is chosen based on the one with the best Fisher's *C* value and lowest Akaike information criterion (AIC) (Garrido et al., 2022; Lefcheck, 2016). The model we used in the analysis had the best AIC (83.555) and included use score and knowledge score both mediating the effects of residence time, village diversity score, and distance to

the invasional front on management score, while also being predicted by those same variables (Figure 2). The alternative two models had use mediating knowledge (AIC = 86.647) and knowledge mediating use (AIC = 86.647). We included two versions of the final path diagram in this study that were identical except for the type of ecological knowledge represented; one SEM included local ecological knowledge scores and the other had scientific knowledge scores instead.

We developed a Bayesian ordinal model using the function *bayespolr* in the *arm* package in R (Gelman & Su, 2024) to link the likelihood of participants responding in a certain way on Likert scale responses with their sociodemographic and geographic factors. Bayesian ordinal regression allowed us to include prior information (in this case, we used flat priors) and obtain a more precise estimate of model parameters (Ru et al., 2022). For each relationship, we calculated the 95% credible interval, and if this value did not include zero, we considered the effect to be significant. We used binomial regression to determine which sociodemographic and geographic predictors impacted the use and management strategies employed by participants.

3 | RESULTS

3.1 | Convergence between local and scientific knowledge

We found mixed support for the invasion biology hypotheses included in this study (Table S4). Most participants tended to agree or strongly agree with the predictions of the biotic resistance (KL = 0.303, Table S4), enemy release (KL = 0.128, Table S4) hypotheses, and predictions that *C. odorata*'s invasion success was in part due to its ability to grow and reproduce more rapidly than native species (KL = 0.00, Table S4). However, we found less convergence between local knowledge and scientific theory regarding the predictions of the invasional meltdown hypothesis (KL1 = 0.771, KL2 = 0.905, Table S4), Darwin's naturalization hypothesis (KL = 0.698, Table S4), and the predictions that *C. odorata* grows or behaves differently in its invasive versus non-native range (KL = 0.667, Table S4).

3.2 | The use of *C. odorata* varies depending on sociodemographic traits and position within its invasive range

Participants reported using *C. odorata* primarily as medicine (59.5%), fertilizer (26.4%), food (7.0%), fodder (5.3%), in home construction (4.9%), as a mosquito repellent (2.9%), and to limit desertification (1.7%). Use differed based upon sociodemographics and participant position within the invasional gradient. For instance, participants living in villages with higher ethnic diversity, such as those in the districts of Tchaurou and Allada, tended to have more uses for *C. odorata* ($\beta = 0.194 \pm 0.028$, $p = .003$, Figure 3). Women were significantly more likely to report using *C. odorata* medicinally than men ($\beta = -0.734 \pm 0.345$, $p = .033$, Table S5), but men were more likely

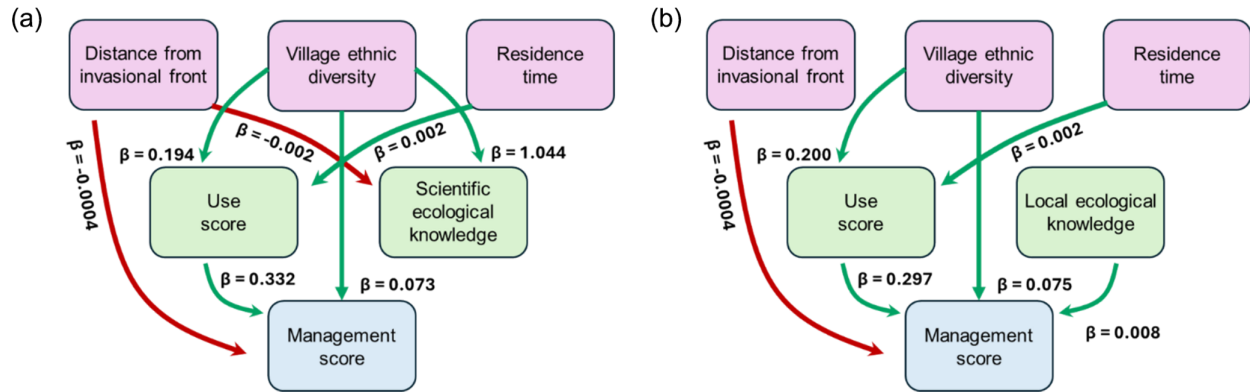
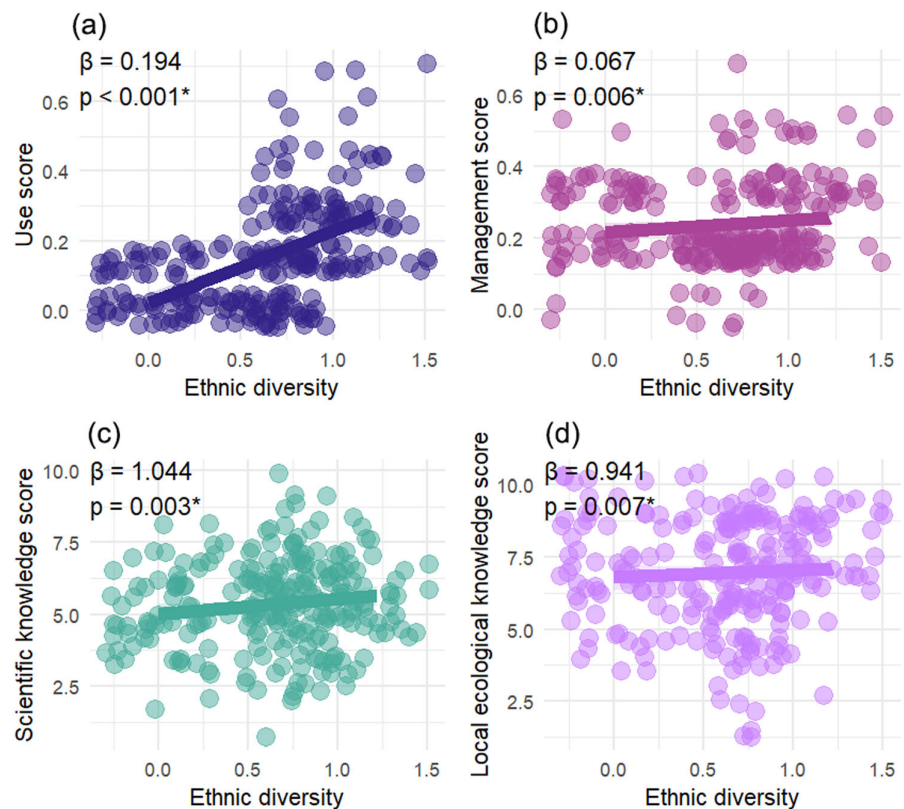


