Mapping Micro-Level Decision-Making for Alligator Management in North Carolina

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Human-carnivore interactions represent a grand challenge to conservation decision-making and legitimacy across all levels of governance. Human populations continue to encroach upon and devastate carnivore habitats and populations, intensifying interactions between a variety of biodiversity interests and beneficiaries. As a result, carnivores most intensely impact those living in their midst, demanding increased attention by local decision makers, who are often best suited to catering to the needs of communities most affected. Their views and desires can serve as a forerunner of public trust and acceptance of policies created. However, due to the complexity of decisions about carnivores, these actors are often overlooked in the formal decision process. To address this need, we applied multi-criteria decision analysis (MCDA) to a case study of American alligator (*Alligator mississippiensis*) conservation in 10 coastal North Carolina counties to identify and postulate legitimate outcomes. We surveyed 25 local decision makers who are or may be responsible for management decisions concerning the American alligator and asked them to evaluate and indicate the level of importance of salient alligator management elements. Results indicate that decision makers strongly favored the wildlife and social factors when making alligator management decisions, as well as the criteria human well-being, attitudes toward alligators, education programs, and storm mitigation. Respondents favored highly managed and balanced management alternatives to maximize preferred criteria and achieve legitimate alligator management at the local level. These results demonstrate that local decision makers are capable of identifying what is important to alligator management decisions, and can provide an insightful look at trade-offs that need to or could be made to achieve optimal alligator outcomes. We conclude that local decision makers should become more involved in shaping carnivore outcomes to enhance legitimacy of alligator policy and help achieve conservation targets. Future research will need to further expand understandings of local decision makers' decision-making process in other carnivore contexts. Researchers will want to consider using and refining decision analysis to cut through the complexity of carnivore conservation decision-making that exists across wide geopolitical expanses.

Keywords: alligator, analytic hierarchy process, carnivore, coexistence, decision-making, multi-criteria decision analysis

INTRODUCTION

Human populations continue to encroach upon and devastate habitats, intensifying interactions between a variety of biodiversity interests and beneficiaries. These trends demand increased attention by local decision makers, who often have an important role in conservation outcomes (e.g., Press et al., 1996, p. 1547; Doyle-Capitman et al., 2018, p. 376). These actors are often best suited to catering to the needs of communities most affected by human-wildlife interactions (Devas and Grant, 2003, p. 307). Hence, their views and desires can serve as a forerunner of public trust and acceptance of policies created (Sjölander-Lindqvist et al., 2015, p. 179) as well as dissent (Redpath et al., 2017, p. 2161). Although plurality of voice is a cornerstone of democratic biodiversity conservation governance, the possibility exists that divergent or overlooked actors and their views, and as well as shifting social and ecological realities, may prevent outcomes that are optimal for both human and non-human species.

Human-carnivore interactions represent a grand challenge to conservation decision-making and legitimacy (Primm and Clark, 1996, p. 1037; Messmer, 2000, p. 1000; Serenari and Taub, 2019, p. 1). The challenge is formidable as positive and negative interactions can strike the core of societies – rousing a range of epistemologies, social and ecological values, perspectives, problem definitions, and solutions (Dickman, 2010, p. 463). Carnivores most intensely impact those humans living in their midst (Serenari et al., 2018, p. 363). For instance, carnivore species worldwide are known for causing economic loss by preying on livestock (Treves and Karanth, 2003, p. 1492) and can pose a significant threat to human safety through vehicle collisions, disease, or direct attacks on humans (Riley and Decker, 2000, p. 51). Therefore, it is arguably intuitive that governing entities should consider the views of those most impacted by interactions with carnivores, as they are often most effective at contributing to and formulating viable decisions and outcomes (Devas and Grant, 2003, p. 306; van der Ploeg and van Weerd, 2004, p. 346; Sjölander-Lindqvist et al., 2015, p. 180).

However, local stakeholders rarely have a say in carnivore conservation outcomes because these species are often held in the public trust, and decisions are made by state and federal authorities (e.g., wildlife or animal health agencies) (Redpath et al., 2017, p. 2158). This omission is a critical oversight in the instance of American alligators (*Alligator mississippiensis*). For instance, the designation of an alligator as a nuisance is often left up to subjective judgments about an animal's behavior or level of danger it poses to humans' livelihood (Johnson et al., 1985, p. 96; Hayman et al., 2014, p. 489), and decisions to leave or remove it from a pond governed by a homeowner's association, golf course, or local park are often left to the space's managing institution; these decisions may be guided by legal liability (Connaughton et al., 2002, p. 74), public response to alligator presence (Jacobsen and Kushlan, 1986, p. 188), or overt threats to public safety (Eversole et al., 2014, p. 15). We note that inclusion of formal and informal local decision makers and how they negotiate carnivore interactions complicates existing carnivore governance arrangements. Hence, picking the appropriate decision-making tool is critical to simplify the complexity of challenges presented by diverse decision-making scenarios and achieve ideal management outcomes (Bower et al., 2018, p. 2).

