# Research needs, environmental concerns, and logistical considerations for incorporating livestock grazing into coastal upland habitat management

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**Highlights:**

- There is interest in exploring livestock grazing for coastal habitat management
- Few resources exist to inform livestock grazing for coastal habitat management
- Cattle and goats were identified as the most beneficial livestock in coastal uplands
- Research to inform livestock type and grazing frequency in coastal uplands is needed

**Abstract**

Along the Gulf of Mexico (GoM) coast, natural resource managers continually struggle with managing coastal uplands due to front-end costs, prolonged maintenance, and habitat-specific ecological needs. Prescribed fire, mechanical removal, and chemical treatments are common habitat management techniques used to remove invasive species, clear understory, and achieve other management goals. However, rapid development and changing climate exacerbate the difficulty in using these techniques. A potential alternative or complementary technique is using livestock for habitat management (i.e., targeted or controlled grazing). In other regions of the world, using livestock for conservation or restoration of managed lands has shown to be a less intrusive and more financially viable alternative. To better understand the research needs, logistical, and environmental concerns related to using livestock for habitat management in the coastal uplands of the GoM, we developed and distributed a survey to three groups of land users, including natural resource managers, researchers, and livestock producers in the region. Survey results show that over 96% of respondents are interested in using livestock for habitat management, but less than 10% of respondents were aware of any information that could be used to inform grazing practices for coastal upland habitat management along the Gulf of Mexico coast. There were differences among surveyed groups, but generally small-sized cattle breeds and goats were identified as the livestock with the most potential for environmental benefit and ease of containment. General concerns and areas for further investigation were implementation (e.g., which livestock type to use and grazing intensity), logistical considerations (e.g., fencing and rotational frequency), impacts of grazing on water quality, wildlife, vegetation, and livestock nutrition. Survey respondents overwhelmingly (at least 75% of each group) indicated that livestock grazing ideally would not be a standalone management practice and should be used in

conjunction with other habitat management techniques such as prescribed burns, mechanical clearing, or chemical treatments. The results of the survey could be used to develop applied research projects and guidance documents that directly address informational needs related to using livestock for habitat management of coastal uplands along the Gulf of Mexico coast.

**Key words:** conservation grazing, targeted grazing, habitat restoration, land management, ecosystem services

## 1. Introduction

Habitat restoration and management is difficult due to the initial investment of resources, continued maintenance, specialized experience, equipment, and training required (Fleischner, 1994; Gibble et al., 2020). Some common habitat management techniques used in coastal uplands include applications of prescribed fire, herbicide, mulching, and other mechanical treatments. Each of these techniques is associated with different levels of cost-effectiveness, intrusiveness, and strategy (Daines, 2006; Franklin et al., 2018). Another practice that has been highly successful in some areas of the globe is the use of livestock for habitat management and restoration (Harnett et al., 1996; Fuhlendorf et al., 2009; Li and Jiang, 2021; Oles et al., 2017; Öllerer et al., 2019; Sharrow et al., 1992). Implementing controlled (i.e., targeted) livestock grazing strategies has been demonstrated to reduce wildfire fuel loads by decreasing biomass as well as increasing moisture content to further suppress wildfire spread (Davies et al., 2022). Additionally, pyric herbivory, the coupling of prescribed fire and accompanying grazing pressure, has been shown to create heterogeneity and diversity in vegetation communities and reduce occurrence of invasive species in grassland communities among others (Fuhlendorf et al, 2009; Porensky et al, 2018). Similar effects of grazing (e.g., suppression of invasives, reducing fuel load) have been observed in forests worldwide where livestock have been used in open forest management strategies to reduce plant biomass with minimal damage to young trees (Ellen, 1990; McEvoy and McAdam, 2008; Öllerer et al., 2019; Sharrow et al., 1992; Sharrow, 2006; Thomas, 1984). While the potential benefits of incorporating controlled livestock grazing into habitat management are evident, these practices require substantial knowledge of both animal husbandry, ecological health, and logistical considerations (e.g., containment, movement, grazing frequency, etc.). For these reasons, livestock grazing is considered to be one of the most cost-effective methods for habitat management, but also the method requiring the most management expertise (Daines, 2006; Greiman, 1988). For example, grazing duration and intensity, livestock type, and timing of grazing activity during the season of the year can all drastically affect the success of a grazing strategy (Bates et al., 2009; Li and Jiang, 2021; McEvoy and McAdam, 2008; Öllerer et al., 2019).

Conversely, livestock grazing has also been linked to habitat degradation in some regions and scenarios. There is a well-known controversy with the ecological impacts of grazing in the arid regions of North America due to large herds of primarily cattle, compacting soils, reducing vegetation, and negatively impacting biodiversity (Jones, 2000). Unlike rangeland or pasture systems where large herds of cattle or other livestock varieties are continuously or seasonally grazed for production purposes, targeted grazing consists of highly controlled stocking densities of livestock applied to selected areas under specific time constraints for the benefit of vegetation communities (Bailey et al., 2019). From a habitat management perspective, best grazing management practices should vary by site specific conditions; while one method may be beneficial in one ecosystem type it may degrade another (Howery et al., 2016). For example,

previous studies of geomorphological impacts of grazing, including targeted grazing, cited soil erosion and higher runoff in saturated soils as a more immediate issue than soil compaction with moderate grazing pressure in riparian areas, but saw limited impacts in upland areas with low to moderate grazing (Trimble and Mendel, 1995). Additionally, fencing options can also be a cause for concern for a multitude of wildlife species (Jakes et al., 2018). However, less-intrusive fencing options, such as invisible and virtual fencing, have been shown to be effective for both cattle and goats (Boyd et al., 2022; Hart, 2001).

There are many terms associated with these practices, such as conservation, targeted, or prescribed grazing, but all essentially use livestock to simulate historically natural herbivory and/or complement other land management activities (Caudle and Daigle, 2016). The geographic focus of most of these grazing efforts are in areas where large herds of native herbivores historically ranged, such as the central and western United States (Davies et al., 2022; Harnett et al., 1996; Van Lear et al., 2005). However, large herds of grazers were historically present in other areas of the United States that rarely use livestock grazers for habitat management activities. One of these areas included the coastal uplands along the northern Gulf of Mexico (GoM) coast, where grazing played a large role in the creation, sustainability, and diversity of habitats in this area, along with wildfires and tropical weather systems, such as hurricanes and tropical storms (Caudle and Daigle, 2016; Noss, 2013). Grazing by large herbivores stimulated the development and maintenance of diverse and productive understory or prairies (Packard and Mutel, 2005). These coastal uplands were once grazed by Bison (*Bison bison*) and other grazers and burned by Native Americans as well as naturally occurring wildfires by lightning strike (Grace et al., 2005; Van Lear et al., 2005); thereby shaping the plant and animal communities in the area. It is suggested that in the historical context of southern grasslands, herbivory by large grazers may have been more influential to the development of savannas as we now know them than fire due to the mix of grazing-adapted rhizomatous grasses and bunchgrasses (Noss, 2013). Lack of fire, loss of naturally roaming megaherbivores except white tailed deer, and free-range laws in response to overpopulation and overgrazing of free-range cattle, led to the overgrowth of woody underbrush that is common in this area today (Caudle and Daigle, 2016). As the concern for habitat degradation increases, efforts to restore and maintain coastal uplands are focusing on practices that reflect natural and historically prevalent processes (e.g., prescribed fire and natural grazing).

