

ENVIRONMENTAL RESEARCH
LETTERS

LETTER

OPEN ACCESS

RECEIVED
29 May 2026REVISED
14 August 2026ACCEPTED FOR PUBLICATION
28 August 2026PUBLISHED
24 September 2026

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What drives institutional action for wildfire resilience?
Determinants of targeted grazing attitudes and adoption on
national forests in the western USBriana Swette^{1,*} , Susan Charnley² , April Hulet³ , Lynn Huntsinger⁴ and Kelly Hopping¹ ¹ Human-Environment Systems, Boise State University, Boise, ID, United States of America² USDA Forest Service Pacific Northwest Research Station, Corvallis, OR, United States of America³ Department of Plant and Wildlife Sciences, Brigham Young University, Provo, UT, United States of America⁴ University of California—Berkeley, ESPM, Berkeley, CA, United States of America

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E-mail: brianaswette@boisestate.edu**Keywords:** wildfire, targeted grazing, adaptive governance, organizational change, theory of planned behaviorSupplementary material for this article is available [online](#)

Abstract

Increasing wildfire severity is driving interest in new land management approaches that can reduce fuels while also remaining feasible within land governance systems. Targeted grazing (TG), the practice of using livestock to manage vegetation, is one potential tool that can be integrated with other strategies to increase wildfire resilience. However, adoption of TG often requires action by public lands managers in complex institutional environments. We quantitatively tested a conceptual framework that integrates the theory of planned behavior and adaptive governance to evaluate factors influencing staff attitudes and actions related to TG. Through a survey of over 1000 United States Department of Agriculture Forest Service staff and a path analysis modeling approach, we identified the key determinants of attitudes and intended actions to implement TG as a wildfire risk management tool. Attitudes about rancher ability to implement TG and general beliefs about the impact of livestock grazing on native vegetation were the strongest predictors of staff attitudes about TG effectiveness. Staff members' perception of their available time was among the most important predictors of their intention to adopt TG. Limited monitoring capacity emerged as the primary constraint on perceived time availability, in contrast to other factors like staff shortages, funding, or environmental regulation requirements. Our findings show how institutional constraints and individual psycho-social factors jointly shape willingness to pursue TG within public land wildfire management.

1. Introduction

Shifts in global fire regimes and the expanding wildland-urban interface require new land management approaches to build more wildfire-resilient landscapes (Smith *et al* 2016, Schoennagel *et al* 2017, Jones *et al* 2023). Current approaches for reducing wildfire risk include managed burning and removal of fuels through cutting, mastication, herbicides and mowing (Agee and Skinner 2005, Pyke *et al* 2014, Prichard *et al* 2021). Each of these tools has advantages and limitations, and no single treatment is sufficient across contexts to make it possible to 'live with fire' (Smith *et al* 2016).

While research has found that prescribed burning is the most important and cost-effective tool, adoption is limited in contrast to the scale needed (Kolden 2019). Smoke production and risk of escaped fires can make the practice unpopular (Brenkert-Smith *et al* 2023, Brunson 2023), and weather windows in which burning is practical are narrowing (Swain *et al* 2023). Physical removal of fuels is likewise not cost-effective or feasible in many areas. Existing fuel conditions mean that tools often must be integrated and repeated to be effective (Schultz *et al* 2019).

Incorporating livestock grazing into wildfire management is thus receiving increased attention from policymakers and land managers in fire-prone

regions (Bailey *et al* 2019, Pillar and Overbeck 2025, Roche and Macon 2025). Livestock grazing is among the most extensive forms of land use globally (Asner *et al* 2004). Through herbivory and trampling, livestock remove fine fuels and can influence patterns of shrub and tree growth (Pillar and Overbeck 2025). In some ecosystems, extensive livestock grazing has been associated with reduced burn probability (Andela *et al* 2017, Siegel *et al* 2022, Starrs *et al* 2024, Perkins *et al* 2025). Targeted grazing (TG) describes intentional changes in livestock grazing to achieve specific vegetation management goals (Bailey *et al* 2019). TG can reduce fuel loads, create fuel breaks, and manage post-fire vegetation (Marchetto *et al* 2021, Donovan *et al* 2022, Clark *et al* 2023).

While fire is intrinsic to most ecosystems in the American West, increasing wildfire intensity and frequency exacerbated by climate change, invasive annual grasses, and a changed pattern of anthropogenic ignitions are harming ecosystems, producing significant economic costs, and creating a substantial threat to human health and safety (Burke *et al* 2021, Steel *et al* 2022). In this context, public land agencies are exploring expanded utilization of TG in wildfire management activities (USDA-DOI Grazing Action Plan 2025), and multiple bills being considered by the U.S. Congress (for example, S.B 1981 and H.R. 1110) could require greater use of the tool. In the case of the United States Department of Agriculture, Forest Service (USFS), livestock grazing allotments that are grazed by private permittees cover 34.6 million ha of national forests and grasslands (USDA-FS 2025). The USFS also devotes a majority of its budget to wildfire suppression (National Interagency Fire Center 2025). The USFS could therefore be an important site of TG practice, but application on national forests is limited compared to other fire management activities (Swette *et al* 2025). This study examines the attitudes and likely actions of USFS staff regarding TG to mitigate wildfire risk in the western United States and gains insight into conditions for expanding its use.