Given that carnivore management is notoriously contentious and multifaceted, tools that evaluate the tradeoffs and co-benefits of different management actions help reveal optimal carnivore management solutions and enhance the legitimacy of those decisions (Lundmark and Matti, 2015, p. 150; Robinson et al., 2016, p. 2). In short, the success of human-carnivore cohabitation schemes and related management relies on the ability to integrate the array of salient social and ecological factors that influence the decision-making process. Multi-criteria decision analysis (MCDA) is one promising method that can help navigate the complexities of decision-making and secure optimal carnivore conservation outcomes (Adem Esmail and Geneletti, 2018, p. 43). It has demonstrated success in identifying potential solutions to natural resource management problems (Redpath et al., 2004, p. 357; Driscoll et al., 2016, p. 202). Despite its utility to elicit socio-ecological tradeoffs in other environmental contexts, MCDA has been underutilized to help resolve conflicts in human-carnivore decision-making (Redpath et al., 2004, p. 351).

We address this need by applying MCDA in a carnivore management context to investigate the decision-making process at the local level in North Carolina. The case of the alligator in eastern North Carolina is a useful place to begin developing systematic understandings of local-level decision-making about carnivores because interactions between people and alligators have become a socially and politically contentious carnivore management issue at the county and municipality levels. Moreover, policy conflict is often a prerequisite for decision analysis in wildlife management (Redpath et al., 2004, p. 358; Riley and Gregory, 2012, p. 103). As we aim to demonstrate, local decision makers are often involved in resolving or stoking such conflict and shaping outcomes.

METHODS

Study Area

The American alligator ranges from the southern tip of Texas along the Gulf Coast to Florida and continues northward along the Atlantic Coast to North Carolina. Historically, alligator populations located in North Carolina are considerably smaller than their southern counterparts. This is due to the cooler annual climate and lower temperatures of North Carolina, which cause slower maturation and, consequently, lower reproduction rates (Gardner et al., 2016, p. 545). Rising sea levels and human expansion have depleted alligator habitat (Carle, 2011, p. 1276; Gardner et al., 2016, p. 541), causing alligators to move further inland in search of food, shelter, and mates and thus interact with humans more frequently (Eversole et al., 2014, p. 15).

Alligators are a state trust resource and are managed by the North Carolina Wildlife Resources Commission (NCWRC, 2017, p. 11). This study focused on local-level formal and informal decision makers within the 10 coastal counties of North Carolina's Alligator Management Unit 1 (AMU 1): Brunswick, Carteret, Columbus, Craven, Hyde, Jones, New

Hanover, Onslow, Pamlico, and Pender. According to the NCWRC's North Carolina Alligator Management Plan (AMP), AMU 1 comprises counties within North Carolina that harbor the most robust alligator populations and quality alligator habitat [e.g., rivers, lake, and estuaries [Gardner et al., 2016]]. As a result, human-alligator interactions are more frequent in these areas (NCWRC, 2017, p. 9). The North Carolina AMP proposed a list of parties that could potentially be impacted by alligator management strategies (NCWRC, 2017, p. 24). Using this list we categorized formal decision makers as those with local governmental positions and informal decision makers as individuals within nongovernmental organizations such as public or private businesses or groups.

The NCWRC is aware of the role that local communities play in helping maintain the viability of the country's northernmost alligator population, which is smaller and more easily perturbed than southern populations. The agency often works closely with local officials to communicate about alligator management, and may also help a local community achieve its alligator management goals, such as targeted removal of nuisance alligators or improving public knowledge of living with alligators (NCWRC, 2017, p. 8). Correspondingly, there is a need to minimize any threats posed by alligators to the public or to alligators by the public. Policy conflict over alligator management came to a head in 2018 when the NCWRC approved permits to hunt alligators in AMU 1 (NCWRC, 2017, p. 32). The decision was hailed by hunting and public safety proponents but rebuked by segments of the public and some local officials[1,2].