The timing of prescribed burning (spring vs. summer), rest periods between fire and grazing, and how much grazing pressure is applied have the greatest impacts on the recovery of plant communities (Bates et al., 2009). Though there are considerable benefits to annual burns in some ecosystems, this practice is not always feasible in current conditions and can permanently stunt growth of pine seedlings (Braasch et al., 2017). In addition to the cost, prescribed fire is becoming more difficult to conduct due to encroaching development and unpredictability of weather windows (Hulme, 2005). Climactic occurrences such as droughts, flooding, and high winds can also prevent or disrupt annual prescribed burn cycles. Additionally, prescribed burns carry risk to human habitation, liability concerns, and heavy costs that are compounded by increasing development along the US Gulf of Mexico coast (Van Lear et al., 2005). Having the option to graze in areas that are difficult to manage with other techniques could give land managers another tool that is less restricted by development, weather, and other environmental factors. Combined with a well-structured habitat management plan informed by locally-relevant research, these land management techniques could replicate historic disturbances within coastal upland plant communities. In other areas of the world, paired land management techniques (e.g.,

prescribed burning and grazing) have been used to maintain habitats. For example, cattle, goats, and sheep are actively used in prairies, shrublands, and open forests to reduce fire loads prior to burning, maintain fire breaks, and create or maintain green strips (Bates et al., 2009; Diamond et al., 2012; Li and Jiang, 2021; Tasker and Bradstock, 2006; Taylor, 2006). There are also several potential economic and community benefits of using livestock grazing for natural resource management. Incorporation of the local community into these management activities could increase awareness of environmental stewardship needs and incorporate local knowledge into the natural resource management process (often termed community-based natural resource systems; Armitage, 2005; Biró et al., 2020; Varela et al., 2018) while also generating a primary or secondary income stream for members of the local community.

Most research available on using livestock for habitat management has been conducted in areas with different environmental conditions and plant community assemblages than coastal upland habitats of the GoM which include pine savannas and flatwoods, prairies, lowlands, and woodlands. The lack of research limits the ability to apply grazing practices with research-based information in this area. Even within the northern GoM region, there are significant differences in habitat types, productivity, and habitat management goals that could impact the implementation or benefit of livestock grazing for land management. For example, the Mission-Aransas National Estuarine Research Reserve in Port Aransas, Texas, is predominantly interested in converting and restoring scrub-shrub communities dominated by Honey Mesquite (*Prosopis glandulosa var. glandulos*a) and Huisache (*Acacia farnesiana*) back to coastal prairie habitats where Switchgrass (*Panicum virgatum*), Indian grass (*Sorghastrum nutans*) and various Bluestem varieties (*Schizachyrium scopariusm, Andropogon gerardii var. gerardii)* once thrived (Diamond and Smeins, 1984; Evans et al., 2012). Conversely, the National Estuarine Reserves in Mississippi (Grand Bay), Alabama (Weeks Bay), and Florida (Apalachicola) are mostly interested in restoration and conservation of pine savannas (Peterson et al., 2007) and flatwoods where lack of management has led to the displacement of diverse herbaceous understory with woody understory (Van Lear et al., 2005). Restoration concerns in these habitats include understory thinning, removal of invasives, and restoration of native plants to include Wiregrass (*Aristida beyrichiana*), Switchgrass (*Panicum virgatum*), Narrowleaf Whitetop Sedge (*Rhynchospora colorata*), Broomsedge Bluestem (*Adropogon virginicus*), Saw Palmetto (*Serenoa repens*) and other tallgrass variations. Some of the invasive species in these pine savanna and flatwoods ecosystems include Chinese and Japanese privet (*Ligustrum sinense*), Japanese climbing fern (*Lygodium japonicum*), Kudzu vine (*Pueraria montana* var. *lobata*), Cogon grass (*Imperata cylindrica*), Purple sesban (*Sesbania punicea*) and Chinese tallow tree (*Triadica sebifera*). While each of these ecosystems are unique and composed of varying ecological communities, anecdotal information from land managers across this region, predominantly private property owners, suggests that incorporating livestock into habitat management in these areas has the potential to be a cost-effective method to reach restoration and conservation goals.

Along the US Gulf Coast region, Pineywoods cattle and various breeds of goats effectively clear dense areas of underbrush and consume invasive species (Albin, 2014; Garcia et al., 2012; Hart, 2001). Pineywoods cattle are a small (360-400 kg weight) mixed breed derived from the Florida Cracker cattle (Simon, 2006). They have historically been used as a land management breed since at least the early 19$^{th}$ century, but, along with goats, are rarely used for habitat management along the US Gulf Coast today. The lack of research available to inform

grazing plans is a barrier to using livestock for grazing on both public and private lands in this region.

To better understand the status, perceptions, and informational needs associated with using livestock for habitat management of coastal uplands, we developed and distributed a survey to natural resource managers, researchers, and livestock producers throughout the GoM region. Specific objectives of the survey were to assess the perceived benefit, if any, of different types of livestock as well as determine environmental and logistical concerns, research needs, and awareness of local livestock grazing management practices or research-based information to inform local management.

## 2. Materials and methods

A team of natural resource managers, scientists, and extension professionals developed a 18-question survey (Supplementary S1) designed to assess the research and logistical considerations for using livestock grazing as a land management technique in US Gulf State coastal uplands (i.e., Texas, Louisiana, Mississippi, Alabama, and Florida). Survey respondents self-identified as natural resource managers, researchers, or livestock producers that either had experience or expertise in habitat or livestock management in pine savannas, lowlands, woodlands, prairies, or pasture. The survey consisted of both multiple choice and open-ended questions that focused on topical areas pre-determined by the project team, such as livestock species, environmental impacts or logistical concerns of livestock species, animal husbandry, research needs, and more (Supplementary S1).