FIGURE 2 Structural equation models showing the direct and indirect links between position within the invasional gradient of *Chromolaena odorata*, participant residence time, village ethnic diversity, (a) scientific knowledge or (b) local ecological knowledge scores, use scores, and management scores. Lines denote a significant relationship; green signifies a positive relationship and red signifies a negative relationship.

FIGURE 3 The ethnic diversity of a village has a positive significant effect on use (a), management (b), scientific knowledge (c), and local ecological knowledge (d) scores. The management, use, and knowledge scores were all continuous variables (noninteger values) and were therefore analyzed using linear regression with Gaussian error distribution. The degree of significance is indicated as $*p < .05$, $**p < .01$, $***p < .001$. NS denotes a nonsignificant difference.



to use *C. odorata* as fertilizer ($\beta = 1.701 \pm 0.458$, $p < .001$, Table S5). The importance of managing *C. odorata* did not significantly vary between men and women ($\beta = -0.499$, 95% CI: -1.027 to 0.029 , Table S6). There was also not a significant difference in how successful men and women reported their management to be ($\beta = 0.321$, 95% CI: -0.208 to 0.846 , Table S6).

Distance from the invasional front also played a role in shaping *C. odorata* use. While the number of uses the participants reported did not significantly change with distance from the invasional front

(SEK SEM: $\beta = 0.001 \pm 0.001$, $p = .485$; LEK SEM: $\beta = 0.001 \pm 0.001$, $p = .281$, Figure 4), the ways in which *C. odorata* was used did vary with distance. Although a small number of participants at the invasional front reported using *C. odorata* for more specialized and risky uses such as food and medicine, participants in regions with longer invasion history were more likely to use *C. odorata* as food ($\beta = 0.013 \pm 0.005$, $p = .004$, Table S5) or medicine ($\beta = 0.010 \pm 0.002$, $p < .001$, Table S5). Residence time also played a role; the longer participants lived in a village, the more likely they were to

