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Original Research

Holistic Management Shifts Ranchers' Mental Models for Successful Adaptive Grazing[☆]

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ABSTRACT

Unprecedented climatic and economic uncertainty, in particular severe drought, calls for management that can preclude some of the costs of reactionary measures for California ranchers. Increasing adaptive capacity has been widely recommended to address such uncertainty. Within this context, holistic management (HM), a decision-making framework marketed for ranchers, is of interest because it emphasizes systems-based thinking, maximizing flexibility and adaptability, ecological monitoring, soil health, and goal setting. Many HM ranchers use adaptive multipaddock (AMP) grazing management, characterized by the combination of moderate to high animal stock densities, fast rotations, pasture rest, iterative monitoring, and adaptive management. We interviewed a small group of AMP-HM ranchers in northern California to 1) examine how their on-the-ground implementation of AMP grazing relates to mental models for rangeland grazing as shaped by HM, including embedded decision-making processes, motivations, barriers, and catalysts; and 2) understand how AMP-HM ranchers believe the strategy helps them respond to increasing challenges. Our findings suggest that first, AMP-HM shifted ranchers' mental models through its emphasis on monitoring combined with increased interaction with land and animals, changing the ways interviewees saw and understood their management. Second, through its decision-making framework and trainings, AMP-HM increased ranchers' agency to operationalize new mental models. Together, these two facets culminated in a common suite of strategies that interviewees viewed as key to ranching profitably and sustainably. These include building flexibility into herd sizes and structures to increase temporal and spatial mobility, diversifying ranch enterprises to increase financial flexibility, building soil health, and reducing input costs—all of which have been recommended in rangeland management practices for decades. These findings suggest that AMP-HM, as an integrated package of rangeland management and decision-making practices, accompanied by education and training, may hold promise in helping ranchers strengthen their adaptive capacity and cope with uncertainty.

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Introduction

Ranchers managing semiarid rangelands face increasing climatic, economic, and cultural uncertainty, sparking a wave of inquiry into their currently used adaptation strategies to inform opportunities for the future. California ranchers face additional uncer-

tainties that are only exacerbated by widely recognized challenges such as climate change and low profit margins (Byrd et al. 2015). These include unprecedented land appreciation and rising costs (NASS 2021), reliance on annual grass-dominated rangelands with highly variable net primary production (NPP), increasingly common and worsening drought conditions (Larsen et al. 2014), policy change and impacts, and a growing anticattle sentiment (Dimock et al. 2021) among some groups.

There is a strong body of literature cataloging ranchers' singular responses to specific independent stressors like drought. For example, research has well documented ranchers' reactionary responses to recent extreme droughts, including reducing herd size (destocking), purchasing additional feed, creating drought management plans (Kachergis et al. 2014; Macon et al. 2016; Woodmansee et al. 2021), and how these responses are influenced by ranch and

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rancher characteristics (Roche et al. 2015). In response to economic stressors, studies show that ranchers commonly supplement their incomes with off-farm work or, in extreme but increasingly common cases, sell a parcel from their ranches or the entire ranch (Sulak et al. 2009). Some estimate decadal ranch turnover rates as high as 45% in certain areas (Gosnell and Travis 2005). Lastly, some ranchers have turned to on-ranch management strategies like compost application to improve soil health and increase productivity as a buffer against changing socioeconomic conditions (Gomez et al. 2021).

Little research, however, has studied how and why some ranchers have found they are able to successfully respond to and, in some cases, mitigate simultaneous sociological, ecological, and economic challenges through more “holistic,” or comprehensive, approaches that strengthen their adaptive capacity (Roche 2016). Building adaptive capacity on grazed rangelands entails being flexible enough in the shortterm to withstand disturbance events and having the long-term ability to adapt to changing conditions, complex challenges, and uncertainties (Folke et al. 2001; Fazy et al. 2010; Olsson et al. 2004). Rather than *a la carte* practices adopted independently, such as destocking in response to drought, a “holistic” approach to increasing adaptive capacity entails adopting a diversified suite of interconnected and mutually reinforcing practices, both at the ranch enterprise and on-the-ground grazing levels (Petersen-Rockney et al. 2021). According to Darnhofer et al. (2010), flexibility, monitoring and learning, and diversification are key components of adaptive capacity. An emphasis on improving soil health is often central to increasing adaptive capacity, whereby efforts to improve soil functions such as water holding capacity and infiltration, fertility, and biodiversity can directly impact continuing ranch operability in the face of climate impacts such as drought (Allen et al. 2011a).

Dealing with the inevitably large complexity embedded in holistic approaches to strengthen adaptive capacity in this way depends on the mental models of those making decisions or their understanding of how the system works. Mental models are internally constructed worldviews that influence our understanding of how the world works and provide the mechanism for filtering and interpreting information (Lynam and Stafford Smith 2004; Jones et al. 2011). Exploring the mental models of ranchers utilizing adaptive grazing approaches is especially important to understanding their decision making, including how they perceive their systems and the impacts of their management; how they monitor, observe, and internalize outcomes; and how they shift management in response. Despite the increasing importance of understanding ranchers’ mental models and how they change over time in the face of complex challenges, they remain underexamined because they are difficult to study and capture in the short timescales of most research. Lynam and Stafford Smith (2004) characterize mental models as “crucial slow variables,” meaning they change slowly but are critical for understanding long-term change.

The overwhelming emphasis on large quantitative methods in social science combined with the short timescales of most research has contributed to this lack of understanding of ranchers’ mental models. Quantitative surveys benefit from large sample sizes and can discern large-scale and generalizable patterns, such as the common adaptation practices used by ranchers, and how these choices correlate with ranch characteristics and rancher demographics. However, these studies are limited in their ability to inform our understanding of ranchers’ mental models and embedded decision-making processes, including both how they change in response to challenges and uncertainties and how ranchers operate within them to make specific management decisions (Sayre 2004). This is especially important for informing our understanding of how and why some ranchers, rather than *a la carte* practice adoption, take holistic approaches to increase adaptive capac-

ity. Building on current theoretical frameworks (Briske et al. 2015), in-depth qualitative work is necessary to understand how ranchers’ mental models interact with their on-ranch management decisions with the proper flexibility and context specificity.

Within this context, holistic management (HM), a decision-making framework conceived of and popularized by Allan Savory, a controversial biologist from Zimbabwe (Savory and Butterfield 2016; Sherren and Kent 2017), is of particular interest because of its adaptive management approach, which embodies many elements of adaptive capacity. Allen et al. (2011b) define adaptive management as “an approach to natural resource management that emphasizes learning through management,” and “has explicit structure, including careful elucidation of goals ... procedures for the collection of data followed by evaluation and reiteration.” HM can be thought of as a mental framework for adaptive grazing management on rangelands because of its explicit emphases on “holism,” paradigm shifts (i.e., mental models), monitoring and feedback loops, embedding flexibility to maximize adaptability to changing conditions, and a suite of ranch and grazing management practices that purportedly improve soil health environmental outcomes. HM training is offered to ranchers through a series of courses offered by the Savory Institute and other similar organizations such as Holistic Management International and Ranching-for-Profit. It emphasizes a “triple bottom line” approach to “holistically” harmonize management goals and tradeoffs on dynamic landscapes in complex scenarios. It provides a framework for ranchers to explicitly define their ecological, economic, and social/personal goals, create detailed plans for executing these goals, iteratively check their decisions against these goals using context checks and ecological measurement and monitoring (including both soils and plants), and adapt their management accordingly (Gosnell et al. 2020).

In practice, HM is often accompanied by a grazing management approach commonly termed adaptive multipaddock grazing (AMP, but has alternatively been referred to as holistic planned grazing or management intensive grazing) (Mann and Sherren 2018). Adaptive multipaddock (AMP) grazing is among the most intensive forms of rotational grazing, where animals are moved frequently in moderate–high stock densities across lands often divided into multiple temporary paddocks. Each paddock is then rested for plant regrowth before being regrazed, a commonly recommended rangeland management practice (Clifford et al. 2020). AMP ranchers often use mobile electric fencing to divide pastures into small temporary paddocks to achieve desired rest and rotation intervals, though some also achieve this through herding and range riding. Land managers adapt (reactively and proactively) both stocking densities and paddock rest periods according to seasonality, exogenous shocks, and stressors (such as droughts), as well as to meet social and market needs. HM and AMP grazing have been the subject of previous research, but often as independent phenomena and within social and ecological disciplinary silos (especially in terms of soil health; Stanley et al. 2018; Mosier et al. 2021). While HM and AMP are distinct yet related concepts, studies’ lack of acknowledgement of their differences and how they work together to create a unique approach to grazing management is an oversight that has contributed to a critical research gap.

Together, AMP and HM form both a theoretical and applied basis for the application of adaptive grazing management, attributes of which may be desirable to help ranchers respond to the complex challenges facing grazing on rangelands (Sayre 2001; Lynam and Stafford Smith 2004; Mann et al. 2019). In an attempt to explore the controversy surrounding rotational grazing systems, Briske et al. (2011) state, “We hypothesize that rotational grazing can facilitate, or follow from, changes in the mental models of managers. Successful applications may reflect changes in how managers see and think about the entire process of managing their

land, water, and animals.” Similarly, we attempt to explore the ways in which these attributes of AMP-HM either facilitate shifts in ranchers’ mental models and/or shifts in mental models lead to adoption of AMP-HM. Though an unknown but likely small (< 20% total; [Whitt and Wallander 2022](#)), population of ranchers globally have adopted AMP and/or HM, the relatively fringe management combined with successes reported by adoptees and some ecological research warrants further investigation.