The survey was distributed using a snowball approach (Creswell, 2014; Vogt & Johnson, 2016) and was created and distributed through several extension networks (Supplementary S1). Initial distribution of the survey was through the project team's networks within the US Gulf States, including both the Land and Sea Grant Extension networks, with instructions to complete the survey and/or distribute it. Additionally, in-person recruitment of survey participants occurred at the National Grazing Lands Conference in December 2021. Responses were collected for a total of four 4 months from October 2021 to January 2022.

Survey respondents were first asked if they identified as a natural resource manager, researcher, or livestock producer. Using their responses to that question, subsequent responses were grouped into those categories for a summarization of results. Within those groups, the percentage of respondents that selected each answer was determined. For multiple choice questions, this process was straightforward. However, responses to open-ended questions were coded into categorical responses to allow for responses to be grouped and percentage of responses in each group to be determined. For example, where a livestock producer may express concern for the restoration of the beneficial "blue-stem grass" and another may specifically list a similar native species of concern, those responses would be coded as "native vegetation".

## 3. Results

There were a total of 54 survey participants that represented ten states. Of those responses, 46 were from US Gulf of Mexico states (Texas, Louisiana, Mississippi, Alabama, and Florida) and one from the adjacent state of Georgia. Results from these collective 47 responses were included in the remaining analyses; the 7 that were not included were due to the participants not being in the desired region. Of those respondents, 30% identified themselves as researchers, 53% as natural resource managers, and 17% as livestock producers and/or hobby producers.

Survey participants were asked to select which type of coastal upland habitat they manage (Supplementary S1). For the purposes of this survey, coastal upland habitats were classified as pine savanna, prairie, lowland, woodland, and pasture. Pine savanna habitat accounted for a third of all responses, which was largely driven by the response of natural resource managers, followed by prairies, woodlands, lowlands, and pastures. A small portion of responses (6%) indicated they work within all of these ecosystems.

When asked if they were aware of any conservation grazing occurring along coastal portions of the US Gulf States (i.e., within 100 miles of the coast), 34% of respondents indicated "yes." There were differences among groups with 25% of livestock producers, 36% of natural resource managers, and 35% of researchers indicating they were aware of coastal conservation grazing efforts. However, when asked if they were aware of any guidebooks or research studies that could inform conservation grazing in this area, 91% of all respondents selected "no." A further breakdown of those responses by category showed that none of the livestock producers, 8% of the natural resource managers, and 13% of natural resource managers were aware of locally relevant guidebooks or research. However, 86% of livestock producers, 95% of natural resource managers, and 91% of researchers indicated they would be interested in using conservation grazing as a habitat management strategy (92% overall across groups).

Types of livestock were subjectively ranked by survey participants for their impacts on the ecosystem and on their ease of management (e.g., containment). Each participant was given the opportunity to rank each livestock type as 'most beneficial', 'somewhat beneficial', 'least beneficial', or 'no impact/negative impact' for their influence on overall ecosystem health. Regarding perceived ecosystem health impacts of different livestock, cattle (including Pineywoods) were rated at least 'somewhat beneficial' by 63% of researchers, 75% of livestock producers, and 78% of natural resource managers (Fig. 1). Nearly half of researchers and livestock producers rated cattle as 'most beneficial', whereas the most common response from natural resource managers was 'somewhat beneficial' (Fig. 1). Goats were highly ranked for ecosystem benefit by livestock producers with 63% selecting 'most beneficial' (Fig. 1). Only 28% of researchers and 15% of natural resource managers selected goats as 'most beneficial'. However, 'somewhat beneficial' was selected for goats by 50% of researchers and 48% of natural resource managers, respectively (Fig. 1). Thirty-eight percent (38%) of livestock producers selected sheep as 'most beneficial' for ecosystem health impacts with no responses in this category from either researchers or natural resource managers. Fifty-seven percent (57%) of researchers, 40% of natural resource managers, and 50% of livestock producers rated sheep as being 'somewhat beneficial' for ecosystem health impacts (Fig. 1). Perceptions of the ecosystem impacts of bison was more variable than other grazers. While 32% of natural resource managers rated bison as 'most beneficial', over 25% of researchers and livestock producers selected 'no impact/negative impact'.

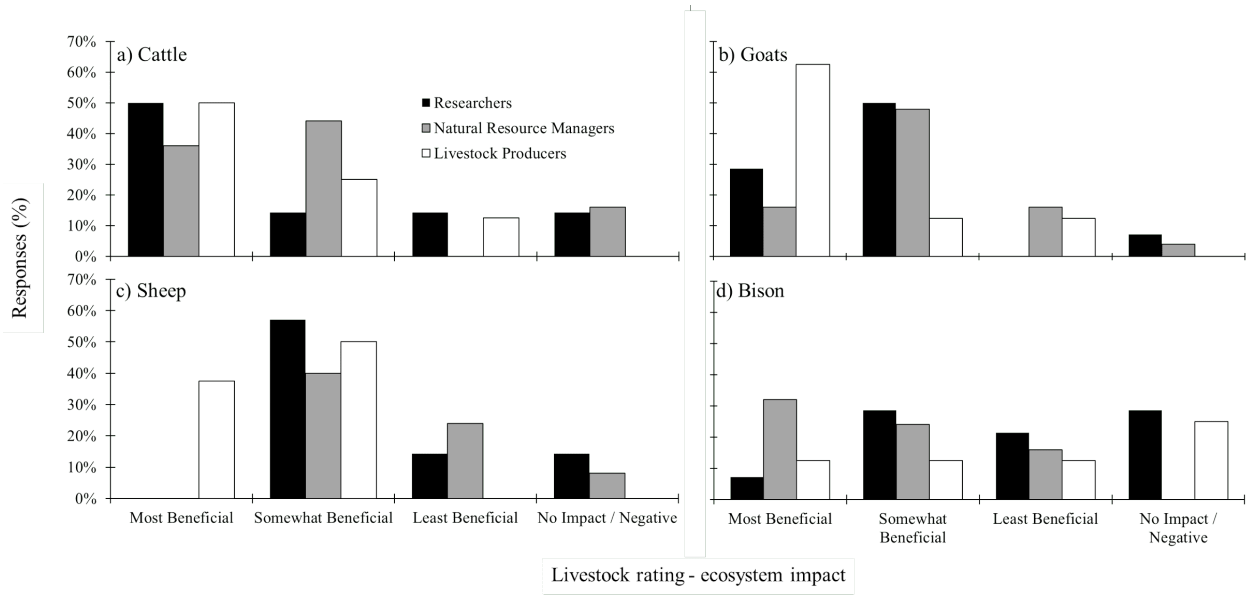


**Figure 1.** Responses of each user group (researchers, natural resource managers, and livestock producers) to the perceived ecological impacts of using a) cattle, b) goats, c) sheep, and d) bison for habitat management.