Implementing TG can be logistically difficult and highly context-dependent (Shapero *et al* 2018). Deployment of TG on public lands requires livestock owners who are able and willing to engage in the practice; coordination among multiple staff disciplines; complex planning, authorization and legal approvals; and the flexibility to apply the tool when needed. Past research highlights a resistance to change in response to new challenges within the USFS (Steelman and McCaffrey 2011, Calkin *et al* 2015). USFS managers of permitted livestock grazing perceive significant barriers to flexibility, including budget and staffing, the environmental review process, lack of capacity to conduct ecological monitoring, and fear of litigation (Charnley *et al* 2025). Expanding TG on public land could thus face similar challenges as other practices that require adaptive

management and institutional change (Platt *et al* 2022).

In general, organizational change is a result of perpetual interaction between institutional factors and individual actions in a particular place (Tsoukas and Chia 2002, Moseley and Charnley 2014). Adaptive governance, the institutional arrangements that support the ability to adapt management to changing ecological and social conditions, is driven by local management factors, influences from above, external social-political factors, and the biophysical context (Platt *et al* 2022). Research has repeatedly found that amidst these multi-scalar forces, key leverage for promoting adaptive management is at the local scale (Wollstein *et al* 2021, Platt *et al* 2022).

Increasing focus on the role of individuals or actors within institutions can further illuminate how to drive organizational change in desired ways (Kaufman 1960, Tsoukas and Chia 2002, Abrams *et al* 2021). Adaptive governance often requires adoption of new management practices, such as prescribed burning or TG. Understanding how staff view these practices and what drives their behavior to implement them can indicate how an institution will change over time and what the most effective interventions would be to increase adoption.

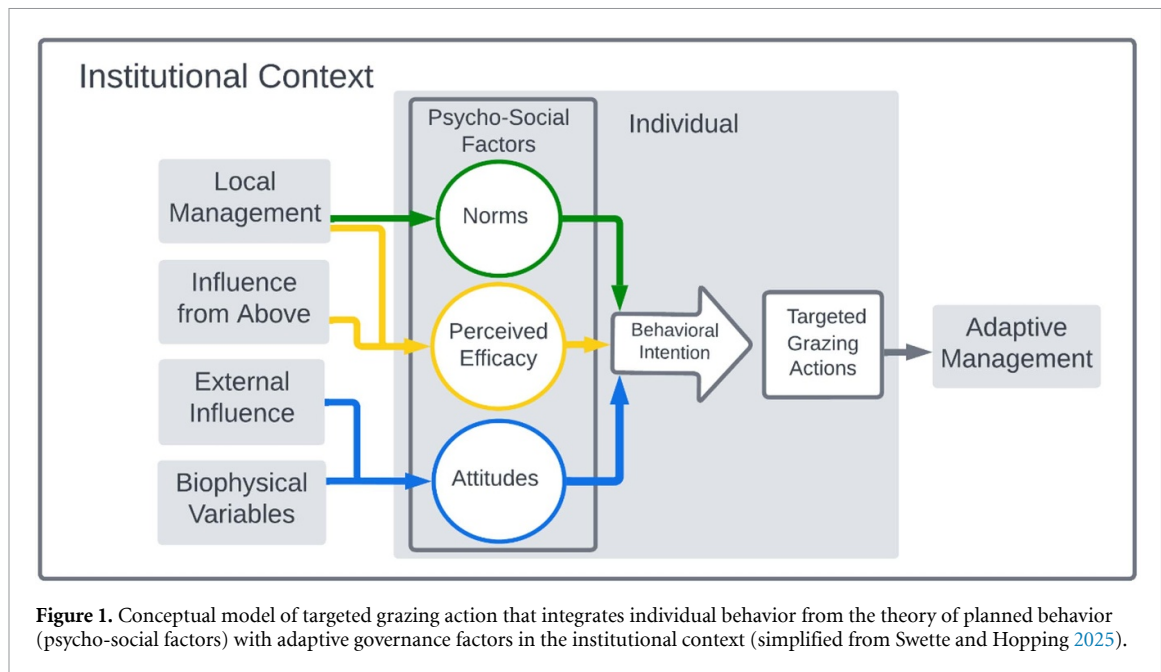
One widely used model to understand individual behavior is the theory of planned behavior, which posits that an individual's intention to perform a behavior is a result of their attitudes, perceived self-efficacy, and subjective norms (Ajzen 1998, figure 1). Attitudes are favorable or unfavorable evaluations of the behavior. Perceived self-efficacy is a personal assessment of the feasibility of executing a behavior given an individual's circumstance and context. Subjective norms are the perceived social pressures toward the behavior.

