Opportunities and Challenges with Grazing Public Grassland in Wisconsin: The Producer Perspective

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Chapter One: Introduction

This thesis is one part of a multidisciplinary agroecological research project on grazing public land in Wisconsin. The overall project goal is to understand the ecological and socio-economic opportunities and challenges with grazing as a land management tool on public land. The goal of my research was to understand the producer perspective on rotationally grazing public land – their concerns with and interest in such a program. My findings complement other graduate student research that is focused on ecological impacts of managed grazing on public grasslands and public land manager interests and concerns. Ultimately, the success of a managed grazing program on public grassland in Wisconsin will stem from the bridging of producer and public land manager needs. My research provides crucial information on producer tradeoffs, influences, and overall interest in such a public grazing program.

This thesis is divided into four chapters. The second chapter presents the results from a statewide contingent valuation survey of cattle producers. We find that producers respond differently to grass-dominated and shrub-dominated public grassland scenarios. Producers who are younger, have more animal units, and/or a less diverse operation are more likely to be willing to rent grass-dominated public land. Producers who have more positive attitudes toward conservation and/or a lower proportion of pasture to total farm acres are more likely to be willing to rent shrub-dominated public land. The chapter details the magnitude of these influencers and the implications for a public agency like the WDNR. The paper also highlights the importance of controlling for sample selection bias in survey research.

The third chapter was co-written with Greta Landis, another graduate student on the UW-Madison grazing project. The chapter describes how the UW-Madison research team and other stakeholders implement adaptive co-management (ACM) to investigate the opportunities and challenges of using rotational grazing as a management tool on Wisconsin public grasslands. The chapter outlines how the UW-Madison grazing project follows three phases of ACM: 1) preparing the system for change, 2) seizing a window of opportunity, and 3) building social-ecological resilience of the new desired state (Olsson et al. 2004, Butler et al. 2015), and provides data and analysis of Phases One and Two. Four key takeaways for grazing public lands in Wisconsin resulted from Phases One and Two and are described in detail toward the end of the chapter. We close the chapter with suggestions for implementing Phase Three of ACM for rotational grazing on public grassland in Wisconsin.

I contributed to Chapter Three in three main ways: a literature review of adaptive co-management, a synthesis of Phase One activities and results, and takeaways from the ACM process thus far. This chapter allowed me to present additional results from my producer survey beyond the contingent valuation model, as well as the results of a producer focus group. Greta's contributions to the chapter included a description of the Wisconsin case study, a synthesis of Phase Two activities and results, the use of ACM core concepts throughout phases One and Two, and a discussion of next steps for Phase Three. However, we both contributed data, writing, and editing throughout the entire chapter.

Chapters Two and Three complement one another. Chapter Two provides a quantitative foundation for producer interest in a managed grazing program on public land in Wisconsin, while the Chapter Three provides qualitative context to support Chapter Two. Additionally, Chapter Three provides a broader perspective of diverse stakeholder interests and needs regarding such a grazing program. Chapter Two is tailored toward an economic audience and contributes a rigorous approach to contingent valuation - *ex ante* analysis of producer willingness to rent public lands for grazing. Chapter Three is tailored toward resource management practitioners and is intended to provide a sort of “how-to” for individuals interested in ACM as a management practice, implementing grazing as a land management tool, or both. Overall, my thesis provides a balanced and representative understanding of producer perspectives on a public managed grazing program. The findings are meant as a useful informational platform for a successful grazing program and should be used by land managers and grazing brokers as such.

The thesis closes with a fourth chapter that summarizes my overall findings. The chapter also provides suggestions for future research regarding grazing public land in Wisconsin and the producer perspective.

Chapter Two: Willingness to Pay to Rent Public Grassland for Rotational Grazing in Wisconsin

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Abstract

The successful development of a rotational grazing program on public grassland in Wisconsin will depend in part on the willingness of beef producers to rent public land. This paper uses contingent valuation survey data and a two-stage Heckman selection model to understand predictors of producers' potential willingness to accept a public grazing contract. We find that younger producers with more animal units and/or less cattle diversity are more likely to agree to rent grass-dominated public land for rotational grazing. Producers with a more positive attitude toward conservation and government and/or with a smaller proportion of pasture to total farmland owned are more likely to agree to rent shrub-dominated public land for rotational grazing. We also find a stark contrast in magnitude and significance of explanatory variables after controlling for non-respondent bias to the survey. Future research should concentrate on "hot spots" or mapping the overlap between producers likely to be interested in a public grazing program and the locations of viable public land.

Background

In the context of this paper, public grasslands refer to land owned by county, state, or national government, such as the Wisconsin Department of Natural Resources (WDNR) or the US Fish and Wildlife Service. These parcels are typically set aside for wildlife habitat and can consist of cool season grasses, warm season grasses, and shrubland. Management-intensive grazing (MIG), also called rotational grazing, refers to grazing where only one portion of pasture is grazed at a time, allowing the remaining pasture to rest and regrow. Pastures are divided up into small paddocks and livestock are rotated from one paddock to the next based on the growth stage of the forage (Undersander et al. 2002). Typically, paddocks are 1-2 ha and stocking densities are 40-100 head ha^{-1}. Under certain circumstances, smaller paddocks and/or higher stocking densities may be preferred; for example if mob grazing is being used (Paine et al. 1996). Often livestock are confined to each paddock for a period of <12 hours to 2 days and are rotated through paddocks on a 15-to-40-day, weather-dependent cycle (Undersander et al. 1991).

MIG is in contrast to continuous grazing where animals are not rotated through paddocks, and pasture is not allowed to rest. MIG generally leads to greater pasture productivity, up to two or three times higher than continuous grazing as a result of the rest period (Undersander et al. 2002). Rested paddocks allow forage plants to renew energy reserves, rebuild vigor, deepen their root system, and give long-term maximum production (Undersander et al. 2002). MIG can also provide ecosystem services for grasslands. As cows are rotated, pastures grow grass at varying heights, which in turn, provides diverse habitat for grassland birds and other creatures. Other ecological benefits include reduced species loss (Barry 2011; Fisher 2012; Bohnet et al. 2007), improved soil health (Bohnet et al. 2007; Clancy 2006; Hubbard et al. 2004; Merrill 2006; Paine and Cates 2013), increased water quality (Clancy 2006; Cox Ohde 2012; Paine & Cates 2013), and management of invasive and woody species (Harrington and Kathol 2009).

The primary purpose of a MIG program on public lands would be for grassland management, and would complement or potentially replace the need for other grassland management tools like burning, mowing, or spraying. According to the WDNR website, the primary goal of state wildlife areas management is to promote the health of grassland-dependent species. The secondary goal of WDNR grassland management is to provide low-impact recreation opportunities, such as hunting, wildlife watching, hiking, and other activities (WDNR website, December 9, 2016). WDNR personnel currently use several management tools to maintain the grassland landscape and minimize brush and tree encroachment, including planting of native grassland species, planting of cool season grasses and legumes, prescribed burning, mowing, and herbicide application (WDNR website, December 9, 2016). However, limited and shrinking conservation budgets at the WDNR have limited their capacity to apply management tools (E. Grossman and L. Kardash, personal communication, May 18, 2015). This concerns land managers because increasing rates of woody species encroachment interferes with conservation of the state's grassland heritage, threatening rare grassland species, upland game species that utilize grasslands, and other environmental outcomes of value to the public. The importance of grassland habitat to Wisconsin paired with public land manager management constraints points to a need for an innovative method, such as MIG.

Minnesota Department of Natural Resources (MDNR) implemented a grassland grazing program on public land starting in 2012 when new state legislation was passed requiring a conservation grazing program. In addition to the legislative mandate, the MDNR Commissioner has been pro-grazing and supportive of the program (K. Anderson, personal communication, November 10, 2016). While Minnesota's grazing program was built from top-down legislative requirements and Wisconsin's approach is more bottom-up, Wisconsin implementers can learn from Minnesota's experience thus far.

As of 2016 between 10,000 and 15,000 acres of MDNR wildlife management areas are managed with grazing in addition to burning and haying. Most producers have been found locally, through word-of-mouth. All grazing sites are required to have a conservation grazing plan written before livestock arrive. Thus far, a grazing specialist from the United States Department of Agriculture has written the grazing plans. This allows producers to know up-front what the conservation expectations are and can self-select as to their ability to manage for that plan. The MDNR purchased all perimeter fencing while producers are expected to provide temporary paddock fencing.

The MDNR grazing program seems to have been successful thus far. The weight gains of the grazed cattle have been good and often better than on the home pasture (C. Nelson, personal communication, February 5, 2015). While most land managers initially felt uncomfortable with grazing on their properties, four years into the program in 2016 most land managers have come on board. This is because those land mangers implementing managed grazing are seeing good results (G. Hoch, personal communication, November 10, 2016). Initially the MDNR fielded concerned phone calls from public land users. However, after seeing the results of the first few years of managed grazing and after multiple publications in hunting and conservation magazines explaining the benefit of managed grazing for wildlife habitat, the agency receives fewer complaints. Long term, the agency hopes to graze about 50,000 acres, especially in the western third of the state (C. Nelson, personal communication, February 5, 2015). However, there are few cattle in that area, so the agency is struggling to find livestock producers within a reasonable distance for managed grazing. Minnesota's experience underscores the possible success of a similar program in Wisconsin.

The primary audience for a public managed grazing program in Wisconsin would likely be beef producers – those farmers who raise at least some non-dairy cattle – as they have more flexibility with cattle management. Dairy cattle require milking multiple times per day and higher quality feed to maintain milk quality. Beef cattle have less stringent feed quality requirements and do not need to be milked. Additionally, many cattle producers, especially beginning farmers, find it challenging to acquire adequate land to start or grow their business (Merrill 2006). Access to land is one of the most cited challenges for cattle producers (Merrill 2006; Kloppenberg 2012). Also, according to USDA Census data, both Wisconsin total cropland and pastureland used exclusively for grazing declined between 2007 and 2012 (USDA Census Quick Stats 2012, 2007). Public grasslands would expand land access opportunities for local beef and (possibly) dairy producers, offering a potentially valuable source of forage. However, grazing management regimes for public grasslands are ill defined and questions surround the potential of grazing as a conservation tool on public lands of the North Central Region. In addition, challenges specific to public land rental for MIG such as grazing restrictions due to grassland bird nesting or hunting seasons, paired with historically less-than-positive relationships between private graziers and government agencies, may limit Wisconsin cattle producers' interest in such a market.

Growing efforts by Wisconsin's public land managers to initiate a conservation (MIG) grazing program, along with the lack of market precedent for public-land rentals, make it important to secure data on producer interest in a rental market for MIG of public land. Research into MIG as a land management tool in Wisconsin is sparse. However, a number of pilot studies are currently underway on public land in Wisconsin that will shed light on the impact of different grazing regimes on the grassland ecology (Landis 2016). With regard to graziers in Wisconsin, qualitative research has been done to understand grazing networks and knowledge transfer (Hassanein 1999), but there is no published research on producer interest in specifically grazing public land in Wisconsin, especially with regard to producer perceptions of associated challenges and opportunities.

Our contribution to this literature is to provide a robust *ex ante* assessment of producer demand for renting public grassland for MIG in Wisconsin. The research strategy involves two steps. First we gathered through a representative random sample, survey producer responses to a series of 'contingent valuation' questions related to their willingness to rent public lands. Second, we probed the factors shaping their responses using an econometric approach – known as a Heckman selection two-step probit on response and contract acceptance – that controls for response bias. This econometric strategy ensures that identification of the factors shaping their willingness to rent public lands is not biased by the differences between who chooses to respond or not to the survey. Controlling for this 'sample selection' proves to be critical to reporting unbiased results from the statistical analysis.

The policy objective of this study is to analyze producer willingness to rent grassland for MIG under grazing restrictions typical of public grassland. We expect this market to develop over the next 5-10 years due to current interest by the WDNR and success with a similar grazing program nearby in Minnesota; therefore, data on producer interest in the Wisconsin market is crucial for efficient market development. Using contingent valuation survey data from a sample of beef producers in Wisconsin, it provides a method of evaluation that broadens farm-level demand decision criteria beyond profitability to include indicators of operation size, amount of pastureland owned, age, proportion of farming income to total household income, current management practices (including MIG and whether they had ever rented land), attitude toward conservation and public land, and operation diversification in terms of types of cattle. The framework builds upon previous *ex ante* assessments of novel agricultural technologies and management practices, and extends the methodology to the case of MIG on public grassland in Wisconsin.

Links to previous CV research

Contingent valuation (CV) research strategies fall under the category of attitudinal or stated preference methods, where individuals reveal their willingness to pay or accept compensation by responding to hypothetical survey questions. Such methods are typically used to value non-market or pre-market goods directly, and are frequently used in environmental and natural resource economics. In their review of contingent valuation methodology, Kling et al. (2012) describe the objective of stated preference methods as measuring economic value for a change in a nonmarket good by predicting respondents' willingness to pay, or willingness to accept, for the change.

According to Mendelsohn and Olmstead (2009), a contingent valuation survey creates a hypothetical market for a good or amenity so that responses can be evaluated in a manner similar to behavior observed in actual markets. A typical contingent valuation (CV) survey includes (a) a description of the good/service/amenity to be valued; (b) the conditions under which the market change is being suggested; (c) a set of choice questions that ask the respondent to place a value on the good/service/amenity, and (d) a set of questions assessing the socioeconomic characteristics of the respondent that will help in determining what factors may shift that value (Mendelsohn and Olmstead 2009).

Questions are commonly asked in the closed-form, yes/no response option to one or more suggested prices; a judgment familiar to households from their daily purchases (Hausman 2012, Mendelsohn and Olmstead 2009). Contingent valuation questions can be phrased in two broad ways: the willingness-to-pay approach seeks to discern what the respondent would pay to avoid a negative outcome (or to achieve a positive outcome), while the willingness-to-accept approach seeks to discern how large a payment the respondent would need to receive in order to accept the negative outcome (or not to receive a positive outcome) (Hausman 2012).

According to Hausman (2012), three long-standing problems exist with regard to contingent valuation: 1) hypothetical response bias that leads contingent valuation to overstatements of value; 2) large differences between willingness to pay and willingness to accept; and 3) the embedding problem which encompasses scope problems (Hausman 2012). A full description of these problems can be found in the supplementary material section appended at the end of this chapter. Taking all into consideration, Hausman (2012) continues to feel that "no number" is still better than a contingent valuation estimate, whereas others think that a carefully constructed number is more useful than no number (Kling et al. 2012).

Unlike the majority of contingent valuation studies, this paper is not focused on pricing a non-market good (such as an ecosystem service). Instead, contingent valuation is used to understand potential market demand for a potential service (renting public grassland for MIG). One advantage here is that beef producers almost certainly have experience with land-use transactions, and are likely to be aware of rental prices for local private grassland. Because those in our sample already graze animals on private land, they have experience with the inputs required for managed grazing. These transactional and land management experiences will help producers make a meaningful decision on whether to rent public land or not across a range of prices. Additionally, beef producers are often land constrained (Kloppenburg 2012) and thus may have a stake in the availability of public land for rent. In line with Carson (2012) and Kling et al. (2012), this suggests that our sample will be more likely to put effort into responding accurately based both on knowledge, relevance, and ongoing commitment to the activities described in the questions.

Multiple authors have applied CV methods to *ex ante* evaluations of agricultural markets. In their review of the literature, Mooney et al. (2014) report that all of the studies they reviewed used dichotomous choice (DC) questions to elicit respondent preferences. What differs across the studies is the number of "bounds" and whether they are used to create supply or demand estimates. Hanneman et al. (1991) show that a double-bounded dichotomous-choice (DB-DC) framework increases statistical efficiency when estimating CV models. Mooney et al. (2014) provide a good example of utilizing a DB-DC framework in their study of an *ex ante* bioenergy feedstock supply. We follow Cooper (1997) and Mooney et al. (2014) in utilizing the DB-DC framework to capitalize on the efficiency gains cited by Hanneman et al. (1991). DB-DC is described in detail below.

Adoption Theory

There is a rich literature on agricultural technology adoption. Grazing public lands, as an *ex ante* market, can be treated similarly to a new agricultural technology. Ultimately, when a producer considers adopting a new technology, or rental contract, they must compare how the new technology will affect their welfare or in economic terms, utility. In order to do this, they must weigh their current level of satisfaction against the returns and the potential risk of the new technology (Anderson 1993).

Common explanatory variables in the adoption literature include farm size or scale of production, education, age, current management practices, attitudinal measures, management ability, and various income measures. This literature hypothesizes that farm size and operation scale will be positively related to adoption for two reasons (Brock and Barham 2008, Foltz and Lang 2005, Kim et al. 2008, Jensen et al. 2015, Gillespie et al. 2015). (1) Larger operations can spread the fixed costs of learning how the new technology or practice works over more acres, cows, or activities. (2) Larger operations are also likely more able to finance the costs or to manage it based on managerial capacities. If the technology has inherent factors favoring its use on larger farms, such as lower unit costs for larger purchases, then they can achieve economies of size in addition to scale. Not surprisingly, farm size can be measured in multiple ways including number of acres owned (including pasture), number of pasture acres owned (especially relevant for an *ex ante* managed grazing program), number of head of cattle, or number of animal units, to name a few relevant ones to cattle ranching.

Specific to grazing technologies, amount of pastureland owned and herd size might be the most indicative of operation size. However, using either of these measures alone, or treating them as independent, is potentially problematic, because combined as a ratio of herd per pasture acre, they create a stocking density measure which reflects how intensively current land holdings are being managed. That could be another indicator of the potential demand for land that is not necessarily related to scale.

Education is a common positive predictor of farm technology adoption (Foltz and Lang 2005; Walton et al. 2008; Feder et al. 1985; Wu and Babcock 1998). Higher levels of education may lead farmers to be better able to adopt complex, integrated management practices (such as MIG). Indeed, Foltz and Lang (2005) found MIG adopters to be more educated with an average of two years of college than non-adopters who had an average of one year of college. A college degree dummy variable or number of years of education are typical measures of this variable used in adoption models.

Farmer age is another commonly hypothesized explanatory variable for technology adoption. Although the relationship could be non-linear, with both younger and older farmers being less likely to adopt new technologies, empirical research typically finds age to be negatively associated with technology adoption (Daberkow and McBride 2003; Soule et al. 2000; Rahelizatovo and Gillespie 2004). This may be an effect of older farmers being less willing to face learning curves (Roberts et al. 2004), and younger farmers already being relatively experienced by the time they become principal operators. Specific to grazing technology, Foltz and Lang (2005) and Jayasinghe-Mudalige and Weersink (2004) found that adoption of MIG decreases with age. Gillespie et al (2015) found age to be negatively related to adoption of goat breeding technologies. Age may also be an indicator of management ability with age reflecting experience (Foltz and Lang 2005). Age is usually measured directly by the age of the principal operator.

Current management practices, such as extant farm inputs, production technologies, or cultural practices, are also frequently used to explain technology adoption (Krishna and Qaim 2007). In particular, operations that are already using farm inputs or practices conducive to technology adoption are likely to be positively related to adoption. Some of the up-front infrastructure costs may be lowered, the opportunity costs of learning the new technology may be reduced, or the technologies may be inter-linked (Kim et al. 2008; Lambert et al. 2014; Aldana et al. 2011). In the instance of renting public grazing lands, current MIG use might be viewed in this light; So might prior experience renting private grazing lands. Either of these 'practices' could contribute to a willingness to rent public lands.

Attitudes can also impact technology adoption, especially if the technology is somehow controversial or political. For example, in studying farmer attitudes toward new Bt (*Bacillus thuringiensis*) cotton varieties in Spain, Ceddia et al. (2008) found that an individual's threshold after which they are willing to adopt the technology is influenced by their attitude toward Bt varieties; Some farmers never adopt because they are strongly averse to the use of genetically modified crops. Barham (1996) reported similar results studying dairy farmers in Wisconsin and their willingness to adopt bST (Bovine somatotropin), a controversial agricultural biotechnology. When examining cattle producers' willingness to adopt or expand prescribed grazing in the United States, Jensen et al. (2015) utilized two attitudinal variables – perceptions about the role of farmers as land stewards and perceptions about the role of government in decision-making. Likewise, Kim et al. (2008) used attitudinal variables to assess the impact of farmer views on laws needed, environmental attitudes, and the role of government in helping farmers in their study of rotational grazing adoption in cattle production under a cost-share agreement with the government. We do something similar as described below.