The next group of questions asked respondents to rank livestock on ease of containment and control based on the ability to keep livestock confined to specific areas and ease of rotating to different areas. The available rankings were as follows: 'easiest', 'fairly easy', 'somewhat difficult', or 'most difficult'. All survey groups (i.e., natural resource managers, livestock producers, and researchers) overwhelmingly indicated that cattle are the easiest grazer to contain and control and bison are the most difficult (Fig. 2). Conversely, the perception of ease of control and containment of sheep varied by survey group. Nearly 38% of natural resource manager survey respondents indicated sheep as 'somewhat difficult' or 'most difficult' to contain (Fig. 2). Livestock producers were largely in agreement on sheep with 37% each indicating 'fairly easy' or 'somewhat difficult' and none selecting 'easiest' or 'most difficult' (Fig. 2). Researchers viewed sheep and goats as relatively equal for difficulty in control and contain with 21% indicating both sheep and goats as 'somewhat difficult' and the majority (43% for goats and 47% for sheep) rating each as either 'easiest' or 'fairly easy' (Fig. 2). Nearly 50% of livestock producers indicated goats were 'somewhat difficult' or 'most difficult' to contain or control while 37% indicated either 'easiest' or 'fairly easy' (Fig. 2). Nearly 36% of natural resource managers indicated goats were either 'easiest' or 'fairly easy' to contain or control while 31% indicated they were 'somewhat difficult' or 'most difficult' (Fig. 2).

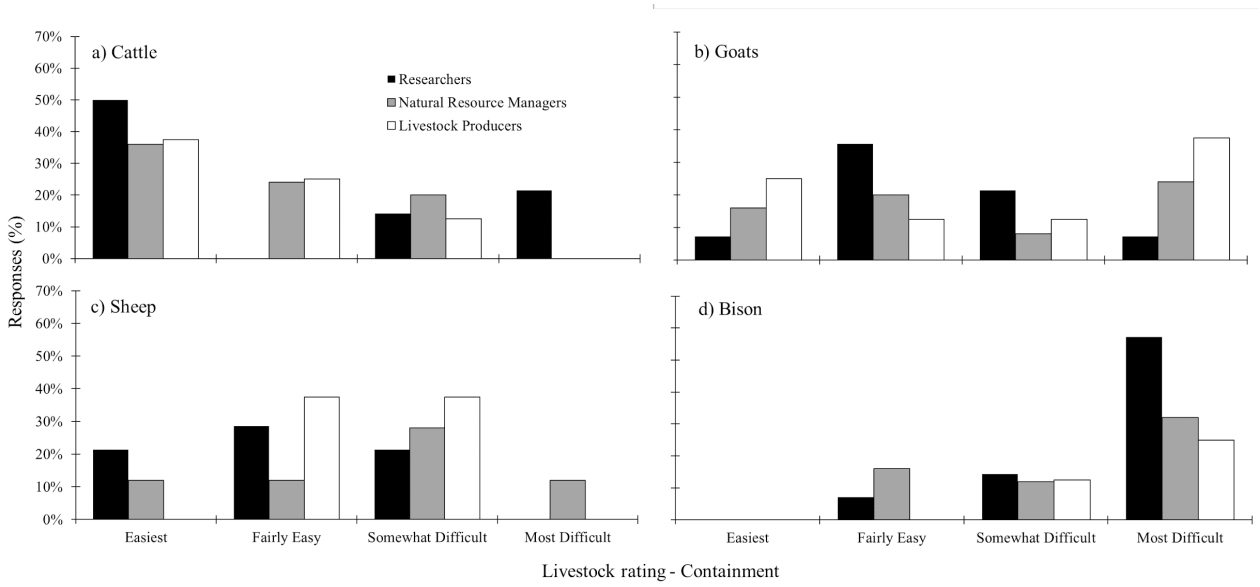


**Figure 2.** Responses of each user group (researchers, natural resource managers, and livestock producers) to the perceived difficulty of containment of a) cattle, b) goats, c) sheep, and d) bison for habitat management purposes.

When asked if conservation grazing was viewed as a complementary or standalone management strategy, at least 75% of each of the response groups (e.g., natural resource managers, researchers, or livestock producers) indicated that complementary management methods should be used. Only 7% of researchers, 8% of natural resource managers, and 23% of livestock producers selected grazing as a standalone management strategy. Open-ended responses were recorded for suggested complementary management methods. Participants responded with various combinations of 'fire', 'chemical (herbicide)', 'mechanical clearing', and 'habitat determined' prescriptions (Fig. 3a). Rotations, timing, number of applications, and other specifics of conjunctive management methods were not recorded in this survey.

Survey participants were then asked about considerations for livestock containment, grazer health, and ecosystem health related to livestock grazing. For livestock logistical considerations, primary concerns by livestock producers were livestock' 'access to water sources' (42%) while researchers were most concerned with 'fencing type' (23%) and the 'environmental impact of fencing' (14%). Natural resource managers were concerned about 'fencing types' (23%) but with the remaining responses (77%) distributed somewhat evenly across other categories (Fig. 3b).

For livestock health considerations, 'nutrition' was overwhelmingly ranked highest by researchers (21%), natural resource managers (24%), and livestock producers (38%) with 'parasite and disease control' as the second highest rated concern among researchers and livestock producers. While not top categories, controlling 'predation' of livestock and exposure to 'toxic vegetation' were also popular concerns discussed among natural resource managers (Fig. 3c).

For ecosystem health considerations**,** concerns were evenly distributed among vegetation, wildlife, watershed, and soil impacts. Both researchers (18%) and livestock producers (18%) rated vegetation impacts as the largest concern with livestock producers rating wildlife impacts similarly (18%). Natural resource managers rated soil impacts (16%) as their highest concern,

immediately followed by vegetation (7%), nutrient cycling (7%), and paired management strategies (e.g., pairing grazing with rotational burning, mechanical clearing, etc.; 7%; Fig. 3d).

