Public Comments received as of 12:20 PM on February 26, 2020

Agenda Item # 4
Toto Ranch Rangeland Management Plan and Grazing Lease in Tunitas Creek Open Space

From: [redacted]
To: Clerk; General Information
Subject: All Board Members - Board Contact Form
Date: Friday, February 21, 2020 8:21:44 AM

EXTERNAL

Name *	Ellen Cuykendall
Select a Choice *	All Board Members
Email *	[redacted]
Location: (i.e. City, Address or District Ward)	San Jose CA 95126

Comments: *

Dear Board Members,

I strongly support the continued lease of grazing land to the Markegard Family. They are honest, hard working people doing a great service to the mid peninsula by providing humanly raised, nutritional meat that we can feel good about eating.
In addition to that, the land stewardship they exhibit is a benefit to our planet since they are faithful followers of regenerative agriculture. These practices create healthy soil, which benefits local plants, animals, non meat eaters, and the environment by providing healthy water, air and increased carbon sequestration.
We need more farmers like the Markegard Family in our area to begin to tackle the effects of global warming in a meaningful way.

I urge you to continue your support of this grazing on public lands, and look for more opportunities as well.

Thank You.
Ellen Cuykendall

From: [redacted]
To: Clerk; General Information
Subject: All Board Members - Board Contact Form
Date: Friday, February 21, 2020 8:24:24 AM

EXTERNAL

Name *	Laura Stec
Select a Choice *	All Board Members
Email *	[redacted]
Location: (i.e. City, Address or District Ward)	Portola Valley
Daytime Phone Number (if you wish to be contacted by phone)	[redacted]
Comments: *	I support the efforts of the Markegards to continue their use of public lands for grazing. We must assist small farmers with efforts to use our local lands for food production. Thank you for working on this important issue.

From: [redacted]
To: Clerk; General Information
Subject: All Board Members - Board Contact Form
Date: Friday, February 21, 2020 10:27:36 PM

EXTERNAL

Name *	Deborah Rose
Select a Choice *	All Board Members
Email *	[redacted]
Location: (i.e. City, Address or District Ward)	Palo Alto
Daytime Phone Number (if you wish to be contacted by phone)	[redacted]

Comments: *

I am contacting you in regards to the upcoming lease for total ranch. While I am respectful of the needs and believes of vegans, I have read extensively about how all the lands of the world need to be rehabilitated by the kind of agricultural practices that The Maarkegard family is employing at Toto Ranch. With their activism, their writings, and interactions with the public in many ways including education, they are a role model for how we can actively Participate in restoring our environment in our fight against the pending environmental worldwide disaster. PLEASE RENEW THEIR LEASE. Thank you for your attention.

From:	[redacted]
To:	Clerk; General Information
Subject:	Yoriko Kishimoto - Ward 2 - Board Contact Form
Date:	Saturday, February 22, 2020 8:59:48 PM

EXTERNAL

Name *	Ann Duwe
Select a Choice *	Yoriko Kishimoto - Ward 2
Email *	[redacted]
Location: (i.e. City, Address or District Ward)	Los Altos Hills
Daytime Phone Number (if you wish to be contacted by phone)	[redacted]

Comments: *

I believe it is vitally important to have local, grass-fed meat and poultry, and the only way to have them is to allow grazing on public as well as private land. I support renewing the Markegard's grazing leases. It is a complicated arrangement, a necessary one to ensure that small family farms survive in San Mateo and Santa Clara counties. Grazing contributes to healthy soli, which in turn supports the biodiversity on which all of us depend. The Markegards practice regenerative farming, which is different from conventional ranching and worlds away from confined animal feeding operations. The Markegard's farming methods benefit rather than compete with wildlife.

If you buy their meat, you can be sure the animals are raised humanely in clean, sustainable surroundings. You can visit Toto Ranch during Ranch Days; you can meet the family and know with certainty where your meat is coming from. You can learn what it takes to operate a ranch.

You don't have to eat meat to appreciate the benefits of regenerative farming. Vegans and vegetarians benefit from healthy soil, which contributes to clean air, clean water and greater carbon sequestration.

For these and many other reasons, I support MROSD's allowing grazing on public land.