We tested a unified framework of individual behavior and adaptive governance to quantify the factors that influence individual agency staff behavior related to TG within the USFS institutional context (figure 1). We conducted a survey of over one thousand USFS staff and used path analysis to identify the most important drivers of attitudes and action related to TG.

2. Methods

2.1. Study region

This research focuses on staff working across 53 national forests in seven states in the Intermountain, Pacific Northwest, and Pacific Southwest Regions of the American West (figure 2). Over half of these USFS lands are allocated to livestock grazing allotments for cattle, horses, and sheep, which are grazed by private ranchers through a permit system (USDA-FS 2025). The study region includes dry interior forests, coastal forests, Mediterranean



grasslands, and sagebrush steppe rangelands that are fire-prone and fire-dependent, but differ in ecological responses to fire and grazing.

2.2. Description of sample and questionnaire

We developed a questionnaire to operationalize the conceptual model of attitudes and intended behavior related to TG that was previously created based on semi-structured interviews with USFS staff in the Intermountain and Pacific Northwest Regions (figure 1; supplemental material). We conducted 15 additional interviews with staff in the Pacific Southwest to refine the survey for broader regional applicability. Survey questions measured indicators of institutional factors, subjective norms, perceived self-efficacy, and attitudes of USFS staff that influence TG attitudes and action (table S1). We measured indicators through closed-ended five-point Likert scale questions. For example, the survey included questions about how much time staff have to take action to implement TG and how knowledgeable they are about TG, as two indicators of perceived self-efficacy. USFS partners reviewed the questionnaire for content relevance and terminology. Five staff pre-tested the questionnaire to ensure clarity and feasibility of the final instrument.

Research methods were approved by the Boise State Institutional Review Board (IRB #24–275). We distributed the survey via email to 4072 permanent, full-time staff that we determined to be in positions relevant to TG (table S2). USFS range program leaders sent an email to our distribution list to notify them of the survey and express their support in March 2025 (Dillman and Edwards 2016). We then distributed the survey via Qualtrics [current online version in March 2025] by email, and sent two reminders in the following weeks.

2.3. Path analysis

We used two models to separately test the set of factors that drive (1) attitudes about TG effectiveness and (2) intention to take action to implement TG for wildfire risk management. A full description of model variables and hypothesized causal paths is included in the supplemental material (table S3). The attitude model is relevant to the full sample of respondents, regardless of their role in the USFS. The action model applies only to staff whose job roles could reasonably include decisions or actions related to TG implementation, notably district rangers and forest supervisors (referred to as ‘line officers’ for their authority to make management decisions for national forests and ranger districts, respectively), and staff in the range, fuels and fire, and invasive plant disciplines. We coded respondents into these groups based on responses to the questions about their occupational series and disciplines included in their job (table S4). Only respondents with complete responses for all relevant variables were included in each model.

We employed path analysis to simultaneously analyze the relationships between the variables in each model. Path analysis is a method of structural equation modeling that is useful for evaluating hypothesized mechanistic processes in complex systems, in which variables both directly and indirectly influence outcomes of interest (Bollen and Noble 2011). Path analysis allowed for quantitative disentangling of the hypothesized linkages between constructs in our adaptive governance-behavior framework (figure 1, Swette and Hopping 2025) through concurrent estimation of parameters and effect sizes to identify the significant pathways consistent with the conceptual framework. We used the lavaan package in R to perform path analyses (Rosseel 2012, R Core Team 2022). Given that all variables were

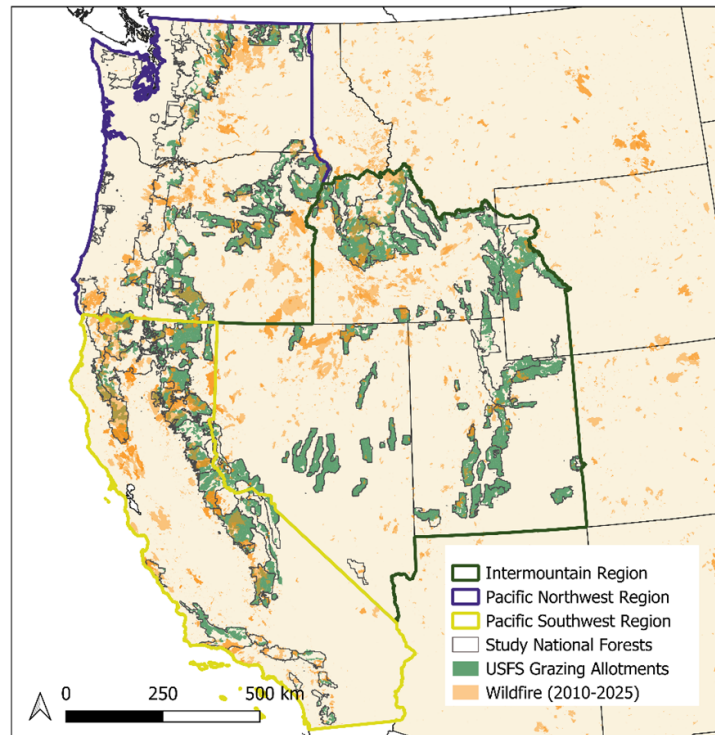


Figure 2. National forests in the study ($n = 53$) in the Intermountain, Pacific Northwest, and Pacific Southwest Regions, with livestock grazing allotments and location of recent wildfires (2010–2025) (National Interagency Fire Center 2025).

