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Ecosystem service assessment of coyote stories reveals tradeoffs from human–coyote interactions in rural Vermont, United States

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Abstract

The ecosystem system services framework has potential to help clarify wildlife management challenges at the single species scale, but existing methods struggle to capture the complex values and tradeoffs at play in human–wildlife interactions. We worked with community scientists to gather and use stories ($n = 150$) as a source of ecosystem services data about living alongside eastern coyotes (*Canis latrans* var) in rural Vermont, United States. Our *a priori* ecosystem service assessment showed that human–coyote interactions can have simultaneous positive and negative human well-being impacts at both the sample scale and for individual interviewees. Our research identified emergent themes that lent insight into how interviewees justified different kinds of relationships with coyotes. We applied a tradeoffs lens to evaluate three policy options based on their potential to mitigate ecosystem disservices and maximize ecosystem services from human–coyote interactions. We found that ecosystem services assessment rooted in a dataset of stories revealed policy-relevant understanding of value conflicts and alignments at the sample scale without overshadowing the nuances of individual interviewees' experiences.

KEYWORDS

conservation policy, coyote, cultural ecosystem services, eastern coyote, ecosystem services, human–wildlife coexistence, narrative, stories, wildlife management

1 | INTRODUCTION

The ecosystem services framework characterizes the ways that nature contributes to human well-being; its primary goal is to help policymakers and practitioners understand tradeoffs between conservation alternatives (Millennium Ecosystem Assessment, 2003, 2005). In many respects, that goal has been met. Ecosystem services has identified pathways to minimize tradeoffs between multiple benefits (e.g., flood mitigation and biodiversity, Watson et al., 2019), and clarified costs and benefits of desired ends (e.g., maintaining marine mammal populations, Riisager-Simonsen et al., 2020).

Since the framework's conceptualization (Ehrlich & Mooney, 1983) and popularization (Millennium Ecosystem Assessment, 2005), ecosystem services concepts have also evolved to meet changing policy needs (West, 2015). As two examples, research has blossomed on nature's

nonmaterial benefits via studies on "cultural ecosystem services" (Gould et al., 2019; Milcu et al., 2013), and on nature's negative impacts via studies on "ecosystem disservices" (Guo et al., 2022; Schaubroeck, 2017). Despite these advances, the framework has not expanded into several environmental valuation contexts where tradeoffs continue to stymie policymakers. One such context is species-scale conservation. Human relationships with individual species are important drivers of conservation (Bowen-Jones & Entwistle, 2002; Garibaldi & Turner, 2004). Yet, ecosystem services researchers have only recently applied the framework to individual species (e.g., Ceauşu et al., 2019). To our knowledge, challenges to this application and methods for addressing them are not widely reported.

1.1 | The need for narrative ecosystem services assessment

Researchers are innovating new methods that may help ecosystem services meet challenges including gathering and analyzing stories as data sources (Chan et al., 2012; Gould et al., 2020; Satz et al., 2013). Although little empirical work has used stories for environmental valuation broadly, the studies that exist are promising (Bieling, 2014; Bredin et al., 2015; Dayer et al., 2007; Kenter et al., 2016). Testing whether stories can provide ecosystem services information at the single-species scale is a natural next step, because stories about human relationships with individual species exist in many traditions (Goyes, 2022; Kaczensky, 2007; Robin et al., 2022). Wild canids in particular—including the eastern coyote—abound in stories across North America (Dove, 1933; Jickling & Paquet, 2005; Leopold, 1968, p. 119).

1.2 | Coyote ecology and coyote stories: A community science approach

Across their range both pre- and post-European colonization, coyotes' adaptability has allowed them to thrive in proximity to humans (Flores, 2016; Parker, 1995) and to captivate and challenge diverse publics, conservationists, managers, and policymakers (Alexander & Draper, 2021; Van Horn, 2018). Today, coyotes occupy landscapes undergoing both ecological and cultural change (Flores, 2016, pp. 151, 153–169; Foster et al., 2002). Eastern coyotes (*Canis latrans* var)—the product of range expansion and hybridization with remnant wolf populations (Kays et al., 2010)—arrived in our Vermont study area in the 1940s and have become the subject of a protracted policy debate (Boglioli, 2009; Margolis, 2018; McCallum, 2022). We believe this debate stems partially from the fact that the species does not require intensive conservation or management in Vermont (Vermont Fish & Wildlife Department, 2018).

North American wildlife professionals often justify conservation or management based on one or more of three reasons: to maintain and restore stable populations of native and naturalized species (Fontaine, 2011), to produce a harvestable surplus of select species (Manfredo et al., 2020), or mitigate acute human–wildlife conflicts (Frank et al., 2019). None of these reasons apply to coyotes in Vermont. Coyotes maintain stable populations regardless of human intervention (Kilgo et al., 2017; Morin & Kelly, 2017). Across the northeastern United States and Canada, coyotes are considered naturalized and not a threat to native wildlife populations (Gulsby et al., 2018; Lapierre, 1985; Levi & Wilmers, 2012; Parker, 1995; Person & Hirth, 1991). And, acute human–coyote conflicts are rare in Vermont under longstanding regulations for hunting and protection of property, livestock, and personal safety (Vermont Fish & Wildlife Department, 2018).

Instead, Vermont's coyote policy discourse centers on social challenges. Existing statutes, regulations, and government and media messaging underscore that nondichotomous perspectives exist. State law requires a coyote control program (Vermont State Legislature, 1985) and coyotes may be hunted year-round with no limit on the number that may be killed (Vermont Fish & Wildlife Department, 2024a). At the same time, government messaging emphasizes the species' ecological value and clarifies that it is not invasive (Vermont Fish & Wildlife Department, 2018, 2023a). Media coverage focuses on different wildlife stakeholders' beliefs and attitudes about coyotes and their impacts on human well-being (e.g., Gribkoff, 2018; Margolis, 2018). Stakeholders often rely on anecdote to illustrate the costs and benefits of different management alternatives (e.g., Evanice, 2017), and simultaneously challenge each other's claims by arguing that stories are not a valid source of data (e.g., Cotton, 2022). These arguments overlook theory that supports individual and shared stories as important sources of information on human–nature relationships (Gould et al., 2014; Silko, 1981; Tsing, 2015).