Management ability is another common explanatory variable for farm technology adoption. Barham (1996) explains how farmers make decisions on technology adoption by matching their knowledge of the technology with their objectives, resources, and management abilities. Foltz and Lang (2005) use two proxies for management ability in their research on the adoption and impact of MIG grazing on Connecticut dairy farms: farm owner's age and years of formal education. In their case the two measures were weighted by percent ownership in the case of multiple owners. In their paper on rotational grazing adoption in cattle production under a cost-share agreement, Kim et al. (2008) found that managerial considerations significantly influenced adoption. They measured managerial ability with operation variables such as number of beef acres, a stocker operation binary variable, a measure of production diversity, and percent income coming from beef, all of which had positive effects on adoption.

Various income measures are often used to explain technology adoption, with adoption often being viewed as more likely among higher income producers. Income measures can be used to explain different things. For example, household income can be a proxy for the ability to invest in new technologies or practices (Walton et al. 2008). The percentage of household income coming directly from the farming enterprise can act as a measure of the financial importance of the enterprise, and hence the potential adoption of a new technology, to the household (Kim et al. 2008). Income diversification can also influence adoption decisions in terms of risk considerations. This measure could have a positive or negative influence on adoption depending on the situation. For example, a very diverse income portfolio could mean the additional enterprise can subsidize another and help mitigate some of the risk of technology adoption (Gillespie et al. 2015).

Alternatively, greater diversification could mean that there is reduced effort put into one enterprise leading to a decreased potential for technology adoption in the smaller enterprise (Gillespie et al. 2015). Below we mostly look at farm income reliance and use wealth variables, such as total land owned, to control for capacity to invest.

In addition to the common measures listed above, there are a series of other potential measures used to explain adoption, including: risk averseness or technology riskiness, expectations of the future of the farmstead, farm ownership structure, operation diversification, where farmers get their information, regional dummy variables, experience and household size. We only include a measure of diversification from this set for reasons we explain more fully below.

Study area and context

Wisconsin is an important state to study MIG on public grassland because of the strong rotational grazing community already present and the interest among public land managers in using grazing as a way to improve ecological and economic outcomes. An annual grazing conference in Wisconsin, GrassWorks, sees a few hundred attendees every year, and there are fifteen county-based grazing networks in the state (Grassworks website, www.grassworks.org/?110500, 2016). Wisconsin beef producers do everything from cow/calf raising to beef finishing, leading to diverse needs of producers across the state. Additionally, public land managers in Wisconsin are eager to move toward implementation of such a program as shown by multiple pilot programs already underway, and WDNR-led meetings and workshops to help land managers develop their own grazing partnerships. As discussed above, the MDNR recently began a rotational grazing program on public grasslands and has experienced successful outcomes for both the land managers and producers (G. Hoch, personal communication, November 10, 2016).

According to the U.S. Census of Agriculture (2012), Wisconsin agriculture is dominated by integrated crop-livestock farms both in number of operations and land area managed. Beef and dairy cattle represent the most common types of livestock raised, followed distantly by goats, sheep, pigs and llamas. Cropping activities include corn, soybeans, small grains, alfalfa, and other hay production, with a large portion used to support livestock. Crop cultural practices vary widely, with many growers practicing long-term rotations and reduced rather than conventional tillage. Grazing cultural practices also vary widely, with 25% of cattle producers claiming to practice MIG on the 2012 US Census of Agriculture.

Expected participation rates in private land rental markets for grazing could be useful to assess the feasibility of public land rental markets for MIG, however there are some key differences between them. A key difference is that public land managers are mandated to prioritize conservation and recreation goals and, therefore have grazing restrictions on their land; Contrastingly, private landowners generally have more flexibility. Restrictions on public lands could include time restrictions based around hunting seasons for grassland animals, grass residual for grassland bird habitat, or periods of rest during bird nesting season. Additionally, public land managers are most interested in grazing as a land management tool on unhealthy grasslands with a high percentage of shrubby species. So the forage quality and quantity may not be at the same level as on a private property. Such challenges associated with public land rental markets are likely to both lower producer willingness to rent and the prices they are willing to pay for public grassland for MIG. This is likely to lead to a smaller set of interested producers.

Double-bounded dichotomous choice construction

To model this process, we consider a situation where multiple utility-maximizing farmers independently choose whether to demand acres of public grassland for MIG from a single supplier. Consistent with random utility theory (Haab and McConnell 2003), a producer is willing to demand whenever the expected gain in utility from doing so is positive. If we define the reservation price R_i as the maximum price per acre where this condition just holds for the *i*th farmer, and we let B denote the price per acre offered to farmers by the public agency; then the decision rule becomes to demand land when $R_i > B$ and decline when $B \geq R_i$. We expect R_i to vary across farmers and, consistent with our understanding of the challenges associated with grazing public land, we expect R_i to be less than the breakeven condition for a large fraction of farmers. In this sense, we treat observations of R_i as realizations of the random variable R. The goal becomes to learn about the distribution of R and the conditional means for the target population and evaluate their implication for public land rental markets for MIG.

Our survey approach uses information gathered from a sample of farmers to identify the distributional parameters for R. Rather than elicit reservation prices directly, we employ a DB-DC framework (Hanneman et al. 1991). Each respondent is asked two DC questions that serve to locate R_i relative to known offer prices. The first question provides respondents with an initial offer price, B^0, and asks whether they would rent any acres. If they respond yes, B^0 is interpreted as an initial lower bound ($B^0 < R_i$). Similarly, if they respond no, then B^0 provides an initial upper bound ($R_i < B^0$). The second question acts as a follow-up to the first and varies depending on the initial response. Respondents who replied yes to B^0 are asked if they would still rent any acres at a higher price B^{H}. In contrast, respondents who said no are asked if a lower price B^{L} would be sufficient to induce rental. The two questions result in four possible response sequences. A yes-yes response refines the lower bound on the respondent's true value ($\mathrm{B}^0 < \mathrm{B}^{\mathrm{H}} < \mathrm{Ri}$), whereas a no-no response improves the upper bound ($R_i < \mathrm{B}^0 < \mathrm{B}^{\mathrm{L}}$). By comparison, the yes-no and no-yes responses have both an upper and lower bound and thus provide an interval over which the true value lies ($B^0 < Ri < B^H$ for yes-no responses, and $B^L < Ri < B^0$ for no-yes responses). Our Heckman estimation uses an overall "yes" variable equal to 1 if the respondent said "yes" at any point (yes-yes, yes-no, or no-yes responses) and equal to 0 if they said "no" to both offers. The Heckman estimation procedure is outlined in the next section.

Data and Estimation

The data come from a 2016 Grazing Public Lands mail survey of non-dairy cattle producers across Wisconsin. The selection process followed a stratified design based on herd size and whether a producer checked the "managed intensive grazing" box on the 2012 US Census of Agriculture. Following the US Census of Agriculture, we used seven herd size strata: 1-19 head, 20-49 head, 50-99 head, 100-199 head, 200-499 head, 500-999 head, or 1000+ head. First we included all MIG over 200 head and 100 farms in the 100-199 head range because these were a relatively small proportion of the sample but a group of potential importance to include. We matched a similar number of non-MIG farms from the same strata. We sampled 100 farms from each of the rest of the strata excluding 1000+. Then we sampled all remaining operations from the 1000+ strata, and 30 more in each of the other strata.

Producer selection relied on a confidential list frame managed by the National Agricultural Statistics Service (NASS). The final sample consisted of 1,172 farmers, 22% of which checked the “managed intensive grazing” box. This analysis uses 142 responses from active beef producers for an effective response rate of 12% after removing ineligible returns. We believe that the low response rate reflects low interest in the potential market in addition to the fact that we were unable to implement a full Dillman survey mailing method[1] (Dillman et al. 2014). Instead, the survey was mailed twice, on February 8, 2016 and March 14, 2016. Of our respondents, 55% checked the “managed intensive grazing” (MIG) box compared to 22% of our survey population. This suggests rotational graziers are more than twice as likely to have responded to the survey than producers not using MIG practices. Additional materials on the survey mailing are provided in the appendix. This difference in MIG is big enough to consider what effect it might have on estimated coefficients. To address this we checked for non-respondent and sample selection biases.

Using additional non-responder data provided by NASS from a previous survey, we tested for significant differences between survey respondents and non-respondents on the following variables available to both groups: age, sex, share of income from farming, retirement status, MIG, total number of cattle head, rental experience, total farm acres, total pasture acres, proportion of total pasture acres to total farm acres owned, year the respondent began farming, and years farming. We found six significant differences between the two groups (Table 1). Respondents were more likely to be older, retired,

[1] The National Agricultural Statistics Service restricted us to only two mailings without a postcard in between or a third mailing.

practice MIG, have smaller farms (smaller number of head), have previous rental experience, and have spent more years farming. The results for MIG and rental experience are most interesting – suggesting that producers who already practice MIG and who have prior rental experience were more interested in the survey topic and therefore more willing to respond to the survey. Perhaps these individuals felt that they would be good candidates for public land grazing program and so wanted to contribute to the research.

Regardless, these differences suggest that individuals may be self-selecting into the respondent or non-respondent groups. This is our main motivation to further investigate if these differences indicate sample selection bias and then influence the regression analysis on who is more willing to accept public land rental contracts. To further check for evidence of differences between the groups, we ran a probit (binary regression) with *responded* as the dependent variable. The marginal effects of the probit on *responded* showed a positive and significant effect of age, MIG, and past rental experience on response, while farmers with larger herd sizes were less likely to respond (Table 2). Some of the marginal effects have very small magnitude. While significant, an individual one year older is only 0.3% more likely to respond. Similarly, an additional animal only decreases the chance that an average individual will respond by 0.1%. The others are stronger – if an individual practices MIG they are about 9% more likely to respond, ceteris paribus. Past rental experience has the greatest impact though, with a 19% increase in likeliness to rent once an individual has rental experience. These outcomes provide reliable evidence that we have a sample selection bias that could affect our willingness to accept rental contract analysis that follows.

To control for sample selection bias, we employ a Heckman selection model where the impact of selection bias is explicitly incorporated into the estimating equation for willingness to undertake the rental contract (Guo and Fraser 2010). These types of sample selection models involve two equations: (1) the regression equation including factors determining the outcome variable and (2) the selection equation that identifies a portion of the sample whose outcome is observed and the factors that shape the selection process (Heckman 1978, 1979). Equation 1 and Equation 2 show our regression and selection equations respectively. These both include age, a MIG dummy variable, past rental experience, and the proportion of total pasture acres to farm acres owned; all variables that were available on respondents and non-respondents through NASS. The regression equation includes additional variables that were only available via the survey for respondents. Those variables are described in detail later in this section.

Equation 1 Regression Equation

$$enroll = \beta_0 + \beta_1 price + \beta_2 tot\_au + \beta_3 age + \beta_4 MIG + \beta_5 short\_att\_index + \beta_6 ever\_rented + \beta_7 prop\_tot\_past + \beta_8 cattle\_diverse + u_1$$

Equation 2 Selection Equation

$$responded = \gamma_0 + \gamma_1 age + \gamma_2 MIG + \gamma_3 tot\_num\_head + \gamma_4 ever\_rented + \gamma_5 prop\_tot\_past + u_2$$

Based on previous work related to significant non-response bias, we expect that the effort to control for non-respondent bias will produce different results than the alternative

(Whitehead et al. 1993). Specifically, we anticipate some variables viewed as significant in the regression equation will not be significant once we control for who 'selected' into the sample. In addition, because of 'bias', other coefficient estimates could be different than they would be in a single stage outcome regression.

Contingent Valuation Module

Data on stated land rental intentions comes from the CV module in the survey questionnaire. The module asked respondents whether they would rent any land for MIG at a given offer price, and if so, to specify the number of acres they would rent and what type of cattle they would put on the land. The module included an introduction, description of what is provided and not provided by the land manager, a list of grazing requirements, grassland composition and contract length, as well as a final reminder that the grazier must adhere to the grazing requirements if they accept a contract and decide to rent any acres. While grazing rental decisions are complex and require a grazier to consider a variety of variables including distance from their farm and infrastructure availability, we felt that sufficient details were provided to allow the respondents to form a personal expectation of profitability and other tradeoffs to make their demand decision. Additionally, we wanted to test farmer willingness to rent based on the grassland quality and grazing restrictions without explicitly saying "public land." Therefore, we worked with a public land agency to ensure that the grassland descriptions and grazing restrictions were accurate for typical public grassland in Wisconsin, but we did not name the lands as explicitly public in the CV module. Later in the survey we asked attitude questions specific to public lands. Reproductions of the CV text and attitudinal questions from the study questionnaire are available in the supplementary material at the end of this chapter.

The module included parallel questions for grass-dominated grassland and shrub-dominated grassland, such that the respondent could choose to rent acreage for one, both, or neither type of grassland. Respondents indicated their willingness to rent by agreeing to rent acreage under a given contract scenario. The decision to rent was voluntary and elicited via the DB-DC format. The first question was identical for all respondents and asked, “At a price of $[initial offer price]/acre, would you rent any acres to graze cattle under this scenario?” The second DC question varied depending on the response to the first. If they said yes, the offer price in the second question increased. If they said no, the offer price in the second question decreased.

Three questionnaire versions were used that were identical except for the rental prices offered. Each version had a low, medium, or high range of offer prices. This was in order to capture a more accurate range of farmer reservation prices. Each respondent was assigned at random to a questionnaire version (Table 3). The range of prices was determined through extensive conversations with grazing professionals from around Wisconsin. The three offer price sets were approximately evenly represented in the survey returns.

Following the initial enrollment questions, debriefing questions asked respondents to specify how many acres they would rent, what class of animal they would put on the pasture, the maximum distance they would travel to graze their cattle under the grazing opportunity, and if they would still rent at the agreed price if they had to provide interior and perimeter fencing. These debriefing questions were asked once per grazing contract scenario conditional on enrollment and tied to the offer price at which the respondent first agreed to enroll. These questions helped us understand how the respondents plan to use rented acreage (e.g. what type of cattle would be grazed), how many acres respondents were interested in, and how distance and infrastructure may affect their decision to rent. Additionally, asking debriefing questions displays "commitment value" or credibility by having respondents engage more deeply with the survey (Carson et al. 2001). A more in-depth discussion of the findings from this section of the survey are presented in Chapter Three of this thesis.

Variable Descriptions

We hypothesized that operation size, education, proportion of farming income to total household income, MIG, rental experience, years farming and attitude toward conservation and public land will be positively related to willingness to rent public land for MIG. Price, proportion of total pasture owned to farmland owned, age, and operation diversity (in terms of cattle types) are expected to be negatively related to willingness to rent public land for MIG. Moreover, we expect these relationships to hold for both grass-dominated and shrub-dominated pastures.

In the regression, we use total animal units (*TOT_AU*) to measure operation size. Total animal units were estimated for each operation by weighting total head of each class of animal with conversion factors provided by an animal science specialist (D. Schaefer, personal communication, July 28, 2016) (Table 4).

We use two measures of current management practices. The first is an indicator variable of whether a producer already practices MIG according to their self-identification on the 2012 U.S. Census of Agriculture. Because this measure could be viewed as 'too similar' to the dependent variable, we checked to see if at least some respondents from both groups (MIG and non-MIG) were willing to enroll in the public land rental program. Even though the percentage of MIG practitioners in our respondent group was much higher than in the entire sample, a substantial portion of non-MIG practitioners were willing to rent public lands. About half of MIG practitioners were willing to rent and about one-third of non-MIG practitioners were willing to rent (Table 5), so including this term in the regression seems reasonable in terms of endogeneity concerns. We expect that if a producer already practices MIG they will be more likely to rent public grassland for MIG as they are already familiar with writing a grazing plan and appropriately implementing a MIG regime. The opportunity cost for a grazier who is unfamiliar with MIG will be much higher. The rotational grazier will also be willing to pay a higher price per acre for renting public grassland because they understand the value of the grassland more than a continuous grazier.

The second measure of current management practices we use is whether the producer has ever rented land (private or public) for grazing as part of their farming operation (*EVER_RENTED*). This question is included as a reflection of transaction cost considerations that could positively affect the willingness of producers to rent public lands. Specifically, if they have not previously rented lands, the fixed costs of renting for the first time are likely to reduce their willingness to participate in this market.

Measuring management ability in a cross-sectional survey is a non-trivial matter. Typically, adoption studies use panel methods to control for this unobservable or attempt to recover it from other production outcome estimations. Neither one of those options is feasible here. One potential measure of management ability that was available to us in the survey, but is not used is the number of years a respondent had been farming (*YRS_FARMING*). Our hypothesis is that this could be a measure of ability and hence positively affect adoption and willingness to pay. However, we do not use this measure because as shown below in the correlation table (available in the supplementary material) it is highly and positively correlated with age, a standard technology adoption measure we are already using.

We expect producer attitudes that are supportive of conservation and government policy in that arena to positively influence willingness to rent public land for MIG. To measure this, we created an attitude index (*SHORT_ATT_INDEX*) that combined a respondent's answers to four attitudinal questions answered on a five-point Likert scale. Those questions were: "It is important to me to keep the ground covered;" "I am willing to meet conservation goals (such as leaving more grass residual) as part of my grazing plan;" "I am willing to work with a public agency, such as the Wisconsin Department of Natural Resources;" and "I would be concerned about my family or friends' perceptions if I graze public land." The index was created by summing the respondent's "score" for each of the attitudinal questions with a high score reflecting more positive attitudes toward conservation and government policy.

Finally, we measure cattle diversity as the number of different types of cattle (e.g. dry beef cows, cow-calf pairs, finish animals, young stock, and/or dairy heifers) in a producer's operation (*CATTLE_DIVERSE*); we expect this to have a negative impact on technology adoption and willingness to pay to rent public pastureland for MIG because of the added management complexity of public lands and diverse animal feeding demands. And, of course, we expect the offer price (*PRICE_GD* and *PRICE_SD* for grass-dominated and shrub-dominated pastures) to be negatively related to rental of public land for MIG. While we were not provided with a respondent's county or region, we did have a de-identified regional variable that allowed us to control for location (*DST_ID*).

Because there are nine of these variables, there is no explicit basis for interpreting them, and we have limited degrees of freedom due to our small sample. Therefore, we did not include these regional variables once they are shown to be insignificant in an initial regression.

Table 6 describes the final variables used in the empirical analysis for shrub and/or grass-dominated public pastureland scenarios. Information on respondents' rental decisions is used to estimate the farmer willingness to pay model. The decisions are summarized by four indicator variables, one for each of the DB-DC response groups. The remaining items in Table 6 are descriptive statistics for the full set of explanatory variables.

We observe from the start of the regression reporting that few respondents (<25%) indicate any willingness to rent under either contract at the prices offered. This high degree of censoring, along with our small sample size, constrains the precision of the estimation. Prior to the regression analysis, we checked the enrollment decisions across the various versions to make sure that we can include the full set of DC-DB responses. Our concern as reflected in Table 7 was that one or more price versions would be nearly or completely censored. Indeed, the high-priced questionnaire Version C had extremely low enrollment rates for both grass-dominated and shrub-dominated scenarios. As such, we remove Version C responses from our dataset when doing our probit regressions. Doing so significantly improves the precision of our estimates.

Results and Discussion

We report the results in two sections. The first section provides the two-stage Heckman results and the second section shows the results of a model that does not control for sample selection as a comparison point.

Heckman Selection Results

The grass-dominant scenario was looked at separately from the shrub-dominant one. The Heckman two-stage estimation results for the grass-dominant scenario are shown in Table 8 while the results for the shrub-dominant scenario are in Table 9. We discuss the second stage results in more detail first, but note that the first-stage response analysis contains many statistically significant results consistent with the response bias estimates presented above.

From the outcome stages, we can identify characteristics of producers who will be most likely to participate in land rental managed grazing programs. In the case of grass-dominated pastures, the producers who are more likely to participate are younger, have larger operations (in terms of total animal units), and less diverse operations. Practically, this means someone ten years older is 9% *less* likely to rent. Total animal units is scaled by 10 in this model, so a farm with 10 additional animal units is 0.4% *more* likely to rent than one with less animal units. Finally, someone with an additional type of cattle is 4.5% *less* likely to rent. These are not negligible effects from a marketing perspective, and they are not surprising based on hypotheses offered above.