In this paper, we provide a narrow but deep investigation into a small subset of ranchers using both HM and AMP grazing in California. Using semistructured interviews, our goal was to identify the core pillars of these approaches, what functions they serve, how and why ranchers use them, and why some ranchers have found this approach to be successful. We then examine how their on-the-ground implementation of AMP grazing relates to their mental models as shaped by HM, including embedded decision-making processes, motivations, barriers, and catalysts. We explore the ways in which ranchers’—through HM trainings, on-the-ground grazing implementation, and iterative learning, monitoring, and adapting—have shifted their mental models, ultimately providing agency to increase flexibility and respond to increasing social, economic, and ecological challenges and uncertainties of the social-ecological systems in which they are embedded. We compare these insights with those provided by conventional (CONV) ranchers, often neighbors, to provide context into their differences.

Methods

Study structure, goals, and defining terminology

This qualitative research was carried out as part of a larger social-ecological analysis of AMP grazing in California. The goal here was to understand the decision-making processes underpinning AMP ranchers’ grazing management and how it is shaped by HM, focusing on why and how they apply this method of grazing management to meet their goals, and how it is different from CONV approaches. In this study, we analyze the relationships, interactions, and feedbacks between ranchers’ mental models and their grazing management in practice. We were interested in the influence of HM on ranchers’ mental models because it is a framework that structures decision making and goal setting, and AMP grazing as the application of grazing management in practice. We use AMP-HM throughout this study as a useful shorthand for the combination of both.

Interviewee selection criteria

In this study, conventional grazing and graziers (CONV) are defined broadly as those relying on traditional practices and who have not taken HM trainings. This includes continuous year-round, season-long grazing, or, more commonly in California, rotational systems among five or fewer pastures, where rotations are commonly based on residual dry matter, wildlife habitat specifications, and/or water availability ([Huntsinger et al. 2007](#); [Roche et al. 2015](#)). We defined AMP-HM and CONV grazing management and developed corresponding selection criteria in consultation with local farm and livestock Cooperative Extension agents, California-based rangeland ecologists, and a small group of ranchers outside of the study population.

Using purposive sampling, we selected AMP-HM ranchers using the following criteria (see):

1. Has completed holistic management, or similar, grazing management training (i.e., Holistic Management International or Ranching-for-Profit).
2. Makes grazing rotation decisions adaptively rather than according to a set regime. This helped to distinguish AMP grazing from other high-intensity but nonadaptive forms of grazing management such as mob or cell grazing, which rotate animals with regularity/schedule rather than based on adaptive outcomes ([Gurda et al. 2018](#)).
3. Uses a grazing plan (either formally [e.g., PastureMap/Gaia] or informally) to premeditate and guide grazing decisions throughout the year.
4. Subdivides land into smaller paddocks throughout the grazing season (> 10 paddocks).
5. Incorporates targeted pasture rest.
6. Uses monitoring to drive adaptive management decisions on temporal rotations and recovery lengths. This includes both formal monitoring by scientists and organizations (e.g., Point Blue Conservation Science, NRCS, Savory Institute Ecological Outcome Verification) or informal monitoring using visual indicators, including forage recovery, ocular vegetation cover, and residual dry matter.
7. Has been using this management for three or more grazing seasons.
8. Uses higher than average animal stock densities (either seasonally or year-round) to meet intended ranch outcomes.

We decided *not* to set arbitrary stocking density, pasture rest, and rotation thresholds because these do not appear in HM trainings and the application of AMP-HM grazing is highly variable and changes seasonally on California rangelands ([Savory and Butterfield 2016](#)). Rather, we focused on ranchers’ self-reported, intentional use of animal movement, pasture rest, seasonally intensive stock densities, and adaptability to reach their management goals.

We identified ranchers who met these criteria using an iterative snowball networking and screening process from May 2018 to January 2020. We first consulted with a key holistic management training center in California to connect us with AMP-HM ranchers who met our criteria and might be willing to participate in the study. Fifteen ranchers who had completed holistic management (or similar) training and claimed to practice AMP-HM grazing responded to an email solicitation. We conducted initial phone interviews with 12 of these AMP-HM ranchers and 6 of their CONV rancher neighbors.

We interviewed CONV neighboring ranchers wherever possible. These ranchers and their grazing management were not the focus of the study, but we include them to provide additional perspective and context to our AMP-HM rancher interviews. CONV ranches were selected from neighboring ranches to pair with AMP-HM ranches, with the following criteria:

1. Uses either continuous year-round, season-long grazing, or low-rotational grazing among five or fewer pastures
2. Does not have HM training or refer to it as affecting practices

We identified seven AMP-HM/CONV rancher pairs with proximate properties based on management and ecological criteria (same soil type based on SSURGO maps, same ecological site descriptions, land-use history, slope aspect, and within < 1 mile) to meet overall study goals. Two CONV rancher interviews were excluded from analysis because they declined to be recorded, and two more were excluded because they are considered “hobby” ranches as defined by ([Peterson and Coppock 2006](#)). This resulted in a sample of seven AMP-HM ranchers and three CONV ranchers.

Our sample population is not a “representative” sample of AMP-HM ranchers in California. Our goal was not to interview all AMP-HM ranchers in California, but rather to gain a deeper understanding of the ranchers in our narrow sample, including their motivations, decision making processes, and mental models under the AMP-HM framework.

Table 1
Categories and example questions extracted from the semistructured interview guide used for rancher interviews.

1. Ranch history and characteristics	
Ranch history	<ul style="list-style-type: none"> • Can you tell me about the history of your ranch?
Ranch characteristics	<ul style="list-style-type: none"> • How many acres do you graze, and do you own or lease this land? • What other (if any) types of agricultural production take place on the ranch (besides beef cattle)? • What type of beef operation takes place on the ranch (e.g., cow-calf, stocker, finisher), and how many animals do you have?
2. Detailed grazing management practices	
Detailed grazing management	<ul style="list-style-type: none"> • Can you please describe your grazing management? (<i>open ended</i>) • <i>Follow-up questions</i> <ul style="list-style-type: none"> ◦ Do you rotate your cattle across your ranch? If so, how often, and how do you decide when to move them? ◦ How does your grazing change seasonally? ◦ Do you subdivide your ranch into smaller paddocks? If so, how many, what sizes, and how do you decide? ◦ If you rotate your cattle, how much rest does each paddock receive? • What do you call your grazing management?
3. Ecosystem responses and feedbacks	
Ecosystem responses and feedbacks	<ul style="list-style-type: none"> • Do you manage specifically for any type of environmental outcomes? • Have you noticed any environmental changes on your ranch that you attribute to your grazing management? • What environmental responses do you seek when informing grazing management decisions (e.g., when to rotate animals, how long to rest pastures)? • Do you measure any of these outcomes, or have you had any monitoring done on your ranch?
4. Management motivations, barriers	
Motivations	<ul style="list-style-type: none"> • What motivated you to graze this way? • How did you learn about this grazing management strategy, and what about it appealed to you? • Why do you prefer this grazing strategy?
Barriers	<ul style="list-style-type: none"> • What challenges do you face in your grazing management? • What barriers do you face that prevent you from reaching your grazing management goals?
5. Information networks and communities	
Information networks	<ul style="list-style-type: none"> • Where do you go when you have questions about grazing? <ul style="list-style-type: none"> ◦ Do you consult with organizations, Cooperative Extension, or other institutions? ◦ What other ways do you receive useful information that helps you in your grazing management?
Communities and neighbors	<ul style="list-style-type: none"> • Do you consider your grazing management to be different from others in the region? • Do you feel like your grazing management practices have impacted nearby ranches? • Have you experienced social challenges or negative reinforcement related to your grazing management?
6. Economics and resources	
Economics	<ul style="list-style-type: none"> • Is ranching your main occupation? <ul style="list-style-type: none"> ◦ If not, what proportion of your income is on vs. off ranch? • Do you have certifications that you find useful? • Have you relied on any grants or funding to help you achieve your desired grazing management or ranch goals?

Semistructured interview protocols and qualitative data analysis

We conducted semistructured interviews from September 2019 to January 2020. Our interview protocols focused on six main categories: 1) ranch history and characteristics; 2) detailed grazing management practices and underlying decision making; 3) ecosystem responses and feedback (including description of monitoring goals); 4) management motivations, challenges, and barriers; 5) information networks and communities; and 6) economics and resources (Table 1). Interviews ranged from 30 minutes to 2 hours.

Interviews were audiorecorded and digitally transcribed verbatim. Qualitative data were analyzed through a five-step iterative coding process. First, interviews were replayed and transcribed, then replayed again and annotated with notes. Upon a third pass, interviewee responses were coded into categories defined by our interview protocol (see Table 1). Interview notes and transcripts were revisited and recoded into emergent themes that arose from the interviews in aggregate. Transcripts were passed through a final time to identify key quotations within our emergent themes. We incorporate ranchers' quotations throughout the results to center these ranchers' experiences and journeys in their own words.

Table 2

Ranch characteristics operated by interviewees. Quantitative characteristics were representatively grouped to protect ranchers' anonymity.