Study Design

Our quantitative survey focused on AMU 1 formal [governmental (e.g., county, city council, police)] and informal (e.g., golf course general manager, HOA board member) decision makers. Novel decision-making tools that objectively evaluate the range of interests and potential outcomes can inform policy conflict resolutions and do so with small sample sizes (Robinson et al., 2016, p. 2; Darko et al., 2019, p. 447). We employed the Analytic Hierarchy Process (AHP), a MCDA method, because it has the ability to quantify the priorities of decision makers through comparisons of explicit criteria and management alternatives in a manner that is replicable and transparent (Adem Esmail and Geneletti, 2018, p. 43) and provide useful insights when samples are small (Darko et al., 2019, p. 447). We focused study questions on eliciting salient elements of decision-making (i.e., factors, issues, and criteria) concerning alligator management.

Decision Tree and Survey Instrument Development

We began by interviewing local-level decision makers who had previously been responsible for making decisions about alligator outcomes within their jurisdiction to elicit which elements decision makers judged as most valuable. Recruitment for interviews occurred by first creating a master list of potential

contacts via a Google™ search using a combination of the search terms *alligator, sightings, hunting,* and *conflict* to identify any decision makers publicly mentioned in past human-alligator interactions or policy decisions in the target counties ($N = 33$). We contacted potential participants by alternating between email and phone calls weekly during August and September, 2019 (Dillman et al., 2014, p. 285), and carried out all subsequent interviews by phone. We first asked informants to elaborate on their occupation and the role they played in making decisions regarding alligator management to ensure that respondents were responsible for alligator management decisions as a part of their occupation. We then asked them to rank and discuss five primary *factors* in terms of importance when making decisions regarding alligator management: social, political, economic, alligator-specific, and landscape-specific, as well as each factor's corresponding *issues* and *criteria*. We conducted four interviews due to constraints caused by Hurricane Dorian in September 2019. The four interview participants consisted of a golf course manager, county commissioner, chief of police, and county manager; three of which had previously made decisions regarding alligators as a part of their job, while the fourth indicated that they would be responsible for alligator management decisions.

We supplemented interviews with a thorough literature review. We searched the Google Scholar database, for relevant literature using a combination of the following search terms: *wildlife, management, carnivore, alligator, decision-making, factors,* and *element/factor*. We considered only articles that directly related to the topic of carnivore management and specifically discussed factors that influence decision-making. We focused our review on peer-reviewed ($n = 44$) and gray literature (e.g., books and reports, $n = 5$), and thematically coded (Guest et al., 2011) to elicit primary decision-making elements. We found that researchers largely focused on topics such as public risk assessment and attitudes toward carnivores (e.g., Riley and Decker, 2000, p. 58; Smithem and Mazzotti, 2008, p. 10), providing education about carnivores (Eversole et al., 2014, p. 19; Skupien et al., 2016, p. 274), human development and associated impact on human-carnivore interactions (Patterson et al., 2003, p. 172; Eversole et al., 2018, p. 7), and the role of wildlife systems in decision-making (Liu et al., 2016, p. 21; Expósito-Granados et al., 2019, p. 9) at the local level. Employing a tripartite coupled human and natural systems framework (Liu et al.'s, 2016, p. 16), the first level of the decision tree consisted of Social, Natural, and Wildlife factors. We renamed landscape- and alligator-specific factors Natural and Wildlife, respectively, to be more inclusive of the issues and criteria mentioned in the interviews. The literature maintained the diminished importance of economic and political factors in local-level alligator management decisions and were, thus, excluded from the decision tree design. The second branch of the decision tree consisted of issues specific to each factor, and the third branch consisted of criteria belonging to each issue (**Figure 1**). The final version of the decision tree aligned with the goal of enhancing the legitimacy of alligator management decision-making at the local level, understanding that legitimate decision-making promotes the inclusion of relevant stakeholders and experts, is transparent and reliable, and produces quality management practices (Serenari and Taub, 2019, p. 2).

We created an online survey in Qualtrics (2020). The survey consisted of pairwise comparisons at each branch of the decision tree to determine the relative importance of each element of alligator management decision-making. To indicate their preference for considering elements when making decisions, we used the Saaty scale (1 = equally preferred, 9 = extremely preferred, Saaty, 2008, p. 86). Using this scoring system, the participants then also compared factors, issues, and criteria among each branch in the tree, and then again between one branch and the elements corresponding directly below it. We then provided decision makers with three management options (alternatives) and asked them to indicate their preference of management to maximize, or enhance, each individual criterion of the decision tree.