Gathering stories as data confronts multiple complications. These include the need to develop trust between researcher and participants (Tsing, 2015), insider–outsider dynamics (Boglioli, 2009), and the impacts of researcher identity on participant responses (Adu-Ampong & Adams, 2020; Chiswell & Wheeler, 2016; Holmes, 2021). Community-based approaches can address many of these challenges and therefore are used in many natural- and social-science contexts (McKinley

et al., 2017; Sullivan et al., 2009, 2014), including species-scale studies of human–coyote interactions (Drake et al., 2021; McKinley et al., 2017; Weckel et al., 2010; Wine et al., 2015), participatory action research (Lopez-Garcia et al., 2021; Milich et al., 2021) and research with youth participants (Cahill, 2007; Skelton, 2008, 2013). Community-based approaches are also used by public-facing folklife centers to generate archives of stories for local cultural purposes and future academic research (Newfont, 2021; Rue, 2021; Stefano & Fenn, 2022).

1.3 | Research questions and objectives

We used a community-based approach in Vermont, United States, to: (1) pilot a method to systematically glean a dataset of stories; (2) test whether the ecosystem services framework can offer a species-scale assessment of well-being impacts from human–coyote interactions; and (3) apply a tradeoffs lens to our findings. We define stories as accounts of experience that convey meaning and argue that analyzing our collection of contemporary coyote stories yields insight into human–environment interaction that practitioners and policymakers can use to evaluate conservation alternatives at the single-species scale.

2 | METHODS

2.1 | Study area

Vermont is a small, northeastern US state (24,000 km^2) with a population of roughly 641,000 (U.S. Census Bureau, 2021). The landscape is over 70% forested (U.S. Forest Service, 2021), with pockets of agriculture and low levels of built development. It has the highest percentage of residents who live outside urban areas of any US state (U.S. Census Bureau, 2022). Vermont is home to a stable coyote population of 6000–9000 individuals (Vermont Fish & Wildlife Department, 2018).

2.2 | Researcher positionality

Positionality statements are gaining traction in conservation research as a way for scientists and practitioners to acknowledge the identities that may influence their work (Boyce et al., 2022; Moon et al., 2019; Pienkowski et al., 2023). Throughout this study, we attempted to be aware of how our individual identities could impact our research approach. Appendix F summarizes the identities we consider most impactful to this study.

2.3 | Project partners and participant recruitment

From 2019 to 2021, we collaborated with the Vermont Folklife Center (VFC) to engage public high school students from 8 of Vermont's 14 counties in gathering stories of human–coyote encounters. Our approach drew on the Foxfire model of training youth as community ethnographers (see Wigginton, 1991) and participatory methods for working with student researchers (Cahill, 2007; Cope, 2009; Foulis, 2018). We trained students in community ethnography methods with a curriculum approved by our university's institutional review board (IRB protocol 00000569). We secured written consent from students and their guardians to anonymously archive students' stories with VFC per the center's human–subject guidelines (Appendices Aa, Ab, and B).

Our sampling goal was to capture Vermonters' diverse experiences with coyotes and generate as close to a demographically representative sample as possible with a nonrandom method. We trained students to select interviewees who represented demographic (e.g., age, gender, race or ethnicity) or experiential (e.g., profession, political affiliation, avocation) diversity. Students interviewed Vermont residents ages 18 or older. We completed sampling when all participating students had been notified twice to submit their materials. All interviewees reviewed an information sheet per VFC's human subject guidelines and gave verbal consent for their interviews to be archived anonymously (Appendix B).

2.4 | Interview protocol

We used structured interviews to gather coyote stories. We drew on multiple sources (Fina & Georgakopoulou, 2015; Georgakopoulou, 2017; Gould et al., 2020; Silko, 1981) to define a story as: an interviewee's account of an event or related series of events that happened to them or others, to convey meaning.

We piloted an initial interview guide in summer 2018. In winter 2018–2019, we worked with a small group of students from a nonsample school to test a revised interview guide with student researchers. This process led to a two-part story elicitation prompt:

1. Please tell me a story about an experience you have had with coyotes in Vermont.
2. Can you tell me why that story was meaningful to you?

We also asked interviewees to describe and rate their overall opinion of coyotes in Vermont and provide demographic details. Our interview guide is available in Appendix C.

2.5 | Data coding, analysis, and storage

The lead researcher coded and analyzed transcripts with NVivo v.20 for *a priori* ecosystem service categories and emergent themes. *A priori* coding definitions drew from multiple studies (Amberson et al., 2016; Gee & Burkhard, 2010; Gould et al., 2019; Gould & Lincoln, 2017; Milcu et al., 2013; Millennium Ecosystem Assessment, 2003, 2005; Russell et al., 2013) and our experience studying ecosystem services in Vermont (Appendix D). We identified five emergent themes: (1) beliefs about coyote ecology not supported by natural science; (2) characteristics of statements about lethal coyote management; (3) tolerance for coyotes; (4) human–human conflict; and (5) interviewees' responses to story elicitation. A research assistant collated demographic data. We archived all interviews with complete consents and usable transcripts ($n = 151$) and audio when available ($n = 127$) with VFC (Appendix E). We excluded one interview from our final research sample ($n = 150$) because the interviewee was untrustworthy—they reported no experience with coyotes, then described experiences with coyotes—but retained it in the VFC archive.

3 | RESULTS

Our research captured diverse human–coyote interactions. Below we describe sample demographics, ecosystem services assessment findings, and emergent themes.

3.1 | Sample demographics

Interviewees ($n = 150$) lived in eight of Vermont's 14 counties and reported coyote encounters that took place between 1970 and 2021 in 13 counties (Table 1). Most ($n = 100$) described unique encounters; of these, 62 occurred after 2010. Our sample roughly approximated the Vermont population in age, gender, proportion of White residents, and representation of hunters. It over-represented rural residents, farm-workers, and American Indians. It under-represented urban residents and Black or African American residents. It did not include any individuals who identify as Asian, Middle Eastern or North African, or multiracial.

3.2 | Ecosystem services findings

We documented six of seven material ecosystem service categories and 12 of 16 nonmaterial ecosystem service categories (Table 2). The following three subsections—"Ecosystem service categories and bundles" "Material and nonmaterial ecosystem services," and "Ecosystem service and/or disservice framing"—detail specific aspects of our ecosystem services findings.

3.3 | Ecosystem service categories and bundles

Most interviews ($n = 145$) could be coded with at least one ecosystem service category, including both services and disservices. Nearly all included multiple categories. For example, one interviewee described her enjoyment of coyotes' howls and perception that coyotes kept rodents from overrunning her garden. We coded this interview with: (1) the aesthetic category framed as a service, reflecting appreciation of nature's sights and sounds; and (2) the pest control category also framed as a service, reflecting appreciation for coyotes' control of the local rodent population. Another interviewee recalled his uncle's marksmanship shooting coyotes to protect calves on the family dairy farm. We coded this interview with: (1) the cultural heritage category framed as a service, reflecting appreciation of a skillset and relationship to coyotes that spanned generations; and (2) the agriculture category framed as a disservice, reflecting the threat coyotes pose to the family's farming livelihood.