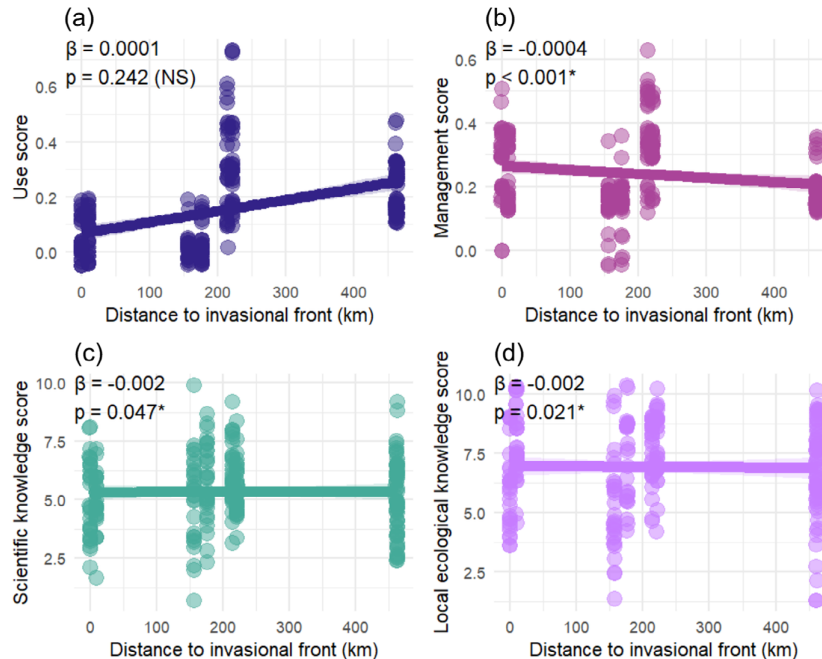


FIGURE 4 How far a participant is from the invasional front impacts use (a), management (b), scientific knowledge (c), and local ecological knowledge (d) scores. The management, use, and knowledge scores were all continuous variables (noninteger values) and were therefore analyzed using linear regression with Gaussian error distribution. The degree of significance is indicated as $*p < .05$, $**p < .01$, $***p < .001$. NS denotes a nonsignificant difference.

report using *C. odorata* as medicine ($\beta = 0.033 \pm 0.014$, $p = .016$, Table S5). Younger participants were also significantly more likely to use *C. odorata* as medicine ($\beta = -0.032 \pm 0.016$, $p = .046$, Table S5), and the likelihood of reporting medicinal use decreased with education level (Primary Education: $\beta = -2.363 \pm 1.168$, $p = .043$; Secondary Education: $\beta = -2.941 \pm 1.204$, $p = .015$, Table S5).

3.3 | Participants in regions with longer invasion history tend to use fewer management strategies than people in the north, but also consider their efforts to be more successful

Participants reported using six unique management strategies to manage *C. odorata* on their land: weeding (79.7%), herbicide (26%), burning (23.14%), cutting (12.4%), leaving the land to fallow (0.01%), and biocontrol by bats (0.01%). Men tended to use more management approaches compared with women ($\beta = 0.033 \pm 0.015$, $p = .026$). Younger participants typically employed fewer management strategies than older participants ($\beta = -0.002 \pm 0.001$, $p = .024$). Education level also played a role; participants with secondary-level education used the greatest number of management strategies, ($\beta = -0.084 \pm 0.034$, $p = .027$), followed by participants with no formal education ($\beta = -0.093 \pm 0.038$, $p = .007$) and those with primary-level educations ($\beta = -0.105 \pm 0.036$, $p = .004$). Participants living in villages with high ethnic diversity tended to have higher management scores ($\beta = 0.073 \pm 0.025$, $p = .004$, Figure 3). There was also an indirect effect of village ethnic diversity on management score; participants in more diverse villages tended to report more uses for *C. odorata* (SEK SEM: $\beta = 0.194 \pm 0.028$, $p < .001$; LEK SEM: $\beta = 0.200 \pm 0.023$, $p < .001$), which in turn predicted higher

management scores (SEK SEM: $\beta = 0.332 \pm 0.053$, $p < .001$; LEK SEM: $\beta = 0.297 \pm 0.051$, $p < .001$). In both the SEK SEM (Direct: $\beta = 0.073$; Indirect: $\beta = 0.064$) and the LEK SEM (Direct: $\beta = 0.075$; Indirect: $\beta = 0.059$), the direct pathway was stronger than the indirect pathway, although they were close in magnitude. Participants in high-diversity villages were also more likely to report that management was important ($\beta = 3.580$, 95% CI: 2.606 to 4.503, Figure 5) and that they successfully managed *C. odorata* on their land ($\beta = 1.655$, 95% CI: 0.763 to 2.547, Figure 5).

Distance from the invasional front had a direct positive effect on management, in that participants near the invasional front typically used more management strategies than those in old-invaded lands (Both SEK and LEK SEM: $\beta = -0.0004 \pm 0.0001$, $p < .001$, Figure 4). Furthermore, participants who used more management strategies were also less likely to agree that they were successfully managing *C. odorata* ($\beta = -3.081$, 95% CI: -5.338 to -0.824 , Table S6). Similarly, participants near the invasional front were more likely to agree with the statement that managing *C. odorata* was important ($\beta = -0.005$, 95% CI: -0.007 to -0.002 , Figure 5). However, these participants were less likely to report success in managing *C. odorata* compared with participants in old-invaded lands ($\beta = 0.008$, 95% CI: 0.006 to 0.011, Figure 5).