Alternatives represented a range of management intensities, which is common logic used in wildlife management: highly managed, balanced, and land-sharing (Redpath et al., 2004, p. 354). Highly managed practices often indicate policies that maximize human benefits (e.g., safety, development) and may be considered equivalent to a zero-tolerance policy of alligators inhabiting space near human settlements. Lethal control or removal is preferred and carried out by governing agencies. Hence, our alternatives characterized a sliding scale of aggressiveness employed by carnivore managers (Serenari, 2020), specifically, alligator management based on frequency of sightings, risk perception, proximity to populated areas, alligator density, predatory behavior of alligators, and governance

arrangement (**Table 1**) (e.g., Johnson et al., 1985, p. 100; NCWRC, 2017, p. 7). A balanced alternative represented equal consideration of human and alligator needs (e.g., prey, habitat). As an example, AMU 1's permitted alligator hunt, in which municipalities can collaborate with the NCWRC to determine alligator population sizes, places of concern for public safety, areas in which alligator hunts can be conducted safely, and number of permits to issue. Land-sharing signifies management practices that largely consider the needs of alligator populations, in which the suggested form of management is to "leave them be," regardless of where the alligators are located. Individuals who report alligators to the NCWRC are provided information regarding alligators and their behavior and advised to leave the alligator(s) alone until it moves from its current location (NCWRC, 2017, p. 7). We provided definitions of each element in the decision tree, as well as the different outcomes of each alternative to respondents to ensure consistent interpretation of meanings (see **Supplementary Materials**).

Recruitment and Survey Administration

We conducted two phases of recruitment of formal and informal local-level decision-makers by email and phone. Formal decision makers were located in AMU 1 counties and included city or county governments, police departments and informal included HOA board members, golf clubs, park rangers, and conservation organizations. The first phase of recruitment occurred every 3–4 weeks between August and December 2019, and the second
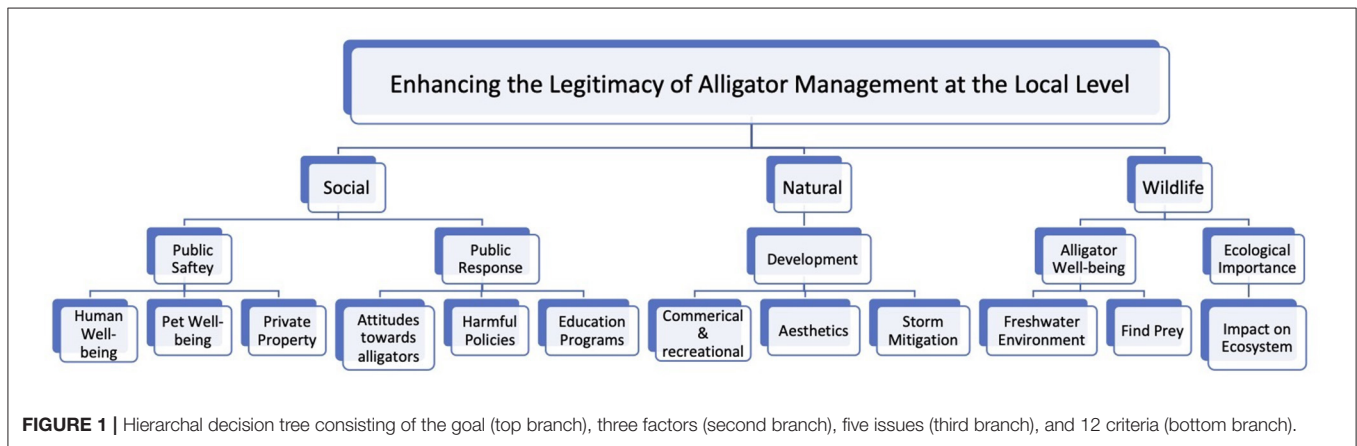

FIGURE 1 | Hierarchal decision tree consisting of the goal (top branch), three factors (second branch), five issues (third branch), and 12 criteria (bottom branch).

TABLE 1 | Management options (alternatives) of alligator management.