Subject: Conservation Grazing - Toto Ranch Property

From: Mohan Gurunathan [redacted]
Sent: Tuesday, February 25, 2020 11:41 AM
To: Lewis Reed [redacted]>; Curt Riffle [redacted]; Kirk Lenington [redacted]
Subject: Re: Follow up from Grazing Meeting

EXTERNAL

Hi Lewis, (+Curt, + Kirk)

Thank you for your detailed reply. I understand the points you make, however I think there is a valid rebuttal to each of them. Since I am not convinced we will reach an consensus via exchange of emails, I will not systematically argue point by point, but I would just like to summarize my key opinions and my position as a voter and taxpayer.

1. MidPen's livestock grazing does not "protect and preserve the natural environment." A natural environment is an ecosystem that develops *naturally*, without human control or influence. Livestock are not part of the "natural environment."

2. The fact that there are invasive or non-native species on MidPen land, and that humans were the ones who introduced these species, does not justify a need for humans or livestock to manage them. What is "native" versus "invasive" is a matter of long-term perspective. Ecosystems evolve and change naturally and part of this process involves migration of "invasive" species into regions where they previously did not exist. Species migration may happen due to human influence, or due to seeds being carried by wildlife, birds or air currents. Is it the job of humans to try to revert the ecosystem to what was "native" at some arbitrary point in time? Any "native" species may itself have been an introduced species a thousand years earlier. Therefore I argue it is futile to try to restore an ecosystem to some "native" state, and we are fighting a never-ending battle against nature. <u>It is not our job to create or maintain biodiversity</u>. It is only our job to stop doing harm to the environment. The best thing we can do is to let the land find its own natural equilibrium.

3. Many types of ecosystems which MidPen considers invasive or unwanted, such as coyote brush and chaparral habitat, serve many purposes and species. They provide food and cover for small animals and wildlife use it for various purposes.

4. If Midpen really wants to help endangered species like the red legged frogs and others, there are ways to do it *without* livestock. For example, water ponds can be added without them having to be for livestock. If grazing herbivores are seen as beneficial, why not re-introduce wild deer or elk to the landscape, instead of cows?

5. Midpen frequently touts a few specific success stories of the red legged frogs and San Francisco garter snake. To understand the true biodiversity picture, we need to also understand what species have been *deterred or pushed out* by the introduction of livestock. There is ample literature showing that many wild species (both plants and animals) suffer when livestock are introduced.

6. MidPen is not listening to the voices of prominent environmental non-profits such as Center for Biological Diversity, Western Watersheds, Sierra Club, and others, who have argued for the elimination of conservation grazing. Several of these groups met with MidPen in January, yet their concerns have not been seriously considered. MidPen also continues to ignore the taxpayer voices speaking in opposition to grazing at recent Board meetings.

7. MidPen continues to underscore the "commitment" they made to ranching communities on the coast. As long as MidPen serves two different mission statements, one of them favoring the environment and the other favoring a for-profit interest (i.e. livestock raising), their scientific credibility is seriously damaged. MidPen is forced to justify the use of livestock to justify their dual mission statement, and they are biased to ignore the many arguments and voices calling for it to stop. The very fact that MidPen is obligated to review their land-management strategy with the Coastal Farm Bureau shows that their decisions are heavily influenced by a for-profit interest.

8. MidPen continues to ignore the methane generation problem of livestock and continues to downplay this as an unimportant issue. Whereas, livestock-generated emissions are one of the most serious causes of the climate crisis. Note: the 700+ page RMP for the Toto Ranch property does not even MENTION methane emissions from livestock as a consideration! It does not matter if it is small-scale or large-scale; all methane emissions are a problem. Methane has a climate-warming potency of 86 TIMES that of CO_2 over a 20 year period. MidPen should not knowingly be involved in <u>any</u> activity which accelerates climate change, on any scale.

9. MidPen admits they have many land-management and wildfire management strategies that don't require livestock grazing. MidPen also admits that areas not managed by grazing have an abundance of biodiversity (in your words, they "include a remarkable variety of habitat types such as chaparral, coastal scrub, oak woodland, mixed evergreen forests, redwood forests, and riparian woodlands to list a few. Each of these broad habitat types supports a unique suite of plants and animals that are part of what make California a globally recognized biodiversity hotspot.") Therefore the use of grazing is not required, and is only justified by the "commitment" made to "preserve the agricultural heritage" of ranching communities on the coast.

10. As a voter and taxpayer, I find the alliance and "commitment" between MidPen and livestock producers to be completely unacceptable. I am opposed to a single dollar of my taxes going towards paying for livestock losses, predator deterrence, fencing, or other projects that support livestock raising on MidPen's lands.