If the public land on offer is shrub-dominated, the type of producer interested varies from the grass-dominant participant. In a shrub-dominant system, the participants with a greater proportion of pasture to farmland owned are less likely to rent shrub-dominated lands. Specifically, an increase in the proportion by 10% means a producer is

71% *less* likely to rent. In other words, interest in renting shrub-dominant land is highly sensitive to a producer's access to owned pasture. A less statistically and economically significant effect is the positive effect of the attitude index on rental interest. In this case, an increase in the attitude index by one point (meaning they have a more positive attitude toward conservation and government by one point) means a producer is 8.3% *more* likely to rent. It makes sense that producers may be more willing to rent shrubland if they believe strongly in conservation grazing and grazing as a management tool on public land. This is demonstrated by the significant impact of the attitude index on program enrollment.

The overall difference between willingness to rent grass-dominant pasture versus shrub-dominant pasture is not surprising. Shrubland provides less quality forage for cattle and so is worth less to a producer. It is also more work – to beat back shrubland may require mob-grazing or another high-intensity grazing method that needs more frequent management. For these reasons, it makes sense that only those producers who are highly pasture-constrained or have some inclination to do conservation grazing would be interested in grazing shrubland at the prices offered in the survey.

As mentioned earlier in the paper, the Heckman regressions (Table 8 or Table 9) did not include survey respondents to survey version C due to censoring concerns. A close look at the results in Table 10 and Table 11 supports this decision. There are no significant regression coefficients when survey version C respondents are included in the analysis.

Closer look at MIG group

In March 2015, I attended meeting of public land managers (mostly from the WDNR) focused on how to utilize grazing as a land management tool on public land. At the meeting, many land managers mentioned that they were concerned about working with inexperienced graziers since many land managers are also inexperienced in this area. As such, most public land managers were only interested in partnering with experienced graziers until they felt confident in their own ability to apply grazing as a land management tool. Based on this specific interest by WDNR land managers, I honed in on factors influencing willingness-to-rent for the MIG group only. To do this, I ran a probit on *enroll* for only MIG practitioners in the grass-dominant scenario using the same explanatory variables as my original Heckman results (Table 12). Since this is a group not meant to represent the survey population, I did not need to use a Heckman selection model. The results of the marginals show past rental experience as the most significant predictor; If they have past rental experience they are almost 50% more likely to rent public land in the grass-dominant scenario. Cattle diversity also shows up as significant; If they have an additional cattle type they are about 20% less likely to agree to rent. I also ran the MIG-only probit for the shrub-dominant scenario (Table 13). The results showed only past rental experience as a significant predictor.

The results for both SD and GD situations are very different for the MIG group versus the results from the overall respondent group. I think they tell us that for the MIG group (the group DNR is most interested in), the biggest barrier to willingness to rent is rental experience, which is something that grazing brokers can provide support with. By helping graziers become more familiar with how a grazing rental could work, they should become more interested. That is something specific DNR can work on - helping inexperienced renters feel more comfortable with the process.

Impact of Correcting for Sample Selection Bias

A comparison of the Heckman two-stage results to a single probit on land rental that does not control for sample selection gives widely different results (Table 14). Whereas with the Heckman model only respondent age, number of animal and operation diversity have an effect on willingness to rent grass-dominant public land, when sample selection bias is not controlled for the significant estimates are now on price, age, MIG, and rental experience. For shrub-dominant scenarios (Table 15) sample selection bias seems to have less of an impact (attitude and proportion of pasture to total farm acres remain significant, though more-so). However, past rental experience shows up somewhat when sample selection bias is not accounted for.

These contrasting results demonstrate the importance of testing and controlling for biases. When we run the Heckman model, age, MIG, total number of head and past rental experience affect who responded to the survey in the first stage. This in turn impacts what is significant in the second stage. Once we control for who responded, the significance of certain variables goes away because the biased selection was influencing our results. Probably most important was the fact that response was biased more toward MIG and those with previous rental experiences.

Summary and Conclusions

This article utilizes contingent valuation data gathered from producers across Wisconsin to assess willingness to rent two types of grassland (grass-dominated and shrub-dominated) under grazing restrictions. For grass-dominated pasture, we expect younger producers with larger farms and less diverse operations to be interested. For policy, this suggests that public agents should target at least their initial marketing/recruitment efforts at these types of producers. Similarly, for shrub-dominated pasture, we expect that those producers with less pasture in their possession and with a more positive attitude toward conservation and government policy to be more interested in participating; recruitment efforts should be tailored as such, when possible.

Ultimately, our results show that grazing decisions, in this instance, are about more than price. Younger producers, for example, may have specific constraints that make them more likely to rent grass-dominant pasture. In general, producers will make their rental decision based on their own operational context – the size of their operation, how many pasture acres they own (and therefore need to rent), and how many different types of cattle they must manage. For shrub-dominant pasture, producers must consider if they are constrained enough in pasture to be willing to deal with the extra management needs of such land. For policymakers, this reflects a need for flexibility in contract design. To entice producers to rent shrubland, they may need to provide incentives in the contract, for example a lower rental price per acre.

Additional research should revolve around producer willingness to travel to graze public land, where the public land is located, and how many graziers are within the radius to further inform whether a government program for MIG in Wisconsin would be successful. This may mean a targeted effort initially in regions with higher densities of young cattle producers, with larger herds. Those data are available from NASS, and could be identified at a county level or township level without compromising the identities of the producers.

Tables

Table 1: Tests for response bias

Variable	Respondents	Nonrespondents	T-stat
Age	58.933 (0.962)	54.222 (0.494)	-4.2027***
(obs)	135	576	[0.000]
Male	0.927 (0.022)	0.957 0.008)	1.441
(obs)	137	576	[0.150]
Share of income from farming	47.254 (2.998)	53.159 (1.614)	1.614
(obs)	126	547	[0.107]
Retired	0.430 (0.045)	0.116 (0.013)	-8.330***
(obs)	121	576	[0.000]
Practice MIG	0.549 (0.042)	0.311 (0.020)	-5.237***
(obs)	142	512	[0.000]
Total number of head	97.789 (8.889)	193.354 (16.794)	2.402**
(obs)	142	789	[0.017]
Past rental experience	0.507 (0.043)	0.112 (0.011)	-11.4053***
(obs)	138	789	[0.000]
Total farm acres owned	423.807 (94.401)	358.518 (22.300)	-1.007
(obs)	137	573	[0.314]
Total pasture acres owned	117.111 (15.345)	86.592 (8.907)	-1.364
(obs)	136	789	[0.173]
Proportion of total pasture acres owned to total farm acres owned	0.377 (0.025)	0.416 (0.115)	0.139
(obs)	133	789	[0.890]
Year began farming			53.498
(obs)	133	576	[0.798]+
Total years spent farming	33.308 (1.171)	19.636 (0.595)	-8.954***
(obs)	133	789	[0.000]

Notes: Sample standard deviations in parentheses. P-values in brackets.
+ Calculated using a Pearson chi2 test
***, **, and * indicate that the values are significant at 1%, 5%, and 10%

Table 2 Probit on "responded" to check for non-respondent bias

Variable	Probit	Marginal Effect
Age	0.021*** (0.006)	0.003*** (0.001)
Male	0.113 (0.331)	0.018 (0.052)
Proportion of income from farming	-0.000 (0.002)	-0.000 (0.000)
MIG	0.551*** (0.141)	0.087*** (0.023)
Total number of head	-0.003*** (0.001)	-0.001*** (0.000)
Past rental experience	1.215*** (0.158)	0.191*** (0.031)
Prop. pasture	-0.269^{+} (0.176)	-0.042^{+} (0.028)
Constant	-2.277*** (0.493)	
Observations	608	
Log likelihood	-228.296	
Pseudo R2	0.226	

Note: ***, **, * and $^{+}$ indicate that the values are significant at 1%, 5%, 10% and 15% levels, respectively.

Table 3 Grazing Contract Offer Prices ($/acre)

	Questionnaire Version		
Grazing Contract (offer)	**Low**	**Middle**	**High**
Grass-dominated			
Initial offer (B^0)	$10	$25	$40
High follow-up offer (B^H)	$15	$30	$45
Low follow-up offer (B^L)	$5	$20	$35
Shrub-dominated			
Initial offer (B^0)	$10	$20	$30
High follow-up offer (B^H)	$15	$25	$35
Low follow-up offer (B^L)	$5	$15	$25

Source: Authors' 2016 mail survey

Table 4 Animal unit conversions by class of animal

Class of animal	Conversion factor
Dry beef cow	1.3
Cow-calf pairs	1.6
Finish animals	1.1
Young stock	0.7
Dairy heifers	1

Table 5 Respondent participation by MIG (number of respondents)

	Grass-dominated	Shrub-dominated
MIG (n=55)		
yes-yes	15	10
yes-no	8	4
no-yes	3	6
no-no	25	20
Total "yes"	26	20
Non-MIG (n=39)		
yes-yes	6	4
yes-no	3	2
no-yes	3	4
no-no	25	18
Total "yes"	12	10

Table 6 Variable Descriptions

Variable	Description	N	Mean	Std. dev.	Min.	Max.
DB-DC response groups for grass-dominated						
yes-yes	Responded "yes" to both DC questions (1=yes, 0=no)	87	0.241	0.43	0	1
yes-no	Responded "yes" then "no" to the DC questions (1=yes, 0=no)	87	0.126	0.334	0	1
no-yes	Responded "no" then "yes" to the DC questions (1=yes, 0=no)	87	0.069	0.255	0	0
no-no	Responded "no" to both DC questions (1=yes, 0=no)	87	0.575	0.497	0	1
DB-DC response groups for shrub-dominated						
yes-yes	Responded "yes" to both DC questions (1=yes, 0=no)	87	0.161	0.37	0	1
yes-no	Responded "yes" then "no" to the DC questions (1=yes, 0=no)	87	0.069	0.255	0	1
no-yes	Responded "no" then "yes" to the DC questions (1=yes, 0=no)	87	0.115	0.321	0	1
no-no	Responded "no" to both DC questions (1=yes, 0=no)	87	0.437	0.499	0	1
Farmer characteristics						
Total animal units (scaled)	Total number of animal units (integer)	87	16.118	16.954	0.13	79.5
Education	1=less than hs, 2=hs or equiv, 3=some college/tech, 4=2 year, 5=4 year, 6=masters	90	3.378	1.362	1	6
Age	Age (integer)	88	57.886	12.588	26	80
MIG	Checked the "MIG" box on the US Agricultural Census (1=yes, 0=no)	94	0.585	0.495	0	1
Short attitude index	Index of conservation and government attitudes (integer from 4 - 20)	79	14.785	1.991	10	19
Proportion pasture acres owned	Total pasture acres owned divided by total farm acres owned (acres)	86	0.388	0.289	0	1
Diversity of operation	Index of diversification of cattle types (integer from 1 - 5)	94	1.681	0.986	1	4
Past rental experience	Indicator variable for if ever rented previously (1=yes, 0=no)	92	0.533	0.502	0	1
Years farming	Number of years farming (integer)	89	31.73	14.9112	6	69
Proportion of income from farming scaled	Proportion of income from farming divided by 10 (integer)	82	7476.186	13507.38	0	70000
District	Coded district id (9 possible ids)	94	1057.489	22.665	1016	1093

Table 7 Enrollment Rates

CV response	Version A (low)	Version B (middle)	Version C (high)
Grass-dominated			
yes-yes	12	8	1
yes-no	5	6	3
no-yes	5	1	3
no-no	22	28	41
Total "yes"	22	15	7
Shrub-dominated			
yes-yes	6	8	2
yes-no	5	1	0
no-yes	7	3	3
no-no	20	18	32
Total "yes"	18	12	5

Table 8 Heckman results (grass-dominant)

Variable	Probit	Marginal Effect
Second stage results: dependent variable = "agreed to rent"		
Price	0.008 (0.013)	0.002 (0.003)
Total animal units	0.016*** (0.005)	0.004*** (0.002)
Age	-0.035*** (0.010)	-0.009*** (0.003)
MIG	0.141 (0.265)	0.035 (0.065)
Attitude index	0.060 (0.064)	0.015 (0.016)
Past rental experience	-0.211 (0.277)	-0.052 (0.069)
Proportion of pasture to farm acres owned	0.190 (0.392)	0.047 (0.097)
Diversity of cattle operation	-0.186* (0.098)	-0.045* (0.024)
Constant	2.039** (1.009)	
First stage results: dependent variable = "responded"		
Age	0.017*** (0.007)	
MIG	0.609*** (0.164)	
Total number of head	-0.002*** (0.001)	
Past rental experience	1.370*** (0.176)	
Proportion of pasture to farm acres owned	-0.306^{+} (0.194)	
Constant	-2.435*** (0.408)	
altrho	-13.472 (23.241)	
Num. obs (uncensored)	70	
Log likelihood	-188.29	

Note: ***, **, * and $^{+}$ indicate that the values are significant at 1%, 5%, 10% and 15% levels, respectively.

Table 9 Heckman results (shrub-dominant)

Variable	Probit	Marginal Effect
Second stage results: dependent variable = "agreed to rent"		
Price	-0.011 (0.046)	-0.004 (0.017)
Total animal units	0.013 (0.017)	0.005 (0.009)
Age	-0.021 (0.019)	-0.008 (0.011)
MIG	0.137 (0.731)	0.050 (0.237)
Attitude index	0.229* (0.137)	0.083+ (0.056)
Past rental experience	0.375 (1.522)	0.136 (0.460)
Proportion of pasture to farm acres owned	-1.945 (1.213)	-0.707* (0.382)
Diversity of cattle operation	0.203 (0.228)	0.074 (0.090)
Constant	-2.648 (4.466)	
First stage results: dependent variable = "responded"		
Age	0.016** (0.007)	
MIG	0.591*** (0.170)	
Total number of head	-0.003*** (0.001)	
Past rental experience	1.395*** (0.181)	
Proportion of pasture to farm acres owned	-0.255 (0.194)	
Constant	-2.430*** (0.419)	
altrho	-0.317 (1.269)	
Num. obs (uncensored)	65	
Log likelihood	-179.09	

Note: ***, **, * and + indicate that the values are significant at 1%, 5%, 10% and 15% levels, respectively.

Table 10 Comparison of Heckman results with and without survey version C (grass-dominant)

Variable	Heckman marginal effects (survey versions A and B)	Heckman marginal effects (survey versions A, B and C)
Price	0.002 (0.003)	-0.009 (0.018)
Total animal units	0.004*** (0.002)	0.006 (0.025)
Age	-0.009*** (0.003)	-0.013 (0.039)
MIG	0.035 (0.065)	0.281 (0.232)
Attitude index	0.015 (0.016)	0.054 (0.104)
Past rental experience	-0.052 (0.069)	0.292 (0.314)
Proportion of pasture to farm acres owned	0.047 (0.097)	-0.088 (0.194
Diversity of cattle operation	-0.045* (0.024)	-0.162 (0.314)

Table 11 Comparison of Heckman results with and without survey version C (shrub-dominant)

Variable	Heckman marginal effects (survey versions A and B)	Heckman marginal effects (survey versions A, B and C)
Price	-0.004 (0.017)	-0.015 (0.019)
Total animal units	0.005 (0.009)	0.004 (0.009)
Age	-0.008 (0.011)	-0.004 (0.009)
MIG	0.050 (0.237)	0.071 (0.089)
Attitude index	0.083^{+} (0.056)	0.036 (0.048)
Past rental experience	0.136 (0.460)	0.088 (0.170)
Proportion of pasture to farm acres owned	-0.707* (0.382)	-0.462 (0.544)
Diversity of cattle operation	0.074 (0.090)	0.034 (0.066)

Table 12 Probit on *enroll* with MIG only (grass-dominant)

Variable	Probit	Marginal Effect
Price	-0.045 (0.036)	-0.018 (0.014)
Total animal units	0.011 (0.015)	0.004 (0.006)
Age	-0.026 (0.023)	-0.010 (0.009)
Attitude Index	0.052 (0.134)	0.020 (0.053)
Past rental experience	1.187** (0.541)	0.467** (0.214)
Proportion of pasture to farm acres owned	-0.064 (1.016)	-0.025 (0.400)
Diversity of cattle operation	-0.531** (0.263)	-0.209** (0.103)
Constant	1.863 (2.236)	
Num. obs.	44	
Log-likelihood	-21.977	

Note: ***, **, * and $^{+}$ indicate that the values are significant at 1%, 5%, 10% and 15% levels, respectively.

Table 13 Probit on *enroll* with MIG only (shrub-dominant)

Variable	Probit	Marginal Effect
Price	0.022 (0.066)	0.007 (0.021)
Total animal units	0.005 (0.015)	0.002 (0.005)
Age	-0.032 (0.027)	-0.010 (0.008)
Attitude Index	0.227^{+} (0.157)	0.072^{+} (0.049)
Past rental experience	1.349** (0.698)	0.425** (0.205)
Proportion of pasture to farm acres owned	-1.729 (1.222)	-0.545 (0.391)
Diversity of cattle operation	0.203 (0.266)	
Constant	-3.333 (2.787)	
Num. obs.	41	
Log-likelihood	-18.630217	

Note: ***, **, * and $^{+}$ indicate that the values are significant at 1%, 5%, 10% and 15% levels, respectively.

Table 14 Comparison of marginal effects with and without sample selection bias (grass-dominant)

Variable	Heckman	No sample selection control
Price	0.002 (0.003)	-0.018^{+} (0.011)
Tot. animal units	0.004*** (0.002)	0.004 (0.005)
Age	-0.009*** (0.003)	-0.009^{+} (0.006)
MIG	0.035 (0.065)	0.302* (0.166)
Attitude index	0.015 (0.016)	0.056 (0.041)
Past rental experience	-0.052 (0.069)	0.440*** (0.167)
Prop. pasture	0.047 (0.097)	-0.347 (0.285)
Operation diversity	-0.045* (0.024)	-0.211** (0.093)

Table 15 Comparison of marginal effets with and without sample selection bias (shrub-dominant)

Variable	Heckman	No sample selection control
Price	-0.004 (0.017)	-0.0033 (0.0132)
Tot. animal units	0.005 (0.009)	0.0027 (0.0033)
Age	-0.008 (0.011)	-0.0051 (0.0049)
MIG	0.050 (0.237)	0.0779 (0.1214)
Attitude index	0.083^{+} (0.056)	0.0661** (0.0330)
Past rental experience	0.136 (0.460)	0.2014^{+} (0.1363)
Prop. pasture	-0.707* (0.382)	-0.5781** (0.2429)
Operation diversity	0.074 (0.090)	0.0572 (0.0644)

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Supplementary Material

Description of WTP issues

Starting with hypothetical response bias, the survey or contingent valuation approach assumes that stated preferences accurately represent what peoples' preferences would be if they had the choices proposed to them (Bingham et al. 1995), however this may not always be true. For example, survey respondents may lack market experience with the proposed good and not understand how to value it (Mendelsohn and Olmstead 2009). In fact, many researchers have found willingness-to-pay results to be upward-biased (Hausman 2012, Kling et al. 2012). Some have found that familiarity with the new product leads to more successful forecasts of whether people will buy, but familiarity with the product will not be present in most contingent valuation studies. (Hausman 2012). One way to address this upward bias has been to deflate the stated willingness to pay by some amount; however choosing the “right” amount is tricky (Hausman 2012). Alternatively, some have proposed that as long as respondents believe that there is a positive probability that their response will influence an outcome they care about, the respondent is more likely to put effort into providing a reasonably accurate price (Carson 2012, Kling et al. 2012). Indeed Carson and Groves (2007) demonstrated that “responses to a good contingent valuation study can reasonably be treated as revealed economic behavior, akin to that obtained in a vote of a representative population on a ballot proposition.”

The second problem of discrepancy between WTP and WTA is well documented (Hausman 2012, Mendelsohn and Olmstead 2009). Willingness-to-accept questions are often greater than the responses to willingness-to-pay (Mendelsohn and Olmstead 2009). Basic economic theory suggests that these two approaches should give (approximately) the same answer (Hausman 2012), but others have suggested theoretical reasons for the discrepancy. Hanemann (1991) shows willingness to pay and willingness to accept for a pure public good are likely to be quite far apart while Wilig (1976) shows that willingness to pay and willingness to accept for a price change should typically be close together.