Option	Description	Frequency of sighting	Risk perception	Proximity to populated areas	Density	Predatory behavior (of alligators)	Governance
A	Highly Managed	Decreased	Minimal	<25 mi from shore to human activity	Low (0–2/km to water's edge)	Limited	Centralized (state as main governing body)
B	Balanced	Random	Limited	Some human activity	Medium (3–5/km to water's edge)	Regulated	Public-Private [co-governing between state and stakeholders (biologists)]
C	Land-Sharing	Increased	High	Anywhere	High (≥6/km to water edge)	Unrestrained	Interactive (collaborative governing between state, stakeholders, and citizens)

Options from A–C represent declining levels of management intensity & the resulting effects of its respective management style.

phase increased contact frequency, occurring biweekly between March and July 2020 (Dillman et al., 2014, p. 336). We terminated recruitment efforts using a 7-attempt callback/email design (Dillman et al., 2014, p. 285). We expanded recruitment efforts to include decision makers that had previously been involved in alligator management decision-making, as well as those that would be responsible for these decisions in the future. We screened participants using the following questions: "As part of your job, do you have previous experience making decisions about alligators (e.g., decision to relocate, leave alone)?" and "As part of your job, is it possible you may someday make a decision about an alligator (e.g., decision to relocate, leave alone)?". We invited decision makers who answered *yes* to the first question and *yes* or *maybe* to the second question to further participate in the survey. If they responded *no* to both questions, they were excluded from the study. We also employed chain referral sampling (Etikan et al., 2015, p. 1) to increase our chances of reaching the person within each organization responsible for alligator management decisions (see **Supplementary Materials** for complete timeline of interview and survey recruitment).

The study (#6291) was approved by the Texas State University Institutional Review Board on April 8, 2019.

Analysis

Using the Saaty scale, scores were attributed to each element based on the preference indicated by the respondent and placed into a matrix. The diagonal values within the matrix equal 1.0 as they represent comparisons of the same element (Harputlugil, 2018, p. 224). Following (Saaty, 2008, p. 85), the element with the greatest assessed importance was assigned the score provided by the respondent, and the reciprocal of that score was given to the corresponding comparison. We first calculated the sum of each column, and then divided each given value by the sum of its respective column to determine the priority weights of each element. Then, we summed calculated values across each row and divided by the total number of elements within each matrix to create the priority weight of each element. This process occurred for each individual respondent's survey responses. Following the calculation of the priority weights as determined by each individual respondent, the average of the weights for each element was taken. When added, the weights of all elements that belong to the same parent element directly above them equals 1.0.

In addition to the average weights attributed to the three management alternatives with respect to each criterion, the global weights of the alternatives were also calculated to determine their relative importance with respect to the overall goal. First, the global criterion weights were calculated by multiplying the averaged individual weight of each criterion by the weights of its respective issue and factor. Next, the global criterion weights were multiplied by the averaged individual alternative weights with respect to each criterion. Lastly, the total of the calculated weights for each alternative was taken to create the final global priority of the three alternatives.

We did not conduct any official collection of nonresponse data because potential respondents became unresponsive. Of the 97 individuals that opened the survey, 72 either responded *no* to both screening questions or did not complete the survey. Moreover, some potential respondents asked us to not contact them again because they were not involved in alligator management decisions, did not have any alligators within their jurisdiction, or were unavailable due to the pandemic. Thus, we posit that most potential respondents that we contacted did not or would not make such decisions.

RESULTS

A total of 97 individuals invited to participate completed at least part of the survey, and 25 provided valid MCDA results for analysis (response rate of 30%). The majority of respondents were 55 years or older, lived in suburban areas, and had a bachelor's degree or higher. More than half of the survey respondents were employed in city or town government, with the remaining participants employed in county government, law enforcement, property management, and others (**Table 2**). Of the 25 respondents, 14 indicated previous experience in making decisions about alligators as a part of their job, while the remaining respondents indicated they would be responsible for any decisions regarding alligator management in the future.

When making decisions regarding alligator management, respondents indicated that the wildlife factor (weight = 0.38) was most important for consideration, followed by social (0.37), and natural (0.25). Within the wildlife factor, about half of the respondents (i.e., 13/25) claimed that alligator well-being and ecological importance of alligators were of equal importance in making a decision regarding alligator management. This finding was reflected in the averaged score of the two issues at 0.55 and 0.45, respectively. Similarly, 20 out of the 25 respondents claimed no difference between the wildlife criteria freshwater environment (0.55) and find prey (0.45). The wildlife criterion impact on ecosystem was the sole criterion of ecological importance and did not undergo a pairwise comparison, and thus resulted in a weight of 1.0.

Concerning the social and natural factors, respondents strongly rated public safety (0.72) over public response (0.28), with seven respondents claiming equal importance of the two issues in decision-making. Only two participants answered that public response was more important. Respondents prioritized the social criteria human well-being (via public safety) (0.59), followed by education programs (via public response) (0.51), and attitudes toward alligators (via public response) (0.34).

TABLE 2 | Occupational makeup of survey participants.

Occupation	N =
City/Town Government	15
County Government	3
Law Enforcement	2
Property Manager (HOA, golf course, campground)	2
Park Ranger	1
Conservancy	1
Total	**25**

Storm mitigation was the highest rated natural criterion (0.61) (**Figure 2**).