As I mentioned above, I don't expect we'll reach consensus over email. I would like to ask if you could document my position for the record, and in particular, please record that I am AGAINST the issuance of a 5-year lease for conservation grazing on the Toto Ranch property. The Toto Ranch RMP does not even mention the issue of livestock methane emissions (though surprisingly it discusses the small amount of methane emissions due to on-site construction!). **Considering that MidPen has committed to do a thorough scientific review of the pros/cons of conservation grazing this year, I think it is premature to issue a 5-year grazing lease until this analysis is complete. I request for MidPen to at least defer the lease until the results of the scientific study are available.** Furthermore, I ask that the livestock methane emission potential be discussed as an important consideration in any plan where an expansion of grazing is being proposed.

Thank you again for the dialogue and for taking my views into consideration. I am sure this discussion will continue in the public forum.

Respectfully,
Mohan Gurunathan

On Mon, Feb 24, 2020 at 5:02 PM Lewis Reed [redacted] wrote:

> Hi Mohan,
>
> Thank you again for your interest in stewardship at the Midpeninsula Regional Open Space District (Midpen). I have attempted to address the general concerns you've raised in the following paragraphs and your specific questions at the end.

It is important to keep in mind that all land management approaches –including doing nothing- can have negative consequences for our environment. In the case of our grasslands, which support a disproportionately large number of rare or sensitive species for our area, we are dealing with a highly altered ecosystem. Rare and sensitive species are the organisms in our environment that are most vulnerable to extinction – the permanent loss of species which erodes our ecological integrity. I emphasize the significance of extinction here because in past conversations you seem to make light of the risk of losing critical habitat for rare, threatened, or endangered species as a result of changing resource management practices such as removing conservation grazing. One of the biggest challenges in protecting native biodiversity in our grasslands is the ever-present threat of invasive exotic plant species – particularly exotic grasses. Many of these problematic grasses were introduced into California grasslands at the time of European contact and settlement and quickly expanded throughout the State's habitats. Simply removing humans or human uses from landscapes will not curtail the negative effects of these invasive species. In fact, the 'do nothing approach' could lead directly to the loss of biodiversity. More and more we are learning that we can manage grazing in ways that moderate the competitive effects of invasive species on native flora and influence the physical structure of these habitats in ways that can be favorable for a wide variety of native wildlife.

The goals of our resource management activities, including the conservation grazing program, are neither arbitrary nor driven simply by aesthetic as your inquiry has insinuated. Rather, they are specifically aimed at preserving the unique biodiversity that we are responsible for as stewards of District lands and meeting our coastal mission to encourage viable agricultural use of land resources. Many of these species are threatened elsewhere, or throughout their range, or in some cases are found almost nowhere else on earth.

One unfortunate shortcoming of the hands-off approach to land management that you are advocating is that the lands we are talking about are already highly fragmented and altered by human activities. With the presence of a multitude of invasive exotic species, extirpation of several locally important species, extinction of numerous species that were present in the evolutionary history of our contemporary native flora and fauna, and the constraints of continuing urbanization; we cannot recuse ourselves of responsibility and expect our native species to simply recover on their own. Our challenge as stewards of one of the worlds biodiversity hotspots is to make decisions that allow us to sustain what we have left of this remarkable natural heritage – despite all the larger scale changes we have already made.

Where we do and do not use conservation grazing depends on a wide variety of factors. Some of the things we consider include: Are there native species or habitats on a site that will benefit from conservation grazing? Are there sensitive resources that could be harmed from the use of conservation grazing and how could we protect them if we do use grazing? Is there infrastructure to support conservation grazing practices? For the most part, grazing is valuable as a management tool for species that occur in some of our grasslands. There are large areas of the Midpen that are comprised of other habitat types (chaparral, mixed evergreen woodland, redwood forest to name a few broad categories) where there probably wouldn't be much conservation benefit from grazing.

With respect to fencing, I have seen no evidence that fencing is limiting or threatening to wildlife on District preserves under conservation grazing management. Even the older standard barbed wire fencing (which is being phased out in favor of more intentionally wildlife friendly designs) seems to impose little obstruction to wildlife on District lands. I do recall that one of the sources you provided in your previous e-mail cited collisions with fencing as a source of mortality for sage grouse. Sage grouse are large ground nesting birds with distinctive behavior that may render them particularly vulnerable to injury or mortality from collisions with fencing. They also don't occur on Midpen lands nor generally west of the Sierra in California. On the other hand, numerous ground dwelling bird species that *are* native to our area benefit from the environment created under conservation grazing management including western burrowing owl, grasshopper sparrow, and horned lark to name a few. One of the highest densities of grasshopper sparrows in our region for example (a Species of Special Concern in California), exists on grasslands in the District's conservation grazing program.