The third problem with the contingent value method comes from “scope” and “embedding,” or the broader proposition that respondents to contingent valuation surveys should be more willing to pay for a large effect than for a subset of that effect (Hausman 2012). However, often this is not what is found. This discrepancy may derive from the possibility that respondents to contingent valuation surveys may have a certain amount that they are willing to spend on certain issues generally, and therefore will tend to respond with this amount in mind regardless of the actual characteristics of the good being valued (Carson 2012). A fourth but somewhat lesser concern is interview bias, where those being interviewed seek to please the interviewer and therefore inflate or deflate their stated price appropriately (Hausman 2012).

Table 16 Correlation Matrix A and B (grass-dominated)

	enroll	price	Tot_au	educ	age	mig	att_index	yrs_farming	prop. farm inc.	prop. pasture	op. diversity	district
enroll	1											
price	-0.3118	1										
tot_au	0.0835	0.1432	1									
educ	0.0424	0.1365	0.3659	1								
age	-0.3395	0.5216	0.0637	0.0522	1							
mig	0.0226	0.0226	0.2603	0.1915	0.082	1						
att_index	0.2349	- 0.0433	0.1412	0.1209	- 0.1032	0.1344	1					
yrs_farming	-0.3436	0.6689	0.2685	0.0151	0.635	0.0953	-0.0951	1				
prop. farm income	0.1767	- 0.0455	0.2648	0.0376	- 0.0518	0.0498	0.0903	0.0419	1			
prop. pasture	-0.0517	- 0.2751	0.1634	- 0.0921	- 0.0486	0.0359	0.1616	-0.0773	-0.1709	1		
op diversity	-0.2195	0.1053	0.4931	0.3373	0.2002	0.249	0.1068	0.1902	0.0137	0.1497	1	
district	-0.0113	- 0.0729	0.0489	0.0701	- 0.1967	- 0.0666	0.0443	-0.1275	-0.0277	0.0732	0.2618	1

	enroll	price	Tot_au	educ	age	mig	att_index	yrs_farming	prop. farm inc.	prop. pasture	op. diversity	district
enroll_gd	1											
price_gd	-0.3027	1										
tot_au	0.081	0.1177	1									
educ	0.0399	0.1197	0.3778	1								
age	-0.3273	0.5334	0.0416	0.0412	1							
mig	0.0782	0.0349	0.2717	0.1661	0.0982	1						
att index	0.2219	-0.0854	0.1448	0.1548	-0.1396	0.1611	1					
ever_rented	0.3747	-0.1949	0.2963	0.0816	-0.1302	-0.0714	0.2836	1				
prop. farm income	0.1593	-0.0724	0.2664	0.0595	-0.0768	0.0536	0.0939	0.202	1			
prop. pasture	-0.0418	-0.2699	0.16	-0.0897	-0.0456	0.0542	0.1564	0.0139	-0.1759	1		
op diversity	-0.2298	0.0971	0.4853	0.3482	0.1908	0.257	0.0865	0.0265	0.0033	0.1453	1	
district	-0.0088	-0.056	0.0426	0.0615	-0.1789	-0.0694	0.0374	-0.1074	-0.0329	0.0755	0.2664	1

Contingent Valuation Module

Section B: Hypothetical Land Rental Opportunities

This section of the survey will help us understand the interest among Wisconsin cattle operators for different types of grazing opportunities. There are many acres of underutilized grasslands in various conditions across the state that may or may not be ideal for producers. For example, they may contain large quantities of woody vegetation. We are interested in learning what interest Wisconsin beef producers have in grazing this variety of underutilized grassland.

We will describe three **hypothetical rotational grazing opportunities**, and then ask how many acres you would be willing to rent under each. You may rent as many acres as you wish, or you may choose not to rent at all.

Please make sure to answer the first question for each opportunity. Depending on your response, you will be instructed on which question to answer next by following the text. You will likely be able to skip many of the questions in this section. Your responses to these questions will remain **confidential** and be used for research purposes only. They will not be provided to any private parties.

PROVIDED

- Electricity for paddock fencing
- A suitable water source (dug out ponds, above ground gravity tank/line system, or other tanks)

NOT PROVIDED

- Handling facilities
- Salt and mineral
- Personnel to help with cattle
- Liability insurance

GRAZING REQUIREMENTS

- Periods of rest to avoid disturbing bird nests. Each year a different paddock will be rested/not grazed until August 1, this will not total more than 20% of the entire pasture.
- **Rotational or short term grazing**
- No less than 4" residual

Grazing Opportunity #1 – Grass-dominated, 1 season

Pasture composition: Grass cover will range from 70-85%. The pasture is a cool-season, non-native, productive (~3 tons/acre) grassland being invaded by Queen Anne's lace, thistles, and other herbaceous and woody species.

Contract length: 1 grazing season

Failure to adhere to the Grazing Requirements on page 6 will mean a breach of contract and lead to contract termination and no future contracts granted.

Grazing Opportunity #2 – Shrub-dominated, 1 season
Pasture composition: Grass cover will range from 40-60%. This grassland is dominated by multiflora rose, buckthorn, willow, aspen, or other woody trees/shrubs. Production is 1-2 tons/acre and the grass cover is dominated by cool season grasses.

Contract length: 1 grazing season

Failure to adhere to the Grazing Requirements on page 6 will mean a breach of contract and lead to contract termination and no future contracts granted.

Please respond to the following questions as if you were offered a grazing contract as described in Grazing Opportunity #2. ***Remember, this contract contains Grazing Requirements.***

Attitude Questions

1. To what extent do you agree or disagree with the following statements? (Check **one** box per row)

	Strongly Agree	Agree	Neither Agree nor Disagree	Strongly Disagree
I know a lot about conservation in Wisconsin	☐	☐	☐	☐
I like seeing wildlife on my pasture	☐	☐	☐	☐
Wildlife is a problem for me on my land	☐	☐	☐	☐
It is important to me to keep the ground covered	☐	☐	☐	☐
I am willing to meet conservation goals (such as leaving more grass residual) as part of my grazing plan	☐	☐	☐	☐
I am interested in grazing public land	☐	☐	☐	☐
I am willing to work with a public agency, such as the Wisconsin Department of Natural Resources	☐	☐	☐	☐
I would be concerned about my family or friends' perceptions if I graze public land	☐	☐	☐	☐

Chapter Three: Rotational grazing on public grassland in Wisconsin through adaptive co-management

Greta Landis and Courtney Robinson

Abstract

The exploration of rotational grazing as a management tool in Wisconsin presents a case study for adaptive co-management (ACM) in agroecology research. In this chapter we describe how an interdisciplinary research team of graduate students and faculty from the University of Wisconsin-Madison (UW-Madison), land managers from the Wisconsin Department of Natural Resources (WDNR) and private grass-fed beef and dairy producers used ACM as a framework to investigate the opportunities and challenges of using rotational grazing as a management tool on Wisconsin public grasslands. We followed the three phases of ACM laid out by Olsson et al. (2004b) and Butler et al. (2015): 1) preparing the system for change, 2) seizing a window of opportunity, and 3) building social-ecological resilience of the new desired state. Here, we describe our process and findings from Phases One and Two as an example of ACM implementation and its value for resource management. From Phases One and Two four key takeaways for grazing public lands in Wisconsin emerged: 1) importance of contextual contract design, 2) opportunities for public land managers and graziers, 3) challenges for public land managers and graziers and suggested solutions, and 4) types of graziers most interested in public pasture rental, and impacts on land managers. We close the paper with suggestions for implementing Phase Three for rotational grazing on public grasslands in Wisconsin.

Grazing public lands as a complex management challenge

Rotational grazing partnerships between public land managers and private cattle producers offer the potential to maintain and improve public grasslands, while increasing the profitability of grass-fed beef and dairy. While constraints on public land management have allowed detrimental encroachment of woody and non-native plants on state grasslands, Wisconsin research has shown that rotational grazing can reduce woody species, enhance soil and water quality, and improve biodiversity (Alber 2014; Hedtcke et al. 2013; Oates et al. 2015; Paine and Ribic 2002; Taylor and Neary 2008; Harrington and Kathol 2009). Grazing has increased in popularity since the 1990s along with other alternative management strategies, but land access remains a significant barrier for beef and dairy operations, particularly for beginning farmers (Brock and Barham 2008; Merrill 2006). The possibility of private rotational grazing on public grasslands could present an exciting win-win opportunity for collaborative conservation, but the development of a public grazing program in Wisconsin will face multiple social and ecological challenges that may prevent successful implementation.

The Wisconsin Department of Resources (WDNR) and other state and federal agencies are responsible for maintaining thousands of acres of public grasslands across the state ('Wildlife Areas' 2016). WDNR managers oversee public lands including state wildlife, natural, and habitat restoration areas. A primary goal is to maintain the landscape for wildlife such as grassland songbirds and upland game birds. In contrast to the expansive rangelands of the American West, the grasslands and prairies of the Upper Midwest are more fragmented, smaller, more densely vegetated and require frequent disturbance to maintain an open, herbaceous plant community relatively free of encroaching woody vegetation and invasive species (E. Grossman and L. Kardash, personal communication, May 18, 2015).

Recent financial constraints are rapidly decreasing the available personnel and budgets available to the WDNR to implement labor-intensive disturbances such as controlled burning, herbicide applications, and mowing (E. Grossman and L. Kardash, personal communication, May 18, 2015). There is growing interest in using rotational grazing as a supplemental management tool and as a way to engage with agricultural communities. However, many land managers are cautious because of a history of overgrazing and land degradation in the west (Briske et al. 2011). Research on rotational grazing is typically context-specific, making it difficult to prescribe the practice as a tool on state wildlife areas that vary in size, soil type, terrain, vegetation, and wildlife use. Grassland management with rotational grazing presents what Briske et al. (2011) refer to as a 'complex adaptive system.' These systems require the integration of social and biophysical components and drivers to understand use, effects, and management direction.

Graziers also face unique challenges with grazing for land management. Rotational or management-intensive grazing (MIG) refers to grazing where only one portion of pasture is grazed at a time, allowing the remaining pasture to rest and regrow. Pastures are divided up into paddocks and livestock are rotated from one paddock to the next based on the growth stage of the forage (Undersander et al. 2002). Typically, paddocks are 1 to 2 hectares (ha) and stocking densities are 40 to 100 head ha^{-1}. Under certain circumstances smaller paddocks and/or higher stocking densities may be preferred, for example if mob grazing is being used (Paine et al. 1996). Often livestock are confined to each paddock for a period of 12 hours to two days and are rotated through paddocks on a 15-to-40-day, weather-dependent cycle (Undersander et al. 1991). This style of grazing contrasts with continuous grazing where animals are not rotated through paddocks and the pasture is not allowed to rest. There are general guidelines for rotational grazing in the Upper Midwest (e.g., Undersander et al. 1991), but each grazier's regime will vary based on their specific context. Biophysical and socio-economic variables such as management goals, cattle breeds, operation size, weather, personal values and market premiums for grass-fed products all affect grazing decisions (Lyon et al. 2011; 2010).

The intricacies of rotational grazing decisions paired with public land-specific grassland management constraints make for a complex challenge when trying to pair the two. Ensuring that the needs of both parties are met effectively is both a social and ecological challenge that requires collaboration, adaptation, and iterative learning. Adaptive collaborative management, also called adaptive co-management or ACM, offers a framework for resource management that facilitates such a process.

Adaptive Co-management Framework

Adaptive co-management (ACM) emerged in the late 1990s as a combination of co-management and adaptive management modes of resource governance to address the complexity and uncertainty of interdependent social-ecological systems (Bown et al. 2013; Olsson et al. 2010; Plummer et al. 2012). Plummer et al. (2012) describe adaptive co-management and its relationship with adaptive management and co-management nicely:

> *"Adaptive management focuses on learning-by-doing, takes place over the medium to long term through cycles of learning and adaptation, and concentrates on the relationships, requirements, and capacity of*

> *managers...Comanagment establishes vertical institutional links, tends to produce snapshots with short to medium timeframes, bridges local level and government level(s), and is concerned with the capacity of resource users and communities. Adaptive comanagment thus forges links (both horizontal and vertical) for shared learning-by-doing between various actors, over a medium to long time horizon. It is multi-scale in spatial scope and concerned with enhancing and including the capacity of all actors with a stake for sustainably managing the resource at hand."*

Systems such as forests, watersheds, or grasslands require adaptive and collaborative governance approaches; ACM is ideal because it utilizes the adaptation, iterative learning, and knowledge generation of adaptive management and the legitimacy, collaboration, power-sharing, and conflict resolution (via stakeholder participation) of co-management (Bown et al. 2013; Plummer et al. 2012; Butler et al. 2015). Beyond combining stakeholder participation and management adaptation, ACM takes a distinctly iterative and explicit learning-oriented approach to management. This is the foundation for active adaptive management wherein "policies become hypotheses, and management actions become the experiments to test those hypotheses" (Gunderson et al. 1995).

In their 2004b paper, Olsson et al. described three phases of an ACM implementation process: 1) preparing the system for change, 2) seizing a window of opportunity, and 3) building social-ecological resilience of the new desired state. Butler et al. (2015) provided robust descriptions of these phases with regard to the Moray Firth and seal-salmon fishery conflict in Scotland. An adapted version of the three phases along with examples from the Wisconsin grazing case study can be found in Table 16.

Additionally, from a thorough review of the ACM literature, we determined six key components of ACM that should be applied throughout each phase that contribute to successful implementation of alternative management practices (Armitage et al. 2007; Plummer et al. 2012; Armitage et al. 2009; Folke et al. 2005; Olsson et al. 2004a; Berkes and Folke 1998; Kendrick 2003 and others):

1. Shared vision, goal, and/or problem definition to provide a common focus among actors and interests; specificity with learning objectives, approaches, outcomes and risks
2. A high degree of repeated dialogue, interaction, and collaboration among multi-scaled actors; a commitment to open communication
3. Distributed or joint control across multiple levels, with shared responsibility for action and decision making
4. A degree of autonomy for different actors at multiple scales; recognition and reflection on how power influences the system
5. Commitment to the pluralistic generation and sharing of knowledge; social learning at different scales
6. A flexible and negotiated learning orientation with an inherent recognition of uncertainty; ongoing assessment and reflection.

1. Shared vision, goal, and/or problem definition to provide a common focus among actors and interests; specificity with learning objectives, approaches, outcomes and risks

A key feature of ACM is that it must be tailored to the context. Rather than a "cookie-cutter" approach to management, ACM requires the development of a shared vision, learning objectives, approaches and outcomes. A discussion of potential risks is also useful. ACM requires an intentional learning plan or strategy to understand and incorporate the socio-ecological feedback from each iteration. Since ACM combines several sources of information and knowledge, stakeholders must have an intentional and collaborative process of interpretation and sense-making (Weick 1995). The shared vision, goal or problem definition helps the group stay focused and maintain trust when co-managing information and knowledge among interest groups with different worldviews (Kendrick 2003).

2. A high degree of repeated dialogue, interaction, and collaboration among multi-scaled actors; a commitment to open communication

When actors feel they are heard and are collaborative partners in resource management, they are more likely to trust their partners. In contexts where actors are traditionally in opposition this is especially important. Most resources are contested by multiple stakeholders and even management institutions can be internally divided (Armitage et al. 2009). Competing interests and values in these circumstances are normal, leading to conflict and complex social relationships (Armitage et al. 2009). Therefore, taking the time to build trust through open communication and collaborative decision-making processes that involve all stakeholders equitably is critical for dealing with such conflict (Butler et al. 2015). Armitage et al. (2009) find that repeated interactions among stakeholder groups and individuals and a commitment to open communication typically increase trust.

3. Distributed or joint control across multiple levels, with shared responsibility for action and decision-making

The adaptive governance framework is operationalized through adaptive co-management whereby the dynamic learning characteristic of adaptive management is combined with the multilevel linkage characteristic of co-management (Folker et al. 2005). The sharing of management power and responsibility may involve multiple and often polycentric institutional and organizational linkages among user groups or communities, government agencies, and nongovernmental organizations (cross-level interactions) (Folke et al. 2005). Adaptive co-management relies on the collaboration of a diverse set of stakeholders, operating at different levels through social networks. This aspect emphasizes the role of multilevel social networks to generate and transfer knowledge and develop social capital as well as legal, political, and financial support to ecosystem management initiatives (Folke et al. 2005).

4. A degree of autonomy for different actors at multiple scales; recognition and reflection on how power influences the system

Exploring the role of power is an important part of any ACM process, and is partially what sets ACM apart from other management approaches. Conventional natural resource management is often adversarial, with stakeholder groups pitted against one another rather than working together (Armitage et al. 2009). Therefore, recognizing and addressing how power influences a resource management system requires trust-building, conflict resolution and social learning (Armitage et al. 2009). This may start with developing a group understanding of the social, economic and other sources of power which influence regulatory bodies and society more widely (Armitage et al. 2009).

5. Commitment to the pluralistic generation and sharing of knowledge; social learning at different scales

Ecosystem management is an information-intensive endeavor that requires knowledge of complex socio-ecological interactions in order to monitor, interpret, and respond to ecosystem feedback at multiple scales (Folke et al. 2003). In this situation, information from all aspects of the system (social *and* ecological) is critical for a robust interpretation of and reflection on each management iteration. This requires careful attention to how learning is defined and conceptualized by all stakeholders. In a multidisciplinary or multi-scaled team of actors, there are likely stakeholders from diverse backgrounds and disciplines that are used to a specific type of language. Taking the time up-front to co-define knowledge and learning will help the team function better and allow for more successful learning.

Different scales of social learning could refer to geographical or hierarchical scales within or between organizations or institutions. Pluralistic generation and sharing of knowledge requires a bridging of knowledge from stakeholders at different scales and in different disciplines or institutions. To reach sustainable outcomes, we must build knowledge in the social dimension of resource management as well as resource and ecosystem dynamics (Folke et al. 2005). Some scholars have pointed out that linking different levels and systems of knowledge requires an active role of individuals and organizations. For example, the role of non-governmental organizations as coordinators and facilitators in co-management processes (Halls et al. 2005; Olsson et al. 2007). Sometimes these coordinating bodies are referred to as "bridging organizations" (e.g., Olsson et al. 2007).

6. A flexible and negotiated learning orientation with an inherent recognition of uncertainty; ongoing assessment and reflection

The iterative, learning-oriented nature of ACM allows for a continually improved fit between management approach, and ecological and social success. As management techniques are tried, the results are examined, learned from and incorporated into a new iteration of management. Armitage et al. (2009) explain that ACM involves more than individual learning; it entails scaling up individual learning outcomes to various social levels. This leads to a common sense of purpose with the learning, and ultimately building the capability to identify, explain and facilitate effective cross-scale institutional arrangements (Armitage et al. 2009). This explains why ACM processes are slow to develop, or will fail to develop at all, without policy environments that are supportive of multi-level learning (Armitage et al. 2009). Ostrom (2005) explains that all policies must be viewed as ongoing learning experiments that need to be monitored, evaluated and adapted over time. Further, Folke et al. (2005) explain that the challenges with managing a socio-ecological system are accepting uncertainty, being prepared for change and surprise, and enhancing the adaptive capacity of the system to deal with disturbance. They argue that non-resilient social-ecological systems are vulnerable to external change, whereas a resilient system may make use of disturbances as opportunities to transform into more desired states (Folke et al. 2005).

Understanding grazing on public lands in Wisconsin: An ACM case study

The grazing research project discussed here was initiated in the autumn of 2014 with the award of a five-year USDA-NIFA Hatch grant to a UW-Madison agroecology research group. The grant, titled, 'Understanding the opportunities and challenges of grazing public land in Wisconsin' was proposed with the intent of (1) exploring solutions for both public grassland management and land access issues for private livestock producers, and (2) further developing understanding of the ecological and socioeconomic impacts of rotational grazing in the Upper Midwest. Improved understanding of rotational grazing and its subsequent effect on plant communities, soil properties, and the potential socioeconomic pitfalls and opportunities of public-private grazing partnerships could provide critical insights for grassland conservation, producer profitability, and many ecosystem services.