Rancher ID	Management category	Acres managed	Enterprises and ownership by acreage	No. and type of cattle
R1	AMP-HM	> 10 000	<ul style="list-style-type: none"> • 1-5 • Private and public leases 	<ul style="list-style-type: none"> • > 2 000 • cow-calf + yearlings
R2	AMP-HM	1 000-5 000	<ul style="list-style-type: none"> • 1 • All privately owned 	<ul style="list-style-type: none"> • 300-1 000 • birth-finish
R3	AMP-HM	1 000-5 000	<ul style="list-style-type: none"> • 5-10 public + private leases • < 500 acres privately owned 	<ul style="list-style-type: none"> • 300-1 000 • cow-calf + yearlings
R4	AMP-HM	5 000-10 000	<ul style="list-style-type: none"> • 5-10 public + private leases • < 50 acres privately owned 	<ul style="list-style-type: none"> • 1 000-2 000 • birth-finish
R5	AMP-HM	500-1 000	<ul style="list-style-type: none"> • 1-3 private leases • < 200 acres privately owned 	<ul style="list-style-type: none"> • 0-300 • cow-calf
R6	AMP-HM	5 000-10 000	<ul style="list-style-type: none"> • 1 • privately owned 	<ul style="list-style-type: none"> • 0-300 • cow-calf
R7	AMP-HM	< 500	<ul style="list-style-type: none"> • 1 • privately owned 	<ul style="list-style-type: none"> • 0-300 • cow-calf
R8	CONV	< 500	<ul style="list-style-type: none"> • 1-5 • private leases 	<ul style="list-style-type: none"> • 0-300 • cow-calf
R9	CONV	> 10 000	<ul style="list-style-type: none"> • 1-5 • private leases 	<ul style="list-style-type: none"> • 2 500 • yearlings
R10	CONV	1 000-5 000	<ul style="list-style-type: none"> • 1 • privately owned 	<ul style="list-style-type: none"> • 0-300 • cow-calf

Results

Ranch characteristics

The ranchers we interviewed included a variety of ranch ownership realities, operation scales, histories, and enterprises. We did not find patterns that helped distinguish ranchers by grazing management: AMP-HM ranchers did not consistently operate larger ranches or own more private acres compared with CONV ranchers in this study.

It was common for ranchers to operate across several land bases, combining grazing on small privately owned home ranches with grazing opportunities from public leases with state parks and organizations or other private leases. Two AMP-HM ranchers and one CONV rancher owned ranches > 1 000 acres, while most other ranches in the sample only owned base acres ranging from 11 to 300 acres. Operational characteristics and herd sizes varied widely among ranchers in our sample, ranging from 50 to 2 500 cow-calf pairs (Table 2).

Grazing management characteristics

Six of the seven AMP-HM ranchers had been AMP-HM grazing for < 12 yr, while one had been AMP-HM grazing for more than 25 yr. All CONV ranchers had been grazing conventionally since they began ranching, all more than 15 yr ago. When asked to describe their grazing management, including number of temporary paddocks and stocking densities, AMP-HM ranchers rarely reported a single definitive value. Rather, they emphasized the variability of these values both seasonally and as a core feature of their adaptive management and HM approach.

Despite managing across a variety of rangeland ecotypes in California, AMP-HM ranchers reported relatively consistent ranges for grazing rotations and pasture rest. During the growing season, AMP-HM ranchers moved their cattle every 1–2 d and aimed for

25–45 d of rest, on average. However, their use of stocking density varied by up to 10-fold. Some AMP-HM ranchers reported using very high stocking densities with very fast rotations to meet their goals during peak grass growth (e.g., 112 AUs in 1 acre for only a few hours), while others use more moderate densities (100 AUs in 10 acres for 2 d). Generally, AMP-HM ranchers reported constructing more than 100 temporary paddocks during the grazing season, except one rancher who manages fewer acres (necessitating fewer paddocks) and another who primarily herds animals on horseback via range riding.

In addition to short-term flexibility within a single growing season, all AMP-HM ranchers also discussed how they adapt their grazing rotations, pasture rest, and stocking densities throughout the year in response to seasonal precipitation. Generally, grazing rotations become slower (up to 20–30 d) and pasture rest periods longer (60–90 d) as conditions become more dry. The herbaceous annuals die and begin to decompose, and herbaceous perennials senesce, leaving dry forage of lower protein content that declines in biomass through the summer (Table 3).

In comparison, two CONV ranchers reported rotating animals between five permanently constructed pastures but did not set target rotation frequencies or pasture rest periods. The third CONV rancher grazed more intensively, rotating every 2–5 d on a set schedule and resting pastures for 10–20 d between grazing events.

Qualitative emergent themes

We identified seven key themes that emerged from our qualitative interview data (Table 4):

1. HM is considered a useful decision-making framework by ranchers.
2. AMP-HM ranchers prioritize strategies to increase adaptive capacity on their ranches, using synergistic approaches (both grazing and ranch-enterprise related) to increase temporal, spa-

Table 3
Grazing management characteristics of interviewed adaptive multipaddock ranchers. Quantitative characteristics were categorized to protect anonymity. Overall cattle stocking rate is calculated as the total animal units divided by total grazed acres. Max stocking density is reported for ranchers who were able to estimate their maximum grazing intensity during the growing season. Rotation schedule and rest duration are averages for each season reported by the ranchers.

Rancher ID	Length of management (yr)	No. permanent pastures	No. temporary paddocks	Overall cattle stocking rate	Max stocking density	Rotation schedule (d)	Rest duration (d)
R1	> 20	25-50	> 100	5-10 ac/AU	NR	Spring: 1-1.5 Dry: < 10	Spring: 45 Dry: 90
R2	0-5	25-50	> 100	5-10 ac/AU	75 AU/ac for < 1 d	Spring: 1-2 Dry: varies	Spring: 30-40 Dry: 60-70
R3	10-20	25-50	> 100	0-5 ac/AU	100 AU/ac for < 1 d	Spring: < 1-1 Dry: < 30	Spring: 25 Dry: 180
R4	10-20	10-25	NA, rotates with horses	15-20 ac/AU	10 AU/ac for 2 d	Spring: 2-5 Dry: < 21	Spring: 30 Dry: 90
R5	0-5	0-10	0-50	15-20 ac/AU	NR	Spring: 1-2 Dry: 14-30	Spring: 30-45 Dry: 45-70
R6	5-10	0-10	> 100	10-15 ac/AU	20-50 AU/ac for 1 d	Spring: 1-4 Dry: < 30	Spring: 30 Fall: 90-180
R7	0-5	10-25	> 100	0-5 ac/AU	112 AU/ac for a few hr	Spring: 0.5 Dry: < 20 d	Spring: 30 Dry: 60

NR indicates not reported.

- tial, and financial flexibility in response to ecological, economic, and social uncertainties.
- AMP-HM ranchers view their management as a continual process of iterative improvement, relying on a closed feedback loop of continued education, experimentation, and monitoring outcomes.
 - AMP-HM ranchers are not an elite subgroup: they are constrained by systemic challenges.
 - There are some unique challenges to AMP-HM in California, which may limit adoption.
 - Motivations for ranchers' AMP-HM adoption were not uniform: ranchers are driven to AMP-HM via many, idiosyncratic reasons.
 - A set of common tools (e.g., low-stress livestock handling, digital software) act as positive catalysts, shifting ranchers' mental models and reinforcing AMP-HM among adoptees.

Theme 1: HM is a useful decision-making framework for ranchers

At the outset of our interviews, we set out to gain an understanding of AMP grazing, including AMP ranchers' underlying decision-making processes. However, throughout our interviews it became clear that ranchers' AMP grazing management was inseparable from HM. In fact, all AMP ranchers we interviewed discussed HM at some point independently and without prompt.

Many AMP-HM ranchers echoed the sentiment illustrated by the quotation in Table 4 (Theme 1): the HM decision making framework was a useful tool to implement a systems approach on their ranches, taking complex financial, social, and ecological contexts into consideration. Before their HM approach, ranchers report their economic and ecological goals were often at odds. But through the HM-mediated process of explicitly identifying their long-term goals, learning tools to reach these goals, tying social and economic contexts into their decision making, monitoring their ecological outcomes, and learning the importance of adapting in response, ranchers report feeling more fulfilled in economic, ecological, and personal spheres.

In this way, HM seems to be a key precursor of AMP management. While animal movement, pasture rest, and the flexible use of high animal stocking densities are taught as grazing tools in HM, the specific typology of AMP grazing seems to arise primarily as a function of HM ranchers' emphasis on monitoring and adaptation. In the words of one rancher:

And, you know, one of his greatest insights [Allan Savory] has been the decision making framework, which is, I mean, I tell people, look, I don't care what you do. Use, I mean on the land use this decision making process, format, and then moni-

tor what you're doing. If you're monitoring what you're doing, I kind of think you're gonna move towards this thing, which, as we've already discussed, is not self-evident on how to do it. (R1)

Theme 2: Strategies for increasing adaptive capacity using AMP-HM

Without being asked directly, AMP-HM ranchers collectively described a variety of strategies they use to increase adaptive capacity. This includes both decisions directly tied to their grazing management and in their business models.

Flexibility is central to ranchers' AMP-HM approach. Ranchers reported efforts to move animals across their ranches quickly during the growing season, often choosing to leave more grass behind than necessary as a way to overcautiously prevent overgrazing and grassbank forage in case of drought. They expressed making decisions about when to rotate, stocking density, paddock size, and length of pasture rest on a day-to-day basis, taking into account a myriad of social and ecological factors including precipitation, grass regrowth in previously grazed paddocks, forage utilization within current paddocks, grass maturity in planned future paddocks, growth needs of different grass species, seasonal wildlife habitats, and planned weekend breaks for ranch staff (see Table 4, 2d). For example, Rancher 3 explained:

And so now we're grazing for animal and soil performance, we're not grazing according to A, B, C like pattern 1, 2, 3 where it's almost more like pulse grazing, we might go from pasture one to pasture 10, and then back to pasture one, depending on how much grass there is and how wet it is, and performance.

All seven AMP-HM ranchers discussed the difficulty of ranching in California, where already temporally variable annual grass growth is increasingly exacerbated by drought. Several ranchers expressed a desire to rapidly stock large herds of cattle in the spring to take advantage of the rapid forage growth, and rapidly destock as resources become more scarce in the summer and with first signs of drought (see Table 4, 2a).