3.4 | Invasive plant use is linked to a negative opinion regarding the importance of management

Participants who had higher use scores were more likely to report success in managing *C. odorata* ($\beta = 6.760$, 95% CI: 4.906 to 8.614, Supplementary information, Table S6), but less likely to agree that management was important ($\beta = -1.669$, 95% CI: -3.336 to -0.001 ,

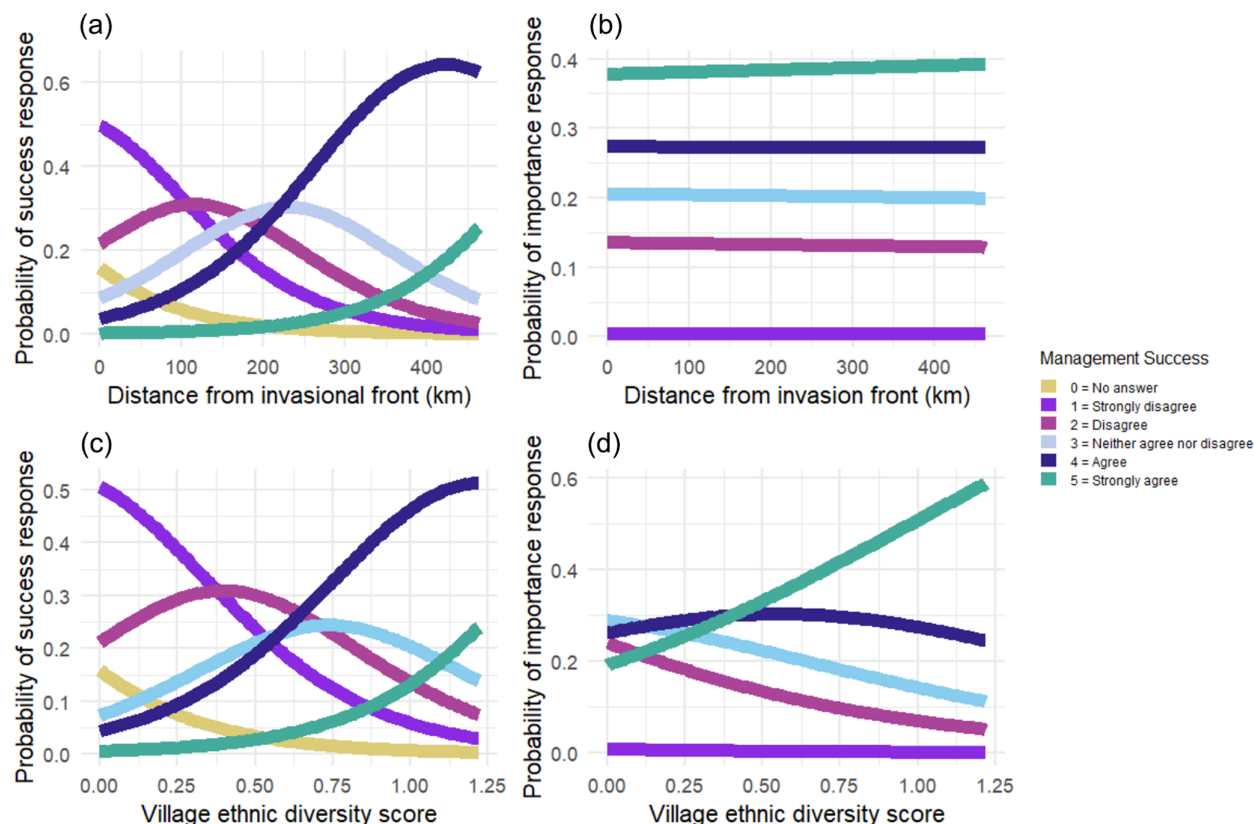


FIGURE 5 Depiction of how distance from the invasion front and village ethnic diversity predict community perceptions of the success and importance of managing invasive *Chromolaena odorata*. The predicted probabilities are derived from Bayesian ordinal regression models, where each line represents one Likert response category (0 = no answer, 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree). (a) The probability of a participant responding that they strongly agree or agree that they successfully manage their land increases with distance from the invasional front. (b) The probability of a participant considering invasive species management to be important stays relatively consistent across the invasional range. (c) The probability of a participant responding that they strongly agree or agree that they successfully manage their land increases with village ethnic diversity. (d) The probability of a participant agreeing that invasive species management is important increases with village ethnic diversity.

Table S6). Similarly, participants who used *C. odorata* as medicine ($\beta = -1.083$, 95% CI: -1.667 to -0.500 , Table S6) were less likely to agree that managing *C. odorata* was important.