Bundles of ecosystem service categories included as many as seven categories (Figure 1). One interviewee described how the shouts and laughter of friends around a COVID pandemic era winter bonfire caught local coyotes' attention:

The most common material category was agriculture, found in 20% of interviews ($n = 30$). The least common was wild game, coded to under 1% of the interviews ($n = 1$). The most common non-material category was aesthetic, found in 65% of interviews ($n = 98$). The least common was life teaching, found in 1% of interviews ($n = 2$, Figure 2).

3.4 | Material and non-material ecosystem services

Interviewees described coyotes' impact on both material and non-material ecosystem services (Figure 3). A majority mentioned only non-material categories (59%, $n = 89$). One interviewee described coyotes' contribution

TABLE 1 Sample demographics compared with the 2017–2021 American Community Survey (U.S. Census Bureau, 2021).

	Sample ($n = 150$)	Vermont population
Median age	49.5 years old	42.7 years old
Gender		
Female	50.0% (75)	50.4%
Male	48.7% (73)	49.6%
Nonbinary	0% (0)	0%
Race		
American Indian	1.3% (2)	0.2%
Black or African American	0.7% (1)	1.3%
Asian	0% (0)	1.7%
Middle Eastern or North African	0% (0)	0%
Two or more races	0% (0)	3.4%
White	92.0% (138)	92.9%
Other	6.0% (9)	
Urban–rural status		
Urban	5.3% (7)	35.1%
Rural	92.0% (138)	64.9%
Interest Group Identifications		
Farming	11.3% (17) stories mention agriculture	7.9% of Vermont residents hold jobs in the agriculture or food industries (Dunham, 2022), 1.9% of Vermont residents are farm producers (U.S. Census of Agriculture, 2017, 2022)
Hunting	10.7% (16) stories mention hunting	Between 11.4% (2021) and 12.4% (2020) of Vermont residents held a hunting license during our study period
Median Vermont Tenure	25.0 years (127 reported), of these 11.8% have lived in Vermont for <10 years	

Note: Tallies for all fields exclude interviews that did not provide the relevant data. Farming statistics are from the 2022 Feeding the Economy report (Dunham, 2022) and the 2017 and 2022 U.S. Census of Agriculture (U.S. Census of Agriculture, 2017, 2022). Hunting statistics are from the Vermont Fish & Wildlife Department (Vermont Fish, & Wildlife Department, personal communication, 2024b). To assign interviewees a Census urban/rural classification, we used ArcGIS Pro 3.03 to calculate the centroid of each Vermont town and determined whether it fell within an urban area or rural area (Census Bureau, 2020).

to her sense of place and aesthetic appreciation of nature: "We live in the valley in the Green Mountains and so you can hear coyotes on one side of the mountain speak to each other on the other side of the mountain... I also love it when their pups are first born, because you can hear them chatter." Two interviewees mentioned only material categories: negative impacts to animal agriculture and positive contributions to pest control.

A sizeable minority of interviewees (36%, $n = 54$) mentioned both material and non-material ecosystem service categories. Describing his childhood on a farm, one interviewee linked coyotes to non-material categories (e.g., cultural heritage) and the material category of carrion control, both framed as services. "We would have several stillborn calves... and we would take all that stuff to the upper field and we would stake it down on the ground for the coyotes to come out and eat it at night. We would also go up there and wait for the coyotes to come out, my dad and my uncle, and we would shoot them." The interviewee went on to explain that this experience was meaningful beyond its physical utility "because we were all there [the interviewee and family members]."

3.5 | Ecosystem services and/or disservices framing

Interviewees named a range of ecosystem services and disservices in their coyote stories. Five categories were

TABLE 2 Examples of ecosystem service categories framed as services and as disservices if this framing occurred in our sample (see Appendix D for coding definitions).

Category	Service framing	Disservice framing
Material ecosystem service categories		
Agriculture	"I haven't really had any poor interaction with coyotes around the barn, they tend not to come up to the barns, so I guess from that standpoint, I haven't had any bad experience with them trying to kill some of the livestock on the farm."	"We would be lambing in the spring, and it got to the point where I had to start doing things to be sure to keep them away because, you know, I had a couple of lambs that were killed. And a coyote kill is different from anything else."
Carrion control	"[Coyotes] can help a clean up the sickly animals and make sure you know that they aren't spreading diseases."	—
Ecological balance	"Also, I don't actually know this but maybe a pack of coyotes can bring down a sick deer, there's always these issues of people saying the deer population is out of control. Maybe having a decent predator population in the state is a good thing."	"I hunt in central Vermont, I don't like them there because they're decimating, they're really putting a hurt on the deer population."
Fur production	"And they also, some people like to hunt them. I think that's a nice opportunity for people and some people like to trap them for their fur."	—
Pest control	"It's meaningful to me because they protect our property from the damage that all the extra rodents would cause to our property. Having too many rabbits, your lawn is destroyed, having too many squirrels, they get in your house, they rip up your screen doors, they destroy your garden too, so it's been nice to see them and see the coyotes around and know they're doing a service. It's made living in this area, this wooded area, possible because otherwise we'd be overrun by all kinds of rodents."	—
Wild game	—	"Generally speaking, I am not typically a fan of them. Based on, my family primarily, our meat source is venison primarily and they are my competition for that!"
Non–material ecosystem service categories		
Aesthetic	"We live in the valley in the Green Mountains and so you can hear coyotes on one side of the mountain speaking to each other on the mountain and they seem to have a lingo going back and forth. I also love it when their pups are first born because you can hear them chatter... It's just beautiful to hear."	"And suddenly it sounded like there were two women screaming at each other outside... and I realized it wasn't women screaming, it was coyotes... It was distinctly not dogs, it was distinctly the coyote sound. And it was very loud, and it was very prolonged."
Biodiversity	"Well, it was meaningful to me just mainly about what it symbolized. I mean that Williston has had a huge number of changes. Over the years it has become a shopping-center-type, office buildings and stuff but it still has a lot of farmland too. It was just nice to see that the wildlife was there and that the coyotes were out doing what coyotes doing, yipping and howling and moving around I assume to try to hunt something."	"They're extremely active in the areas where I spend a lot of time in, and fairly threatening to the wildlife around me... They're more of an invasive species than they are a natural species in Vermont."
Cultural heritage	"I just think interesting events that happen throughout your life are what build you as a person, and it was really just for me as a hunter it just was kind of like a coming-of-age experience. All my daddies and granddaddies before me also killed coyotes when they were around 19 which is how old I was when this happened."	"Uh, I guess it all kinda goes back to our enjoyment of deer hunting which is kind of a tradition in my family, so we like protecting the deer population. It kind of revolves around that aspect of it."