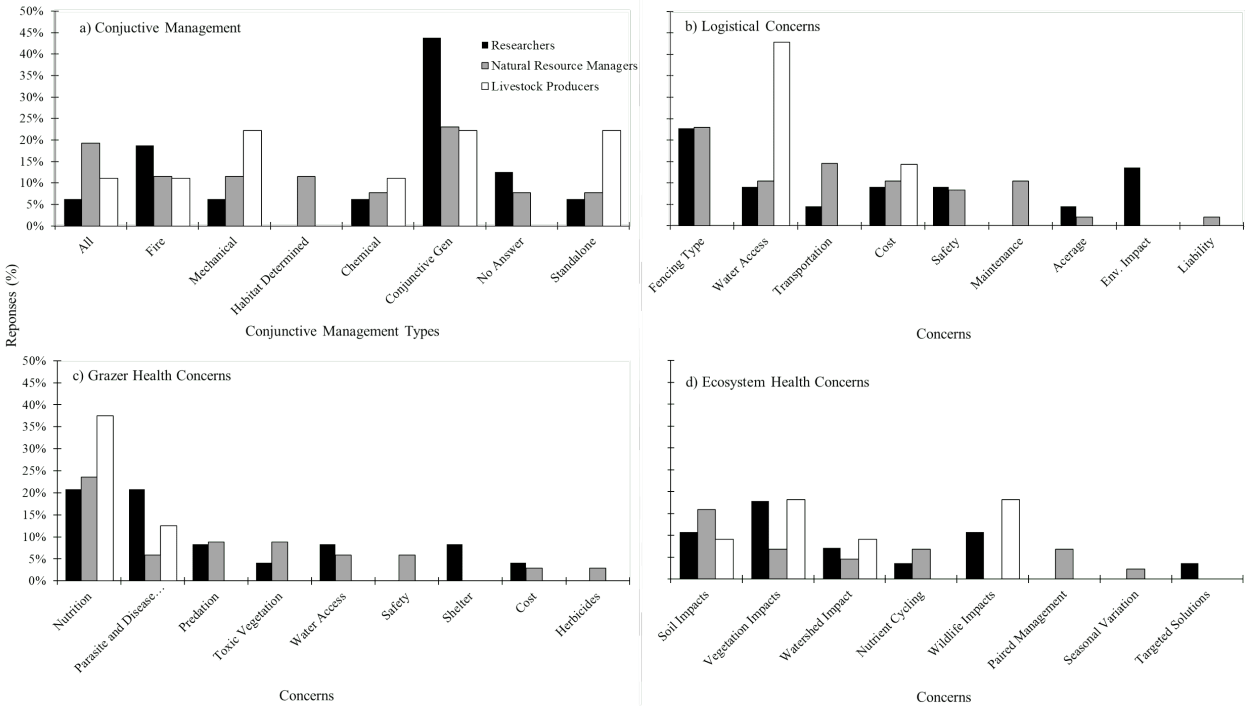


**Figure 3.** Responses of each user group (researchers, natural resource managers, and livestock producers) for a) conjunctive management or standalone, b) logistical concerns, c) grazer health concerns, and d) ecosystem health concerns of using livestock grazing for habitat management purposes.

When asked to identify the most pressing research needs related to using livestock for coastal upland habitat management (open ended responses), survey participants responded with a wider range of responses than to the other questions (Fig. 4). Coding of responses was difficult due to open ended questions, but responses, for example, focused on livestock management and logistics were coded as ‘implementation’, targeted plant species and overgrazing were coded as ‘vegetation impacts’, livestock access to water and supplemental feeding were coded as ‘livestock nutrition’. Once coded, pooled responses across all respondent groups showed that ‘environmental impact’ had the highest percentage of responses (21%) followed by vegetation impacts (16%), implementation (14%), nutrient cycling (14%), livestock choice (14%), biodiversity (13%), and livestock nutrition (10%; Fig. 4). Within user categories, ‘vegetation impact’ was highest ranked for researchers (16%), ‘implementation’ for natural resource managers (14%), and overall ‘environmental impact’ for livestock producers (22%; Fig. 4).

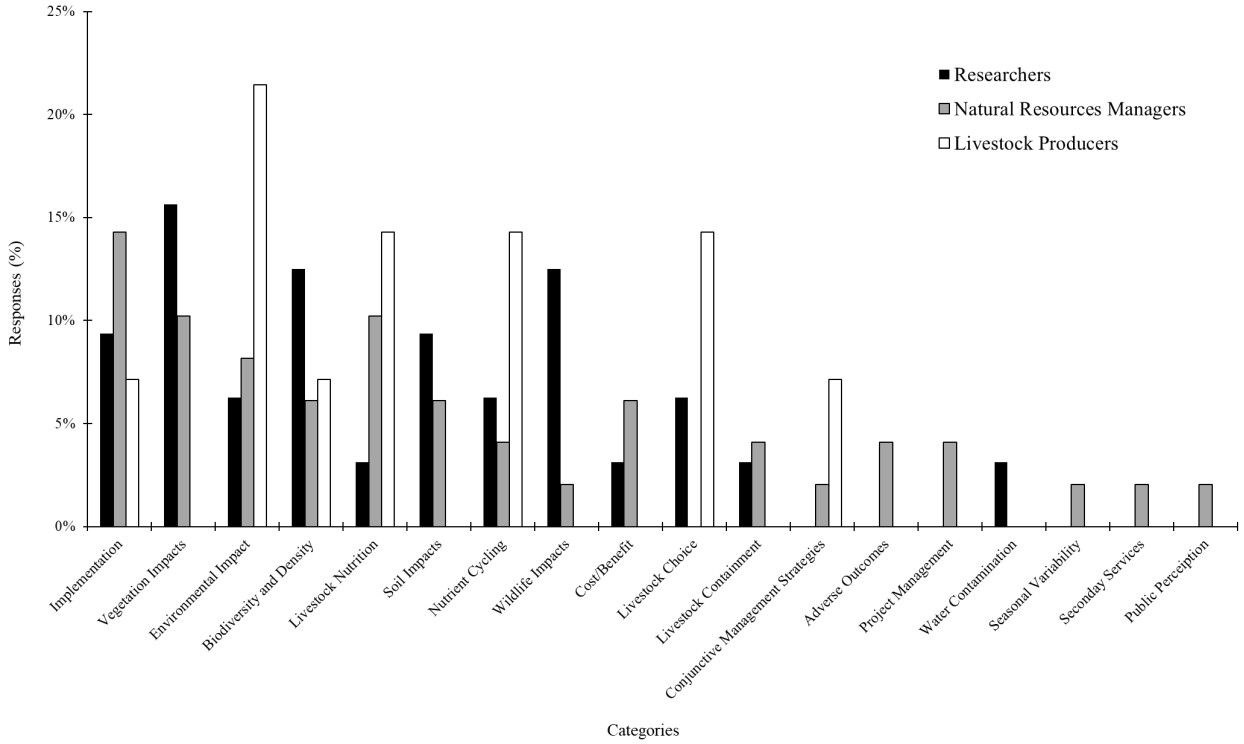


**Figure 4.** Responses of each user group (researchers, natural resource managers, and livestock producers) for research needs related to using livestock grazing for habitat management purposes.

## 4. Discussion

This study is the first to our knowledge to assess the logistical (e.g., containment, movement, and grazing intensity) and environmental concerns, perceived ecosystem health benefits, and research needs for using livestock grazing as a land management technique in the northern Gulf of Mexico. The results of this study show there is interest from surveyed natural resource managers, livestock producers, and researchers for incorporating livestock grazing into coastal upland habitat management in this region. However, there is limited research and research-based guidance documents specific to this region that provide information about grazing and environmental and logistical concerns within these ecosystems.