3.5 | SEK scores highest near the invasional front and in villages with high ethnic diversity

We found no significant association of participants' age, gender, land ownership status, or level of education with their knowledge scores. However, participants from villages with high ethnic diversity tended to have higher SEK (SEK SEM: $\beta = 1.044 \pm 0.334$, $p = .003$, Figure 3). Additionally, participants in regions with longer invasion history tended to also have lower SEK (SEK SEM: $\beta = -0.002 \pm 0.001$, $p = .047$, Figure 4). There was no effect of village ethnic diversity (LEK SEM: $\beta = 0.549 \pm 0.436$, $p = .209$, Table S7) or distance from the invasional front (LEK SEM: $\beta = -0.001 \pm 0.001$, $p = .250$, Table S7) on LEK scores.

3.6 | Participants with greater knowledge tend to consider management to be more important

Using SEM, we found that participant SEK score was not significantly related to the number of management strategies they employed (SEK SEM: $\beta = -0.003 \pm 0.005$, $p = .422$, Table S7). In our second SEM based upon LEK scores, however, we found a direct significant positive link between participants' LEK and management scores (LEK SEM: $\beta = 0.008 \pm 0.003$, $p = .022$, Table S7). Participants with higher LEK scores were also less likely to agree that they successfully managed *C. odorata* on their land ($\beta = -0.171$, 95% CI: -0.332 to -0.010 , Figure 6). We did not find a relationship between SEK scores and participant reports of management success ($\beta = -0.039$, 95% CI: -0.190 to 0.112 , Figure 6). Participants with high SEK ($\beta = 0.159$, CI: 0.005 to 0.313 , Figure 6), but not LEK ($\beta = 0.129$, CI: -0.036 to 0.295 , Figure 6), were more likely to agree that managing *C. odorata* was important.

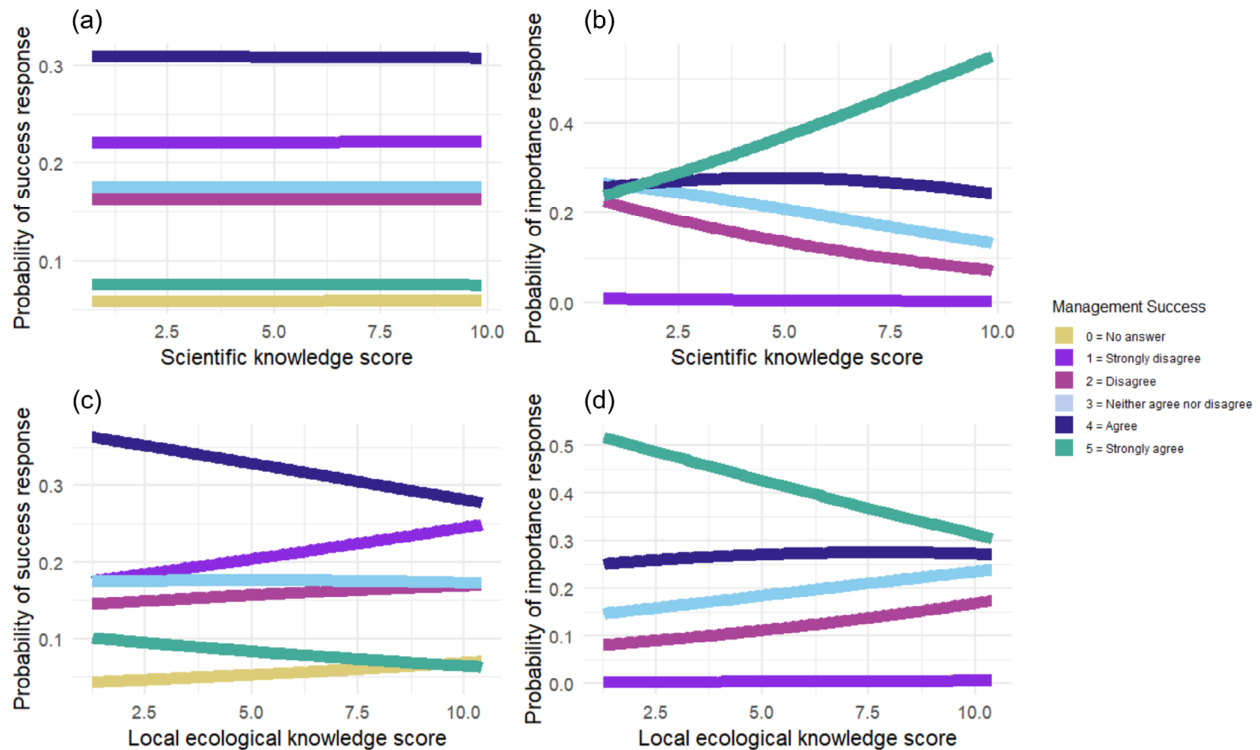


FIGURE 6 Depiction of how scientific knowledge scores and local ecological knowledge scores predict community perceptions of the success and importance of managing invasive *Chromolaena odorata*. The predicted probabilities are derived from Bayesian ordinal regression models, where each line represents one Likert response category (0 = no answer, 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree). (a) The probability of a participant responding that they agree that their management is successful remains relatively stable with increased scientific ecological knowledge score. (b) The probability of a participant considering management to be important increases with scientific ecological knowledge score. (c) The probability of a participant agreeing that their management does not significantly vary with increased local ecological knowledge. (d) The probability of a participant agreeing that management is important increases with scientific knowledge.