measured on ordinal, five-point scales, we used a diagonally weighted least squares estimator to calculate model parameters (Rossee *et al* 2025). We treated these variables as composite indicators representing broader conceptual constructs rather than indicators of latent variables.

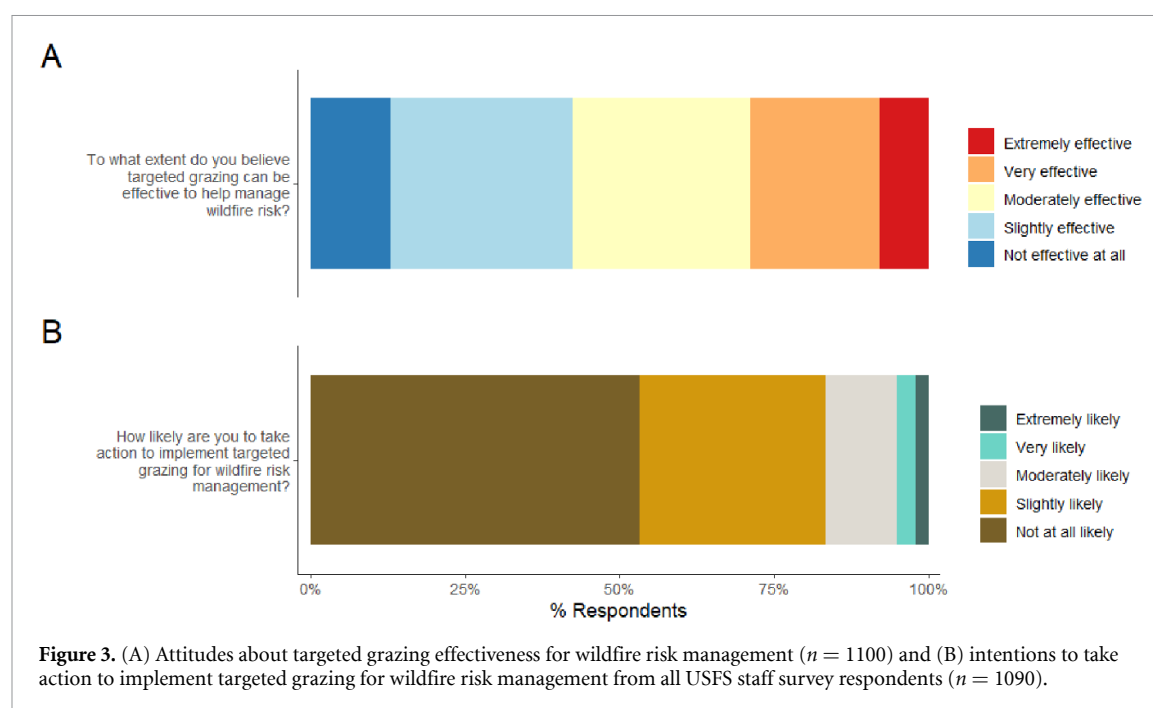
For both the attitudes and action models, we first tested a full model with all hypothesized variables, including those hypothesized to have weak relationships based on interviews, and then dropped non-significant variables (p -value > 0.05). Given the large number of variables in the action model, we also used a backward elimination approach to drop variables with small standardized coefficients ($<|0.16|$) and variables that did not contribute to model fit based on fit indices (Tarka 2018). For the attitudes portion of the action model, we retained only relationships from the attitudes model that were significant and exceeded a standardized coefficient of $|0.16|$. We checked the robustness and validity of the models with overall and comparative goodness-of-fit measures that are used widely in the literature, including standardized root mean square residual (SRMR), the root mean square error of approximation (RMSEA), the Tucker–Lewis index (TLI) and comparative fit index (CFI) (Marsh and Balla 1994). Conventional thresholds for acceptable fit are ≤ 0.1 for SRMR/RMSEA and ≥ 0.9 for TLI/CFI. The literature emphasizes that these criteria are somewhat arbitrary, and the model can fit the data even if one or more fit measures suggest bad fit (Hu and Bentler 1999).