### 4.1. Local ecological knowledge

Throughout the survey, natural resource managers and researchers were less comfortable with using livestock for habitat management purposes than were livestock producers, likely due to the lack of research that justifies use of these practices on public property as well as producer familiarity with livestock use. Our results highlight the need for more studies focused on gathering the local ecological knowledge possessed by many private landowners and livestock producers to inform future research and case-studies (Biró et al., 2020; Raymond et al., 2010). Local ecological knowledge and traditional management practices can provide information on a myriad of grazing strategies that can possibly lead to environmental benefits. Gathering information from the case-studies and stories developed over many generations of practice by

private landowners and livestock producers can provide the basis for further investigation of applied techniques to create sound habitat management strategies (Molnár et al., 2020).

Another aspect of this study was that livestock producers were much more confident in the abilities and low environmental impact of livestock, especially cattle and goats, than other respondent groups were likely due to history of use. Livestock producers only began to question ecological impact at the level of nutrient cycling, while researchers expressed concern for lack of study on all aspects of environmental health. Natural resource managers were most interested in the types of paired management strategies and how implementing livestock would change the way and on what timeline, other previously implemented habitat management techniques would be employed. These findings are likely a result of local ecological knowledge within the livestock producer and private landowner communities that have refined their habitat management strategies based on trial and error over many generations, whereas the natural resource manager and research community are less comfortable due to the lack of peer-reviewed research. Evidence of prescribed burning dates to early Native American tribes and the first European settlers as a way of moving herds of game animals. However, prescribed burning as an organized land management technique that is relatively new and wasn't introduced to managed lands until the late 1940s and early 1950s (Waldrop et al., 1987). In 1946, one of the first experiments on long-term effects of repeated burning in southern pine ecosystems was conducted by the Southeastern Forest Experiment Station. The study showed that annually burned forests were more accessible to wildlife, more protected from wildfires, and had increased soil fertility compared to unburned forests. However, annual burns increased the risk of growth deceleration in young pine stands (Waldrop et al., 1987). The known benefits of prescribed fires and the associated difficulties are likely one of the reasons why survey respondents overwhelmingly suggested livestock grazing as a complementary habitat management strategy to existing activities. Nuanced studies on the livestock grazing preferences for different life stages of local plants (e.g., Fitzgerald et al., 1986; Jones et al., 2011) could also be informed by local ecological knowledge to aid in the design and scope of future studies of livestock grazing within coastal uplands along the US Gulf of Mexico.

### 4.2. Habitat management with cattle and small ruminants

In other areas of the world, research has been conducted with varied livestock in pine dominated savannas as well as grasslands. A study on substituting cattle for annual prescribed burns in pine savannas in La Sepultura Biosphere Reserve in Chiapas, Mexico showed that high stocking rates of cattle did trample a moderate number of planted pine seedlings and suggested that low stocking rates or temporary livestock exclusion be employed (Braasch et al., 2017). Additionally, occasional burns were still applied to help maintain seedling establishment of pines, and pine tree recruitment was significantly higher in grazed sites than in the burned-only and grazed-only sites (Braasch et al., 2017). Several comments related to the use of Pineywoods cattle for land management were observed in the survey results. They are adept at clearing undergrowth in pine savanna and similar habitats, heat tolerant, resistant to parasites and diseases, and able to be productive on marginal forage (Pitts and Sponenberg 2010). Many local invasive plant species are consumed by Pineywoods cattle that would not be consumed by other more particular breeds, such as Chinese Privet (*Ligustrum sinense*), Cogongrass (*Imperata cylindrica*), and Chinese Tallow (*Triadica sebifera*). The other livestock type identified by survey respondents as highly desirable for land management of coastal uplands in the southeast US were goats. As with Pineywoods cattle, goats specialize in consuming woody vegetation

commonly found in overgrown or unmanaged understory along the northern Gulf of Mexico coasts. Goats are popular for conservation grazing implementation due to their small size, ease of transport and containment, and their ability to survive in various types of terrain (Hagan, 2015). Additionally, goats consume a wide range of plants, including several common invasive species along the US Gulf Coast including Kudzu (*Pueraria montana*), Japanese Honeysuckle (*Lonicera japonica*), Multiflora rose (*Rosa multiflora*), English ivy (*Hedera helix*), and Chinese privet (*Ligustrum sinense*) among others (Hagan, 2015), many of which are considered wildfire fuels. Studies have also been done with goats as a method of kudzu control in pine systems in Tuskeegee, Alabama. Goats were successful at thinning wildfire fuels such as woody underbrush but were also observed browsing on young pine seedlings which could have negative effects on young stands (Bonsi et al., 1992). Goats are also known to tolerate higher levels of tannins and toxicity than cattle and are less likely to bloat as a result of ingesting toxic plant matter (Hart, 2001). In another study by Tuskeegee University on stocking rates of goats in pine stands, goats were found to change composition of pine stands by increasing grass species and decreasing forbes (Kumi et al., 2015).

Sheep are another less-commonly used grazer for habitat management purposes. However, studies show they can effectively maintain habitats of interest. For example, sheep were found to be successful at facilitating conifer seedling development through understory maintenance in Tahoe National Forest (Thomas, 1984). Additionally, it was observed that mature sheep (4+ years of age) had a preference of grazing underbrush while avoiding seedling conifers while younger sheep were more generalistic and consumed some seed stands (Thomas, 1984). In other areas, sheep have also been observed to graze seedlings of pine (*Pinus* spp.), Douglas Fir (*Pseudotsuga menziesii*) and Spruce (*Pinaceae*) in order of decreasing susceptibility when sufficient woody underbrush is not readily available, but it was not a forage preference (Ellen, 1990). In areas where the primary plant species of concern for conservation benefit could be susceptible to livestock grazing, temporary protective fences or cages have been used until the target vegetation is above reach of livestock grazers (Li and Jiang, 2021; Öllerer et al., 2019).