Because our grass here comes on so quickly, like between April and June, we're like we don't have enough cows. Everytime. We're like, we don't have enough cows, we don't have enough sheep, we need to hire more. And then like July 4th comes and we're like "sell all the cows" so it's just so fast. (R2)

In response to these challenges, 6/7 AMP-HM ranchers reported shifting their herd sizes and types to improve spatial and temporal mobility. This included shifting the composition of their cattle

Table 4

Illustrative AMP-HM (adaptive multipaddock and holistic management) and CONV (conventional) rancher quotations categorized by emergent theme.

Theme 1: HM is a useful decision-making framework for ranchers			
<p>"I was so overwhelmed by all the things you have to think about to run a property, that I was searching for something to help me compartmentalize all that stuff, like the financial part, and the grazing planning part, and the land planning part. The reason why Holistic Management felt right to me is because those were all the pieces that I couldn't figure out how to work together. Yeah, like how do I manage the land? How do I manage the books? How do I manage the animals? The feed? And like so Holistic Management kind of is an umbrella of how to manage it all and that was what was so attractive to me because it organized for me all the things that I felt were separate, and it was like, "No, you have to manage them all together and you have to have like a North Star and that kind of helps you gauge everything" and it, and it made it just made sense in my brain. Like, they could have called it anything. Like I don't give a \$##& what it's called, but I just needed a way to organize the complexity of owning a property." (R2)</p>			
Theme 2: Strategies for increasing adaptive capacity			
<p><i>Changing herd size & type (a)</i></p> <p>"So '14, we had the worst drought ever. And I never want to be stuck in a position like that again. So I leave a lot more residual than I ever have. And like December 1st is my critical rain date. If we don't get an inch or two of rain by December 1st, I'm starting to sell animals." (R3)</p>	<p><i>Improving soil health to reduce external inputs (b)</i></p> <p>"My ideal thing is I don't want to buy hay. I don't want to pay when I can go to animal grazing. That's the other reason to consider going to stockers is that if you're putting too much pressure on, you get rid of the animals and start building up the soils and building up the plant base." (R6)</p>	<p><i>Diversifying with smaller ruminants (c)</i></p> <p>"Our management with them [sheep], has been putting them in areas where we can't necessarily reach with the cows." (R2)</p>	<p><i>Flexible grazing management (d)</i></p> <p>"My first trigger is when I get down to 60% of the forage, you need to move. With the steers, it's pretty much every day. So I just kind of go okay, this paddock was a little bit too small today, we left less than 60% of the forage. So we'll make the next paddock next week a little bigger and move them with the cows. It changes, you know." (R6)</p>
Theme 3: Education, experimentation, and monitoring			
<p><i>Experimenting with grazing (a)</i></p> <p>"We've tried different things, trying to understand how this best works ... Early on, we tried to use shorter recovery periods during the grazing season. And it didn't produce bigger plants. I think we just weren't giving the plants enough recovery. But we were giving plenty of recovery in the dormant season. So we were seeing some good things, but not as much, so we've kind of shifted to a little bit longer or twice as long recovery periods during the growing season." (R1)</p>	<p><i>Monitoring outcomes (b)</i></p> <p>"When the NRCS guy would come out to monitor, I would sit out there with him and ask like, 100 questions, and then I got my report and I was like, "Oh, this is helpful." Like because I didn't know any of this. I didn't know what to look for." (R2)</p>	<p><i>Continuing education (c)</i></p> <p>"I talk to ranchers around the world...I talk directly to them or if I know them, go to a few conferences, not too many, the Ranching for Profit thing was kind of what I did for about five years. And that, that was a great network of ranchers. You know, hear about people, YouTube soil scientists from around the world." (R1)</p>	<p><i>Experimenting beyond grazing (d)</i></p> <p>"I have lots of plans and hopes to do some seeding, some like annual cover crop type seeding, and some soil inoculation, and some compost applications, and a whole bunch of other things, too." (R5)</p>
Theme 4: AMP-HM ranchers are constrained by systemic challenges			
<p><i>Insecure land access (a)</i></p> <p>"Since I've had it I've been trying to build up- just try and let plant material grow and then try and knock some down. It gets tough because it's in the context of other grazing properties I have that are totally unstable. And so the grazing has not been to the level that I would like it to be." (R5)</p>	<p><i>Debt/economics (b)</i></p> <p>"They're, they're like fighting each other, the amount of cattle that I need to be able to pay my bills is forcing me to make decisions that are compromising or slowing soil health." (R3)</p> <p>"I mean, the economics are really tough. For ranching, especially as everything gets more and more expensive. And if you're not doing well financially, then it's hard to innovate and put that time towards innovation." (R4)</p> <p>"We just, we have so much debt right now, and there's just no way it's gonna happen. So you kind of limp along." (CONV rancher)</p>	<p><i>Labor (c)</i></p> <p>"There's a lot more busy work. So I mean, there's a certain part of kind of going, "God, it's a boat load of work to do it this way." But what you get out of it is significant greater, like anything. But you know, you kind of look at some of my neighbors and say, "Well, that's kind of nice. You just turn your cows out and they eat until it's dirt and then they start feeding them and go down to Baja or whatever, This definitely takes more day to day attention." (R6)</p> <p>"I think I would say that a lot of people don't want to deal with the labor of rotational grazing." (CONV rancher)</p>	<p><i>Infrastructure (d)</i></p> <p>"For us, if we had a permanent water system, then a little more cross fencing, then it would be a more proactively managed regenerative situation." (CONV rancher)</p> <p>"And it was a lot of work because the fences were a mess. And so they wouldn't get through the electric fence they'd get through the ends. And then everywhere we went, we had to set up chargers and ground rods and all that stuff and just go field to field. Now I have a massive charger I finally bought this year up here and now it's like, this is easy. Once you have the infrastructure." (R7)</p>
Theme 5: Unique challenges			
<p><i>Institutional disapproval (a)</i></p> <p>"It can be frustrating for sure. Even just covering certain topics at the summit, or at different meetings or conferences or events is just like pulling teeth I feel like. Around grazing management. And in conversations about the development of grazing plans, they're just like "Don't have prescribed grazing plans." Seriously some NRCS people are just like, "No, don't put in a rotation, there's no benefit to that." So the prescription can literally be season long." (R5)</p>	<p><i>Noncontiguous leases (b)</i></p> <p>"I wish I had a larger and more stable land base to demonstrate on. Like if my other grazing properties were more stable and consistent... I feel like I could be so much further and really be able to like, show some stuff." (R5)</p>	<p><i>Learning curve (c)</i></p> <p>"I'd say learning curve is a challenge, when you don't have anyone on your team that's done it before where you're all kind of learning together." (R2)</p> <p>"So, the cons are that, you know, you make a lot of mistakes cause you're trying a lot of new things. But you get better at, you know, the mistakes you're making are generally small." (R1)</p>	<p><i>Small communities of practice (d)</i></p> <p>(discussing the possibility of being able to market and distribute beef collectively), "That would mean your whole region needs to be like I am, but I am THE only holistic grazer." (R2)</p>

(continued on next page)

Table 4 (continued)

Theme 6: Idiosyncratic motivations for AMP-HM			
<i>Philosophical (a)</i> “But it’s something that I’m just driven to do it, I need, I think we need as a society to kind of figure these things out, as we manage so much of the Earth’s surface is rangeland, that’s what we’re doing so, what are we doing, if we’re not trying to do it as well as we can?” (R1)	<i>Ecological (b)</i> “I’m trying to create more awesome soil. And then that’s going to ultimately grow more grass, and then ultimately convert that to more protein that I can sell.” (R3) “It’s the ecosystem we need to manage, not the pastures. And I used to think as a cattleman that I thought I was a, you know, grass grower and a water steward, and now it’s really about the land and the soil. You know, you can do whatever you want everywhere else and if you don’t have a living soil, you’re out of luck.” (R6)	<i>Economic (c)</i> “I built the ranch at the same time I was doing my day job. I was moonlighting like crazy. I was at a breaking point where I was either gonna get a divorce or die of a heart attack. And I grew up on the ranch where we were basically broke, you know, did it so you can make it again, do it again the next year. I never want to be like that. So to leave a safe secure job where I had a 401k and great benefits all that was a big deal.” (R3) “So I think that what motivated us to do it more intensively was because we want it to improve our soils and improve our plants and improve our weight gains on our our animals, because we sell meat.” (R4)	<i>Connectivity to land and animals (d)</i> “I enjoy it. I like going out and being with the cows twice a day, right? It just chills me out. And there’s no better sound than like, when they’re all kind of, you know, ready to go and you move it up. And then it’s just the silence of them eating—250 cows eating. I could just lie down in them. There’s no better ... so I just really like it personally, you know, and so that’s my holistic framework.” (R7)
Theme 7: Positive catalysts reinforcing AMP-HM			
<i>Leveraging opportunistic funding (a)</i> All AMP-HM ranchers have leveraged funding opportunities from bodies such as USDA, California Fish and Wildlife Service and CDFA to fund flexible infrastructural improvements (i.e., removing interior fencing, improving perimeter fencing, developing mobile water sources), allowing them to more easily and effectively implement AMP-HM.	<i>Techniques and Technologies (b)</i> Low-stress livestock handling “From a stockmanship standpoint, it’s been kind of fun. I’ve been really using low stress livestock handling principles for the last two years, and the difference I see in the way my cattle handle is phenomenal. Seeing them stick together more, it’s just been cool to see them graze differently.” (R5) PastureMap “I knew we weren’t utilizing lots of pieces that we could. So when I took the classes and started holistically managing, I think it was only like five or 600 acres that I would say we managed holistically, and I plugged them into PastureMap to help make sure we didn’t go back too early.” (R2)	<i>AMP-HM Networks (c)</i> “But the literature on this was pretty scant. I mean, you know, you had your Savory, you had your Joel Salatin but there just was not any guidance. Then [names redacted] introduced me to a community which gave me more confidence in what I was doing, and more impetus to double down on what I was doing. But it’s kind of like you’re working on your research and then all of a sudden you come into some colleagues and that kind of steps it up just because there’s a community that validates what you’re doing. Seeing the success, hearing the stories, and just not feeling you’re completely alone. It’s more on an inspirational basis.” (R6)	<i>Changing mental models (d)</i> “And once you finally learn how to see that stuff, that’s the thing is my eye is changing. I’m starting to see stuff that I didn’t, that I would have never noticed before.” (R2)

herds away from cow-calf pairs toward more diversified or solely yearling enterprises (see Table 4, 2a). Rancher 1 illustrated by saying:

We’ve moved from a cow-calf year-round enterprise to a stocker enterprise, which is seasonal ... It was a business decision. And actually, drought pushed us in that direction ... because there have been some pretty serious droughts.