Respondents indicated that highly managed was the preferred management method for maximizing social criteria (private property, education programs) and natural criteria (aesthetics, storm mitigation). Respondents preferred a balanced management approach, maximizing all wildlife-specific criteria, most of the social criteria, as well as the natural criterion commercial and recreational development (**Table 3**).

Balanced management (0.37) was the most preferred alternative to achieving the overall goal of enhancing the legitimacy of alligator management decision-making at the local level, closely followed by highly managed (0.35). Land-sharing was ranked last to maximize all criteria except for human well-being and attitudes toward alligators. In both cases, land-sharing was greater than highly managed by <0.01.

DISCUSSION

Respondents appear attuned to the role alligators play in local social and ecological systems. Decision makers in our study demonstrated awareness of and agreed on the importance of the wildlife system in the carnivore management decision-making process. Though slightly more important to decision-making than other factors, respondents offered a balanced view, giving nearly equal weight to alligator welfare and the role of alligators in local ecosystems. There are three distinct explanations for why formal and informal local decision makers held the alligator system in high regard. First, wildlife can be an integral part of the identity of some regions and localities (Treves et al., 2006, p. 387). For instance, residents in Florida favor the presence of alligators, as it is seen as an indicator of a healthy environment (Smithem and Mazzotti, 2008, p. 15). In this case, eastern North Carolina is known for its wild landscapes (Serenari et al., 2018, p. 361), and it is conceivable that respondents' answers reflect this internalization. Second, local decision makers may be considering how their communities need to adapt to novel social and ecological dynamics to increase the legitimacy, communication, and understanding of their decisions among

the public (Patterson et al., 2003, p. 173; Lundmark and Matti, 2015, p. 147). Dynamic change is occurring to North Carolina's coasts. For instance, human activities, sea level rise, and saltwater intrusion are having and expected to have substantial impacts on social-ecological systems, particularly wildlife distribution and abundance and human-wildlife interactions (Bhattachan et al., 2018, p. 127). Considerations for these realities and growing emphasis on legitimacy, salience, and empowerment of local decision-making may have influenced our findings (also evidenced by preference for storm mitigation qualities of alligator habitat). Finally, public cognitions concerning large carnivores can play an important role in the decision-making process (Lute and Attari, 2017, p. 139). Researchers have theorized that values oriented toward wildlife are shifting from the sole belief that wildlife are to be used for human benefit to the idea that wildlife are meant to be appreciated and respected, particularly among urbanizing human populations (Manfredo

TABLE 3 | Average of individual AHP weights for alternatives related to each criterion.

Criterion	Highly managed	Balanced management	Land sharing
Human Well-being	0.29	0.42	0.30
Pet Well-being	0.34	0.37	0.29
Private Property	0.37	0.36	0.27
Attitudes toward Alligators	0.27	0.43	0.30
Harmful Policies	0.35	0.36	0.29
Education Programs	0.36	0.34	0.30
Commercial & Recreational Development	0.37	0.38	0.25
Aesthetics	0.38	0.35	0.27
Storm Mitigation	0.47	0.35	0.22
Freshwater Environment	0.35	0.38	0.27
Find Prey	0.31	0.39	0.30
Impact on Ecosystem	0.33	0.35	0.32

Balanced management was most preferred among participants for maximizing eight of the 12 criteria, and highly managed was preferred for the remaining four criteria.
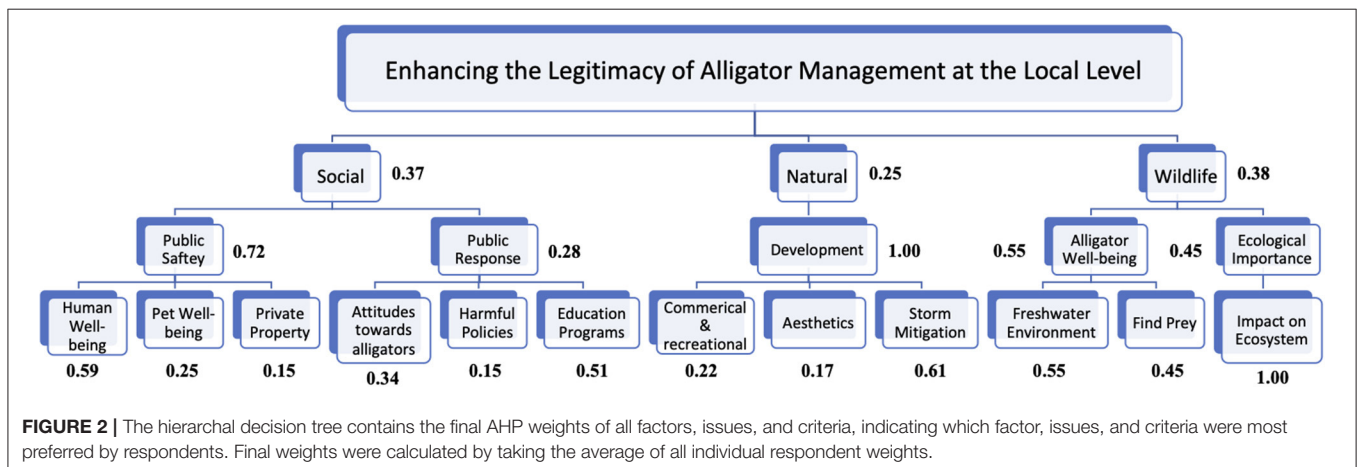