3.7 | Ethnotaxonomy reflects invasion history

The local names reflected where the participants thought *C. odorata* originated, its invasive nature, use, and its botanical traits (Table S8). The most frequently cited name, particularly near the invasional front, was *yorihonsonhona* (58 responses), which means “the *Hyptis suaveolens* of Nigeria,” indicating that *C. odorata* acts like *Hyptis suaveolens*, a plant they know to be invasive (Table S8). The name *touro son* (47 responses), which was commonly cited in the middle of the invasional gradient, means in the Bariba language “a plant that creates a forest on its own.” This suggests that only a small amount of *C. odorata* is required for an entire area to be dominated by the plant. Similarly, *xwéflou* (25 responses), used primarily in regions with longer invasion history, means in the local language Fon “The house is blurry.” This directly discusses the invasive nature of *C. odorata* and its fast growth, describing that the plant grows so densely that it can cover structures, lowering visibility. Certain names also insinuated that participants understood the alien status and recent introduction history of *C. odorata*. Participants near the invasional front used *yakassou kparou* (7 responses), which in Bariba means “new weeds,”

demonstrating understanding that the plant has recently arrived in the area. Regions with longer invasion history, participants used *avion/man* (5 responses), or “Leaf from plane” in Fon, which reflects participant knowledge of the fact that *C. odorata* is an alien, even if they are uncertain about the origin of invasion (Figure S1). Participants in the recently invaded land pointed to the Northern border of Benin, near the city of Malanville, as the origin of the species. In regions with longer invasion history, the local names for *C. odorata* captured its usage. For instance, the species is referred to as *n'gbè'doto* (5 responses), or “I don't need the doctor,” to highlight the medicinal value of the plant (Figure S1). Users reported that they did not need to go to the hospital to see a doctor because they can use *C. odorata* as medicine instead. *Chromolaena odorata*'s use as fodder was also recognized in the name “*nague eletebou*,” meaning “cattle sugarcane.”

4 | DISCUSSION

Choosing which management strategies to use to control invasive species requires knowledge of the underlying processes shaping its

invasion, as not all removal techniques are equally effective. For instance, if an invasive relies upon a large seedbank, then simply cutting back individuals likely would not be effective long-term. Identifying which invasion biology hypotheses (e.g., biotic resistance or enemy release) local people tend to agree with is therefore important because it shows which processes farmers believe underline the invasion of *C. odorata*. This knowledge helps managers select management techniques that more effectively control the plant. Furthermore, this study revealed specifically which management techniques local farmers are actively using, as well as how successful farmers found those management techniques to be, which further helps inform the selection of larger-scale management efforts. By incorporating management strategies and invasion biology frameworks that align with local knowledge and beliefs, managers may be able to encourage greater community buy-in (Ruiz-Mallén et al., 2015; Wali et al., 2017). When people see their knowledge and practices represented in management plans, they are more likely to feel a sense of ownership and engage actively in conservation efforts.

The hypotheses with the least public support were the ones that explicitly discussed native or nonnative species (e.g., invasional meltdown, Darwin's naturalization hypothesis, and aspects of EICA). Although it is possible that such hypotheses do not apply in this system, the disagreement could also originate from limited knowledge of scientific concepts. For instance, perhaps participants did not agree that invasional meltdown was an underlying mechanism in the invasion of *C. odorata* because they were not sure which species were introduced, making it difficult to identify nonnative mutualisms. Similarly, participants likely had limited knowledge of the growth of *C. odorata* in its native range, making it difficult to respond to the statement, "*Chromolaena odorata* tends to grow less and establish less outside of its native area." Insightful local knowledge might therefore be masked by limited scientific knowledge, leading to inflated levels of disagreement for more jargon-heavy predictions.

The second objective of this study was to investigate how knowledge LEK, SEK, and usage of invasive species is shaped by sociodemographics and position within its invasional gradient. Patterns of *C. odorata*'s use were not uniform across different demographics or throughout Benin. First, women were more likely to use *C. odorata* as medicine than men were, whereas men were more likely to report using it agriculturally. In many cultures, consistent with our findings, women are healers and therefore tend to be knowledgeable about the medicinal uses of plants (Beltrán-Rodríguez et al., 2014; Souto & Ticktin, 2012; Voeks & Leony, 2004, but see Laleye et al., 2015; Torres-Avilez et al., 2016). Contrary to expectation, we found that age did not affect knowledge or use scores. Younger people were significantly more likely to use fewer management techniques compared with older people, however. Similar studies have found that because older people have more time to accumulate knowledge, they tend to have higher knowledge scores than younger people (Flores-Silva et al., 2023; Ndavaro et al., 2024; Turreira-García et al., 2015). Knowledge or use scores might not have varied with age in this study because *C. odorata* is new enough in many parts of the country that different generations were exposed