AMP-HM ranchers also aim to increase economic flexibility by diversifying income streams and reducing external inputs. For example, several AMP-HM ranchers we spoke to have chosen to diversify their herds by either newly incorporating sheep or growing their existing sheep herds, shifting their overall composition of cattle:sheep (see Table 4, 2c). Incorporating sheep provides a second form of income when cattle markets are unfavorable and also increases spatial mobility on hard-to-reach grazing locations.

However, maximizing the number of animals produced was not their profitability strategy. Instead, AMP-HM ranchers opted for overall smaller herds of cattle, which they could graze sustainably year-round on their land base with fewer inputs, as opposed to larger herds, which required expensive hay feed. Reducing herd sizes to more carefully match their animals (in number, breed, and species) to their available natural resources was part of a concerted effort to reduce their external input costs and increase overall profitability (see Table 4, 2a, 2b).

But [redacted] has 80 cows on 200 acres, that’s like, less than three acres per cow. He’s feeding the crap out of them for 3

months or 4 months of the year, and I’d rather have 40 cows and never feed them. (R3)

I’ll get [people asking] like, “how’s the Savory program going?” And then I’ll explain that it’s going great, and that it helped me a lot, and then we got rid of our hay bill and that always blows their mind that it got rid of the hay bill. Not the whole bill, but a large chunk of it ... Yeah, we’re down to seven loads of hay vs. 22, I think, when I got here ... So that’s, that’s another thing is I haven’t been growing the herd because I’m trying to get the genetics of this environment right. We’re doing seven loads of hay and you’re moving all the time. I need the herd that can handle that. (R2)

In contrast, one interviewed CONV rancher turned to the opposite strategy. This profitability approach prioritized producing the maximum number of animals by increasing inputs, primarily irrigation, and the rancher expressed frustration at not having access to more irrigation water.

We’ve added some irrigation on one piece ... we’d like to do some more additional improvement but we don’t have money to do it. You probably can’t maximize our pastures, maximize production, the way that this irrigation system is set up right now and the way our water availability is. Two thirds of it only gets water once every 2 weeks. And so, yeah, we’re always behind on the water. And until we can pour more water to it, we’re never gonna be able to maximize production. (R10)

Theme 3: Education and experimentation

All AMP-HM ranchers described their grazing as an iterative and lifelong process of continued improvement, whereby they constantly seek new information (see Table 4, 3c), test their hypotheses through on-ranch experiments (see Table 4, 3a, 3d), monitor their outcomes (see Table 4, 3b), and change their decisions accordingly. These ranchers don't solicit grazing management help from traditional channels, such as NRCS, but instead network and engage in vast online communities, attend specialized regenerative agriculture and HM conferences (i.e., Regenerate, EcoFarm), and seek out targeted advice from trusted experts with experience in AMP-HM systems. All of the AMP-HM interviewees were highly motivated to experiment with both their grazing management and other aspects of their ranch management, including changing grazing intensities to reduce weedy species, taking penetrometer measurements under windrows, and testing outcomes of different combinations of practices like seeding, microbial inoculation, and compost application. Here is an example of a rancher experimenting with pasture rest durations during the growing season and reflecting on their monitored outcomes (see Table 4, 3a, 3b):

We've tried different things, trying to understand how this best works ... Early on, we tried to use shorter recovery periods during the grazing season. And it didn't produce bigger plants. I think we just weren't giving the plants enough recovery. But we were giving plenty of recovery in the dormant season. So we were seeing some good things, but not as much, so we've kind of shifted to a little bit longer or twice as long recovery periods during the growing season. (R1)

In addition to the experiments they've been able to carry out, these ranchers also repeatedly discussed practices and ideas they aspired to try in the future.

Theme 4: AMP-HM ranchers are constrained by systemic challenges

AMP-HM ranchers expressed constraints imposed by systemic challenges that are well documented among ranchers both broadly and in California. For example, like many California ranchers, these ranchers often cannot afford to purchase contiguous land bases and are instead forced to cobble together several grazing leases to reach profitable scales. In cases of insecure land access, including short-term leases, ranchers feel disenfranchised in implementing AMP-HM management because they may not be able to reap the long-term benefits (see Table 4, 4a). In one extreme example, an AMP-HM rancher had recently lost access to the largest land lease (accounting for more than half of total managed acres) despite positive ecological outcomes arising from management, jeopardizing the rancher's future, stating:

That's what they want to do ... It's their ball. And all the people who were monitoring, they're really happy with how the land is responding. Yeah. I mean, if I don't [find another lease], I can't keep my little business, my guys together. So, I really want to do that. And, you know, I'm trying to think about, okay, it's an opportunity, it's painful, but what can you do? (R1)

Both AMP-HM and CONV ranchers expressed significant economic challenges associated with ranching in California (see Table 4, 4b). For example, several ranchers illustrated scenarios where they were forced to sell animals in suboptimal market conditions because of worsening drought or even to pay looming debt. Infrastructure and labor are additional challenges shared among all California ranchers in our interviews (see Table 4, 4c, 4d), though we came across several examples of AMP-HM ranchers finding ways to partially mitigate these challenges. For example, it is commonly assumed that labor and fencing costs are prohibitive to

adoption of AMP-HM grazing. AMP-HM ranchers openly acknowledge the increased labor needs and expenses associated with their management but have reportedly managed to still increase overall profitability by drastically reducing other input costs. To our surprise, none of the AMP-HM ranchers interviewed reported mobile electric fencing as a significant economic or infrastructural challenge. When asked directly, one rancher responded:

Oh my God, no. Last year we spent \$800, that's with batteries and all sorts of stuff. Then I budgeted it in this year, like another 1 500 bucks. No, that isn't, that has not been a barrier. (R2)

Though AMP-HM ranchers are generally less reliant on permanent interior fencing, poor perimeter fencing and water development are infrastructural challenges they share in common with CONV ranchers (see Table 4, 4d).

Theme 5: Unique challenges to AMP-HM that may limit adoption

We found several unique challenges associated with AMP-HM compared with more conventional forms of grazing management in California. First, four of seven interviewed AMP-HM ranchers expressed that they've been subject to institutional disapproval of their grazing management (see Table 4, 5a). They reported scenarios ranging from feeling shunned from prominent grazing institutions, opposition to discussing AMP-HM at institutional gatherings, and hearing prominent rangeland experts actively advising against the use of AMP-HM (see Table 4, 5a).

I get more pushback from the University of California. There's some rangeland consultants out there that would really love to see me just crash and burn. ... I go to meetings and they slam their hand down on the table, and say "the Society for Range Management hasn't accredited these kinds of things, and they have no business writing rangeland plans at all." (R1)

Some ranchers also reported difficulties finding land owners willing to let them try AMP-HM on their grazing leases because of local antipathy. One rancher recalled knowledge of a scenario involving direct censorship of a public employee after organizing a rancher-requested HM meeting:

I know a guy who was put on 2 weeks of administrative leave, because he—and the ranchers asked for it—he organized a meeting with a group of ranchers and Allan Savory and he was put on administrative leave from NRCS. This was back in the day. So it's like that's the kind of stuff that happened and that's why people didn't pursue it. (R5)

Second, AMP-HM ranchers consistently discussed frustration with the steep learning curve of AMP-HM grazing (see Table 4, 5c). In early adoption, they struggled with learning which ecological cues to consider, which grazing levers to adjust in response, how to recover from management mistakes, and how to balance social and personal needs. One rancher described it by saying, "it's been like, drinking out of a fire hose, basically," (R2) illustrating the challenge of applying their newfound knowledge from HM trainings on the ground, and with few local communities of practice to rely on (see Table 4, 5d). In the words of one rancher:

But the literature on this was pretty scant. I mean, you know, you had your, Savory, you had your Joel Salatin has been around for a while and some folks but there just was not any guidance. (R6).

Instead, AMP-HM ranchers turn to their robust online communities, as well as ranchers and instructors they met in their HM training courses. As they gain experience and become more comfortable with the process of monitoring outcomes, changing man-

agement, making mistakes, and starting again, these ranchers come to understand and find meaning in AMP-HM as a life-long journey of iterative learning, rather than a formulaic method.

So, the cons are that, you know, you make a lot of mistakes cause you're trying a lot of new things. But you get better at, you know, the mistakes you're making are generally small. If you're monitoring, you can correct them really, pretty quickly. And there's, you know, it's kind of a little blip on the screen. (R1)

The lack of local communities of practice poses other challenges, including lack of collaborative distribution opportunities (see Table 4, 5d). For example, in response to low profit margins of beef wholesale markets, some ranchers have opted to form cooperatives within their regional ranching communities and sell their product collaboratively in higher-margin direct-to-consumer outlets. This was not possible for the AMP-HM ranchers, however, because their neighbors do not share their management approach. As one rancher put it:

That means your whole region needs to be like I am THE only holistic grazer. Like the only. (R2)

Lastly, AMP-HM ranchers reported difficulties implementing their ideal management across noncontiguous ranch leases (see Table 4, 5b). Noncontiguous leases are a known challenge for California ranchers. However, it seems to especially challenge AMP-HM management: When ranchers manage separate herds on spatially discrete ranches, they found it difficult to rotate animals as frequently and intensively as they would have liked. According to one rancher managing more than five separate grazing leases in separate locations:

But maybe the thing that's most likely to be good is really high stock densities applied systematically across the landscape. And that has been super challenging for me to do. It wouldn't have been very much of a challenge if I had 12 000 acres on one ranch. It virtually has been, you know, almost impossible.