FIGURE 2 | The hierarchal decision tree contains the final AHP weights of all factors, issues, and criteria, indicating which factor, issues, and criteria were most preferred by respondents. Final weights were calculated by taking the average of all individual respondent weights.

et al., 2020, p. 7). However, we note that this research occurred on the heels of public outcry over the NCWRC's proposed hunting of alligators in 2018; therefore, our results may reflect an underlying preference for coastal communities to share space with alligators, but with caveats. While public outcry may have roused strong policy preferences among respondents, responses were anonymous. Therefore, social desirability bias should be of little concern in this study, but future research will want to consider how public outcry over carnivore policies might impact local-level decision-making.

Human welfare was a top priority for local-level decision makers in our study, specifically, human well-being linked to public safety (e.g., health, safety, and social relations). Previous studies demonstrate that concern for public safety is a top factor in decision-making at all levels of governance and is underpinned by risk perceptions (Riley and Decker, 2000, p. 58; Gore et al., 2006, p. 40; Smithem and Mazzotti, 2008, p. 19). Although perceived risks concerning alligators may be attributed to social and cultural beliefs (Dickman, 2010, p. 459) or situational factors such as living near water or having children or pets (Hayman et al., 2014, p. 484), many times they evolve from exaggerated ideas about alligator behavior (Eversole et al., 2014, p. 17). This paradoxical nature of perceived risk may throw a wrench into plans to integrate alligators into the coastal North Carolina landscape, particularly if policies address atypical alligator behavior (Rogers, 2011, p. 293). The status of alligators on the North Carolina coast is at a critical juncture, and intentional educational opportunities that create "Alligator-Wise"[3] initiatives at the community and regional scales would be invaluable to help communities promote novel perceptions of risk grounded in empirical data and probability.

Respondents also considered public response in their decisions, but to a small degree. Similar to the NCWRC, the decision makers within our study placed great importance on public education about alligators. One goal of the NCWRC AMP is to provide comprehensive knowledge of alligators and their management to the public through education and outreach strategies. Some proposed strategies include formal and informal public forums, technical guidance to landowners and managers, and educational information dispersed through various media outlets (NCWRC, 2017, p. 8). Research demonstrates that deficient knowledge of carnivores and their ecological importance can be detrimental to promoting coexistence between humans and carnivores (Lute and Gore, 2014, p. 1065; Expósito-Granados et al., 2019, p. 9). Future consideration should be given to finding ways to involve local decision makers in designing and administering educational opportunities to promote human-alligator coexistence. Our study suggests that content should include integrating net positives that benefit humans, alligators, and the coastal ecosystem such as protecting habitat which would in turn buffer communities from increasingly intense storms (Gedan et al., 2011, p. 8).

If local decision makers are to become more involved in carnivore management outcomes, as we argue they should, we

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[3]https://www.santafenewmexican.com/news/we-saved-the-alligators-then-moved-onto-their-turf/article_a4defe7d-0d70-58b9-9fd8-8ec7b56f743b.html.