TABLE 2 (Continued)

Category	Service framing	Disservice framing
Education	"But what I ended up learning about in the course of the next several years as I began to learn about the importance of maintaining the coyote population that you have that is well trained to fence, and basically we had 40 acres that was really good deer hunting land and I basically said to any of the folks that I gave permission to hunt on my property don't you dare shoot a coyote on my property because we have a good relationship with them right now and I do not want to mess that up."	—
Life teaching	"Oh, well, it was about me... it was about learning to live in harmony, not in conflict, with the animals around me and that was one of the formative experiences that led me to my outlook where we are now as well, which is how do we farm without messing up nature and the natural systems that are functioning so nicely and so well without us."	—
Mental health	"When I lived in Charlotte there would be a lot of coyote sounds at night... They would howl and it was kind of enjoyable to be about... I think I found it peaceful to be connected to nature."	"It's kind of disturbing to imagine my 11-year old having to slaughter maimed chickens and bury them, but I guess that's part of farm camp! It was a bloodbath and the coyotes killed or maimed a bunch of chickens, and then middle schoolers had to clean up the rest. That's a very gruesome picture!"
Perspective	"Yeah it was fun, you know I'm a hunter so I'm a predator in the woods but yeah turning from a predator to a prey of another animal was just kind of a unique experience and made you realize that you know, there is a food chain and you could be part of it."	—
Recreation	"You're out on a dark night and you hear the call, the coyotes, and you also sometimes can call back. It's a weird connection but, it is one that's natural, healthy, and it's fun."	"...They chase the deer and drive 'em push 'em. So, the things that I enjoy hunting and the activities that I enjoy doing outdoors, the coyote population in some instances negatively impacts that experience by reducing the game that's out there."
Security	"And he came up out of the woods and came onto the trail that I was on with the dog, maybe only 30 feet away. And he looked at me just for a second and then he turned and he walked the same direction I was walking on the trail. And he really didn't care that I was there; didn't really look at my dog and my dog didn't really do anything about him. So I watched him for, I don't know, probably 10 or 15 minutes and he proceeded to walk to the end of the trail where he got to a road."	"I was absolutely horrified and devastated that my dog was killed. I saw it happen and I couldn't, I couldn't help her, I couldn't intervene, um. So it was, it was a horrible experience, and, you know, I know coyotes are predators and I know all of that, but it just was very personal."
Sense of place	"So, it was kind of part of my um... part of having moved to Vermont, and having moved to an old farm. It was part of the whole thing. And the coyotes came along with it."	"I've always felt at peace in the woods and, you know, out in the country more 'cause that's where I grew up, but at that moment [when the coyotes were howling] I was pretty scared.'"
Social capital	"At our last house, five years ago, right across the street in a really big neighborhood, in town, neighbors had said that they had seen coyotes and we didn't believe them. Our house backed up to the woods and we've never seen any... it was really neat to see a coyote and validate the neighbors' stories."	"Sort of a sad follow up to that story was not a week later my neighbor shot that coyote and had it hanging from his wood shed. I'm pretty sure it was the exact same animal. So that was kind of upsetting, but I did have that really interesting interaction with it, which was neat."
Stewardship	"Well, I really love wild animals, and I have a special connection with them. I don't have any pets, intentionally, because I do feel like the animals outside in nature and around my house, are my pets. I feel that strongly about them and I feel they need someone, sort of, advocating for them and championing them."	"I'd say like, an animal like that, that's much harder for me to protect against because it doesn't follow sort of the ruleset of like, hunting at dusk and things like that, outliers like that I feel less conflicted about getting rid of. But I appreciate when I don't have to."

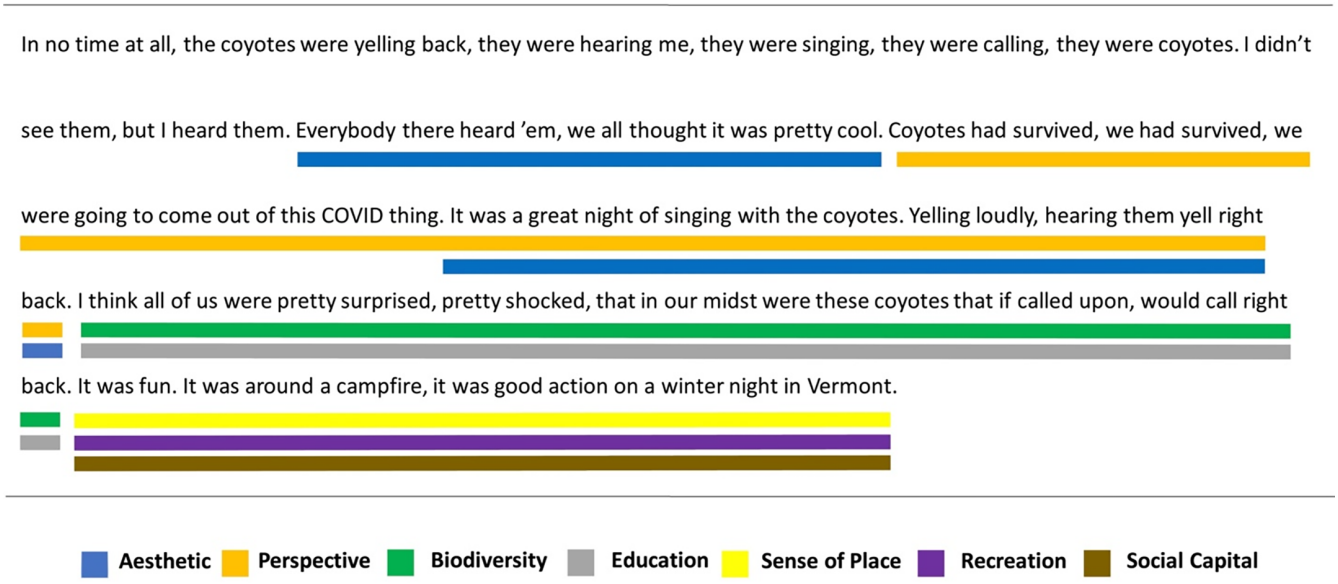

FIGURE 1 Colored strips represent different ecosystem service categories and help visualize the coding process. The excerpt provides a particularly rich account of multiple ecosystem service categories tied to a single coyote encounter.

mentioned only as services: perspective, life teaching, carrion control, pest control, and fur/pelts. Wild game was mentioned only as a disservice. The remaining categories were described as services and disservices by different people. For example, one interviewee framed coyotes' impact on biodiversity as a service: "positive because they're part of the natural environment, you know?" Another interviewee framed coyotes' impact on biodiversity as a disservice due to perceived competition with native species: "coyotes are, I believe, not native to Vermont... they are potentially displacing bobcats in the process of their expansion."