The core UW-Madison research group included four faculty members, four graduate students, one project coordinator, and two additional graduate students who joined the research group in the spring of 2016. Though the research group had an agroecology focus, the faculty and students brought expertise from agronomy, wildlife ecology, environmental resource management, natural resource policy, and agricultural economics for an interdisciplinary approach to grazing and land management research. The agroecology emphasis of the research group and the public-private scope of the proposal necessitated a collaborative approach between public land managers, private graziers, and other groups to investigate the questions around grazing on public lands. As such, building partnerships with different individuals and organizations was key to the goals of building grassland and grazing knowledge, and developing practices to manage, support, and respond to grassland resources. We realized part-way through year two of the project that our work fit nicely into the ACM framework, and that ACM could guide the remaining years of the project. The sections below outline how our project has already followed an ACM framework and suggestions for how we can utilize ACM in the remaining years.

In the first year of information-gathering for the project, and the second year of implementing pilot grazing projects and graduate research, the university research team acted as a 'bridging organization' between local graziers, grazing specialists, land managers and administrators with the WDNR, and other organizations (Olsson et al. 2007; Olsson et al. 2004b). Over this first year of research, the university team attended meetings and workshops collecting data on interests and issues already part of the dialogue around grazing as a land management tool. In this 'bridging organization' role, as described by Olsson et al. (2007), the team worked to catalyze and facilitate the discussion around grazing management wherever possible. Two events—a grazing network annual conference and a workshop on grazing for WDNR land managers—were particularly critical in developing research questions and building partnerships for the grazing project in the first year, while other events emerged according to an ACM framework in the following years. We will discuss the information-gathering activities and events that lead to the development of five pilot grazing management partnerships, and takeaways from the pilot partnerships after their first year of implementation.

While the information-gathering process and the implementation of pilot projects were guided by six key features of ACM, the evolution of the research partnerships and graduate thesis projects also matched the three phases of ACM implementation identified by Olsson et al. (2004b) and further developed by Butler et al. (2015). These phases are described with the corresponding events from the Wisconsin grazing research partnership in Table 16. Here, we outline events as they developed throughout the first two phases of ACM, and propose key findings for the eventual launch of Phase 3 for grazing management practices in Wisconsin. Figure 1 and Figure 2 show the phases of ACM over time and how the grazing project parallels the timeline.

Phase 1: Preparing the System for Change

In the first phase, 'preparing the system for change,' bridging organizations or actors "build ecological knowledge of the problem, develop bridging social networks between stakeholders from different levels, and provide a vision and goal for an alternative pathway" (Butler et al. 2015; Olsson et al. 2004b). In the Wisconsin grazing context, this phase was triggered by the encroachment of woody species on Wisconsin's public grasslands, and the challenges public land managers faced in controlling the encroachment. Constrained land managers sought alternative management methods and became interested in the potential win-win opportunity of using rotational grazing for land management (see letter of support provided separately). At the same time researchers from UW-Madison were awarded a USDA-NIFA Hatch grant to conduct research on the social and ecological opportunities and challenges to rotational grazing on public lands. The grant proposal was produced as a result of stakeholder input and researcher interest. Together, the WDNR and UW-Madison researchers sought to build ecological knowledge of the problem and the use of grazing as a solution through an information-gathering phase that included stakeholders meetings, survey of cattle producers, producer focus group, and visits to public land sites with grazing potential. Table 17 summarizes how the data from each part of the information-gathering phase were used to inform Phase Two, while the detailed methods and findings from each are provided in the sections below.

Meetings with Stakeholders

Three key stakeholder meetings took place during the information-gathering phase: a high-level planning meeting with key stakeholders, a larger WDNR land manager meeting, and a poster session at GrassWorks grazing conference.

1. Key stakeholder meeting - October 23, 2014 - WDNR, grazing specialists and UW-Madison

The UW-Madison research team met with WDNR wildlife staff and grazing specialists to develop a shared vision, goal and problem definition for rotational grazing and grassland management. Twelve individuals attended the meeting: two grazing specialists, two WDNR wildlife managers, and eight representatives from the UW-Madison research team. During the meeting the UW-Madison research team introduced the project scope and potential for collaboration and facilitated activities to develop possible research questions, and to generate a prioritized list of bio-physical and logistical factors in site selection. They also facilitated the generation of a list of potential land manager participants from the WDNR. In addition, the WDNR representatives discussed policy and process considerations for research on public lands with an emphasis on process and timing. Grazing specialists provided an initial discussion of factors that might influence participation by graziers and producers.

The research questions that emerged from the group activity were mostly focused on comparing the impacts of multiple types of grazing, comparing the impacts of rotational grazing with other kinds of land management, biophysical and biological impacts from rotational grazing, forage quality measurements, how to involve the public, tensions and/or lack of trust between producers and WDNR land managers, logistics, and cost-benefit analyses. These themes were used to develop graduate student research questions and projects, and ultimately will be answered in Phase Two.

There were nine main categories for site selection that were brought up during the second group activity: infrastructure, variable biophysical traits across sites, proximity to graziers, DNR acceptance, public users, size of site, research capacity, land managers, and ecological sensitivity of the site. A more detailed list is presented in Appendix 1. This information was used by the UW-Madison research team to select viable sites for the grazing trials in Phase Two.

2. WDNR land manager meeting - March 2, 2015 - Viroqua, WI

The WDNR held a meeting on March 2, 2015 on using grazing as a land management tool. The meeting took place in Viroqua, Wisconsin and was attended by WDNR ecologists, biologists, technicians, limited term employees, and administrators, grazing specialists, Minnesota Department of Natural Resources representatives, and UW researchers. During the meeting the UW-Madison research team gave a short presentation on grazing public land. As part of the presentation we collected real-time anonymous input on land manager interest in using grazing as a land management tool through audience response technology with clickers. Clickers were distributed to the audience and attendees were asked to answer multiple choice questions about their interest in using grazing for land management, their concerns, where they would apply grazing, and vegetation and wildlife management goals that would show up on the PowerPoint presentation as real-time frequency tables. In addition, we collected data through an anonymous questionnaire following the presentation.

This meeting was an important initial data source on the opinions of land managers on using grazing as a land management tool. Twenty-six individuals at the meeting provided data on a variety of topics regarding grazing as a land management tool. Fifty-eight percent of respondents had prior experience with grazing either from growing up in a farming family or using grazing for land management in Wisconsin or elsewhere. Attendees listed experience with both goats and cattle for land management. Ninety-three percent of attendees said they were interested in using grazing as a habitat management tool. The WDNR professionals said they would apply grazing to cool-season or warm-season grass- dominated lands, restored prairies, native remnant prairies, woodlands, savannas, and wetlands. The main vegetation management goals of attendees were woody plant suppression, weed/invasive plant suppression, and to promote greater species diversity. Attendees also voted on their top wildlife habitat goals that they hope grazing will help them with; the top choices were promoting habitat for upland game birds, grassland birds, threatened and endangered species, and non-game animals.

In addition to the interactive voting, questionnaires following the presentation provided further information on the opportunities and challenges to using grazing as a land management tool. The most frequently cited opportunities included using grazing to control invasive species, manage grasslands with heavy brush and woody species control, and to save money. All responses can be seen in Figure 7 in Appendix 2.

Despite seeing potential for using grazing for land management, attendees also voiced concerns. Foremost among these were associated with infrastructure, such as fencing and water supply, and in particular how to fund fence installation. Another key concern focused on finding experienced graziers who would be willing to adhere to restrictions such as residual height, timing, and access to sensitive areas. Lastly, attendees were unsure as to how to access informational resources (such as grazing specialists) that could help write contracts and implement grazing. Figure 8 in Appendix 2 shows a full list of these concerns.

3. GrassWorks Grazing Conference 2015

To begin the information gathering process among producers, members of the university research team attended the GrassWorks Grazing conference in January 2015. Regional grazing networks are a key system for farmer education and support in Wisconsin (Paine et al. 2002). The research team presented a poster and initiated informal discussions about three different vegetation scenarios and five variables (available acreage, distance to travel, duration of grazing period, herd size, and cost per acre) for decision-making to rent public land for conservation grazing partnerships. The scenarios presented for discussion were a cool-season grass dominated site, a shrub and cool-season grass-dominated site, and a weedy mixed warm-and cool-season grasses site. During the presentation period the researchers facilitated discussion and collected 37 written comment-cards on these variables and additional ideas and concerns related to grazing public lands. The poster was also displayed unattended for the final day of the conference, and accumulated some additional anonymous written feedback during that time. The conference was attended by over 350 attendees including graziers, researchers, education and outreach specialists, and agricultural business partners from Wisconsin and the Upper Midwest ('Grazing Conference' 2016).

These discussions provided strong evidence of the importance of trade-offs for graziers in making grazing partnerships feasible and economically viable. Graziers demonstrated a systems approach to the decision-making variables presented, where changes in one variable would result in related changes in their decision-making for other variables. For instance, with an increase in the cost of pasture rental, graziers expressed expectations for higher quality forage or longer grazing periods. This theme of flexibility continued throughout the poster presentation and discussion. Graziers were willing to travel between ten and fifty miles, wanted to graze herds as small as ten animal units and as large as 200. The additional comments were focused around themes of logistical issues, such as liability and ownership of equipment, and potential risks to animals such as predators or public land users. There were numerous questions surrounding infrastructure on public land—permanent perimeter fencing, portable electric fencing, water sources, and road access—and who would fund, install, and maintain it.

Statewide survey of cattle producers

In 2016, we conducted a mail survey of non-dairy cattle producers across Wisconsin. The selection process followed a stratified design based on herd size and whether a producer said they practiced rotational or management-intensive grazing on the 2012 U.S. Census of Agriculture. Farmer selection relied on a confidential list frame managed by the National Agricultural Statistics Service (NASS). The final sample consisted of 1,172 farmers and the surveys were mailed using a modified Dillman method of two mailings (Dillman et al. 2014). Returned surveys from 142 active beef producers were used in analysis for an effective response rate of 12% after removing ineligible returns.

The survey had four sections: (1) cattle operation information; (2) contingent valuation module; (3) perceptions of benefits and barriers to renting public land; and (4) demographics. The survey, and especially the contingent valuation module, is described in Chapter Two. The survey results have been divided into three sections: Perceptions of benefits and barriers to renting public land, Contingent valuation module, and Producer intentions.

Perceptions of benefits and barriers to renting public land

The perceptions and barriers to renting public land section contained three questions on the most important concerns the respondent has when considering renting public land in particular, the most important opportunities they consider when thinking about renting public land, and eight attitudinal questions related to conservation preferences and feelings toward government (see full questionnaire in attached supplementary material). Producers are primarily excited about the potential closeness of public land to their farm (Figure 3). The next most popular first choice was “none of the above.” While popular, only 16% of the respondents who voted for this answer also agreed to rent public land in the grass-dominant hypothetical scenario. This is in comparison to answers like “access to additional pasture” and “grazing with a conservation focus” which had 50% and 40% enrollment rates respectively. Therefore, the popularity of “none of the above” may be a reflection of lack of interest in renting public land by many survey respondents.

Figure 4 shows the distribution of primary challenges identified by survey respondents. Producers are primarily concerned with liability issues, forage quality and quantity, and the distance of the land from their farm, or nothing is of primary concern (i.e. “None of the above”). Figure 5 displays producer attitudes toward conservation and public land. Respondents had largely positive conservation attitudes, however only a minority was willing to work with a public agent or graze public land. About half of the respondents were not interested in grazing public land.

Contingent Valuation Results

To briefly reiterate my results from Chapter Two, econometric analysis of responses to the contingent valuation module in the Grazing Public Lands survey showed that producers with a greater number of animal units in their operation, who are younger, and who have less diverse operations (fewer different types of cattle) are more likely to be interested in renting grass-dominated public land. Producers who have more positive attitudes toward conservation and working with government and who have a lower proportion of pasture to farmland owned are more likely to be interested in renting shrub-dominated public land.

Producer Intentions

In total, 33% of respondents to the hypothetical survey module agreed to rent for both the grass-dominated and shrub-dominated scenarios (n=135 and n=105 respectively), signaling interest by the producer community in grazing public land. Debriefing questions asked respondents to specify how many acres they would rent, what class of animal they would put on the pasture, the maximum distance they would travel to graze their cattle under the grazing opportunity, and if they would still rent at the agreed price if they had to provide interior and perimeter fencing. These debriefing questions were asked once per grazing contract scenario conditional on enrollment and tied to the offer price at which the respondent first agreed to enroll.

Table 25 in Appendix 3 shows the range of acres that survey respondents would want to rent at various prices, as well as the classes of animal they would put on the pasture and the range of maximum distance they would be willing to travel. For the most part, producers are willing to rent less than 40 and up to 640+ acres at all survey offer prices. They are also overwhelmingly interested in grazing dry beef cows and cow-calf pairs, finish animals and young stock on grass-dominant pastures; they are interested in dry beef cows, cow-calf pairs and young stock on shrubland. The maximum distances producers are willing to travel range from 20-75 miles and do not seem to be correlated with price. Table 26 in Appendix 3 shows the percent of survey respondents who were still willing to rent public land if they had to provide fences (the initial contracts had the public land agency providing the perimeter fences). For the most part, producers are still willing to rent even if they must provide fences. These percentages are likely to be higher if the contract is for a longer term, such as three, five or seven years.

Producer Focus Group

A focus group of cattle producers was held on October 15, 2016 in Seneca, Wisconsin to unpack some of the Grazing Public Lands survey results and to collect qualitative data on producer interest in grazing public lands in Wisconsin. There were nine focus group participants with a variety of operation types, all from the southwest part of Wisconsin where grazing is more common (Table 18; additional descriptive data are in Appendix 4). The focus group lasted for two hours during which participants responded to a variety of questions on renting pasture generally, and renting public land specifically. See Appendix 4 for a full list of questions.

The focus group results provided further evidence that producers are interested and willing to make tradeoffs based on the specific context. When thinking generally about renting land (public or private) participants consider infrastructure, forage quality, distance of the land from their farm, whether someone can help keep an eye on the cattle, and their operation's needs. All of these variables are flexible however, depending on the situation. These tradeoffs are described in more detail in Section VII of this paper.

When deciding how many acres to rent, participants said they consider how many animals would make it worth it to go and check on them, what their financial constraints are, whether they would be able to control the entire area, and the quality of pasture. There was a lot of discussion around preferring to control an entire pasture versus sharing it with another grazier, leading to a willingness to pay more in order not to share. They also mentioned that they almost always base the decision on the cattle they already have;

Only in rare market circumstances are producers willing to buy more cattle to fill a large area of land. When deciding what class of cow to put on the pasture, producers will put their best cows on the best pasture available, which is often their home pasture. Additionally if it is a dairy operation, dairy cows will be kept close to home while dry cows, heifers, or cow/calf pairs may be kept on a rented pasture. Producers also consider what types of cows are on a neighboring pasture when deciding which class of animals to put on rented land.

The focus group participants had largely positive or neutral feelings about the idea of using rotational grazing as a land management tool on public land. There was agreement that the land manager will need to have a clear idea of their management goals and how they want to integrate grazing on the land. This may include aesthetic goals in addition to management goals. Participants also made it clear that the contract would need to meet their own economic goals and that they would not do conservation grazing altruistically. There were concerns about infrastructure (fencing, water access, and handling facilities), but most participants said they would be willing to work with most situations, including working with a public land manager and spending time educating/collaborating with them, as long as the contract still made economic sense. One of the focus group participants explained that they found the idea of working with a public agency interesting and challenging, and as an opportunity to help change people's attitudes toward livestock and grazing. There was also a general sentiment that contracts for rotationally grazing public land should have clear specifications and penalties for non-compliance to help ensure the right producers are interested.

Participants provided further insight into concerns about liability and public access to the land. Some potential liability issues mentioned included being near an interstate highway or other busy road (e.g. a car crashes into the perimeter fence and cattle flow out onto the highway), having a bull on the pasture, public land users accidentally leaving gates open, or people petting or picking up calves. The group mentioned a few possible solutions to mitigate these issues: taking out renter's insurance, clear and detailed signage, and self-closing gates.

Finally, when asked what advice they would give the director of a public grazing program in Wisconsin, participants said they would recommend contracts with restrictions to help ensure appropriate graziers are on the land. They also felt that there would need to be incentives for graziers to make them interested in the opportunity. Similarly, they suggested that there be flexibility in the grazing contract or flexibility within the grazing program to allow for contextual contracts that meet everyone's needs.

Throughout Phase One, UW-Madison researchers acted as a bridging organization to facilitate the compilation of ecological and socio-ecological knowledge of the use of rotational grazing as a land management solution through multiple methods. The data collected was then used directly to inform Phase Two, or was used to build context for the eventual implementation of Phase Three. Table 19 shows this in detail.

Visits to public land sites with grazing potential

Site visits were conducted with 20 land managers (18 WDNR, 2 U.S. Fish and Wildlife Service) at 13 state-owned properties between May and July of 2015, with 35 sites between them proposed for grazing management (Figure 6). The intention of the site visits was to collect biophysical data on public sites with grazing potential, and to collect qualitative data on land manager interests and concerns with grazing as a land management tool (Table 19). Biophysical data were collected on indicators developed from the initial stakeholder meeting (October 2014 meeting). Land managers were interviewed during site visits using a conversational interview guide, and the interview questions were informed by land manager interests and grazier concerns identified at the previous meetings (e.g., Viroqua and GrassWorks) (Quinn Patton 2002).

Discussion focused around the biophysical attributes, land management history and management goals that would make the sites most viable for grazing partnerships and research. Conversing with land managers in person and physically walking the sites instead of looking at listed information encouraged dialogue around biophysical observations and logistical questions about the specific feasibility of rotational grazing management. The site information, land history, and land management goals were compiled by the research team and brought to the WDNR to collectively select sites for pilot grazing projects and monitoring by the research team.

In addition to the biophysical site information, the land managers presented a number of site-specific questions, concerns, and goals related to their experiences and the specific features of the properties they managed. While land managers were interested in grazing management for a variety of reasons, a lack of generalizable research and information about site-specific problems made land managers cautious as well. For example, land managers were concerned about finding an experienced grazier who would be willing to cooperate with site-specific conservation goals and participate in knowledge exchange. Land managers also felt uncertain about the upfront investment in equipment and infrastructure such as permanent exterior fencing and water tanks. Though land managers wanted to maintain ownership of the equipment to make the partnership more attractive to potential graziers, there were a number of limitations on the time and personnel required to purchase and install it. In addition, land managers were wary of potential negative reactions from public land users such as hunters and bird-watchers, and wanted to install infrastructure that would permit those activities.

Land managers expressed interest and optimism in the opportunities around grazing as a land management tool. As with the Viroqua meeting, many sites were situated in areas that made them difficult to mow or burn to maintain grassland bird habitat, so grazing cattle offered a potentially more versatile tool for managing shrub encroachment and invasive species. In general, the lands proposed were low quality in diversity and habitat, so grazing offered a way to actively manage property while allowing WDNR personnel to focus on other work. Finally, a few land managers considered rotationally grazing private cattle on the landscape as a way to engage with and build relationships with the agricultural community.

Phase 2: The Window of Opportunity

In this phase, the actors begin to implement their alternative management ideas and continually monitor and respond to both successes and problems. In the Wisconsin grazing project, the research team, graziers, and public land managers began working collaboratively to implement grazing trials on the ground and monitor their biophysical and socio-economic impacts. This phase of ACM was implemented through graduate research projects, the initiation of five grazing partnerships through pilot projects, and a number of pasture walks and workshops related to the pilot projects. The installation of infrastructure and introduction of cattle drew on efforts and knowledge from the land managers and graziers and input from the research team and grazing specialists. Two significant themes of ACM emerged from the interviews and are reflections from the first year: 1) ongoing adaption to trade-offs and trial-and-error in grazing management; 2) potential for social change on the project and in the broader community through communication and knowledge exchange. This section details the development of the pilot grazing projects and graduate research, including trade-offs and trial-and-error, communication and decision-making, and knowledge exchange and social change. Additionally, the section details the pasture walks and workshops that were a component of Phase Two.

Development of pilot grazing projects and graduate research

The transition from Phase One of ACM into Phase Two came with the selection of several sites for pilot grazing projects and graduate research on the ground during the 2016 growing season. Five sites from the original 35 visited in 2015 were selected collaboratively by the WDNR and UW. To help with site selection, the UW research team shared biophysical and management information on potential sites, such as their range of plant community composition and shrub encroachment, and their geographic distribution around the state. Ultimately, the initiation and continuation of grazing partnerships was largely dictated by land manager interest and enthusiasm for the projects and the likelihood of finding a local grazier to participate. All were selected as pilot projects for their potential for habitat improvement under grazing management, with the aim of reducing woody shrubs and invasive species and encouraging plant community diversity and grassland bird habitat.