must better understand the ideology underpinning decisions and examine how they align with alternatives in use to provide a clearer picture of the efficacy of those alternatives, as well as full consideration for novel alternatives and arrangements where necessary. Local decision makers in our study favored a landscape with a strong human presence to moderate interactions between humans and alligators and to maximize human activity and protect private property from damage. Yet, a balanced management plan was preferred to maximize human well-being, human attitudes, and the remaining suite of criteria. These results speak to the heart of the so-called predator paradox (Shivik, 2014), empowered by the mass media and characterized by a persistence of memory and perpetuation of an unwillingness to alter our imaginations about how to live peacefully with carnivores (Debord, 1967). Retaliation, separation, and aggressive carnivore management are often the rallying cry and default outcome when human safety and damage to private property are a major concern (Treves and Karanth, 2003, p. 1492; Lute and Attari, 2017, p. 140). Critics argue that the ideas about how to live with carnivores on an increasingly crowded planet require upgrading (Carter and Linnell, 2016, p. 577; López-Bao et al., 2017, p. 1; Lute et al., 2018, p. 231; Serenari, 2020, p. 7), as the system of ideas that embrace and promote total separation of humans and carnivores are deficient in a holistic understanding and appreciation of carnivores (Skupien et al., 2016, p. 266). Carnivore populations are decreasing as a result of carnivores leaving their natural habitat range due to loss of habitat, as seen in the alligator populations in North Carolina. Consequently, there is a growing necessity to incorporate decision-making tools that allow for impartial and equal consideration of all relevant criteria to create legitimate alligator management. Our study suggests that local-level decision makers may provide an insightful look at trade-offs that need or could be made to achieve optimal alligator and other carnivore conservation outcomes, promoting local understanding and support, and ultimately legitimacy, of the decision-making process (Doyle-Capitman et al., 2018, p. 379).

Use and Limitations of MCDA

The use of decision modeling in this study allowed quantification of the decision-making process of alligator management at the local level. Unlike attitudinal measures, participants were able to analyze and compare multiple elements at one time. Though the method has great potential, administering the study's scope and MCDA across a broad scale requires refinement. We hope to elaborate on these lessons in a future paper, but provide a brief overview here. First, due to the exploratory nature of the study, a roadmap for preparing the sampling frame did not exist. Hence, overall participation was voluntary and based on a convenient sample. Additionally, recruitment for this study was hampered by forces out of our control, including Hurricane Dorian (2019), Tropical Storm Arthur (2020), and the COVID-19 pandemic (2020). Second, we achieved greater participation from government officials than from informal decision makers. Therefore, our results may reflect biases in this regard. Third, though representativeness was not the goal of this study, only one-fourth of respondents who began the survey completed the

MCDA portion (although it was placed in the first third of the survey). We attribute this outcome to the cumbersome nature of the MCDA design and applying it across a wide geospatial area rather than in a collective setting (e.g., workshop). Fourth, the broad scale of our research may have resulted in survey question design that lacked context or underrepresented the suite of factors, issues, and criteria specific to the local scale in North Carolina. For example, during the interview process, informants revealed that economics and politics received little consideration when making decisions about alligator management, and thus these factors were not included in our survey. These factors were claimed to be irrelevant to decision makers in North Carolina's AMU 1 as well as the broad alligator literature. Nevertheless, future studies should contextualize factors to the best of their ability and strive for representativeness. Finally, although there was sufficient data to obtain useful insights into local-level decision makers' preferences for alligator management using AHP, the small sample size did not allow for comparisons among different groups of formal and informal decision makers. Out of the 25 respondents, 20 were formal decision makers and five were informal decision makers. The small sample sizes of formal and informal decision makers separately prevented us from making any assumptions on the individual groups that would accurately represent the individual groups. Also, due to the imbalance between the two group sizes, we were unable to compare formal and informal decision-making processes for alligator management. Future research would benefit from a concerted effort to recruit formal and informal decision makers to achieve a richer representation of their decision process, as well as further exploration in comparisons between the decision-making process of formal and informal decision makers.

CONCLUSION

The purpose of our study was to highlight the current gap in carnivore management decision-making, specifically at the local level. We applied MCDA to give voice to those decision-makers who are often overlooked in the carnivore management decision-making process. We surveyed formal and informal decision makers in eastern North Carolina and asked them to equally consider principle elements of alligator management. Our study highlights that these critical actors considered the wildlife and social factors when making decisions, and preferred either balanced or highly managed practices to manage for alligators. While carnivore management policies created at the

macro-level are essential to carnivore conservation, coexistence between humans and carnivores is best promoted when these large-scale policies can be adapted to specifically target the needs of the local people. Understanding what local-level decision makers consider important when managing carnivores is critical to increasing local involvement in the decision process and ultimately improving the legitimacy of management policies.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Texas State University Institutional Review Board (#6291). The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

RC and CS conceived and developed the project and collected data. RC, CS, and DK analyzed the data and wrote and edited the manuscript. All authors contributed to the article and approved the submitted version.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fcosc.2021.650339/full#supplementary-material

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