A plurality of interviewees addressed both ecosystem services and disservices (46%, $n = 69$, Figure 4). One interviewee exemplified this in her account of losing a pet to coyotes: "I just needed to figure out a way to keep them from killing my dogs and keep them away from my yard," she reflected. While acknowledging coyotes' negative impact to her security, the interviewee also believed that predators should exist on the landscape. After bringing a guardian dog to her property, she stated: "I feel like we're coexisting again with animals that are predators... I love having them around, I think that they are awesome animals."

In addition to those who mentioned both ecosystem services and disservices, 57 interviewees mentioned only services, 17 mentioned only disservices, and 5 interviews could not be coded for ecosystem services (Figure 4).

3.6 | Emergent themes

Emergent themes spoke to Vermonters' relationships with coyotes in ways our a priori ecosystem service categories did not capture. The following five subsections–3.7-3.11—detail specific emergent themes.

3.7 | Beliefs about coyote ecology

Some interviewees made statements about coyote ecology that were inconsistent with peer-reviewed literature or government messages. Some believed coyotes harm native wildlife. One interviewee justified his dislike for coyotes on the grounds that "they're decimating—they're really putting a hurt on—the deer population." For evidence that coyotes do not threaten deer populations in Vermont or similar environments, see Bragina et al. (2019), Crete et al. (2001), Foster et al. (2002), and Vermont Fish and Wildlife Department (2018). Others believed human activity and development harms coyotes. "We are in the middle of their habitat, and they have no other place," said another. "It's sad that they're so close, but they're so close because we've taken over their habitat." For evidence that coyotes are well adapted to living in developed areas in Vermont and similar socio-ecological systems, see Hudenko et al. (2008), Hunold and Lloro (2019), Vermont Fish and Wildlife Department (2018), and Wilkinson et al. (2023).

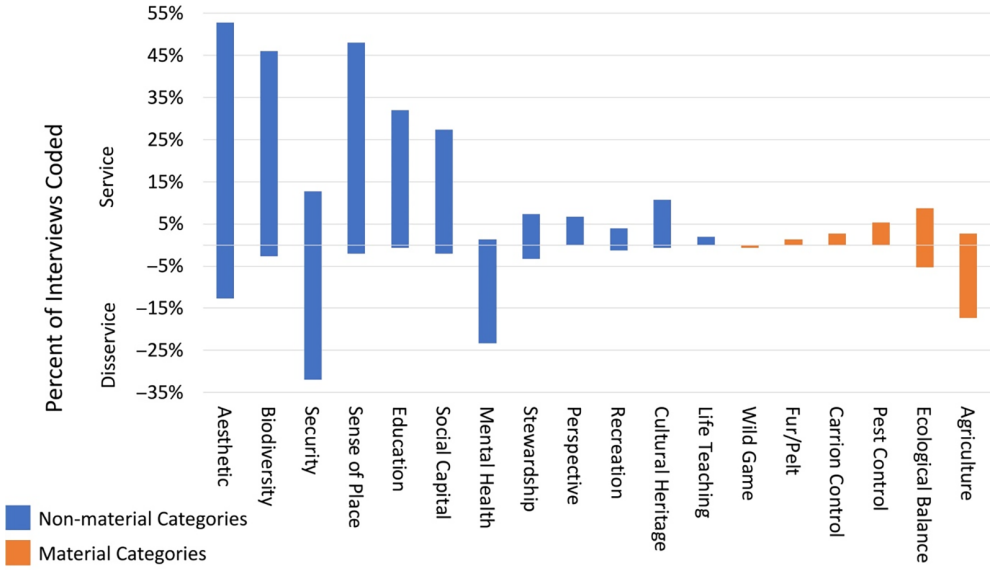

FIGURE 2 Percent of stories coded with each ecosystem service category. References to each category are further categorized into ecosystem services or disservices, reflecting whether the interviewee described coyotes making a positive or negative contribution to their experience.

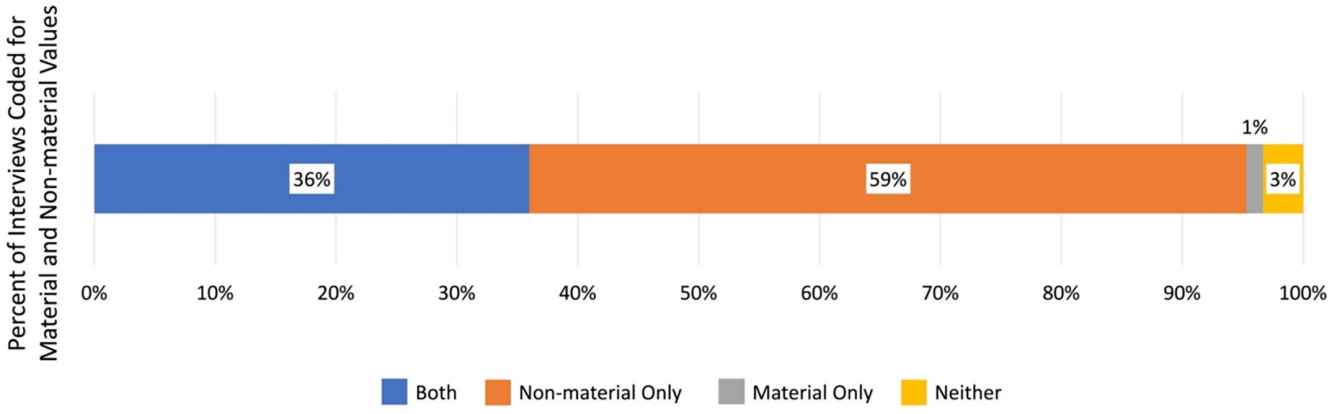

FIGURE 3 Percent of stories that mentioned material values, non-material values, both, or neither.