Theme 6: Idiosyncratic motivations for AMP-HM

One key focus of our semistructured interviews was to understand the motivations underlying adoption of AMP-HM. All of the AMP-HM ranchers we interviewed had unique, and often highly personal, reasons for adopting and maintaining AMP-HM on their ranches. Motivations were diverse, and no singular motivation applied uniformly to all AMP-HM interviewees. We grouped "motivators" into four groups, though they are interrelated: philosophical, ecological, economic, and connectivity to land and animals. In constructing these groups, we pulled on rancher responses to questions directly involving motivations, as well as motivational reflections throughout the interviews.

The motivations we describe below are also influenced by unique rancher contexts. Of the seven AMP-HM ranchers we interviewed, two adopted AMP-HM during a familial ranch transition, two were relatively new ranchers (< 10 yr) who began ranching with AMP-HM, and three transitioned to using AMP-HM > 10 yr ago from more CONV grazing systems.

We describe the first group of motivations as "philosophical" (see Table 4, 6a). AMP-HM ranchers collectively reflected on large societal challenges they felt compelled to, in some way, address within their ranching contexts. These conversations spanned issues of climate change; struggling rural communities and declining ranching viability; the connections among industrial agriculture, public health, and environmental degradation; and a deep desire to contribute to a regenerative food system of the future.

There really should not be these stark distinctions that we've drawn between wild landscapes or wild lands and then working landscapes and so I think grazing lands offer like the easiest opportunity to be able to merge those, but then even in crop and orchard production, there's a lot of opportunity to merge those and I think just for fate, all purposes, whether it's health of the environment, human health, through healthy food and human health through social well-being, we need to break down those walls that have basically been set up and we need to start to blend those lines more and more. So that's I guess, yeah why. Like in terms of, yes, how I came about that cause I definitely was not raised with that or exposed to that and like, through education. So it's been a combination of a lot of observation and conversations on the ground and just the opportunity to attend so many different events, that it's just become a connecting of the dots like process. (R5)

This sentiment was similarly echoed by the majority of AMP-HM ranchers we spoke to. Some sought out HM courses specifically for this reason, while others admitted to recognizing these issues but thinking about them separately from their management before HM. For many, HM's explicit linkage of society and culture to ecology, grazing, and its decision-making framework to incorporate these issues into their everyday decisions was an "epiphany" moment, which allowed them to connect philosophy and practice.

And I grew up in a Catholic family, and had a big kind of emphasis on social justice and the common good ... And finally, finally I stumbled on to, you know, Wendell Berry kind of helped me understand the connections between agriculture, and culture, and civilization. And I was, it was, you know, one of those epiphany moments. (R1)

We describe the second group of motivations collectively as "ecological" (see Table 4, 6b). This includes scenarios of ranchers recognizing declining rangeland conditions under their prior management, a longing to restore previously observed diversity of plants and animals on their ranches, a deep appreciation and reverence for "Mother Nature" (though this may not be unique among AMP-HM ranchers; see Huntsinger et al. 2010), and an understanding that healthy soils are their primary resource base.

And sometimes you get it wrong. You know, you might have heard me say the analogy of Mother Nature's like our dance partner, and once in a while we'll always step on each other's toes. If you keep stepping on each other's toes over and over, you're going to get a new dance partner, pretty quick. Because it doesn't work that way. Usually, you might step on each other's toes once or twice and figure it out. Okay. You follow me. You know. The same way with Mother Nature. She'll put you out of business if you keep stepping on her toes. It's really true. (R3)

All seven AMP-HM ranchers tied their ranching philosophies and management decisions back to a fundamental focus on promoting healthy soils. They emphasized their desire to increase soil health as an important virtue of regenerative agriculture and strategically to increase their productivity by shifting away from inputs and instead relying on improved functionality of healthy soils to sequester carbon, hold more water longer, and increase grass growth.

It is the ecosystem we need to manage, not the pastures. And I used to think as a cattleman that I thought I was a you know, grass grower and a water steward and now it's really about the land and the soil. You know you can do whatever you want everywhere else and if you don't have a living soil, you're out of luck. (R6)

Some AMP-HM ranchers described reaching an economic breaking point on their ranches where they knew they'd soon be forced to either sell their ranches or make a radical change (see Table 4, 6c). The two ranchers whose stories we highlight below to illustrate “economic” motivations both opted to make radical ranch enterprise changes by turning to AMP-HM. One rancher, after taking over management of their family's ranch, realized that the ranch could no longer economically sustain its yearly hay purchases.

Then after looking at the books and adding up the hay bill, I realized that we had to make a dramatic change. For one I wanted better grass because I was trying to finish animals for the beef company. So I was like, “how do I do that?” Researched every book I could, conferences, and then I found the Holistic Management Program ... So I dove in pretty much headfirst into the holistic grazing thing because I knew we have a lot of property. I was like, “Hi, I need help. My Dad thinks I'm crazy, but we can't buy any more hay. So I need to make it work better.” (R2)

These economic motivations are closely related back to the types of ecological motivations we describe earlier. For example, the second rancher's story we highlight here involved a historic drought that drove severe ecological, economic, and psychological hardships and ultimately catalyzed a radical change in their approach to ranching.

So 2013 and 14, we had like the worst drought ever. And I never want to be stuck in a position like that again. So I leave a lot more residual than I ever have. And like December 1st is my critical rain date. If we don't get an inch or two of rain by December 1st, I'm starting to sell animals. And this year rain, you know, I was like, preparing to sell mama cows and stuff. And it rained on November 29th. Last time in 13 and 14, I waited. And then it didn't rain in January. And then it didn't rain. And I was out of money, had skinny cattle, horrible pastures, like nothing left on the pastures. And February 2nd, it started raining. We had a spring, it was a decent spring. But I don't ever want to be in that situation again. (R3)

The remaining motivations we encountered throughout our interviews were collectively related to ranchers' feelings of joy and connectedness to their animals and landscapes (see Table 4, 6d). These ranchers expressed being drawn to AMP-HM because it gave them an opportunity to be outside, spend much more time with their animals, and guide them through monitoring ecological outcomes. In the words of one rancher:

I just want to be out there on land riding, doing what I love, like that's why I do this because I love being out there. Like it's so fun to see the country and to really get to observe it and observe the cattle. I think more people actually want that than even acknowledge or recognize that they want it and if our support systems and economics were different like we could just get that realization.

In contrast, one CONV rancher expressed the opposite sentiment, stating, “We do a rotation system. It's not really super fun.”

Theme 7: Positive catalysts reinforcing AMP-HM

Several sets of tools seemed to catalyze AMP-HM management by either reducing barriers or facilitating faster learning. For example, all AMP-HM interviewees reported leveraging funding opportunities such as USDA-NRCS EQIP or CDFA for more flexible infrastructure, primarily for improved water distribution (see Table 4, 7a). Interestingly, despite their emphasis on soil health, none of the AMP-HM ranchers we interviewed reported applying to CDFA's Healthy Soils Program funding. These ranchers did not

rely on “pay-for-practice” mechanisms tied to their grazing management but rather operationalized infrastructural funding, like many other ranchers, to meet their management goals.

Several ranchers also reported the use of helpful tools and technologies that either made implementation of AMP-HM easier or allowed them to optimize their application of AMP. For example, many AMP-HM ranchers discussed that using low-stress livestock handling techniques helped them move their animals more easily, enabling more flexible and intensive rotations. In discussing their application of low-stress livestock handling, one rancher reported:

My animals are really calm. I have almost no death loss, which isn't necessarily tied to holistic management, but my expression of it, it's a great deal to do with livestock handling. I think it, it opens up opportunities that a lot of ranchers aren't, you know, exploring. (R1)

Though not all, several AMP-HM ranchers in our interviews also employed grazing record keeping apps such as PastureMap or Gaia. Using these apps to record and visualize their rotations, stocking densities, and pasture rests helped them more efficiently plan and scale up their management (see Table 4, 7b).

AMP-HM is knowledge and experience intensive, but AMP-HM ranchers feel isolated from traditional grazing and rangeland groups. Consequently, they did not view traditional information channels as helpful resources for AMP-HM management.

Yeah, I really haven't had a lot to do with NRCS. Or Cooperative Extension. They're really nice people. But I just, just haven't, and I would have worked more with them and not so much on questions of how to do some of this stuff, because none of the NRCS people or Cooperative Extension seem very interested in this. But in terms of, you know, working with them to, you know, for infrastructure purposes. (R1)

As a result, AMP-HM ranchers rely heavily on their AMP-HM networks for support (see Table 4, 7c). These networks serve as important catalysts in these ranchers' learning and troubleshooting and provide inspiration when they see others' success with AMP-HM. This seemed to be especially important for the female AMP-HM ranchers we spoke with, who reported feeling even more marginalized because of their gender. In her words, “Yeah, and also no one really talks to me because I'm like, a girl.” In contrast, one male AMP-HM rancher reported the opposite sentiment, that he's accepted into some traditional ranching groups *despite* his AMP-HM approach because he's a well-respected cowboy in the community [rancher ID redacted for anonymity]:

Well, it has been helpful that I'm a pretty decent cowboy. So, you know, they still invite me to brandings, you know, we get along fine.