to the invasive plant near-simultaneously. Use and knowledge varied across the invasional gradient. Participants throughout *C. odorata*'s range tended to use the plant for the same number of applications, but the type of usage varied depending on distance from the invasional front. Participants in regions with longer invasion history were more likely to report eating the leaves of the plant, or to even use it medicinally to reduce fever in infants. Many exotic plants are intentionally introduced as a source of food or medicine (Drobnik, 2023; Williams et al., 2021). *Chromolaena odorata*, however, poses an interesting case because it was introduced into West Africa unintentionally (Uyi & Igbinosa, 2013), meaning that people were not provided with knowledge of its useful properties. Local people had to experiment with the plant before fully adopting it as an ingestible herb. Near the invasional front, where participants have not had the time to fully experiment with the plant, they are more likely to use the plant for lower-risk applications, such as for construction. Exposure time likely influences whether local people select invasive species for more high-risk uses. Additionally, we found that SEK scores, but not LEK scores, were lowest in long-invaded regions. This is likely because the southern portion of Benin is not as rural as more northern areas, meaning that overall exposure to and knowledge of the environment tends to be lower in the south.

Village ethnic diversity had both a direct and an indirect positive impact on management. The direct relationship between village ethnic diversity and management score indicates that regardless of whether farmers use *C. odorata*, those in ethnically diverse villages are more likely to employ a greater diversity of management strategies. Previous research has revealed that different ethnic groups have unique environmental management strategies (Hashiguchi et al., 2021; Sitorus et al., 2024). Horizontal transfer of knowledge largely hinges on interactions between neighbors and nonkin folk (Li et al., 2024; Rathore et al., 2021). Such differential knowledge between cultures therefore suggests that farmers in more ethnically diverse villages are exposed to a broader range of ideas for controlling the plant. Knowledge and cultural practices spread through storytelling, observation, and discourse between communities (Berkes, 1999; Pretty et al., 2009), and when many different cultural backgrounds coexist, the likelihood of transmitting novel management strategies for *C. odorata* may increase.

The indirect pathway, in which plant use mediated the positive relationship between village ethnic diversity and management score, was stronger than the direct pathway. Farmers in diverse villages tended to use *C. odorata* for more applications, and those who used it more also reported trying more management strategies. This likely reflects the same underlying mechanism as the direct pathway—farmers who are more engaged with the plant through use may also be more embedded in the knowledge networks where management strategies are discussed and shared. These findings suggest that interventions promoting knowledge exchange in low-diversity regions could be an effective way to increase engagement with *C. odorata* management.

Evidence of the transmission of knowledge regarding *C. odorata* is also reflected in ethnotaxonomy. Different ethnic groups had names

for *C. odorata* that reflected similar sentiments: *Touro son* in Bariba, for example, meant “One person forest,” which is also the meaning of the Fulani name *Sakoukou*. While knowledge regarding *C. odorata*'s invasion and management strategies may transmit naturally over time, interventions might hasten the rate at which effective management practices permeate traditional knowledge bases. This may be particularly important in low-diversity regions in the north that may be more isolated from discussions on which management strategies most effectively remove *C. odorata* from farmland.

We found support that participants who had high use scores and those who used *C. odorata* medicinally were less likely to consider management to be important. Such a finding is a testament to how use can impact management opinion and is reflected in past demonstrations that if invasive species have beneficial uses (pets, ornamental aesthetics, hunting, etc.), people will protect the organism despite ecological consequences (Estévez et al., 2015; Nuñez & Simberloff, 2005; Remmele & Lindemann-Matthies, 2024). Participants with higher SEK scores tended to consider management to be more important, potentially indicating that a better understanding of the ecological consequences of an invasive plant may encourage someone to view its removal as being more important (Braga et al., 2017; Novoa et al., 2017; Potgieter et al., 2019; Raymond et al., 2010; Remmele & Lindemann-Matthies, 2024; Wilson & Tisdell, 2005). For instance, Wilson and Tisdell (2005) found that participants were more willing to allocate funds toward conservation of threatened birds at the expense of more common species once they were informed of the underlying ecological consequences. A common conclusion from studies discussing the link between knowledge and conservation support is the importance of implementing programs in local communities to help promote the development of knowledge regarding conservation concerns (Braga et al., 2017; Novoa et al., 2017; Remmele & Lindemann-Matthies, 2024). By this logic, developing programs in Benin that incorporate both local and scientific knowledge regarding the invasion and consequences of *C. odorata* may be another effective way of garnering more public support for *C. odorata* removal efforts.