With the aim of generating immediately utilizable ecological knowledge, the graduate research projects at each pilot location were directly informed by the interests and priorities identified by land managers and graziers during Phase 1. Students developed on-site trials at three sites to compare grazing in combination with other grassland management practices such as mowing and herbicide application, and monitored plant community composition and soil conditions at all five sites. Students also surveyed grassland birds under different grazing treatments and monitored invertebrate communities. Additional graduate research projects generated plans for program evaluation to assess the successes and problems of the overall five-year project. Research is ongoing and the majority of site-specific findings will not be discussed here.

The main methods used to generate the following results in Phase Two are observations from the grazing trials in five locations, follow-up interviews with the grazing trial actors (part of ongoing program evaluation), and meetings and information-sharing sessions. The follow-up interviews and site visits were conducted near the end of the first grazing season in August of 2016 at each of the 5 sites with a total of 9 land managers and 4 graziers. The interviews focused on reflections on the first season of grazing projects, current observations of the vegetation and wildlife, and goals and plans for future years of grazing. The analysis was guided by grounded theory (Chamaz 2000; Corbin and Strauss 1998) and its application in the work of previous agroecology research groups (Lyon et al. 2011; 2010). Notes were read after each interview, and the topics of discussion were adjusted and refocused based on the previous interviews. Identifying information has been removed for participants' privacy.

Trade-offs and trial-and-error in pilot projects

Implementing the five pilot projects entailed negotiating a number of trade-offs to establish fair grazing partnerships between land managers and graziers. With agency funding, the WDNR purchased and installed infrastructure including permanent fencing and water tanks, gates, portable interior electric fencing, and improved loading and access areas at 4 out of 5 pilot sites. Land managers explained that this ownership arrangement offered the WDNR power to remove a grazier from the property if there were problems achieving their conservation goals, and simultaneously meant the graziers had fewer upfront financial barriers to grazing public land. In the instance where the grazier installed his own permanent fence, a ten-year grazing contract compensated the upfront cost and labor, while the other graziers had year-to-year or 5-year contracts. At the end of the first season, several land managers explained they planned to reuse equipment such as moveable water tanks for future grazing projects. Though delays in fencing installation, electrical issues with interior fencing, and malfunctions with pumps and water tanks were the primary frustrations in the first season, initial concerns about WDNR investment of time and personnel for the startup and installation of grazing projects diminished by the end of the first season.

Grazing specialists brokered partnerships between the WDNR and graziers who had appropriate animals for the available forage on their sites. A site dominated by reed canarygrass and other cool-season grasses was grazed by dairy heifers, while highland cattle were grazed on the site with the highest shrub density. Two beef cattle herds were grazed on sites with mixed warm and cool season grasses and patches of low to medium shrub density. One particularly passionate grazier was working to train his herd to eat weedy and undesirable species such as thistles and ragweed. Matching cattle breeds to sites with appropriate forage quality was a factor listed as important to keep graziers satisfied with the health of their herds and land managers meeting their conservation goals.

Four of the five graziers of the pilot projects lived within 10 miles of their grazing site, close enough for frequent rotations and monitoring cattle health and vegetation heights during grazing. One grazier traveled over an hour to graze cattle, but noted he was an exception because of his commitment to the learning exchange and no rental fee in his contract.

At the end of the first season, land managers could compare rotational grazing to other grassland management techniques with much more detail and depth. The versatility of rotational grazing was brought up numerous times. Land managers felt that when implemented appropriately, it was more responsive, precise and adaptable than mowing, less labor intensive and more lasting than herbicide, and more flexible in timing than controlled burning. Trade-offs between cost and control over conservation objectives became particularly evident during these conversations, as well as the desire for cost-effective management that could be easily controlled and adapted. Land managers noted the high start-up costs of rotational grazing in equipment, infrastructure, and planning, but were quick to discuss its cost-saving benefits after the initial investment. The clarification that it wasn't 'money-making' but 'money-saving' was a frequent area of emphasis, that grazing is active management that can relieve agency personnel and labor. Land managers noted that with recent staffing issues and turnover, using grazing to supplement mowing, herbicide applications, and controlled burns offered substantial relief in workload for staff. Though land managers at 3 of the 5 pilot projects still cited a lack of knowledge and experience as a potential challenge going forward, they expressed more confidence in maintaining control of their conservation goals working with a grazier they trusted.

Communication and decision-making

Land managers and producers in the state have varying experience levels with rotational grazing. As such, flexibility and communication are critical for successful grazing partnerships. In the early stages of the pilot project most land managers prioritized working with an experienced grazier with good observation skills to manage wildlife goals. In cases where the land managers had some experience with grazing they were more open to working with producers who were inexperienced with rotational grazing. In situations where land managers had little-to-no grazing experience, graziers, grazing specialists, and university research team had more influence in the implementation of grazing projects.

While land managers and graziers noted that interest in grazing public lands was not overwhelming among graziers in their community, they did acknowledge an increase in questions and interest during the first season related to the partnerships. Arguably, the key unifying features between graziers and the successes in the five grazing projects were not their experiences with rotational grazing, ages, rental history, or their interest in conservation, rather their commitment to the health of their cattle and interest in making the partnership successful and profitable.

Though aware of the risks and challenges, the graziers participating in the pilot projects had few concerns about the startup challenges of grazing public lands. One commented that the project had not been a high priority for him that summer, while another noted that his herd was no worse off on public pasture than at home. The risks and challenges they did bring up surrounded the topic of cattle health, citing issues with flies, potential illness, predators such as wolves, or insufficient shade and poor weight gains. However, all deemed their cattle health and body condition acceptable and none had serious concerns about predators or negative interactions with the public.

Even with these positive experiences from the first year and a desire to engage the community and demonstrate active management on otherwise ‘wasted’ or ‘idle’ grasslands, land managers continued to express significant caution. While the grazing specialists assisting the project prescribed conservative stocking densities for the first year to avoid overgrazing, many of the land managers felt significant pressure from their agencies and stakeholders to be successful. One land manager explained that for every 30 successful projects, only one would reach the public, but that one bad example could shut a project down; s/he also noted that in the process of engaging the agricultural community they could not forget their stakeholders among hunters and other public land users. Similarly, another land manager noted that grassland habitat is not typically prioritized in the same way that forests and wetlands are in the state, and that a shift in cultural consciousness might be necessary to see support for grazing.

Knowledge exchange and social change in pilot projects

The potential of grazing partnerships as a social opportunity gained substantial emphasis by land managers and graziers over the course of the first grazing season. Good interpersonal relationships were important in the first year of the pilot project, particularly regarding knowledge exchange between farmers and land managers. Close communication was key for monitoring, adapting to changes, and keeping up to date on observations as well as activities of the graduate research projects. Both land managers and graziers discussed the importance of knowledge exchange and communication with the broader community through press releases, posting informational signs at the grazing site, or answering questions from friends and neighbors. There were assumptions that the public’s immediate reaction would be one of distrust or indifference about cows and conservation, but believed that with patient explanations and good ecological results the project partnerships could change perceptions of both the WDNR and farming community in a positive way.

Land managers, particularly in more rural counties, expressed the potential for their partnership with local graziers to change public perceptions of the WDNR. Frequently, land managers referenced the possibility of graziers as spokespeople for the WDNR, representing them as an active, innovative part of the community by initiating partnerships in conservation. One land manager noted that in general, the agricultural community doesn't have the same kind of buy-in that hunters do for conservation, whose purchase of tags fund numerous conservation projects; bringing graziers onto wildlife areas was a way to involve them more directly in stewardship. Graziers recounted questions they fielded from neighbors and friends about their activities throughout the first season, even noting that the conservation partnership had even become a business feature and a selling point for his products in local markets.

Pasture walks and workshops

To discuss, share, and compare experiences between these five pilot projects, a number of events were held before and during this first season. The graduate students and research team attended the 2016 GrassWorks Grazing conference to give a presentation on project progress, solicit feedback, and organized a panel discussion with one grazier and two land managers from different agencies to discuss their experiences with grazing management. Graziers expressed interest in the structure of grazing contracts, forage quality and availability as well as in the social implications of grazing, what interactions with the public were like and what kind of outreach or education was conducted. This venue provided the research team with opportunity to gain feedback from a broader community of graziers, and the discussion reinforced the themes of trade-offs, communication, and decision-making already in play in planning of the pilot projects.

Additionally, monthly conference calls organized by the WDNR administrators between land managers, researchers, and grazing specialists invited partners to provide updates and ask one another questions throughout the season. Two August pasture walks gave partners a chance to give small presentations and engage in dialogue prompted by the biophysical changes occurring on the landscape under grazing management. Each pasture walk hosted about 20 people, with one attended largely by graziers and one attended largely by land managers. Because of the contextual problems and opportunities with biophysical and socioeconomic features of each pilot project, pasture walks offered a venue for land managers, researchers, and graduate students to see different solutions in action and report back on lessons-learned during the first season. Discussion ranged from the broad, statewide goals of grazing as a management tool to small-scale, project-specific problems and benefits. Topics included the potential benefits of grazing for wildlife, watershed improvements, economic relief for the WDNR, and social engagement community, as well as anecdotal information about interactions with the public, reduction of specific weedy species, and problem solving around infrastructure issues. Land managers in particular spoke highly of the pasture walks as an opportunity to ask detailed questions and get feedback from others, building the discussion around the future and sustainability of the grazing projects. These findings and the takeaways from events in Phase 2 are summarized in Table 20, and their integration of key features of ACM are described in Table 21.

Takeaways for grazing public land in Wisconsin

Phase three, 'building resilience of the desired state,' or in this case, building the sustainability of grazing as a land management tool in Wisconsin, will be highly dependent on activities and lessons learned in Phases One and Two. While Phase Three of ACM for grazing public lands will likely be initiated after the end the Hatch-funded research projects, there are a number of key takeaways that will be critical to the future of grazing as a land management tool structured by ACM. It is clear that both parties are interested in the possibility of grazing public lands; However, the motivations for participating in such a program are different for both groups. Graziers are mainly motivated by economics. They are willing to work with a variety of contract parameters as long as they are making a profit. Land managers are primarily driven by the desire to manage grassland more efficiently and more economically, while prioritizing habitat management for key grassland species. While these groups have different motivations, they are not necessarily in opposition. Ultimately, the success of any public grazing program will require an understanding of key tradeoffs and collaborative problem solving. This section of the paper highlights four key takeaways from our research results to be considered when implementing a grazing program on public land: Contextual contract design, opportunities, challenges/concerns and suggested solutions, and types of interested graziers. These four takeaways and our suggested considerations and practices are summarized in Table 22.

1. Contextual contract design

From the results of the Grazing Public Lands survey and focus group, it is clear that producers in Wisconsin are interested in grazing public land as long as it is economical for them. They are willing to deal with grazing restrictions, short contract terms, cooperation with and time teaching a land manager, low quality forage, long travel distances and more, as long as it is still economical. This is crucial information for a land manager or public land agency looking to implement grazing on public land because it suggests that contracts can be tailored to address these tradeoffs. A higher rental price requires higher quality forage, longer contract length, shorter distance for the grazier to travel, fewer infrastructure installation requirements, and/or less time spent teaching a land manager. Alternatively, a lower rental price will allow producers to be willing to graze their animals on lower-quality forage, for a shorter contract length, farther away, and they will be more willing to install infrastructure like fences (Table 23). For example, the farther the distance, the greater the forage quality must be, the longer the contract should be, and infrastructure installation should be lower. Thus far, the research is inconclusive as to which variables (if any) are more important in producer decision-making.

At the same time, land managers face their own management tradeoffs. Factors that land managers must consider are biophysical (land size, vegetation, wildlife), economic (land use, time/personnel, infrastructure, available producers), and social (knowledge, institutional momentum, stakeholders, and agriculture-community relationships). Depending on the particulars of each land manager's context, a contract can be developed that takes into account the relationships between producer tradeoffs so that each party can maintain their economic and ecological bottom lines. If flexible contracts are not possible due to the need for transparency and fairness, a number of different contract templates can be developed based on typical public land scenarios.

Similarly, guidelines and best practices can be developed and attached to basic contract templates.

2. Opportunities for graziers and public land managers

As mentioned already, both land managers and graziers see opportunities with using rotational grazing as a land management tool on public land. Namely, that rotational grazing can be a win-win solution to woody species encroachment on public grasslands. For land managers, grazing offers versatility since it is feasible on many tracts of land where other management techniques will not work. They also see grazing as a way to save labor and money while simultaneously improving wildlife on a small (localized) and large (landscape) scale. Graziers see opportunities to save money via inexpensive (or less expensive) rental rates. If the land happens to be located nearby their operation, this is also an exciting opportunity to access land without having to travel far distances. Both groups mentioned grazing public land as an opportunity to improve relationships with the public. Land managers see it as an opportunity to strengthen social networks with the agricultural community who may see ungrazed land as “wasted” or “unused,” and with public land users like hunters and hikers. Graziers also mentioned the opportunity to improve relationships with other members of the agricultural community and general public who may lack knowledge of, or have a negative view of, livestock farming. Additionally, some producers mentioned their willingness to work with a land manager to improve their mutual understanding of how grazing can help managers meet their wildlife goals. Understanding the shared and separate visions for opportunity with rotationally grazing public land helps align potential partners and provides the shared focus that is key to ACM.

3. Challenges and suggested solutions

While graziers and land managers see opportunities with rotationally grazing public land, they also see potential challenges. In the pilot studies, actors are experiencing some of these challenges first-hand. It is important to understand these challenges and develop methods for mitigating them up-front to help ensure a smoother partnership process. The main challenges include liability and issues of the public, trust and communication between public land managers and private graziers, contract negotiation and grazing implementation.

Liability and dealing with the public is of particular concern for graziers, though it is important from a land manager perspective as well. Land managers and graziers must share public land with hunters, bird-watchers, hikers, and other recreationalists and this can lead to a number of problems. First, if there is not good signage to explain why rotational grazing is present on the land, the public may become upset upon seeing cattle on their favorite grassland. This is a concern for the public land agency as they will likely see the brunt of public comments. Therefore, co-creating acceptable signage is crucial for public land. There is also concern that the public may interfere with the cattle in some way. If there are gates that recreationalists must walk through there is concern that they may not shut the gate after they are though, and cattle will get out; Gates that automatically close are one potential solution. Similarly, producers mentioned experiences with or concerns about the public seeing a calf on its own, thinking it needs help, and picking it up and moving it. Additionally, if there is a bull on the property, this could pose a risk to recreationalists if they come to close to the animal and it reacts negatively. Again, clear and detailed signage that warns people of the risks to meddling with cattle may be sufficient to mitigate these liability issues. Land managers also face socio-economic risks if the partnership doesn't work or if the public doesn't buy into it. Detailed explanations of the benefits of grazing on public land may help mitigate this.

There is a relevant history of the relationship between farmers and the WDNR to the potential for grazing public land in Wisconsin. The usual stereotype by WDNR is that farmers are "rule-breakers" while the stereotype of WDNR held by farmers is that public agents are the "rule-enforcers." This has created tension between public agents and private producers that must be overcome in order for a grazing public lands program to be successful. Many land managers mentioned concerns about finding a grazier that they could trust to follow habitat management grazing restrictions such as specific residual heights of grass or restricted paddocks during nesting seasons. Even if a grazier is willing to follow a restricted grazing plan, land managers are also concerned about finding graziers with enough experience with rotational grazing that they can trust their ability to implement the grazing plan. This is particularly important for land managers because many feel that they have little to no experience with or knowledge of rotational grazing for land management. So their ability to monitor the grazing is limited. Even after pilot projects began to be implemented and relationships were developed between land managers and graziers, land managers maintained at least some lack of trust.

On the producer side, focus group participants mentioned that while they have extensive experience with managing land for grass health, they lack an understanding of the wildlife management goals of public land managers. Some graziers mentioned frustrating experiences working with public land managers who mandated grazing restrictions without an explanation of why. This concerns graziers who may be willing to work with a public agent but are worried about misunderstandings or misinterpretations of grazing plans because of a lack of knowledge of wildlife management goals. Communication is key here – land managers must communicate clearly and fully their needs for habitat and wildlife management and how they think grazing fits into the picture. Concurrently, graziers must be able to take the time to teach land managers how rotational grazing works and suggest ways that grazing can address the land manager's goals. A clear contract with repercussions to graziers who fail to follow the grazing restrictions may help facilitate trust.

Another significant challenge is the actual contract negotiation and implementation of rotational grazing as a land management tool. As mentioned already, land managers have separate bottom lines that need to be brokered in order for a contract to be enticing for both parties. The use of a third party grazing broker can help facilitate this process. In our pilot studies, the use of a grazing broker was effective in finding contract terms acceptable to both parties, and they were also able to act as a liaison between two parties who don't necessarily speak the same language. Once the contract is negotiated, the implementation may still be tumultuous. Our pilot projects are good examples of this - even when there was a clear plan for water infrastructure there were unexpected implementation challenges. Managing expectations and assuming that there will be implementation challenges along the way will help both parties remain committed and enthusiastic about the partnership when challenges do occur.

4. What kind of grazier is interested and what does that mean for land managers?

For cool season grass dominated public land, a broader and larger group of graziers is interested in renting. In general, producers who have more animal units are more likely to be interested in grazing grass-dominated public land, perhaps because they have a greater need for pasture than producers with smaller amounts of animal units. Younger farmers are more likely to be interested in renting grass-dominated public land because it is challenging for new farmers to find and/or purchase pasture. Finally, farmers with less diverse operations with regard to number of cattle breeds and classes are more likely to want to rent grass-dominated public land because it is less complicated for them to do so with regard to operation management. However, from the focus group and GrassWorks results, it is clear that producers are interested in grazing grass-dominated public land even if the above variables do not hold. For grass-dominated land, land managers will have an easier time finding interested graziers, and if they do want to advertise they should seek graziers that fit the description above.

Shrub-dominated land is more challenging. The results of the survey showed that graziers with a positive attitude toward conservation and working with government are more likely to be interested in renting shrubland than other graziers, as well as those with smaller proportions of pasture acres to their total farmland acres. Land managers may need to explicitly seek out these types of graziers in order to find an appropriate match.

The survey response bias also provides insight into interested graziers. It is not surprising that older farmers with smaller operations were more likely to respond as this population is also more likely to have time on their hands. Older farmers may be retired or partially retired with family members or hired workers doing most of the farm labor. Smaller operations also suggest more time to fill out surveys because they may be less labor intensive. Contrastingly, the fact that farmers who practice MIG and who have prior rental experience were more likely to respond to the survey is significant. These farmers would not necessarily have more time to fill out surveys than their counterparts, so their higher response rate may reflect a greater interest in the topic. This suggests that the "right" people are interested in rotationally grazing public land. Those who already have rotational grazing experience and are familiar with pasture rental are interested in grazing public land. This population matches the needs of land managers seeking experienced and knowledgeable graziers.

Phase 3: The future of grazing in Wisconsin through ACM

Phase Three of the ACM process is when a "policy community" is formed that consists of social networks and alliances between stakeholders with common interests that arise during the window of opportunity. This community acts to build resilience of the social-ecological system's desired state (Olsson et al. 2004b). During this phase actors revisit what they have learned from phases One and Two in order to build a more resilient management program. While the Wisconsin grazing project is still in Phase Two, Phase Three will incorporate a number of the grazing takeaways discussed here, expanding shared knowledge and building the 'resilience of the desired state.' To conclude, we offer a few recommendations for a successful implementation of Phase Three using the 6 key features of ACM discussed throughout. These recommendations are summarized in Table 24.

The decision-making around grazing as a land management tool for the first season of the pilot projects was successful in part by the flexibility and commitment to learning that land managers and graziers showed during the beginning of Phase 2. To guide future plans, current ongoing graduate research is developing program evaluation tools to assess activities of the pilot projects and provide more structure for ongoing feedback and decision-making. To enable that feedback, constant communication was emphasized again and again throughout the first year of the pilot projects and the implementation of ACM. While pasture walks and conference calls have been successful ways to share and discuss experiences so far, documentation will likely be an important feature of ongoing partnerships and projects. Though the publication of graduate research will aid with documentation, revisiting grazing plans and using frequent reports or other written summaries about ongoing activities may strengthen the ACM practices and smooth the transition from Phase 2 to Phase 3.