Several variables included an option to select ‘do not know’ in the questionnaire because these questions were about assessing other people’s actions, capacity, or beliefs (Krosnick and Presser 2010). Our interviews suggested an absence of information in these cases is closely aligned with a slightly negative perception rather than neutrality, so we coded these responses as a two or ‘slightly’ on the Likert scale. For example, believing that your supervisor is slightly supportive of TG is equivalent to not knowing whether they support it. We maintain the ‘do not know’ responses because an absence of information can have an important role in subjective norms and attitudes in our model. As part of our sensitivity analysis, we tested ‘do not know’ responses coded as one or three, with no meaningful changes to the results.

3. Results

3.1. Summary of responses

We received a total of 1178 responses to the survey. After excluding 49 undelivered surveys, the adjusted overall response rate was 29%. Responses by region were 377 (36% response rate) for the Intermountain, 374 (23%) for the Pacific Southwest, and 388 (28%) for the Pacific Northwest. We received responses from staff on all national forests and 178 (92%) of the ranger districts in our study area. These included 187 responses from fuels staff, 156 from range staff, 127 from fire staff, 82 from line officers, 70 from



invasives staff, and 515 from staff in other job types (for example, archeologists or soil scientists; tables S2 and S4).

3.2. Attitudes about TG effectiveness

Among all survey respondents, staff attitudes about the effectiveness of TG to help manage wildfire risk on the ranger district or national forest where they work were highly variable and approximately normally distributed (figure 3(a)).

We limited the attitude model to respondents working on ranger districts or national forests that currently have permitted livestock grazing ($n = 870$) (figure 4). All paths are significant at a 99% confidence level (p -value < 0.01). We report the standardized coefficient (β) of all correlations, with a higher absolute value indicating a stronger connection between the predictor and outcome. The model fit measures (SRMR = 0.042; lower 90% CI of RMSEA = 0.07; TLI = 0.931; CFI = 0.563) demonstrated an adequate model fit, although CFI was below conventional thresholds.

How effective staff think grazing permittees could be at implementing TG ($\beta = 0.36$) was the largest predictor of staff attitudes about TG effectiveness for wildfire risk management. Attitudes about permittee effectiveness were more strongly associated with perceived permittee willingness to participate in TG ($\beta = 0.31$) than by beliefs about the quality of their management in general ($\beta = 0.20$). Belief about how livestock grazing impacts native vegetation was the second-strongest predictor of attitudes about TG effectiveness ($\beta = 0.30$). If staff believed grazing has a generally positive impact on native vegetation, they were also more likely to have a positive attitude about TG effectiveness.

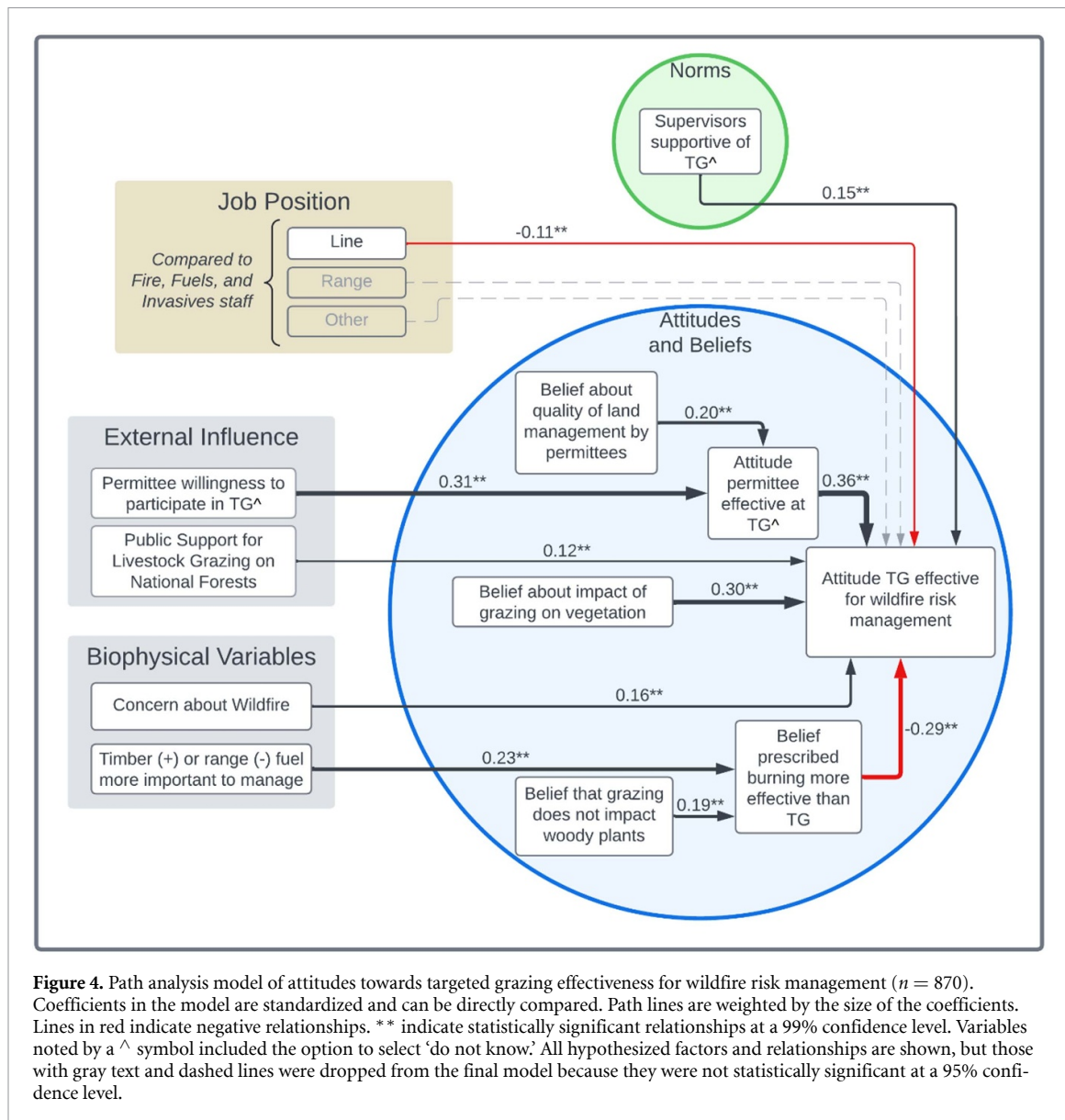
Staff belief about prescribed burning was also important in determining attitudes about TG effectiveness. Those who perceive prescribed burning as more effective than TG for wildfire risk management tended to independently have lower assessments of TG effectiveness ($\beta = -0.29$). The belief that prescribed burning is more effective than TG was positively correlated with the belief that it is more important to manage timber than herbaceous fuels associated with rangelands to mitigate wildfire risk ($\beta = 0.23$), and likewise with the belief that grazing does not impact woody plants is a barrier to TG effectiveness ($\beta = 0.19$).