We did not find a positive connection between SEK or LEK scores and participants' likelihood of reporting management success. This may be a result of how new *C. odorata* is to Benin; it has only been in the oldest invaded lands for about 40 years and still has not reached certain regions in the north. Perhaps there has not been enough time for knowledge regarding effective management to permeate local cultures. In many conservation instances, local people have generations of experience that lead to the development of effective management traditions (Weiss et al., 2013; Williams et al., 2021), but *C. odorata* has only been in Benin for approximately two generations in the oldest-invaded regions. Local people and scientists are in the process of developing their knowledge bases and management strategies to cope with the consequences of *C. odorata*'s invasion. Still, it is clear from models of effective management plans that for effective invasive species management to be developed, scientists must incorporate the knowledge of local people in Benin who have invaluable and long-standing insights regarding their land (Adom, 2016).

5 | CONCLUSION

Our study revealed that local farmers' knowledge of invasion dynamics best aligned with the predictions of enemy release, biotic resistance, and the idea that *C. odorata* has increased growth and reproduction compared with native species in the area. This suggests that farmers know which physical traits and environmental conditions (high native biodiversity, lack of herbivores) facilitate the invasion of *C. odorata*. Researchers should therefore collaborate with local farmers to develop management rooted in LEK. Examples could include promoting the planting of native species or cutting *C. odorata* individuals before they reach reproductive maturity. We also investigated how knowledge, use, and management evolved over the invasional gradient of *C. odorata*. Participants in regions with longer invasion history were more likely to report using the plant in higher risk ways, such as ingesting *C. odorata* as a medicinal herb or food. Participants who used the plant in more ways, and particularly those who used it medicinally, were less likely to agree that controlling *C. odorata* populations through invasive species management was important. Interestingly, we also revealed that participants whose knowledge of the invasion dynamics of *C. odorata* aligned closely with scientific theory were more likely to consider management of the plant to be important, even if they also reported using the plant. Participants in regions with longer invasion history were the most likely to report that they successfully managed *C. odorata*, despite using overall fewer management techniques compared with those near the invasional front.

Additional work should expand upon the methodological limitations within this study. Although we attempted to represent the scientific hypotheses as clearly as possible, the use of jargon (such as “native” vs. “nonnative”) or unfamiliar concepts (the growth of *C. odorata* in its native range) within the interview questions may have concealed the full extent of LEK. We also could not accurately capture all the dimensions of the scientific hypotheses used in this study. For instance, to truly capture whether local farmers agreed with the predictions of EICA, we would have had to ask about evolutionary trade-offs, which were not feasible given language and cultural constraints.

Survey and interview data can also be subject to social desirability bias (Grimm, 2010), in which participants choose to respond in a way that aligns with what they perceive to be socially acceptable. In this study specifically, participants may have inflated how important they considered management to be to conform with what they thought was expected of them. Similarly, future work should consider observing the use and management of *C. odorata* directly instead of relying upon self-reported knowledge and behaviors. Participants in this study were interviewed at a single point in time, which hinders our ability to draw causal conclusions. Although we used SEM to test directionality between hypothesized relationships, these findings reflect associations between variables rather than definitive causal pathways. Follow-up studies should also consider using a longitudinal approach to track how participant responses change over time. Doing so may help establish causality and will also allow us to better detect social desirability bias. If someone repeatedly states that management

is important to them, but their management effort remains low across time, it would be important to explore whether social desirability bias or realistic barriers are driving their management behaviors.

Our research also introduces several avenues of future research. For instance, here we posit that outreach highlighting the ecological dynamics of biological invasions could garner public support for management. A study testing the effect of outreach on long-term management opinions and behaviors would clarify whether increased knowledge can contribute to the reduction of culturally important invasive plant populations.

AUTHOR CONTRIBUTIONS

Laurel Mae Philpott and Orou G. Gaoue conceived the ideas of this study and developed the methodology. Laurel Mae Philpott collected and analyzed the data and wrote the original draft of the manuscript with editorial contributions from Orou G. Gaoue. All authors read and approved the final version of the manuscript.

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ETHICS STATEMENT

All work with human subjects was in accordance with the University of Tennessee- Knoxville IRB guidelines. Our approved IRB document is #23-07799-XP. All participants were made aware that the findings of this work would be published, and we received verbal informed consent (in accordance with our IRB protocol) from each participant before conducting interviews. We also received verbal consent from the chiefs of each of the villages we worked in.

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no conflict of interest.

DATA AVAILABILITY STATEMENT

Scripts can be accessed via Figshare: <https://figshare.com/s/6d5251aea86c0b8c130e>.

ORCID

Laurel Mae Philpott  <https://orcid.org/0000-0002-7298-0111>

Orou G. Gaoue  <https://orcid.org/0000-0002-0946-2741>

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SUPPORTING INFORMATION

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

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