Within the development of evaluation and processes for decision-making is an awareness of fairness and, again, the respective trade-offs and challenges faced by each of the partners. Ultimately, the WDNR holds decision-making power as the owner of the public grazing lands, and land managers directly involved with on-the-ground pilot projects still need to answer to their agency, and potential financial or political changes that could reshape the projects. Balancing that uncertainty for graziers and university researchers will be a factor as the project moves forward. Continuing to respond to feedback and input for decision-making will be important for all partners, aided by an awareness of power in decisions and knowledge exchange. These social and decision-making factors will be key for ACM alongside what biophysical changes happen on the landscape.

The commitment to learning and the idea of change has been consistent throughout the first two phases of ACM grazing research. The ongoing dialogue between land managers, researchers, and graziers immediately involved in pilot grazing projects as well as with larger groups at conferences, meetings, workshops, site visits has directly informed the research questions and direction of the grazing projects. However, one of the goals discussed among land managers, graziers, and researchers is a broader social change in the understanding of conservation and land use in Wisconsin, integrating the public land user into the grazing management. This has been tentatively broached in phases One and Two through press releases, in-person conversations with community members and neighbors, and the installation of informational signage at the grazing sites, but a larger and more inclusive approach with public stakeholders has not been taken. Gaining support and understanding from community members will be key as the project moves forward.

Something lacking from the ACM approach thus far has been the input of the public. Part of the reason the public have not been involved yet is because we are still in a pilot stage. The WDNR will facilitate public engagement based on agency protocol, and once we have a better understanding of how grazing partnerships on public land will transpire, the WDNR will feel ready to involve the public. We acknowledge that this will be a crucial part of successful grazing on public land in Wisconsin.

Finally, to build the sustainability of this alternative land management partnership, there need to be provisions in place to continue without the university as a bridging organization. While other funding sources may support continued research and monitoring on the same five pilot grazing sites or other new ones, the WDNR and grazing specialists involved in public-private partnerships may need to find other organizations to assist with brokering relationships, developing research questions, and encouraging the learning process. These key features of grazing as a potential land management tool in the Upper Midwest and area for agroecology research guided by ACM will require ongoing research efforts in coming years. The role of adaptive co-management and increased interest in conservation agriculture, ecosystem services, and community resource-sharing will be critical to sustain complex agroecological systems with resilience.

Tables

Table 16 The three phases of adaptive co-management, adapted from Olsson et al. (2004b) and Butler et al. (2015), and examples from Wisconsin grazing case

Phase	General Description	Examples from Grazing Case
1. Preparing the system for change	Triggered by a resource crisis or shared problem during which leadership emerges amongst resource stewards. These individuals (called "policy entrepreneurs") build ecological knowledge of the problem, develop bridging social networks between stakeholders from different levels, and provide a vision and goal for an alternative pathway (Olsson et al., 2004).	• Key stakeholder meeting • Land manager meeting • GrassWorks 2015 • Site visits and field interviews • Grazing survey • Grazing focus group • Literature review
2. The window of opportunity	The "policy entrepreneurs" from phase one exploit policy windows at higher political levels to enact the alternative management agreed on in phase one (Olsson et al. 2004). This phase could also include on the ground testing of alternative management ideas in the form of pilot projects to be scaled in phase three.	• Follow up interviews with pilot grazing project sites • GrassWorks 2016 • Hook Lake WDNR meeting • Pilot projects • Pasture walks
3. Building resilience of the desired state	A "policy community" is formed that consists of social networks and alliances between stakeholders with common interests that arise during the window of opportunity. This community acts to re-build resilience toward the social-ecological system's desired state (Olsson et al. 2004).	• Potential continuation of these or other projects after the end of UW-Madison funding • Filling knowledge gaps with publications and outreach about grazing as a management opportunity • Evaluation of these particular projects, what was achieved, how successes were defined

Figure 1 Three ACM phases over time

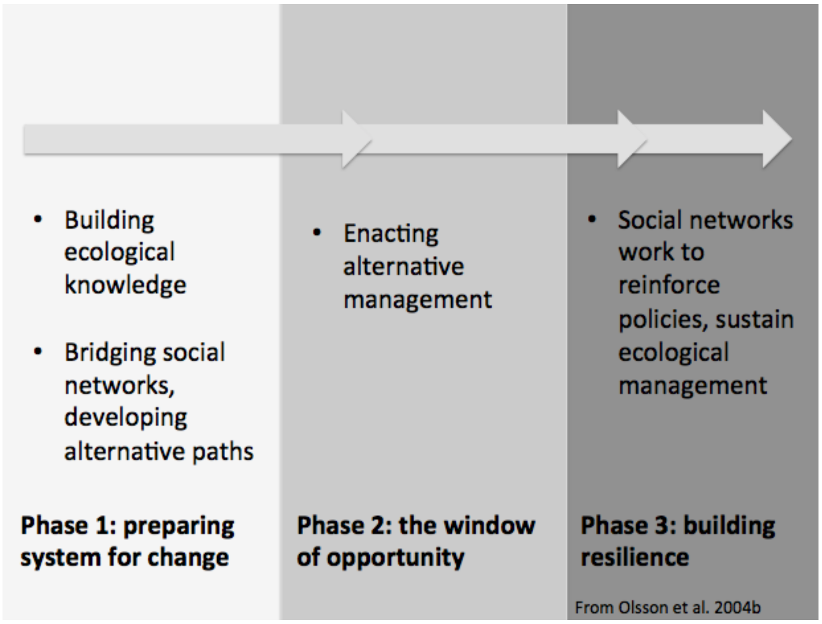

Figure 2 Grazing project timeline and ACM phases

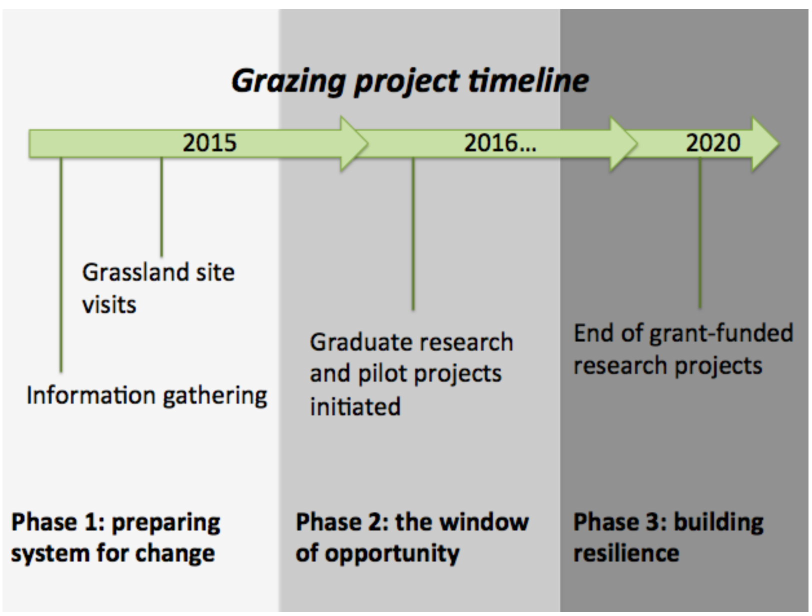

Table 17 Key findings and application from Phase One throughout ACM process

Event or Data collection method	Participants	Key findings	Application/use in ACM process
Initial key stakeholder meeting (October 2014)	• Grazing specialists • WDNR representatives • University researchers	• Collective research interests • Nine main site-selection factors for pilot projects	Collective research interests were incorporated into graduate student research questions and projects Site selection factors were used as indicators during initial WNDR site visits and field interviews; eventual pilot project sites were determined based on these
WDNR land manager meeting in Viroqua (March 2015)	• WDNR ecologists, biologists, technicians, and administrators • Grazing specialists • Representatives from the Minnesota Department of Natural Resources • University researchers	• Main land manager vegetation management goals • Land manager experience levels with grazing • Types of grassland managers want to implement grazing on • Main wildlife management goals • Opportunities and concerns regarding grazing as a land management tool (land manager perspective)	Land manager vegetation and wildlife management goals, and types of grassland available for grazing management informed the producer survey hypothetical contract scenarios
GrassWorks grazing conference (2015)	• Dairy and beef producers from across Wisconsin • University researchers	• Trade-off considerations/decisions faced by producers • Initial idea of distance willing to travel • Logistical concerns and risk considerations	Informed the producer survey
Grazing survey	• Cattle producers whose cattle receive at least part of their ration from pasture	• Main producer concerns and interest in grazing public land • Producer attitudes toward conservation and public land agencies • Influencers on producer willingness to rent public land • How much land producers would like to rent, how far they are willing to travel, and what type of cattle they would put on the land in various scenarios	All data can be used to inform the design of a public grazing program in Phase 3
Producer focus group	• Cattle producers who have at least some non-dairy cattle	• Qualitative information on producer decision-making and tradeoffs when considering renting public land for rotational grazing	All data can be used to inform the design of a public grazing program in Phase 3

Event or Data collection method	Participants	Key findings	Application/use in ACM process
Site visits and field interviews	• WDNR land managers • University researchers	• Site-specific biophysical information and land management goals • Site-specific land management history • Additional opportunities and concerns regarding grazing as a land management tool	Biophysical data was used to select sites for the pilot projects

Figure 3 Primary and secondary producer opportunities

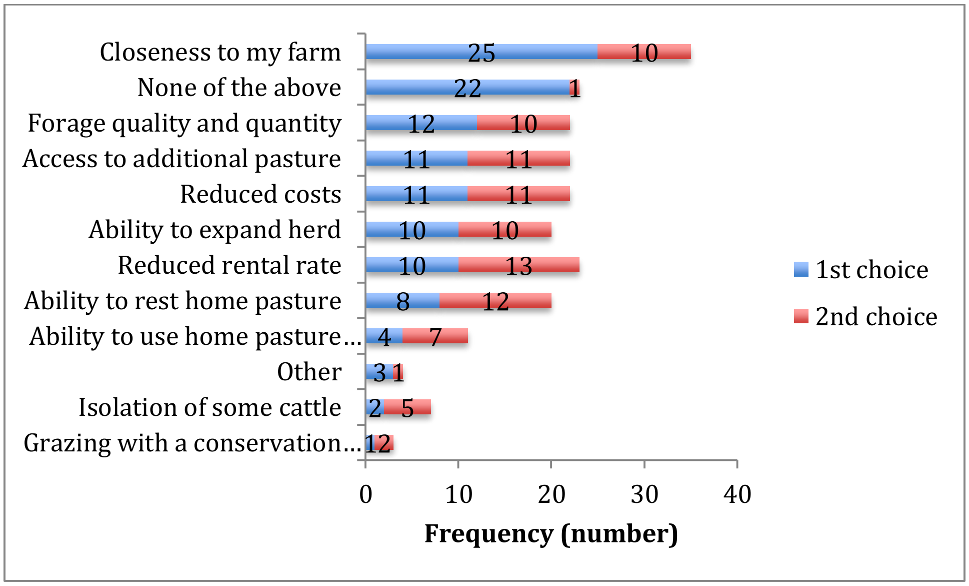

Figure 4 Primary and secondary producer concerns

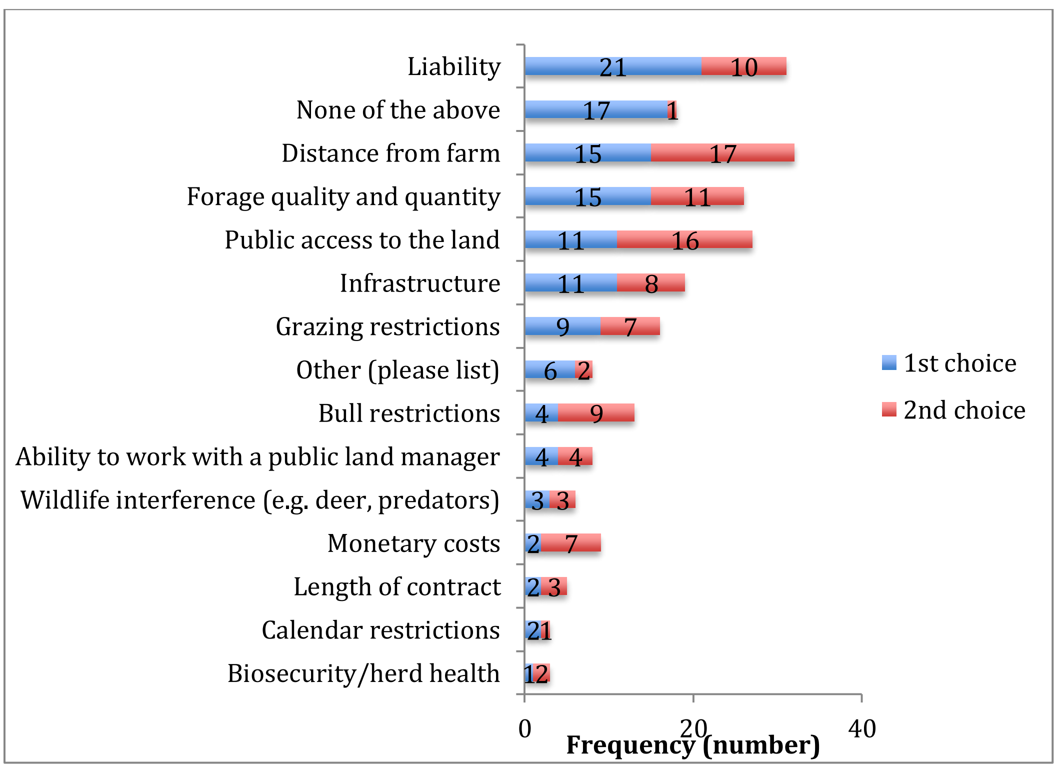

Figure 5 Attitudes toward conservation and public land

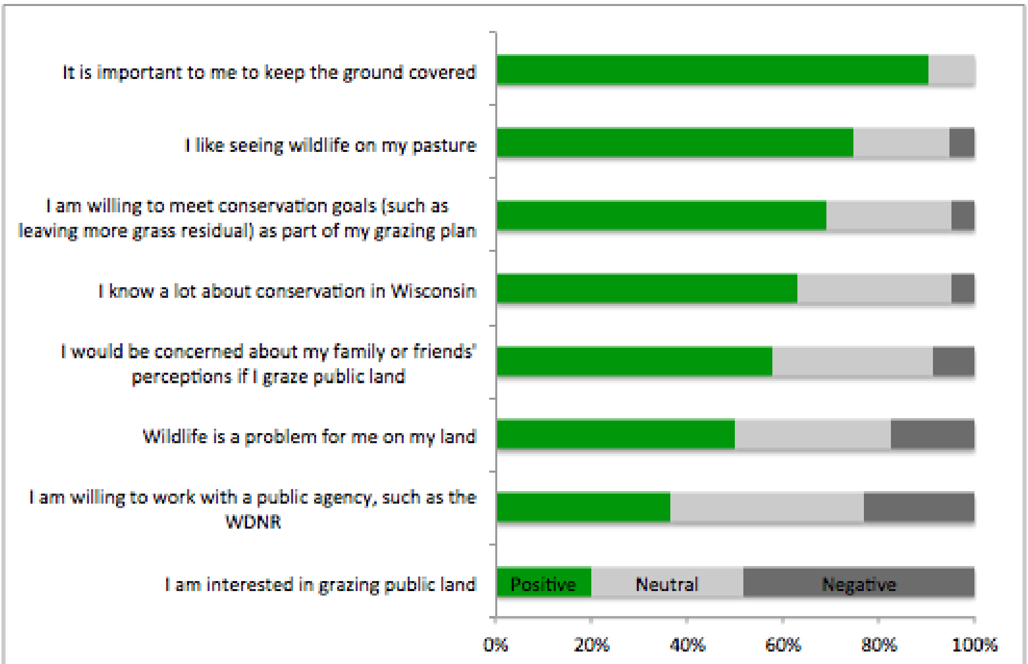

Table 18 Producer focus group operation characteristics

Participant	Types of cows	Rental experience
1	Organic dairy	Currently rents 40-50 acres
2	Beef heifers	Currently rents 25 acres
3	Beef cattle and heifers	Past rental experience; currently doesn't rent
4	Dairy cows	Past rental experience; currently doesn't rent
5	Dairy cows, steers, heifers, dry cows	Currently rents 100-200 acres
6	Dairy cows, dairy heifers, steers	Currently rents a fair amount
7	Pure-bred cows, feedlot	Currently rents several hundred acres
8	Dairy heifers	Currently rents 55 acres
9	Dairy cows, heifers, calves	Does not have rental experience

Table 19 Topics of interest from site visits and conversational interviews with land managers, focused on biophysical site attributes and land management questions

Biophysical site attributes	Land management questions:
1. Acreage 2. Terrain and soil type 3. Existing infrastructure 4. Road access 5. Available water and electricity 6. Pre-existing fencing 7. Shade availability	1. What is the typical land use for this site? 2. What is the management history of this site? 3. What are the common wildlife species? 4. Vegetation of interest? 5. What are the conservation goals of grazing management? 6. Are there any known graziers in the area?

Figure 6 Map of WDNR sites proposed for grazing management

Table 20 Key findings and application from Phase Two throughout ACM process

Event or Data collection method	Participants	Key findings	Application/use in ACM process
Site selection meeting (July 2015)	WDNR administrators and university researchers.	• Assessment of feasibility and trade-offs for grazing management across the 35 sites surveyed • Defined interests for graduate research projects across sites: brush density and plant community variety, grassland bird populations	Collaborative decision-making on sites for initial implementation of grazing management. Research interests were built into the design of pilot projects.
GrassWorks Grazing Conference (Jan. 2016)	WDNR ecologists, biologists, technicians, and administrators, grazing specialists, dairy and beef producers, university researchers	• Deepened understanding of grazier interests: grazing contracts, cattle health, forage, infrastructure issues • Interactions with the public and community education on grazing conservation management	Brought the project to a larger community of graziers to solicit feedback, broaden interest, and encourage group leaning.
Pilot projects and graduate research projects (May-Oct. 2016)	Grazing specialists, dairy and beef producers, WDNR biologists, technicians, and administrators, university researchers and graduate students	• Site-specific findings are in development.	Graduate projects were directly informed by the interests and concerns expressed by partners throughout Phase 1.
Pasture walks (August 2016)	Grazing specialists, dairy and beef producers, WDNR biologists, technicians, and administrators, university researchers and graduate students	• Discussion of goals and problems from grazing season.	The WDNR showed commitment to learning on multiple scales, on site-specific pilot projects and at an administrative level to better allocate support and resources.
Site visits and field interviews (Aug.-Sept. 2016)	WDNR land managers, participating graziers, graduate students	• Site-specific feedback on first year of pilot projects • Deepened understanding of interests, issues, and goals for the future	Developing tools for program evaluation will assess the project activities and provide feedback for decision making. Contributes to iterative learning and year to year changes.

Table 21 Integration of ACM components throughout phases 1 and 2

Note: The six core components of ACM were utilized throughout Phase One and Phase Two in order to most effectively explore the opportunities and challenges associated with grazing public lands in Wisconsin, develop pilot projects based on initial learnings, and to ultimately devise a shared vision for alternative grassland management in Wisconsin using grazing.