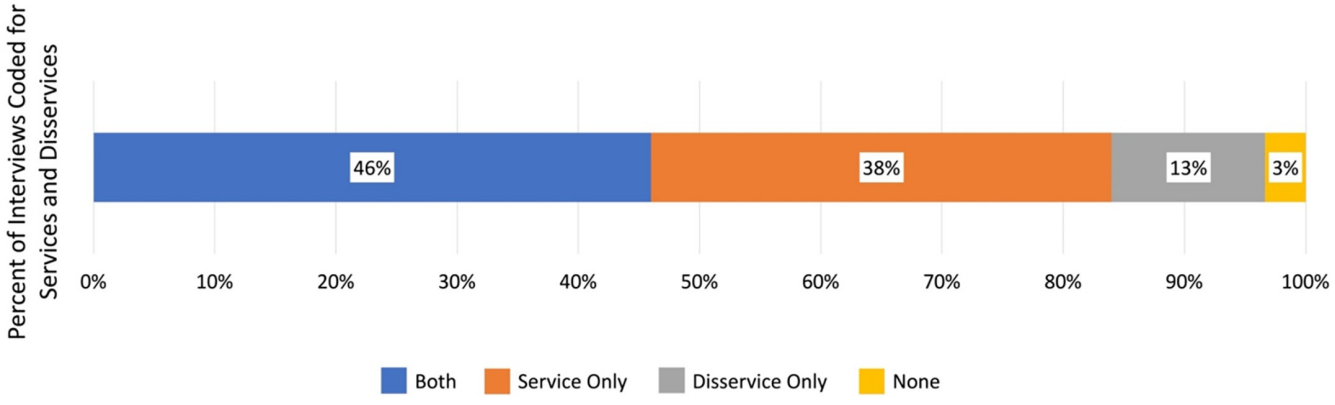

FIGURE 4 Percent of stories that mentioned ecosystem services, disservices, both, or none.

3.8 | Killing coyotes and ecosystem disservices

Some interviewees cited real or perceived negative impacts to ecosystem service categories associated with hunting, farming, and safety to justify killing coyotes. One interviewee put it succinctly: "We kind of treat them like a nuisance and try to protect our deer population, so if we're hunting or whatever, we will try to kill them." Another gave the following account: "I shot one the other

morning that was walking up the lane way, like, way too close to the cattle." The interviewee added that although this coyote did not engage with his herd, he had no way of knowing whether the individual had killed a calf before and that the need to protect his animals was paramount.

3.9 | Tolerance for coyotes

Some interviewees believed that the ecosystem services coyotes contribute outweigh the disservices that they cause. "I do understand that sometimes [coyotes] cause some destruction," said one interviewee. "But mostly I would say that they're really positive and certainly, they're just doing what is in their nature." Others believed that coyotes have a right to exist even if they cause ecosystem disservices. One interviewee explained: "I think that I moved into the forest where the coyotes lived and other than having to hear them kill every once in a blue moon, they don't bother me and it's their habitat too."

Some interviewees believed that coyotes could be tolerated when they exhibited a wariness of people. One interviewee weighed his perception that coyotes contributed to ecological balance against his concern they could negatively impact security: "I personally think they should have been afraid of me and they didn't seem to be... I actually value coyotes in that they keep the rabbit population down around our house... but I do think they need to have a fear of man."

3.10 | Human–human conflict

A single interviewee explicitly identified human–human conflict rooted in different valuations of coyotes. He told a story about seeing a "beautiful" coyote while deer hunting on his family's land, only to recognize the same individual hanging dead from his neighbor's woodshed later in the season. He said this was "sad" and "upsetting." We coded this unique instance as social capital, framed as a disservice related to coyotes but stemming from human–human conflict rather than human–coyote conflict.

3.11 | Responses to story elicitation

Some interviewees relished storytelling. Their accounts were long, descriptive, and featured interactions between interviewer and interviewee beyond the scripted interview guide. For example, when interviewer and interviewee were family members or neighbors, interviewees referenced familiar geographies, acquaintances, and experiences and interviewers responded with recognition, excitement, or questions. This quality aided coding by drawing attention to especially meaningful portions of the story.

Interviewees also used storytelling to evoke emotions, a feature that also aided coding. "On beautiful moonlit nights, you'll hear them howling and yapping and singing and just having an absolute knockdown drag-out coyote party, the likes of which humans just don't get to partake in," said one interviewee. "I'd like to just kind of put on a little coyote suit and go over and hang out with them and maybe have a cocktail... because they're sharing our existence, and they're kind of letting us into their existence a little bit." Another interviewee used a lively performance and a play-by-play account to draw the interviewer—his grandchild—into the story. After sharing how he had followed a group of deer while hunting, the interviewee vividly described the moment when nearby coyotes made their presence known. "And my hair stood on end [said with feeling], and it was that high-pitched yip, yip, yip, yip sound they make... You just freeze. It's freaky. So that's one I'll never forget." Links to a selection of exemplary stories and the full collection are available in Appendix E.

4 | DISCUSSION

Stories were a valuable source of ecosystem services information, and the ecosystem services framework effectively captured human well-being impacts from species-scale wildlife interactions. These methods allowed us to characterize human well-being tradeoffs from different kinds of human–coyote interactions with attention to policy alternatives.

4.1 | Stories of human–wildlife interactions can be systematically analyzed for ecosystem services data

Stories effectively elicited information about coyotes' impact on human well-being, both in ecosystem services terms and more expansively. Gould et al. (2020) argue that stories should be tested as a method that allows researchers to gather ecosystem services data in study participants' terms and framings, rather than the terms and framings that researchers select. Our results demonstrate this potential: though our interview protocol did not explicitly prompt for services or disservices, or emphasize material or non-material framing, we

collected data on each of these dimensions. And though we did not introduce language related to conflict, coexistence, livelihood, or wildlife management, we gathered commentaries on each of these concepts. In short, a story-centered prompt allowed us to characterize—both qualitatively and quantitatively—many dimensions of human–coyote interactions without priming our interviewees to interpret and convey their experiences through the research frameworks we employed. This is important because researcher priming can influence what interviewees disclose, particularly on sensitive topics (Brenner, 2020); avoiding priming is a best practice for gathering trustworthy data (Adler, 2022; Cairns-Lee et al., 2022).

Our two-part prompt helped interviewees tell more specific stories without priming. Our pilot demonstrated that when asked to "tell a story about your experiences with coyotes," interviewees often limited their response to recounting events without interpreting their importance. Our follow-up prompt, "tell me why that story was meaningful to you," guided interviewees to discuss significance without directing them to focus on a particular dimension.

Our experience with story data suggests a new way environmental valuation may be able to build understanding across difference—a long-standing goal for conservation (Isacs et al., 2023). Storytelling is a way to co-create meaning and facilitate understanding across difference (Silko, 1981; Tsing, 2015). We experienced this firsthand as we read these stories from our perspectives as researchers and residents of Vermont. As one example, we were moved to greater understanding and empathy by accounts of intergenerational relationships formed around coyote hunting—a practice in which neither we nor people in our close circles engage (see Appendix F). We think conventional interview or quantitative survey data would be unlikely to have as powerful an effect as our story data did.