I also don't know of any wildlife species that are limited on District lands by forage competition with livestock. This is in part because we don't have any other large grazing animals in our landscape (deer for example are largely browsers – preferring forbs and the shoots of shrubs and trees over grasses) but also because the ever-present exotic annual grasses create a surplus of biomass most years. This accumulation of biomass is a major factor limiting native flora, it impacts the physical structure of habitat for numerous grassland animals, and if unmanaged, it accumulates as standing dead litter (thatch) that ultimately limits the net primary productivity (the ability to perform photosynthesis, produce forage, capture carbon, or perform any of the other functions that live, actively growing plant tissue provides) of the grasslands themselves and it becomes a fire hazard.

As a point of clarification, the District has no general commitment to the global livestock industry and actually has a rather minimal involvement with the livestock industry as a whole. Within our coastal service area, we do have a commitment to protecting local agricultural heritage. This commitment arose from the voicing of voters and taxpayers of that area who, in the late 90's and early 2000's, expressed an interest in having the District expand its work of protecting open spaces to the coast including protecting agricultural lands. This expansion has allowed the Midpen to protect approximately 11,000 acres of coastal habitats from the threat of subdivision and development. While the impact of global methane emissions from livestock is a serious concern, it is important to temper that concern with the relatively small scale of livestock operations in our area and the numerous ecological benefits of conservation grazing. Eliminating livestock grazing from District lands would do relatively little to effect climate change but would likely have immediate and long-term deleterious consequences for numerous species that rely on our grasslands for habitat – again, many of which are found almost nowhere else on earth. Given the habitat value of lands under our conservation grazing program I would say this management is complimentary to the Districts original mission not conflicting with it as you have suggested. I also believe we can have a much greater effect on regional conservation if we work collaboratively with our local ranching and agricultural community rather than excluding or alienating them.

Here are responses to your more specific questions:

1. Are there coastal lands that are not being managed with livestock grazing? If so, what is the area of this land, and how is it managed (if at all)?

There are approximately 5,000 acres of District land within the coastal service area that are not managed with conservation grazing (out of approximately 11,000 acres total District land in the coastal service area). Much of the management in these areas falls within our Integrated Pest Management Program which you can read about here but also includes a variety of other restoration or habitat enhancement efforts on a case-by-case basis. For example, last year district staff, contractors, and volunteers spent over 10,000 hours manually removing invasive exotic plant species such as French broom from District lands. Other management activities have included things like structural habitat enhancement for native salmonids in San Gregorio Creek, watershed-scale efforts to reduce sedimentation in El Corte de Madera Creek Preserve by decommissioning and or redesigning trails and roads, and restoration of native grassland species on highly degraded non-grazed grasslands sites at Russian Ridge open space preserve.

2. How does MidPen mitigate the threat of wildfire on the 55,000+ acres that do not have livestock grazing?

Midpen undertakes several actions and activities on our lands to prepare for fire season. The actions related to fuel maintenance and reduction and fire management include:

- Maintaining existing fuelbreaks in Open Space Preserves along the wildland-urban interface (WUI), including but not limited to Pulgas Ridge, Windy Hill, Sierra Azul, Saratoga Gap, and Monte Bello OSPs;
- Defensible space clearing around 117 Midpen-owned structures;
- Maintaining hundreds of miles of fire roads; and
- Implementing over 8,500 acres of conservation grazing, in part to manage fuels.

Midpen's Integrated Pest Management Program (IPMP), adopted in 2014 with an addendum certified and adopted in January 2019, prescribes pest management activities on Midpen lands over a 10-year period covering five major categories of work, including vegetation management. Vegetation management prescriptions address vegetation management within the WUI and around structures to reduce the potential rates of spread, and intensity and flame lengths of wildland fires, within treated areas. This includes the spread of wildland fires that originate in and around buildings. This work is accomplished primarily through mechanical means, using handheld power tools or heavy equipment.