General concern about wildfire ($\beta = 0.16$) had a positive but relatively small influence on attitudes about TG effectiveness. Perceiving supervisor support for TG ($\beta = 0.15$) and public support for livestock grazing ($\beta = 0.12$) also had relatively small, but positive associations with attitudes about TG effectiveness. Job group was also relevant, with line officers having significantly more negative attitudes ($\beta = -0.11$) about TG effectiveness, compared to fire, fuels and invasive plants staff.

3.3. Factors leading to TG adoption

Among all survey respondents, a vast majority of staff were only slightly or not at all likely to take any action to plan or implement TG for wildfire risk management in the next three years (figure 3(b)). Only 16% of respondents were at least moderately likely to take TG-related action.

We limited the model about TG action to staff that we assumed are able to take TG action within their job role ($n = 486$, figure 5). The reduced model had acceptable fit for most indices, although CFI remained below conventional thresholds



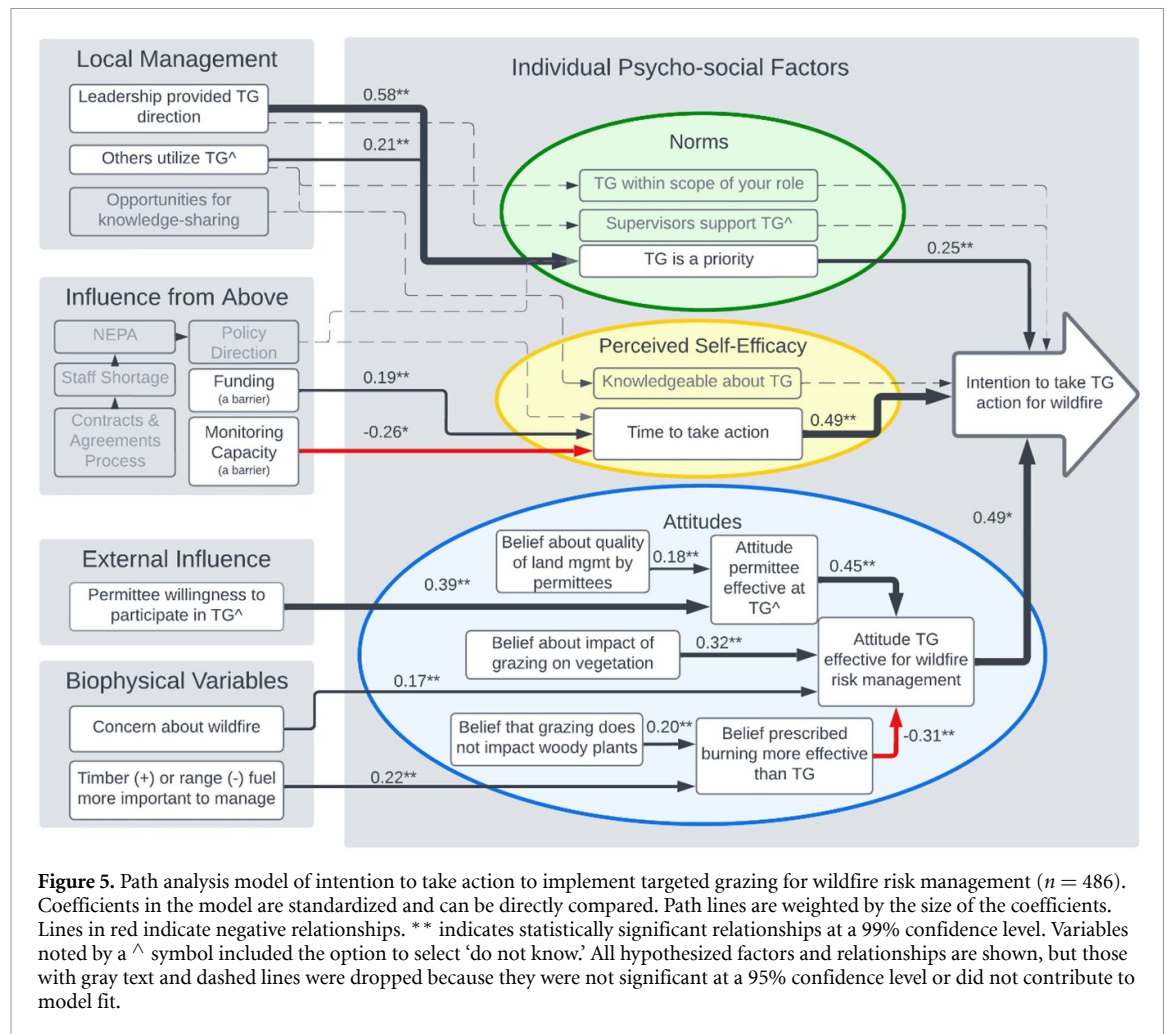
(standardized SRMR = 0.095; RMSEA = 0.078; TLI = 0.904; CFI = 0.617). All paths are significant at a 99% confidence level (p -value < 0.001).