4.2 | Ecosystem services framing captured human well-being tradeoffs from single-species interactions

Our ecosystem service assessment of coyote encounters (Figure 2) makes tradeoffs associated with human–coyote interactions explicit. Our data demonstrate many potentially incommensurable positive and negative well-being impacts between different ecosystem system service categories and within individual categories (Table 2). These nuanced tradeoffs indicate that competing perspectives exist in our sample (Ceauşu et al., 2019).

Although competing perspectives are a hallmark of conservation cases plagued by human–human conflict (Morse & Clark, 2019; Primm & Clark, 1996; Vernon & Clark, 2016), more interesting is the plurality of individual interviewees who attributed both ecosystem services and disservices to coyotes (Figure 4). In the literature on ecosystem services and broader wildlife valuation evidence that wildlife can both positively and negatively impact the same human individual's well-being is scant, although some studies document nonbinary well-being impacts from single species at human–community scales (Kansky et al., 2021; Kansky & Kidd, 2024; Mendia et al., 2019). Practically, our results challenge the accuracy of conventionally grouping wildlife stakeholders into proponent/opponent binaries for a given species or policy (e.g., Grima et al., 2021; Larson et al., 2019). Theoretically, we are concerned that research that imposes such binaries may obscure the possibility for different stakeholder groups to find middle ground and reduce policymakers' and practitioners' attention to the complex relationships that exist between human individuals—regardless of their group affiliations—and wildlife.

Our overall finding that human–coyote interactions impacted 6 material and 12 nonmaterial ecosystem service categories in both positive and negative ways (Table 2 and Figure 2) aligns with more common applications of the framework focused on groups of species. For example, a study in Iceland linked six material and seven nonmaterial ecosystem services categories to whales (Malinauskaite et al., 2021), and researchers showed that Chicago residents experience both services and disservices from bird communities (Belaire et al., 2015). This alignment suggests that ecosystem services are a reliable way to capture well-being impacts from human–wildlife interactions at the single-species scale.

Our results also add to the human dimensions of wildlife management literature on coyotes specifically. Some prior studies focus on just a few impacts from human–coyote interactions, such as perceived risk (e.g., Sponarski, Miller, et al., 2016; Sponarski, Vaske, et al., 2016). Others use wildlife value orientations to characterize beliefs about human–coyote interactions (Vaske & Sponarski, 2021) or preferences for management actions in specific situations (Glas et al., 2019) or at large (Alexander & Draper, 2019). These approaches acknowledge the well-being tradeoffs inherent in managing human–wildlife interactions. But, they do not offer a comprehensive assessment of the well-being dimensions involved in these tradeoffs, as ecosystem services allowed us to do.

Non-material ecosystem service categories' predominance in our sample (Figure 3) was noteworthy. Without prompting, 59% of interviewees mentioned non-material (and largely positive) ecosystem services. Research shows that most reported coyote encounters do not involve physical conflict, but those that do involve physical conflict figure disproportionately in news media and policy (Alexander & Draper, 2019; Alexander & Quinn, 2012). Our results shed light on elements of coyote encounters that do not receive such attention. For example, the most frequently mentioned ecosystem service category in our sample—aesthetic experience—is non-material and was framed positively much more often than negatively (Figure 2). This quantitative result adds to first-person and historical analyses that document coyotes' positive human well-being impacts (Flores, 2016; Van Horn, 2018). Although prevailing narratives of human–coyote interactions in settler colonist cultures have largely focused on negative impacts to material dimensions of well-being (e.g., Kellert, 1985) our study joins the work of Flores (2016), Van Horn (2018), Alexander and Quinn (2012), Alexander and Draper (2019, 2021), and others who argue that positive, often non-material, well-being impacts from coyote encounters deserve attention.

Our results also pinpoint two often-overlooked, non-material, elements of coyote interactions where human well-being suffers. Most disservices in our sample were linked to two closely related non-material ecosystem service categories: security and mental health (Figure 2). Security describes nature's impact on interviewees' sense of certainty, control, and safety; mental health described nature's impact on interviewees' feelings of calm, wholeness, and relief from stress (Table 1, Table 2). Security exists in what some ecosystem services researchers have described as the "fuzzy space" between nonmaterial and material categories because it encompasses both the risk (non-material) and reality (material) of physical harm. Our security coding included accounts of coyotes harming or killing pets, but most stories we coded as security or mental health as a disservice reflected a fear of harm or general unease rather than an actual altercation. This finding is consistent with other studies' focus on perceived risk as a major influence on human–coyote interactions (Alexander & Quinn, 2012; Sponarski, Miller, et al., 2016). The non-material disservices mentioned in our sample contrasts with the preoccupation with physical harm and loss of property in research (White & Gehrt, 2009) and popular press coverage (e.g., Gorman, 2020; Jensen, 2019) on coyote conflicts. One past result—that perceived risk from and attitudes about coyotes vary even within user groups exposed to a (truly rare) fatal coyote attack (Sponarski et al., 2015)—also suggests the importance of nuance in understanding how material and non-material disservices interact.

4.3 | Cultural narratives and ecosystem disservices

Culture can influence whether individuals interpret experiences with wildlife positively or negatively (Farrell, 2015; Jolly et al., 2022; Vernon & Clark, 2016). Different interviewees often interpreted the same experience with coyotes in different ways. For example, coyotes' howls could be beautiful or threatening (Table 2). These individual differences may have roots in contrasting narratives of fear and dislike of coyotes, or reverence and admiration for coyotes, that exist in different North American subcultures (Alexander & Draper, 2019; Flores, 2016; Van Horn, 2018).

One common negative impact from coyotes described in research and popular culture (Bekoff, 2001; Flores, 2016) was affirmed in our sample: loss of livestock or the costs incurred to protect livestock. Unlike many other disservices in our sample (e.g., negative experiences of howling, a category most people described as positive), we saw no evidence of competing perspectives related to livestock impacts (i.e., nobody described coyote depredation on livestock as a service). Instances when participants described coyotes as having a positive impact on agriculture were linked to pest control (coded as a separate service) or when coyotes were expected to target livestock but did not (coded to agriculture as a service; Figure 2 and Table 2).

4.4 | Policy implications

Policy interest in coyotes is longstanding in Vermont. A 1985 statute triggers a coyote control program if coyotes are found to have negative impacts on domesticated animals or wildlife (Vermont State Legislature, 1985). More recent legislation banned coyote hunting competitions (Vermont State Legislature, 2018), and stakeholders have unsuccessfully petitioned the state to implement a limited hunting season for coyote (Gribkoff, 2019). Yet, coyotes have no negative impact on Vermont's native wildlife, and coyote hunting competitions and the current open season have no negative impact on the coyote population (Vermont Fish & Wildlife Department, 2018). Because recent policymaking has responded to highly engaged stakeholders' beliefs and values about coyotes, policymakers and practitioners need nuanced information on well-being tradeoffs related to human–wildlife interactions for the less-engaged majority of residents.