In turn, in addition to the networking channels that nearly all AMP-HM interviewees reported finding useful such as their HM training groups and instructors, Ranching for Profit, and HM-centered social media groups, women AMP-HM ranchers also found support in networks such as “Girls with Grass” and “Women in Ranching” groups.

Lastly, “seeing” the first signs of ecological improvement seemed to be a critical aspect for AMP-HM ranchers, catalyzing a pathway of positive reinforcement. Several AMP-HM ranchers reported feeling frustrated and discouraged early in their adoption, making many mistakes and not seeing any changes on their ranches.

Which again, you know, pushes back on any incentive to do this, it's like, you know, your first steps are almost a negative. (R1)

However, once AMP-HM ranchers saw the first signs of improvement, they reported feelings of excitement, accomplishment, and a new sort of connectedness to nature. This seemed to be an important catalyst for continued AMP-HM—a moment that marked a shift in their mental models and reinforced their desire to continually learn and improve their grazing (see [Table 4, 7d](#)).

That was the first pasture that we've managed holistically, really densed them up and moved them every day, and then got off of it. So that was the first pasture that we really did that with, and I, it was, it was like, there was just so much more growth per square foot than there was before. And it was all different plants and it just looked really good and so that was exciting. (R2)

Discussion

Shifting mental models and the agency to operationalize change underscore AMP-HM success

In a recent review of HM, ([Gosnell et al. 2020](#)) concluded with a call to future research, stating, “The core question that has to be asked about HM is not just about ecological outcomes ...; it is about how a social-ecological regime like HM can help bring about necessary shifts in the systems, structures, assumptions and worldviews in order to support a sustainable society.” Our results from in-depth rancher interviews suggest that AMP-HM works by shifting ranchers' mental models in several key ways. Mental models are “cognitive representations of external reality that people use as the basis for acting with and within the world around them” ([Lynam and Stafford Smith 2004](#); [Jones et al. 2011](#); [Jones et al. 2014](#)). AMP-HM is not a singular practice or prescription; it involves deep paradigm shifts in the ways ranchers see themselves as agents of change, their ranches within social-ecological contexts, and how they approach learning and adapting to changing conditions ([Mann and Sherren 2018](#); [Gosnell et al. 2019](#)). Using our qualitative data, we illustrate two key mechanisms by which AMP-HM works to influence ranchers' mental models.

[Lynam and Stafford Smith \(2004\)](#) point out that the local ecological knowledge constituting ranchers' mental models determines “what observations are made, where and how those observations are made and how they're interpreted.” AMP-HM, as a decision-making framework and grazing management strategy, works to change ranchers' opportunities for making these observations in several ways, as found in the Savory Institute's online course, “105: Monitoring your Decisions,” and in chapters of [Savory \(1998\)](#) and [Savory and Butterfield \(2016\)](#): 1) HM teaches ranchers on-the-ground monitoring strategies for both biological and financial outcomes; 2) the HM framework facilitates closed management-monitoring feedback loops by providing mechanisms and platforms for internalizing monitored outcomes and checking them against ecological and financial goals; and 3) features of AMP require ranchers to interact with their land and animals more frequently, physically getting boots and eyes on the ground to make monitoring observations on shorter timescales. Previous work has similarly identified the importance of monitoring in shifting mental models ([Sayre 2001](#)) and the link between HM and mental models ([Gosnell et al. 2019](#)), though to our knowledge our study is the first to capture ranchers' experiences of shifting mental models under AMP-HM.

[Sayre \(2001\)](#) notes that careful monitoring speeds up the learning process by “reveal[ing] the effects of management decisions well before they are apparent to the naked eye, greatly increasing one's ability to avoid lasting damage and to encourage range improvement.” We hypothesize that the combined emphasis on monitoring (including the tools, knowledge and iterative check-

ing against goals) with the increased, often day-to-day, interaction with land and animals under AMP-HM allows ranchers to more quickly connect their management decisions with ecological outcomes. Interviewees all agreed that learning through monitoring was an important part of what they got from HM, and that as a result, they experienced changes in how they thought about the land, making decisions, and their relationship with land and animals.

The influence of monitoring on shifting mental models is reflected in the ways in which the AMP-HM ranchers recalled “seeing” the land differently through monitoring over time (see [Table 4, Theme 7d](#)). [Gosnell et al. \(2019\)](#) also captured this phenomenon among ranchers transitioning to “regenerative” grazing with HM: introduction to the principles of HM and elucidating the linkages between their management and ecosystem outcomes through farm assessments allowed these ranchers to “see” the land differently—an epiphany that contributed to the creation of a new mental model and inspired radical cognitive and behavioral change. While this has also been observed outside of HM, HM seems to provide a framework that increases ranchers' ability to form new mental models. For example, [Rissman and Sayre \(2012\)](#) document interesting shifts in conventional ranchers' mental models and perceptions after observing improved rangeland conditions following grazing rest during a severe drought. Upon observing these changes, ranchers voluntarily and dramatically reduced their stocking rates and in some cases simultaneously improved profitability compared with their prior approach.

Many of the AMP-HM interviewees were also making efforts to partner with scientists and monitoring bodies like Point Blue Conservation Science to monitor ecological outcomes beyond their reach (e.g., soil carbon sequestration).

Point Blue, and you, and [redacted], I have all these people kind of looking over my shoulder, helping me see things that I never would have seen, and I'm not really prepared to understand all the variations on a theme. (R1)

These new mental models are also exemplified by the interviewed AMP-HM ranchers' discussions of how they now view ecology and economics as reinforcing, rather than competing goals as they once did. For example, R4 reported:

“I wanted to try and figure out a way that I could raise more pounds of beef. And the way to do it was to, you know, graze more intensely, so that I could grow more forage. And then, really about 6 or 7 years ago, when I started with the Marin Carbon Project, I started focusing on soil health, it was like, oh, really, I'm not a grass farmer. I'm a soil farmer, I'm trying to create more awesome soil.” (R4)

This observation cannot elucidate whether these ranchers' appreciation of their natural resource base as an economic tool arose out of monitoring or if this connection was emphasized as a pillar of HM and *drove* monitoring. In either case, AMP-HM ranchers in our study seem to have all come to the same conclusion: that improving their ecological resource base (with a specific emphasis on soil health) translates to higher profitability. These ranchers see healthy soils as a foundation, fundamental to their mental model of their grazing operations.

Reducing inputs by bolstering ecosystem functions such as soil health has been promoted in the forms of “ecological intensification,” agroecology, and diversified farming systems ([Kremen et al. 2012](#); [FAO 2018](#); [Spiegel et al. 2018](#)). Interestingly, AMP-HM ranchers' reported increased profitability seems to arise not from increasing animal numbers, but rather from their concerted efforts to reduce their cost-to-income ratio. Most AMP-HM ranchers we interviewed achieved this by successfully reducing external input costs, especially related to hay. AMP-HM ranchers focused on

growing more and healthier grasses and sometimes even *reduced* their herd sizes to better match their yearly forage availability. Emboldened by their new mental models, these AMP-HM ranchers had the confidence and tools to risk changing their approach to profitability, weaning themselves off of their inputs and focusing on improving their ecological outcomes. Importantly, AMP-HM is associated with some increased costs in other areas, such as mobile electric fencing (and associated needs such as solar panels) and water development. However, these costs differ in their periodicity and volatility: Costs such as hay are annual and highly volatile, while infrastructural costs associated with AMP-HM are often one-time fixed costs. Ranchers we interviewed did not report mobile electric fencing as a significant input cost and primarily rely on grants and funding opportunities to help mitigate the costs of water development. Together, these factors may have contributed to their success in ultimately reducing their total annual input costs relative to their profits.

Despite these ranchers' reported successes, all AMP-HM ranchers we interviewed pointed to the initially steep learning curve as a challenge. This is important because it highlights that even successful AMP-HM ranchers make mistakes along the way, but that they find a way to learn from them and persist. Once the management-monitoring feedback loop is built into AMP-HM ranchers' approaches, it seems to inspire continued curiosities that push them to overcome the challenging learning curve. Observing positive ecological feedbacks from their management, as well as becoming more intimately familiar with and connected to their land and animals thus likely reinforces ranchers' incentives to monitor (Stinner et al. 1997).

Oh man. Well, I love learning. And I can be pretty enthusiastic about the things I want to learn about ... I was really, you know, immersed in looking at stuff, and the animals, and the land, and the plants, and how they grew, and how they regrow. And then I was, you know, through all these means of finding or connecting with teachers around the world. As I was doing this, and I just started finding fascinating connections between, you know, animals and their management, and then Allan [Savory], and then people in South Africa, and all over the place, I was, so I was on fire and just loving it but you know, I wasn't naturally inclined to business. (R1)

Second, AMP-HM seems to increase ranchers' agency, or feeling of control over their management and outcomes, which is necessary to operationalize their new mental models on the ground (Gosnell et al. 2019). This is a crucial aspect in AMP-HM ranchers' behavioral shifts: without the tools to translate and mobilize their new mental models into tangible actions, they may not feel empowered to assume the risk embedded in the associated behavioral change, instead causing them to revert to old ways (Burton and Wilson 2006; Knapp and Fernandez-Gimenez 2009). The combination of AMP-HM's emphasis on "holistic" systems thinking (Mann et al. 2019) and the framework for synthesizing multiple information streams (financial, social, and ecological) layered onto the monitoring-driven mental model shifts acts synergistically to succeed under AMP-HM. As illustrated from an excerpt of a quotation in Table 4:

The reason why holistic management felt right to me is because those were all the pieces that I couldn't figure out how to work together. Yeah, like how do I manage the land? How do I manage the books? How do I manage the animals? The feed? And like so holistic management kind of is an umbrella of how to manage it all and that was what was so attractive to me because it organized for me all the things that I felt were separate, and it was like, "No, you have to manage them all together and you have to have like a North Star and that kind of helps you

gauge everything" and it, and it made it just made sense in my brain. (R2)

In fact, previous studies report that both of these aspects—paradigm shifts and holistic thinking—are explicit teaching objectives of HM trainers (Mann and Sherren 2018).