Core Concept of ACM	**Description**	**Phase 1 of Grazing project**	**Phase 2 of Grazing project**
Common Focus	• Shared vision, goal, and/or problem definition to provide a common focus among actors and interests • Specificity with learning objectives, approaches, outcomes and risks	Entire group of actors: • Shared goal of a win-win solution to woody species encroachment on public grasslands	UW, WDNR, Pasture Project: • Ongoing phone calls to ensure everyone is on the same page Land managers and graziers: • Grazing plan provides a shared vision for grazing management Land managers, graziers and grad students: • Document outlines learning objectives and research methods
Communication and Collaboration	• A high degree of repeated dialogue, interaction, and collaboration among multi-scaled actors • A commitment to open communication	Dialogue: • First meeting of UW, WDNR and grazing specialists • Land manager meeting in Viroqua • Grazier focus group • Ongoing conversations between graduate students and grazing specialists and WDNR wildlife specialists to inform the design of their projects • 2015 site visits and land manager interviews • Dodgeville meeting between UW and WDNR wildlife specialists Interactions: • Grassworks 2015 • Consistent meetings with the full UW research team	Dialogue: • Pasture walks, Hook Lake land manager meeting • Grassworks 2016 panel discussion • Ongoing phone calls with UW/WDNR/Pasture Project Collaboration: • Development of grazing plans for pilot projects

Core Concept of ACM	Description	Phase 1 of Grazing project	Phase 2 of Grazing project
Shared control and responsibility	• Distributed or joint control across multiple levels, with shared responsibility for action and decision making	• Determination of pilot project sites • Within UW team, shared governance approach with PI's and graduate students	• Pilot project implementation • Signage at pilot sites • Public relations • Grazing plans and contracts • Ongoing conversations and check-ins about how each actor is feeling during pilot implementation
Autonomy and Power Dynamics	• A degree of autonomy for different actors at multiple scales • Recognition and reflection on how power influences the system	• Conversations between UW and WDNR about levels of power at WDNR to inform process • Constant consideration of potential for political backlash and reprisal to DNR and other colleagues due to their inherently political positioning	• Ongoing grazing decisions at each pilot site • Graduate student research plots
Pluralistic Knowledge	• Commitment to the pluralistic generation and sharing of knowledge • Social learning at different scales	Sharing of knowledge: • Key stakeholder meeting (UW, WDNR, grazing specialists) • Viroqua land manager meeting (UW, WDNR) • Grassworks 2015 (graziers) • Site visits and field interviews (land managers) • Grazing focus group (graziers) Knowledge generation: • Grazing survey (economics; grazier)	Sharing of knowledge: • Follow up interviews with pilot grazing sites (land manager, graziers) • Grassworks 2016 (UW, graziers, land managers) • Hook Lake land manager meeting (land managers, UW) • Pasture walks (UW, land managers, graziers) Knowledge generation: • Pilot projects (biological, ecological, socio-ecological)
Iterative Learning	• A flexible and negotiated learning orientation with an inherent recognition of uncertainty • Ongoing assessment and reflection	• Information gathered from land manager and grazier meetings incorporated into research design and pilot project site selection • Grazing survey developed based on iterative process	• Pilot projects will update their grazing plans annually based on previous year's experience • New graduate students will build on and adapt research based on learning

Table 22 Four key takeaways and suggested considerations and practices for grazing public lands

Key findings and takeaways	Suggested considerations and practices
Contextual grazing contract design	• Grazing public land must be economically viable for interested graziers • Contracts should accommodate tradeoffs around economic variables, such as forage quality, contract length, time, and infrastructure investments in their rental rates
Opportunities for graziers and public land managers	• Grazing offers potential cost-effective ecological management on a both a small scale and landscape scale • Public land rentals offer graziers affordable pasture access • Improving relationships with the public through active land management and agricultural land stewardship

Challenges for graziers and public land managers, and *suggested solutions*	• Liability and interactions with the public
	    • *Clear, detailed or interpretive signage*
	• History of negative stereotypes and poorly communicated goals between graziers and land managers
	    • *Using good communication and trust-building techniques*
	• Contract negotiation and implementation
	    • *Managing expectations, clearly defining roles and activities*

Which Wisconsin graziers are interested in grazing public land, and what does that mean for public land managers?	• Grass-dominated land is more attractive to most graziers • Graziers with a positive attitude toward conservation, working with public agencies, or those with smaller pasture acreage are more likely to rent shrub-dominated lands • Graziers experienced with MIG and pasture rental are more likely to be interested in grazing public lands

Table 23 Relationships between rental variables (producer perspective)

	Distance	Forage quality	Contract length	Willingness to teach/initial effort	Infrastructure installation/provision
Price	negative	positive	positive	positive	negative
Distance		positive	positive	negative	negative
Forage quality			negative	positive	positive
Contract length				positive	positive
Willingness to teach/initial effort					negative

Table 24 Integration of ACM into Phase 3, the future of grazing projects

Core Concept of ACM	Description	The Future: Phase 3 of Grazing project
Common Focus	Shared vision, goal, and/or problem definition to provide a common focus among actors and interests; specificity with learning objectives, approaches, outcomes and risks	Partners in pilot projects participate in program evaluation to revisit goals and interests throughout the projects and assess gaps or weaknesses.
Communication and Collaboration	A high degree of repeated dialogue, interaction, and collaboration among multi-scaled actors; a commitment to open communication	Continued communication between project partners, documentation of year-to-year project activities.
Shared control and responsibility	Distributed or joint control across multiple levels, with shared responsibility for action and decision making	Integration of new land management agents (interns, volunteers, short-term staff) to assist grazing projects during growing season.
Autonomy and Power Dynamics	A degree of autonomy for different actors at multiple scales; recognition and reflection on how power influences the system	Commitment to fairness in grazing contacts, clearly defined activities for each partner, and inclusivity in decision-making and knowledge exchange.
Pluralistic Knowledge	Commitment to the pluralistic generation and sharing of knowledge; social learning at different scales	Publications from graduate student research, continued exchange at workshops, conferences, and meetings, and the addition of public outreach or educational events.
Iterative Learning	A flexible and negotiated learning orientation with an inherent recognition of uncertainty; ongoing assessment and reflection	A new bridging organization

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Appendices

Appendix 1 List of prioritized list of bio-physical and logistical factors in site selection from October 23 key stakeholder meeting

This list was captured from an initial key stakeholder meeting during Phase One. They are suggested factors that should be considered for site selection for the pilot projects in Phase Two. The list is arranged in order of number of group mentions, with the most popular categories first. Each category is in bold, with the actual comments written below.

Infrastructure

Road and electric access
Accessibility
Ease of access (for producer and researcher and manager)
Vehicle/equip access
Water access
Proximity to water/stream too close
Access to water lines/electricity (fence)
Water access for cattle
Acceptable conditions for grazier: 1. Access; 2. Fencing; 3. Water
Availability of infrastructure (fencing, watering, handling facilities)
Infrastructure (fencing/water) present, or worth installing based on expected returns
Infrastructure development (Flat? Wet? Dry? Hilly? Rocky?)

Variable biophysical traits across sites

Vegetation type – cool/warm, prairie rest, shrub, wet/dry
Different soil types
Variable biophysical traits across sites (soil, veg)
Include a range of soil types
Different shrubby species
Sites in different landscapes (%grass varies)
Have both native and cool season sites
Soil/plant/landscape characteristics
Low slope

Proximity to graziers

Close to interested graziers
Proximity to interested/capable producer
Interest from local livestock community
 # interested producers and proximity
Willing graziers nearby

DNR acceptance
Min use conflict
DNR property master plan objectives and approved activities
Pasture establishment on sharecropping
Site poses challenges for typical management practices
Revenue generation to DNR

Public
Public access risk?
Current public land uses (i.e. hiking, water access)
Acceptance from larger community of grazing
Stakeholder/user acceptance

Size of site
Large enough to provide ample forage to grazier
Grassland large enough for multiple treatments
Large enough for plots and to try to avoid animal behavior issues while in confinement

Research capacity
Locational capacity for research treatments
Sites that fit with research questions
Can we envision benefits of grazing for the biota, beyond brush control, that might broaden the sideboards for site selection? - E.g. include c.s. monocultures to monitor impact on diversity

Land manager
Flexibility of land manager to work with scientists
History of management actions on the property (Rx? Rowcrop? Herbicide? "Traditions")
Used to working with ag producers and contracting

Sensitivity
Not highly sensitive (rare/endangered species, sensitive for public)
Sensitivity of land to animals – "conservative" natives, seasonal wetness

Appendix 2 Land manager opportunities and concerns from Viroqua meeting

Figure 7 Opportunities for habitat management from Viroqua land manager meeting

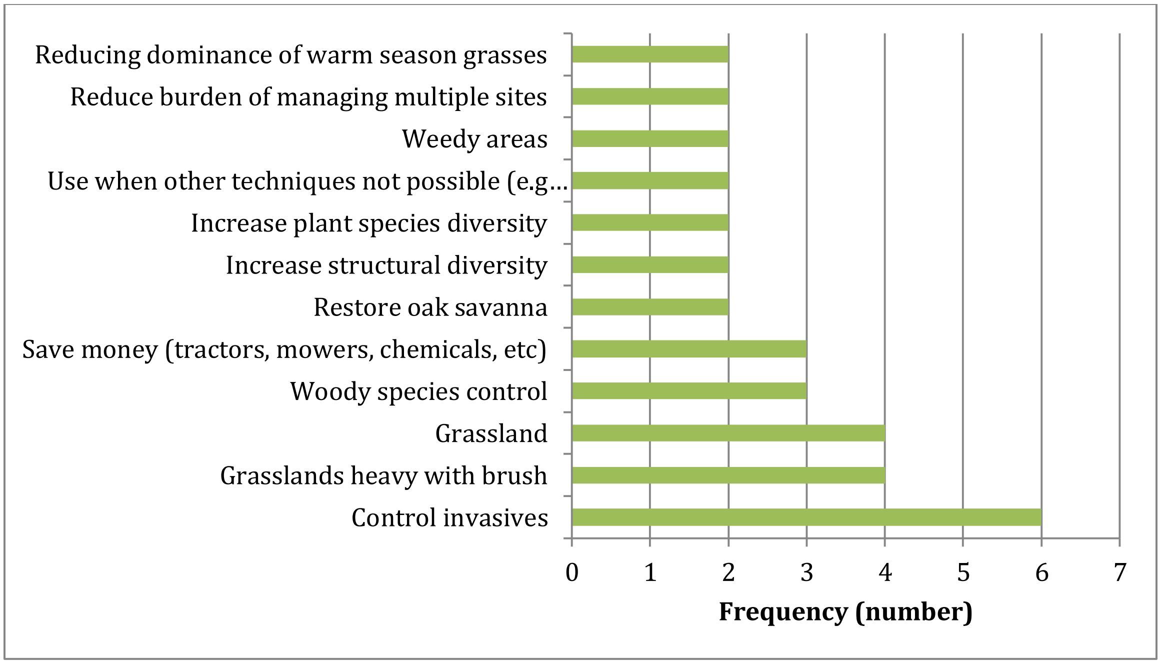
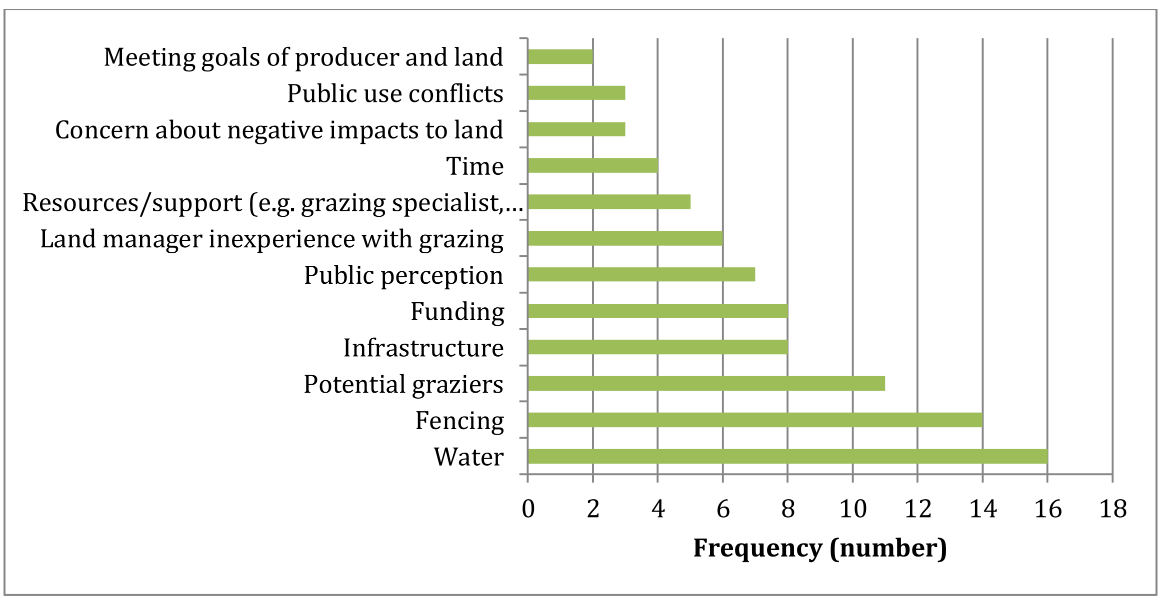


Figure 8 Concerns about grazing as a land management tool from Viroqua land manager meeting



Appendix 3 Grazing Public Lands survey results

Table 25 Acreage, animal class, and travel distance interest by rental price

Type of pasture	Rental Price/acre	Acres	Class of animal	Max. distance
Grass dominated	$5	less than 40 to 640+	dry beef, cow-calf pairs, finish animals, young stock	50
Grass dominated	$10	less than 40 to 640+	dry beef, cow-calf pairs, finish animals, young stock	50
Grass dominated	$15	less than 40 to 640+	dry beef, cow-calf pairs, finish animals, young stock	50
Grass dominated	$20	less than 40 to 319	cow-calf pairs, finish animals, young stock	20
Grass dominated	$25	less than 40 to 319 and 640+	dry beef, cow-calf pairs, finish animals, young stock	40
Grass dominated	$30	less than 40 to 319 and 640+	dry beef, cow-calf pairs, finish animals, young stock	40
Grass dominated	$35	less than 40 and 80-159	cow-calf pairs, finish animals, young stock, heifers	30
Grass dominated	$40	less than 40, 80-159, and 640+	dry beef, cow-calf pairs, finish animals, young stock, heifers	50
Grass dominated	$45	80-159	dry beef, cow-calf pairs	20
Shrub dominated	$5	less than 40 to 640+	dry beef, cow-calf pairs, young stock	50
Shrub dominated	$10	less than 40 to 640+	dry beef, cow-calf pairs, finish animals, young stock	50
Shrub dominated	$15	less than 40 to 640+	dry beef, cow-calf pairs, young stock	50
Shrub dominated	$20	less than 40 to 319 and 640+	dry beef, cow-calf pairs, young stock	40
Shrub	$25	less than 40 to	dry beef, cow-calf pairs,	75

dominated		319 and 640+	young stock	
Type of pasture	**Rental Price/acre**	**Acres**	**Class of animal**	**Max. distance**
Shrub dominated	$30	less than 40 to 79 and 640+	cow-calf pairs	50
Shrub dominated	$35	40-79 and 640+	cow-calf pairs	50

Table 26 Willingness to rent public land even if have to provide the fence infrastructure

Pasture	Price	Agreed to rent	Would still rent if had to provide fences	%
Grass-dominated	$10	17	6	35%
Grass-dominated	$25	14	4	29%
Grass-dominated	$40	4	1	25%
Grass-dominated	$5	12	1	8%
Grass-dominated	$20	5	2	40%
Grass-dominated	$35	4	1	25%
Shrub-dominated	$10	11	2	18%
Shrub-dominated	$20	9	3	33%
Shrub-dominated	$30	2	2	100%
Shrub-dominated	$5	10	2	20%
Shrub-dominated	$15	9	2	22%
Shrub-dominated	$25	4	1	25%

Appendix 4 Producer focus group results

Grazing Public Lands Focus Group Questions:

7. Tell us who you are, what kind of cattle you raise, where your operation is located and whether you have rented pasture before.
8. What are the most important things you consider in deciding whether or not to rent a pasture?
9. If you were to rent pasture to graze your animals, how would you decide how many acres to rent?
10. If you were to rent pasture to graze your animals, how would you decide which class of animal to put on the pasture?
11. What do you think about using rotational grazing as a land management tool on public grasslands?
12. Beyond what you already mentioned about renting land in general, What are the most important things you would consider in deciding whether or not to rent *public* land?
13. Survey respondents said **liability** is an important concern for them when thinking about renting public grassland. Any thoughts on that response?
14. Survey respondents said **public access** to the land is an important challenge for them when considering renting public land. Why might graziers be concerned about this?
15. In our survey, producers who practice managed intensive grazing are more interested in renting under these scenarios than producers who don't. Why might this be the case?
16. In the comments section of the survey, a couple of producers expressed frustration around the possible competitive advantage of producers who get to rent cheap government land. I would like to know what you think about this concern. Do you feel similarly? Can you tell me more about your feelings on this?
17. If you had a chance to give advice to the director of a public grazing program, what advice would you give?
18. I wanted you to help me evaluate the findings from a statewide grazing survey focused on the potential for grazing public lands. I also wanted to learn your thoughts and opinions on renting public land for grazing. Is there anything I missed that you think is important for the discussion of rotationally grazing public lands?

Table 27 Summary statistics from Grazing Public Lands focus group

Variable	Obs	Mean	Std. Dev.	Min	Max
years farming	9	27.44	18.74	0	50
total farmland owned	9	507.00	947.56	0	3000
total pasture owned	9	109.44	103.03	0	310
proportion of pasture acres to total farmland	7	0.46	0.34	0.07	1
farthest pasture	9	61.50	159.87	0	485
Why don't rent	2	3.50	2.12	2	5
"I feel I need more pasture acres"	9	2.11	1.17	1	4
Total number of head	9	102.11	110.93	0	350
Total animal units	9	110.28	135.41	0	440
Subdivide pastures into paddocks	8	1.00	0.00	1	1
Plan grazing schedule based on forage height	8	1.00	0.00	1	1
Have managed grazing plan	8	0.75	0.46	0	1
Received cost-sharing for grazing operation	8	0.50	0.53	0	1
Used mob grazing	8	0.63	0.52	0	1
Used stream as water source or paddock	7	0.57	0.53	0	1
Stream buffer	7	0.71	0.49	0	1
"I know a lot about conservation in Wisconsin"	9	2.11	0.33	2	3
"I like seeing wildlife on my pasture"	9	1.89	0.60	1	3
"Wildlife is a problem for me on my land"	9	3.11	0.93	2	4
"It is important to me to keep the ground covered"	9	1.22	0.44	1	2
"I am willing to meet conservation goals as part of my grazing plan"	9	1.89	0.78	1	3
"I am interested in grazing public land"	9	2.33	1.00	1	4

Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
"I am willing to work with a public agency"	9	2.22	0.83	1	3
"I would be concerned about my family or friend's perceptions if I graze public land"	9	3.33	1.12	1	5
Age	9	53.22	15.56	27	71
Sex	9	1.11	0.33	1	2
Work on farm full or part time?	9	2.00	0.87	1	3
Education	9	4.22	1.39	2	6
Household income	9	3.56	1.67	1	7
Proportion of income from farming	9	62.22	36.07	0	100
Retired	9	0.44	0.53	0	1

Chapter Four: Conclusion

There were a number of lessons learned from my thesis research. The main lesson was that my initial research plan was too broad in terms of objectives. For example, I was interested in MIG practitioners and non-MIG practitioners, even though public land managers are primarily interested in partnerships with MIG practitioners. This objective overreach negatively impacted my sample size because I included non-MIG producers for whom the survey was less relevant. If I were to re-design my research approach I would have only surveyed the MIG group. Similarly, administering the survey in only two parts instead of three (initial mail, reminder, final mail) likely impacted my response rate. In the future I would clarify with those administering the survey that I require a three-part approach.

My results also provide the basis for additional research. It is clear that there is interest from some producers, though not the majority. It is also clear that producer interest is highly contingent on the specifics of the contract. What is still to be determined is whether producers who are most likely to be interested are also located close to public land. Future research should focus on identifying hot spots where there is overlap between interested graziers and available public land. Knowing these hot spots will allow the WDNR to target their initial efforts at the most viable locations. Identifying hot spots will also illuminate any gaps where there is available public land but no interested producers. Minnesota has been struggling with such gaps. Most of the cows in Minnesota are located in the center of the state in the prairie-forest or forest areas. The western third of Minnesota has grassland, but there are no cows, so finding livestock producers within a reasonable distance has been one of the MDNR's biggest issues. It would be helpful to identify if Wisconsin has a similar problem before the WDNR or others invest in the development and implementation of a managed grazing program.

Alongside the mapping of hot spots, additional focus groups in other parts of Wisconsin would be useful further research. My focus group included producers who were almost entirely from the southwest part of the state. Producers in other parts of the state may have different perspectives on a public grazing program, and it is important to understand if and how those perspectives may differ.

Finally, this research focused heavily on cool season grasses and shrubland. However much of Wisconsin's public grasslands contain warm season grasses. Future research should include inquiry into producer interest in grazing warm season grasses, and at what price and under what contract conditions.