### 4.3. Research needs and logistical concerns

Given the preference for using cattle and goats by survey respondents and lack of research information that could guide their decisions, local or regional studies focused on the individual and paired impacts of livestock on ecosystem management should be conducted. From survey responses, researchers were generally most concerned with overall environmental impacts, whereas natural resource managers were more concerned with the process of livestock implementation, and livestock producers with identifying livestock species for best management practices as well as supplemental livestock nutrition. Logistical concerns and research needs associated with using livestock for land management were also a recurring theme from survey respondents. Logistical concerns included informational needs such as transport, livestock stocking density, grazing duration, rotational grazing frequency, and combination with other land management activities. Interestingly, most logistical concerns expressed by survey respondents were more generic and not coastal focused. We expected to receive more specific responses to coastal livestock grazing logistical concerns, such as how to graze around large predators (e.g., alligators), in and around coastal wetlands, and tropical systems (e.g., hurricanes). The lack of these coastal-specific concerns is likely an indicator of the limited state of knowledge and research related to using livestock for habitat benefits in the GoM area. Survey respondents, including natural resource managers and researchers, expressed a need to better understand basic

research questions related to these logistical concerns, such as identifying overgrazing metrics per habitat type, what species should be used, rotational frequency, paddock size, and fencing type. Rotational frequency and paddock size tend to vary by livestock type (Kott et al., 2006), but generally focus on intense short duration grazing events in relatively small paddock sizes (Holechek, 1983) for habitat management purposes. For example, goats used to clear Kudzu (*Pueraria montana*) and sheep used to control grasses (McEvoy and McAdam, 2008) are often stocked at high densities and grazed for short periods of time before being rotated to another area. However, no research could be found that could be used to directly inform these logistical and research concerns for the use of livestock grazing for habitat management in coastal uplands of the GoM. Another area of concern and opportunity for grazing identified by survey respondents is its effect on invasive plant species. In other areas of the world, livestock have been successfully used to remove, reduce, or suppress invasive plants (Diamond et al, 2012; Porensky et al., 2018; Rhodes et al., 2021), reduce fire hazards (Davidson, 1996; Manday and West, 1983; Taylor, 2006; Nader et al., 2007), and maintain managed areas (Bates et al., 2009; Li and Jiang, 2021; McEvoy and McAdam, 2008; Öllerer et al., 2019; Porensky et al., 2018; Sharrow et al., 1992; Tasker and Bradstock, 2006), among other benefits. Some concerns expressed by survey respondents were focused on the potential transport and spread of local invasive plant species, such as cogon grass, Chinese tallow, Japanese climbing fern, etc., by livestock through external attachment of seeds (epizoochory) or through the digestive tract (endozoochory). In a study by Chuong et al. (2016) of cattle as dispersal vectors in California grasslands, both invasive and native grasses and forbes were seen to be transferred by cattle by both epizoochory and endozoochory. It was observed that grasses were mainly dispersed on the cow's exterior and forbes in fecal matter. Levels of transport varied by plant species and changed as the study continued. Additionally, invasives were far more likely to be dispersed on the exterior rather than in fecal matter (Chuong et al., 2016). However, due to the high diversity of transported species, cattle were essential to native plant dispersal in California rangelands (Chuong et al., 2016). Due to lack of research in the GoM region, there is little data to determine which species of invasive local grasses or forbes would or would not be passed by livestock. Goats, however, have been shown to significantly reduce the viability of ingested seeds, but not eliminate it in all plants (Harrington et al., 2011). Therefore, the potential for goats and cattle to spread invasive species exists and should be explored for invasive plants specific to the region, such as Chinese tallow (*Triadica sebifera*), Chinese privet (*Ligustrum sinense*), Brazilian pepper (*Schinus terebinthifolius*), and Guinea grass (*Megathyrsus maximus*).

Cost-effectiveness of using livestock grazing for habitat management purposes in US Gulf of Mexico coastal uplands was also identified as a research need by survey respondents. An example of the potential cost-effectiveness of using the techniques in other areas of the world is the construction of a habitat management plan to suppress woody underbrush in Tahoe National Forest prior to a wildfire (Greiman, 1988). In this area, livestock was projected to be the most cost- effective habitat management technique. Estimates of aerial herbicide were approximately $70 per acre, mechanical removal was $100-$200 per acre, and hand removal upwards of thousands of dollars per acre (Greiman, 1988). The grazing model the US Forest Service used in this area was to lease out portions of property for grazing to livestock producers, which led to a generation of $0.30 to $0.40 per acre per year of grazed area; thereby being a net profit instead of sink for the natural resource manager (Greiman, 1988). There are several other examples of land leasing throughout the United States where natural resource management entities charge livestock producers for grazing their lands such as the leases or permits given by the US Bureau

of Land Management or Forest Service. This model provides funds for the natural resource manager and also provides a means for livestock producers to operate without owning large expanses of land. These practices are more common in rangeland areas where livestock are present in large paddocks throughout a large portion of the year. However, there are other situations where livestock producers charged private landowners and natural resource managers for their grazing services (Frost et al., 2012). These practices usually involve high-density and rotational frequency grazing that is more labor intensive due to constant moving of fences and livestock (Frost et al., 2012). These types of practices are likely more analogous to what would be feasible at the beginning of livestock grazing implementation along the US Gulf of Mexico coastal uplands.

Small paddock sizes, temporary fencing, and short duration grazing events have been shown to be most beneficial in pine ecosystems (Hart, 2001). Another potentially cost-effective method that should be explored to help address research needs related to logistical concerns is the use of no-fencing options such as invisible fences or rotation of livestock using desktop or mobile device applications via GPS enabled collars (Boyd et al., 2022). Temporary fencing options such as these are less intrusive to the surrounding environment as well as native wildlife (Jakes et al., 2018). It has also been shown that cattle and sheep respond well to both electrical fencing and invisible fencing, with invisible fencing being the most cost-effective solution (Marini et al., 2022).

### 4.4. Caveats

While the results of the survey are very informative, the sample size of respondents across groups was lower than anticipated. The survey was distributed broadly throughout the co-author'' networks through email distributions and at broader outreach events. All states along the GoM were represented by the study, however, there were far more respondents located in Texas (25%), Mississippi (34%), Alabama (19%), and Florida (17%). The state of Louisiana, while underrepresented in the survey, provided networking opportunities for the author team to conduct grazing field visits to visualize the results of long-term targeted grazing in coastal upland habitats. There is inherent bias and limitations in the distribution methods of the survey, but the process of distribution made it evident that there were very few people along the US Gulf of Mexico coast from the natural resource manager, livestock producer, and researcher communities that were aware of any use of livestock grazing for habitat management purposes on public or federal lands. Due to the success of using livestock grazing for habitat management in other regions of the world and on some stretches of private land, lack of research-based information to guide application of local livestock grazing practices for habitat management, and interest from the surveyed communities, this topic should be explored to potentially add another technique for natural resource managers to implement.