Interviews revealed that reinforcing these new mental models acts to embed the HM approach into larger societal contexts (see Table 4, theme 6a). While unclear if the effect is directly or indirectly mediated by HM, the shift in ranchers' mental models under AMP-HM seems to accompany a sense of purpose and activism. For example, AMP-HM ranchers often connected their efforts to reduce external inputs and build more robust natural resource bases with mitigating climate change, building soil health, increasing biodiversity, and building highly local and regenerative agricultural systems. Early studies of HM similarly reported that adoption of HM increased farmers' awareness of biodiversity, causing them to incorporate it as a goal of their management (Stinner et al. 1997). This "sense of purpose" that AMP-HM ranchers feel likely entrenches their new mental models.

Ranchers increase adaptive capacity under AMP-HM to ranch viably in uncertain times

Decades of literature have documented that the ranching lifestyle is a primary motivation for ranchers to persist: maximizing profitability is not a primary motivation, and ranchers will often endure financial hardships (including taking off-ranch jobs) to maintain their ranches (Smith and Martin 1972). The AMP-HM ranchers we interviewed were no exception.

I guess that my passion is that I like challenges, and it's not about the money. I mean sure I want to be financially secure. But the passion is I mean, when you get the bug of ranching you want to ranch or be farming you want to grow ... **Like if somebody gave me \$10 billion tomorrow and said, you don't need money anymore. I'd still ranch.** You know? I might go on a few more big vacations a year. But I wouldn't do a lot more different than I am now. (R3—emphasis added)

While taking off-ranch jobs to subsidize their ranching lifestyles was reported by the majority of the CONV ranchers we interviewed, AMP-HM interviewees collectively went the opposite direction. Either they adopted AMP-HM as a strategy to prevent selling the ranch or taking off-ranch jobs or to quit off-ranch jobs and reach their ultimate goal of full-time ranching. In other words, many of these ranchers have turned to AMP-HM *in order to ranch viably without dependence on outside income*. This is supported by previous literature, in which HM adopters attribute improved profitability to their AMP-HM approach (Stinner et al. 1997; Sherren et al. 2022).

The types of common decisions made by interviewed AMP-HM ranchers—a culmination of their shifted paradigms and operationalized actions—suggest purposeful strategies to strengthen their adaptive capacity are crucial to their ability to not only continue ranching but also to ranch profitably and sustainably, amid significant uncertainties. Adaptive capacity entails strategies that work at different time scales to increase short-term flexibility and longer-term adaptation but synergistically increase the ability to cope with uncertainties (Allen et al. 2011b). Short-term flexibility is embedded in AMP practices themselves and in the ways in which they change on a day-to-day basis during the growing season. For example, stocking animals more densely in paddocks, rotating quickly, and increasing pasture rest periods resulted in the AMP-HM ranchers using significantly less land at any given time, increasing flexibility to grass-bank forage across the ranch to hedge against unexpected drought. They often also make deci-

sions and changes to each of these aspects of their grazing management on a day-to-day basis based on their observed outcomes, which reduces response time and increases flexibility of potential response options (Darnhofer et al. 2010). In combination, these AMP-HM ranchers have made operational shifts to proactively plan and *adapt* their management and operations in the long term to increasing climatic and economic uncertainties. Common ranch enterprise shifts among our interviewees included shifting from cow-calf to yearlings (Whitt and Wallander 2022), matching animal numbers to year-round forage capacity to reduce inputs, and diversifying their on-ranch operations (i.e., incorporating sheep and chickens, building **on-ranch** agrotourism enterprises, etc.). These shifts collectively work to increase their spatial, temporal, and even financial mobility, allowing them the flexibility necessary to successfully adapt and reorganize in the face of ecological and economic challenges.

Many of the individual adaptation strategies reported by AMP-HM ranchers in this study are neither new nor novel. In fact, previous studies have recommended practices employed by our interviewees, like incorporating yearlings to improve temporal flexibility (Torell et al. 2010), using flexible stocking rates (rather than set, conservative stocking rates) to adjust to variable precipitation (Ritten et al. 2010), enterprise diversification (Joyce et al. 2013), incorporating smaller livestock to increase spatial mobility (Polley et al. 2013), or combinations of these practices (Joyce et al. 2013; Kachergis et al. 2014; Briske et al. 2015). However, adoption of some of these adaptation strategies remains notoriously limited among ranchers. For example, in a survey of 507 California ranchers, 24% reported incorporating pasture rest, and only 11% and 3% reported adjusting stocking rates and diversifying their livestock, respectively (Roche et al. 2015; Macon et al. 2016; Roche 2016).

Limitations, Implications, and Future Work

Our small sample size limits the ability to understand if the features of AMP-HM ranchers and their management in our study are generalizable to the broader AMP-HM population (which is likely a small group overall). Our findings are largely complementary to prior studies of HM, but further research is needed to deepen our understanding, namely studies including larger populations of AMP-HM ranchers to improve generalizability, studies including ranchers who've considered but failed to adopt or chosen not to adopt AMP-HM to better understand barriers, and social-ecological studies that explicitly link ranchers' mental models and decision-making processes to measured ecological outcomes. We hope to expand on the latter in our future work. Additionally, the role of gender is greatly understudied in rangeland sciences. Our interviews revealed some potentially telling linkages among gender, social norms, and rangeland management that deserve exploration in future research.

Our approach of examining retrospective shifts in ranchers' mental models after point-in-time interviews limits our interpretations and subsequent understanding. To more completely understand shifts in ranchers' mental models, including whether ranchers who adopt AMP-HM are enabled by previous conceptualizations, would require iterative observation and interviews over time during a practice change. While our approach of reporting and interpreting mental model shifts of producers post AMP-HM adoption does not overcome the short research timescale limitation highlighted earlier, our work could serve to inform more long-term investigations of mental model shifts among producers in early stages of practice adoption.

Lastly, future studies will need to include technical assistance providers and institutional actors (i.e., academics, rangeland consultants, and prominent rangeland organizations) who play a role in the social norms and agenda setting of rangeland management.

This is critical because our results suggest that antipathy toward HM, likely in part by association with Allan Savory, has become a variable of importance. Ranchers we interviewed and reports from other studies show that above and beyond skepticism from their peers, AMP-HM ranchers have been subject to stigma from the academic community (Sherren and Kent 2017; Gosnell et al. 2019). The intense criticism and rejection they've received from these actors has ostracized them from rangeland communities they desired to be a part of and even prevented them from publicly associating themselves with AMP-HM. This behavior is antagonistic and counteracts the current efforts to study and manage rangelands as social-ecological systems, where ranchers themselves are coproducers of knowledge. Preventing criticisms of Allan Savory and the Savory Institute (Nordborg 2016; Sherren and Kent 2017) from further damaging relationships with AMP-HM ranchers could be a first step in rebuilding these relationships. Rebuilding these relationships may also offer future opportunities to revisit the ecological outcomes of AMP-HM, especially because these ranchers seem motivated to submit their ranches to academic ecological monitoring.

Conclusions and Implications

Our in-depth interviews with AMP-HM ranchers in Northern California provide new insights about their mental models and associated decision-making processes, including motivating factors, barriers, and catalysts for their management. We identified seven emergent themes from our interviews: 1) the HM decision-making framework is a useful tool for ranchers to organize complexity; 2) AMP-HM ranchers use a series of strategies to increase adaptive capacity, including diversifying their herds and reducing external inputs; 3) AMP-HM ranchers view their approach as a process of iterative improvement, relying on a closed feedback loop of continued education, experimentation, and monitoring of outcomes; 4) like most ranchers, AMP-HM ranchers are constrained by systemic challenges like insecure land access, forage seasonality, and limited infrastructure; 5) AMP-HM ranchers face several unique challenges that may limit adoption, including a steep learning curve and institutional rejection that isolates them from important communities; 6) myriad motivations drive ranchers' transition to AMP-HM, all of which relate to their desire to ranch viably; and 7) there are several positive catalysts reinforcing AMP-HM, including low-stress livestock handling and seeing improved ecological and/or economic outcomes resulting from their management.

Our interviews suggest that AMP-HM's combination of training in "holistic" thinking, decision-making framework, monitoring, and grazing management tools successfully shifts ranchers' mental models, creating new ways of "seeing" and thinking about their landscapes and their role in managing them. Among the ranchers we interviewed, this was often accompanied by a sense of purpose and activism and a shift toward viewing their ecological and economic goals as reinforcing rather than opposing, leading them to focus on improving their soil health and ecological outcomes and reduce their inputs as their "new" profitability approach. Second, the collective decisions arising from ranchers' shifted mental models align with strategies to strengthen adaptive capacity. This includes actions in their AMP grazing management such as adaptive rest and rotations and actions at the enterprise level, such as diversifying their herds to include more yearlings or smaller ruminants. These strategies work synergistically to improve AMP-HM ranchers' ability to ranch viably in the face of increasing ecological, economic, and social uncertainties.

Many of these emergent themes relate back to the core principles of HM, suggesting that HM-AMP offers a strategy for ranchers to both shift their mental models toward ones that involve more "holistic," systems-based thinking, and to operationalize these

models into on-the-ground actions that work to synergistically increase day-to-day flexibility and long-term adaptation. We identify the needs for future research and suggest a way forward in rebuilding relationships between AMP-HM ranchers and the broader rangeland academic community.

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