Intention to take TG action was most strongly predicted by positive attitudes about TG effectiveness ($\beta = 0.49$) and having time to take TG action ($\beta = 0.49$). Perceiving TG as a priority on the local ranger district or national forest also positively predicted intention to take action ($\beta = 0.25$), but was about half as important as attitudes and perceived self-efficacy.

Results for the drivers of TG attitudes within the action model followed the same pattern as in the attitude model presented above, so we now focus on the drivers of subjective norms and perceived self-efficacy. The subjective norm that TG is a priority was most strongly driven by local leadership providing direction for TG ($\beta = 0.58$), followed by the perception that other colleagues are utilizing TG ($\beta = 0.21$). However, higher level policy direction was not significantly associated with the perception that

TG is a priority. Perceiving that supervisors support TG or that TG is within the scope of one's job were positively correlated to TG action, but inclusion of these predictors in the model negatively influenced model fit (table S5).

Viewing monitoring capacity as a barrier to implementing TG negatively influenced whether staff believe they have time to take action ($\beta = -0.26$). Conversely, perceiving funding as a barrier was positively related to having time to take action ($\beta = 0.19$). No other variables related to perceived self-efficacy were retained in the final model. Additional 'Influence from Above' variables (policy direction from above, completing National Environmental Policy Act approvals, staffing shortages, and the lengthy contracts and agreements process) were either not significantly associated with having time to take action or had very low coefficients, and thus were dropped to improve model fit (table S5). As a sensitivity analysis, we also tested the direct effects of these variables on the action variable,



rather than being moderated by the time variable, and these variables still did not have significant relationships with TG action (table S6). Likewise, how knowledgeable one is about TG was not a significant indicator of action, and opportunities for knowledge sharing with other staff did not significantly predict how knowledgeable one is about TG.

4. Discussion

Our results reveal highly variable attitudes about TG effectiveness for wildfire risk management among USFS staff, and limited intentions to take action to implement the tool. While TG is far from a mainstream practice, 192 (16%) respondents in our sample were at least moderately likely to take action to implement TG, which could translate into wider use of TG on national forests in the near term.

Our approach that integrated the theory of planned behavior and adaptive governance revealed distinct drivers of TG action, compared to if we only focused on the USFS as an institution. The path analysis provided quantitative evidence that supports past findings that organizational change in public natural resource management, including response to wildfire,

is not just a function of policy direction from above, but a result of uneven adoption of new practices by individual frontline actors in response to internal and external factors (Moseley and Charnley 2014).

Our model showed that attitudes about permittee management and how livestock generally impact native vegetation are the most important drivers of attitudes about TG effectiveness. Managers can have entrenched views, either positive or negative, about livestock producers and grazing from past experiences, and those attitudes shape their views about TG (Puntenney *et al* 2025). Given the importance of producer willingness in driving staff action, designing TG in a way that works for livestock producers could further influence the ultimate use of the tool (Macon 2014, Shapero *et al* 2018). Staff evaluations of the biophysical fit of TG to the management problem also shape attitudes about TG effectiveness, particularly through comparisons to other tools like prescribed burning. Indeed, there is uncertainty about the role of grazing in woody-encroached areas, although recent work points to its potential effectiveness (Yantes *et al* 2025). Staff are also concerned with negative impacts to native or non-target plants. These concerns are valid, given limited knowledge of impacts to non-target species and outstanding

questions about scaling TG to larger spatial extents and longer time periods (Marchetto *et al* 2021).