Below we examine three policy alternatives that differently address the tradeoffs between services and disservices Vermont residents experience in coyote interactions. To evaluate the alternatives, practitioners, and policymakers must determine the wildlife values constituents hold and the kind of human–wildlife relationships they seek (Clark et al., 2015). Our research models how ecosystem services analysis may help practitioners accomplish this in the growing number of human–wildlife interactions around the globe where nonbinary individual and community well-being outcomes of human–wildlife interactions are being documented at the single-species scale (e.g., Arbieu et al., 2024; Llanos et al., 2020).

4.5 | Alternative 1: Coyote management status quo

Current Vermont regulations permit lethal control in response to security and adverse agricultural impacts from coyotes, as well as year-round hunting for recreation and cultural heritage (Vermont Fish & Wildlife Department, 2023b). The management benefit is to ensure coyotes remain wary of people; that serious coyote conflicts remain rare in Vermont is seen as evidence this approach is working (Vermont Fish & Wildlife Department, 2018). Under the status quo, we predict that disservices to agriculture and security will remain roughly constant and recreational and cultural heritage benefits to consumptive users will be sustained. However, human–human conflict could continue to rise as polarization around lethal management and predator species (which can be proxies in wider culture wars) continues (Casola et al., 2022; Glas et al., 2019; van Eeden et al., 2021).

4.6 | Alternative 2: Depredation compensation

Disservices to animal agriculture were the most unambiguous negative impact from coyotes that we documented. Agriculture (a material ecosystem service) is more commonly monetized than many non-material ecosystem services (Milcu et al., 2013), which makes depredation compensation a viable approach to mitigate this disservice. Many countries and U.S. states use monetary compensation to mitigate the negative effects of predators on agricultural livelihoods (Macon, 2020; Muhly & Musiani, 2009). Yet, depredation compensation does not always result in greater tolerance for predators (Janeiro-Otero et al., 2023; Naughton-Treves et al., 2003). Although depredation compensation could mitigate agricultural disservices from coyotes in Vermont, we are not confident this would translate into a more favorable tradeoff between services and disservices in culturally contested categories like mental health and sense of place.

4.7 | Alternative 3: Conflict-prevention outreach

Coyotes' impacts on most ecosystem service categories were variably interpreted as positive or negative by interviewees—likely depending on cultural context. This phenomenon is common in many human–wildlife relationships (Dickman, 2010; Jolly et al., 2022). Some interviewees described how learning about coyote ecology and implementing diverse conflict-prevention strategies could address negative mental health and security impacts from coyote encounters and create appreciation for the species' role in the ecosystem. This finding aligns with evidence that education can shift perceived risk in coyote encounters (Sponarski, 2014; Sponarski et al., 2019; Sponarski, Vaske, et al., 2016). We predict outreach on conflict prevention could reduce agricultural conflict with coyotes and individual experiences of negative security and mental health impacts from other kinds of coyote encounters.

4.8 | Limitations

Our sample is not representative. It roughly matches the population only in age, gender, proportion hunters, and proportion of White residents (Table 1). Some important perspectives may be missing; for example, we underrepresent urban residents. Because coyotes are well adapted to urban environments (Elliot-Hogg, 2014; Gehrt et al., 2023), urban Vermonters will likely encounter coyotes more frequently in the future. That said, our sample includes rural and urban residents, women and men, young and elderly adults, violent encounters and peaceful ones, and the voices of those who love, hate, respect, fear, give little thought to, or are curious about coyotes. We are confident our sample reflects the range and rough proportions of ecosystem services and emergent themes that the predominantly White, predominantly rural Vermont population experiences in coyote encounters.

Our study focuses on human well-being impacts from human–coyote encounters; it offers less insight into coyotes' well-being. This focus partially stems from the ecosystem service framework's fundamental anthropocentricism (Davidson, 2013; Himes & Muraca, 2018). Within ecosystem services research, attention to nonhuman well-being mostly occurs when humans identify

other beings' existence as morally or ecologically valuable (Brevik et al., 2020). Nonhuman well-being is gaining attention fields from conservation biology (Bredin et al., 2015; Wallach et al., 2020) to sustainability science (Gavin et al., 2018; Jacobs et al., 2020; Morgan et al., 2023), and in coyote coexistence research specifically (Boesel & Alexander, 2020). We will explore this dimension of our data more fully in a future publication.

5 | CONCLUSION

It is tempting to classify wildlife (and wildlife stakeholders) in black and white terms: coyotes as a source of ecosystem disservices, for example, or "the public" as hostile to coyotes. Our results offer an alternative. Our ecosystems services analysis of stories revealed that people can hold a broad range of values and perspectives related to coyotes. Importantly, in many cases, individuals described multiple and sometimes (seemingly) contradictory well-being impacts from living alongside coyotes. We urge our fellow researchers to embrace methods that allow us to better engage with the nuanced realities of wildlife coexistence and management, and our peers in policy and practice to heed the complex and messy findings these methods may yield.

AUTHOR CONTRIBUTIONS

All authors contributed to study design and article development. The lead author performed fieldwork and data analysis.

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CONFLICT OF INTEREST STATEMENT

The lead author became a full-time employee of the Vermont Fish and Wildlife Department in 2021. The Vermont Fish and Wildlife Department allowed the lead author to allocate professional development hours towards completing his dissertation, of which this article is a part. Project funding in amounts ≤$500 came from two local conservation organizations with an interest in coyote conservation and management: the Vermont Trappers Association, a consumptive use organization, and Cold Hollow to Canada, a wildlife habitat conservation organization. The Vermont Fish and Wildlife Department, Vermont Trapper's Association, and Cold Hollow to Canada provided feedback during project conceptualization on how using stories as data could be relevant to coyote conservation and management in Vermont, but had no role in study design, data collection, analysis, or reporting.

DATA AVAILABILITY STATEMENT

The interview data (transcripts, and audio when available) are anonymously archived for public and research use in the digital collection of the Vermont Folklife Center at https://vtfolklifearchive.org/collections/collections/show/10.

ETHICS STATEMENT

Our curriculum and field methods for training student community scientists were approved by the University of Vermont's institutional review board (IRB protocol 00000569). Human subject protections for interviewees were approved by the Vermont Folklife Center (Appendices Aa, Ab, and B).

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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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