## 5. Conclusions

The results of similar targeted grazing case-studies as well as results of this survey infer that the use of livestock to manage coastal uplands should be explored. Overall, all surveyed groups were interested in incorporating livestock grazing into their habitat management plans as a complementary technique to their existing activities. However, very few respondents (including researchers) were aware of any research-based information that could be used to

inform the use of livestock grazing for habitat management purposes in coastal uplands. Most respondents selected cattle and goats as the ideal livestock to use for their habitat management purposes due to perceived environmental benefit and ease of containment. Major informational needs were related to the lack of basic research information, such as which livestock species to use, how often to graze, and how to complement existing habitat management activities. These results highlight that fundamental research-based information is needed to inform livestock grazing for habitat management purposes in the unique and diverse coastal uplands along the Gulf of Mexico. While surveyed livestock producers were generally comfortable with using livestock for habitat management purposes, natural resource managers and researchers were less comfortable due to the lack of research that would justify these practices. Addressing basic research needs related to livestock grazing for habitat management in this area could alleviate some discrepancies between current comfort levels with livestock grazing across stakeholders and potentially provide an additional habitat management tool for natural resource managers in the GoM coastal uplands.

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## 7. Credit author statement

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**Supplementary material**

S1. Survey instrument

Thank you for considering participation in this survey. This survey was developed by a team from Mississippi State University and the Grand Bay, Weeks Bay, Mission-Aransas, and Apalachicola National Estuarine Research Reserves. The purpose of this survey is to identify research needs and logistical considerations for incorporating conservation grazing into land management programs throughout the U.S. Gulf Coast.

Risks or Discomforts
No risks or discomfort are expected from taking part in this survey. If you feel uncomfortable with a question, you may skip the question or withdraw from the study altogether.

Confidentiality
Your responses will be kept completely confidential. Your IP address for an online survey will NOT be known. Only the researchers will see your individual survey responses.

Decision to Quit
Participation is completely voluntary. Feel free to withdraw your participation from the study at any time. If you do not want to continue, you can simply leave the website. If you do not click on the "Submit" button at the end of the survey, your answers and participation will not be recorded. If you decide to quit before you have finished, your answers will NOT be recorded.

Acknowledgement
By beginning the survey, you acknowledge that you have read this information and agree to participate in this study. You acknowledge that you are free to withdraw your participation at any time without penalty.

Background
Natural resource managers currently use combinations of prescribed fire (burning underbrush), chemical treatments (spraying herbicides), and mechanical removal (cutting trees and thick underbrush, mulching, etc.) to clear underbrush, remove invasive species, and increase habitat value of natural areas. Each technique mentioned above is associated with different levels of costs, damage to the land, risk, planning, and limitations. Conservation grazing, or the use of livestock (e.g., goats, cattle, other herbivores) for natural habitat management, presents a potentially cost-effective technique to manage coastal upland habitats and has been used extensively in other areas of the world. As management of natural areas becomes more difficult over time, there is a need to consider all methods, including conservation grazing. Please visit our website (https://coastal.msstate.edu/grazing) to learn more about conservation grazing and this project.

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* Required

Instructions

The questions below may be tailored toward livestock producer, natural resource manager, or researcher communities. Don't feel like you need to answer all of the questions. If you determine you don't have an informative response to a question, feel free to skip it. Be sure to hit "submit" at the end of the survey to record your answers. If you do not hit submit, your answers will not be recorded.

The survey includes 18 questions and should take an estimated 30 minutes to complete.

1. Which state(s) do you work in the most (select all that apply)? *

*Check all that apply.*

- [ ] Texas
- [ ] Louisiana
- [ ] Mississippi
- [ ] Alabama
- [ ] Florida
- [ ] Other: _____

2. Which counties are the main focus of your work area?

_____

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3. Select which group you most associate yourself with. *

*Mark only one oval.*

- ◯ Livestock Producer (including hobby producers)
- ◯ Natural Resources Manager
- ◯ Researcher

4. If you selected "Livestock producer" in the question above, please indicate which types of livestock you work with (select all that apply).

*Check all that apply.*

- ☐ Cattle (Including Pineywoods)
- ☐ Goats
- ☐ Sheep
- ☐ Bison
- ☐ Other: _____

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5. What are the primary types of habitat that are the focus of habitat management efforts in your area?

*Mark only one oval.*

- ◯ Woodland
- ◯ Pine Savannah
- ◯ Lowland
- ◯ Prairie
- ◯ Other: _____

6. What are the primary types of plants that are the focus of habitat management efforts in your area?

*Mark only one oval.*

- ◯ Herbaceous
- ◯ Woody
- ◯ Cover Crop
- ◯ Other: _____

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7. From the definition of conservation grazing at the bottom of the previous page, are you aware of any conservation grazing occurring along the coastal portions of US Gulf States (i.e., within 100 miles of the coast)?

8. From an ecosystem health perspective, please rank grazers from most to least beneficial for conservation grazing in your area?

*Mark only one oval per row.*

| | Most Beneficial | Somewhat Beneficial | Least Benefical | No Impact or negative impact |
|---|---|---|---|---|
| **Cattle (Including Pineywoods)** | ◯ | ◯ | ◯ | ◯ |
| **Goats** | ◯ | ◯ | ◯ | ◯ |
| **Sheep** | ◯ | ◯ | ◯ | ◯ |
| **Bison** | ◯ | ◯ | ◯ | ◯ |

9. Please briefly describe your rationale for the rankings in the question above.

10. From a livestock control and/or containment perspective, please rank from most to least difficult grazer to use for conservation grazing in your area.

*Mark only one oval per row.*

| | Most Difficult | Somewhat Difficult | Fairly Easy | Easiest |
|---|---|---|---|---|
| **Cattle (including Pineywoods)** | ◯ | ◯ | ◯ | ◯ |
| **Goats** | ◯ | ◯ | ◯ | ◯ |
| **Sheep** | ◯ | ◯ | ◯ | ◯ |
| **Bison** | ◯ | ◯ | ◯ | ◯ |

11. Please briefly describe your rationale for the rankings in the question above.

12. Are you familiar with any guide books or research studies related to conservation grazing in the coastal portions of the US Gulf Coast states? If yes, please paste links in the answer box below or upload directly to this folder - https://drive.google.com/drive/folders/1Zyr_k20vGnLOI1S0e_IDFxZ67B3qXxOk?usp=sharing

13. Would you be interested in using conservation grazing as a habitat management strategy? If yes, please describe how you think it should be used.

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14. Do you view conservation grazing as a standalone habitat management practice in your area or is it used in conjunction with other habitat management practices (e.g., prescribed fire, mechanical clearing, chemical treatments, etc.)? Please explain your answer.

15. What do you think are the most pressing research needs related to conservation grazing? Please list and describe as many as possible.

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16. From a grazer containment perspective, what are the primary considerations for implementing conservation grazing? Please list and describe as many as possible.

17. From a grazer health perspective, what are the primary considerations for implementing conservation grazing? Please list and describe as many as possible.

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18. From an ecosystem health or benefit perspective, what are the primary considerations for implementing conservation grazing? Please list and describe as many as possible.

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