The attitude model also showed that line officers (i.e. district rangers and forest supervisors, who are the primary decision-makers with authority to approve management actions) had more negative views about TG effectiveness than fire, fuels and invasives staff. Our data suggested that leadership direction to use TG had a stronger influence than the perception that other colleagues are using the tool, in contrast to others' findings that general early adoption of new rangeland practices influences individual innovation (Meredith *et al* 2021). If TG is required by new legislation or policy directives, outreach with local leadership, such as line officers, would therefore be especially important.

Perceived self-efficacy was equally as important as attitudes for driving adoption of TG. As in other studies of rangeland managers (Puntenney *et al* 2025), we found that staff are very time-limited. Our study additionally identified that their assessment of their available time is most connected to whether they feel the agency has sufficient monitoring capacity. Monitoring to assess impacts of TG might be more important than for other fuels treatments due to the complexity of working with animals to achieve aims. Practical monitoring approaches that efficiently but accurately assess TG impacts could therefore increase adoption of the practice (McCord and Pilliod 2022, Smith *et al* 2025). Other influences from above, including top-down policy direction, were not strong predictors of perceived self-efficacy or norms. This aligns with the finding by Charnley *et al* (2025) that laws and policies governing grazing are perceived as only a minor constraint to flexibility on Forest Service lands.

Our results further elaborate previous findings that capacity and funding are the primary limitations on the use of prescribed fire in the USFS (Schultz *et al* 2019). Our model indicated that the more staff rated funding as a barrier for TG, the more they reported having time to take action. During interviews, many staff reflected on the challenges that came with trying to spend funds made available through the recent Infrastructure Investment and Jobs Act (H.R. 3684 2022) without adequate workforce (Swette and Hopping 2025). These results together show that while adequate and stable funding is important, a simple injection of funding without long-term investment in forest- and district-level staff may not substantially increase capacity to adopt new management tools.

TG requires collaboration and expertise among multiple staff types. The USFS rangeland management program has received little investment, and range staff report being overburdened (Charnley *et al* 2025, Swette and Hopping 2025). In order to overcome the challenges of perceived self-efficacy,

expanding TG might require creating a new position that straddles range and fuels disciplines. This position could serve as a boundary-spanner to increase networked governance that is generally supportive of adaptive management (Abrams 2019, Wurtzebach *et al* 2019, Davis *et al* 2021).

5. Conclusion

We identified two critical drivers of TG action for wildfire risk management on national forests: staff attitudes toward TG and their available time to carry out related actions. Staff attitudes about TG effectiveness were strongly shaped by their beliefs about how livestock grazing generally affects native vegetation and their attitudes about livestock producers' ability to implement TG. Relatedly, understanding more about producer willingness to participate in TG could inform and potentially shift manager attitudes about the efficacy of the practice. The findings showed that investments in agency monitoring capacity will likely be more effective at increasing staff capacity to implement TG than general funding increases or high-level policy directives alone.

Creating fire resilient landscapes requires adaptive land management that can flexibly integrate all tools available, as appropriate. The study showed how institutional and individual-psychological factors jointly shape adaptive management behavior in a land management agency context. Our focus on individual staff revealed constraints on TG action that would be less visible if attention was placed only on institutional factors, with relevance for other agencies where grazing is a widespread land use and wildfire risk management is a priority. While the specific factors will vary, the approach could be applied to other fuel management strategies, such as prescribed burning. These results are also applicable to fire-prone rangelands worldwide, where land governance is generally characterized by complex, multi-level ownership and management structures.

Acknowledgments

We are grateful for collaboration with Robert Garcia, Heidi Heyrend, Dawn Coultrap, Jenny Jayo, and Terry Padilla of the US Forest Service, who provided their expertise and logistical support to conduct this research. We appreciate the editor and two anonymous reviewers whose comments improved this article. We also thank all the survey respondents who generously gave us their time and shared their experiences. This work is supported by the Agriculture and Food Research Initiative, project award no. 2024-67012-42243, from the U.S. Department of Agriculture's National Institute of Food and Agriculture.

Data availability statement

The data cannot be made publicly available upon publication because they contain sensitive personal information. The data that support the findings of this study are available upon reasonable request from the authors.

Supplementary material available at: <https://doi.org/10.1088/1748-9326/aea00b/data1>.

Funding

This work was funded by the USDA National Institute of Food and Agriculture (Award #2024-67012-42243).

Ethical statement

This study was carried out in accordance with the recommendations of the Boise State University Office of Research Compliance and Institutional Review Board (IRB #24–275) and the Declaration of Helsinki. All participants provided informed consent to participate in the study.

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