District preserves themselves have very little risk of ignitions, given the lack of human activity that typically spark fires. The District does not allow activities typically associated with fire ignitions; smoking, campfires, and off-road vehicles are prohibited. However, to reduce possibility of any ignitions, the District employs a number of prevention measures such as reducing fuels in critical ignition areas (e.g., parking areas, picnic facilities, and other sites with an ignition risk). Staff or contractors must monitor the weather and have a water source, fire extinguishers or hand tools onsite during fire season if their activities have the potential for creating sparks or ignitions, and construction and maintenance activities that could potentially spark a fire are stopped when weather conditions warrant. The District also facilitates utility company access to electric transmission and distribution lines for the purpose of cyclical fuels management and maintenance of these lines and poles to prevent accidental ignitions. The District has staff trained in wildland firefighting who are equipped with wildland fire gear and pumper trucks for initial response. Additional staff, Biologists with fire training, are Resource Advisors to help fire responders avoid impacts to sensitive resources.

3. How would you characterize the biodiversity of District lands where grazing is not used as a management technique?

Like the grasslands in our conservation grazing program, the District lands outside of our conservation grazing program are quite diverse. These include a remarkable variety of habitat types such as chaparral, coastal scrub, oak woodland, mixed evergreen forests, redwood forests, and riparian woodlands to list a few. Each of these broad habitat types supports a unique suite of plants and animals that are part of what make California a globally recognized biodiversity hotspot. As described above, it is important to recognize that conservation grazing is only one of a wide variety of management approaches that the District employs to steward the unique biodiversity and resources of our lands. Determining which techniques are appropriate for a given scenario is very site specific and context dependent.

In addition to the references I provided in our previous e-mail exchange, I'd recommend three more references (below). These standard texts may help you build a better basic understanding of California's ecosystems and our contemporary resource management challenges and strategies. You should be able to access these through your local library or through inter-library loan. I have found used copies relatively inexpensive online.

1) Mooney, H. & Zavaleta, E.A. 2016. *Ecosystems of California*. University of California Press. Oakland, CA.

2) Barbour, M.G., Keeler-Wolf, T., & Schoenherr, A.A. 2007. *Terrestrial Vegetation of California (3rd ed.)* University of California Press. Berkeley, CA.

3) Stromberg, M.R., Corbin, J.D., D'Antonio, C.M. 2007. *California Grasslands: Ecology & Management*. University of California Press. Berkeley, CA.

I hope this dialogue is helping you better understand the unique ecology of our area and the work Midpen is doing to protect it on behalf of all of us. We have a lot of important work to do and appreciate the support of concerned citizens such as yourself.

Sincerely,

Lewis Reed

Rangeland Ecologist/Botanist

Midpeninsula Regional Open Space District

February 25, 2020

Board of Directors, Midpeninsula Regional Open Space District
Lewis Reed, Lewis Reed, Rangeland Ecologist/Botanist
Omar Smith, Senior Property Management Specialist
330 Distel Circle
Los Altos, CA 94022

Sent Via Email: [redacted]

RE: Toto Ranch Rangeland Management Plan and Grazing Lease in Tunitas Creek Open Space Preserve (R-20-09)

Dear Misters Reed and Smith, Midpeninsula Regional Open Space District management and Board of Directors,

We submit these comments responding to the Midpeninsula Regional Open Space District (hereinafter Midpen) proposed *Toto Ranch Rangeland Management Plan and Grazing Lease in Tunitas Creek Open Space Preserve* (R-20-09) herein referred to as the proposed RMP.

On February 21, 2020 we were first made aware of the proposed RMP after receiving the Midpen email regarding the February 26, 2020 Board of Directors meeting. We are unable to determine when the public comment period began on this proposed RMP. I, Deniz Bolbol, previously requested that Midpen add me to all interested-party contact lists relating to livestock grazing on Midpen-managed lands. I never received any notification.

Because this proposed RMP has not been adopted and due to the public opposition, we urge the Board and Midpen staff to remove Agenda Item #4 from the agenda in order to address the public comments.

We strongly oppose the proposed RMP as it fails to adequately address important environmental concerns that result from the proposed actions. We request Midpen allow the public an opportunity to provide meaningful comments on this RMP through a public comments review process. Additionally, we strongly oppose the Mitigated Negative Declaration. Midpen must conduct an Environmental Impact Report (EIR) given the significant impacts that livestock grazing – at any level – has on the natural environment. The EIR must consider cumulative environmental impacts of all Midpen actions regarding livestock grazing.

I. BACKGROUND

The proposed RMP is to govern, for a five-year period, the private-commercial use of specific properties purchased and managed by Midpen with tax dollars.

In 1972, voters in Santa Clara County passed Measure R establishing Midpen as a government agency. Voters were told that the purpose of the district is "to acquire land primarily in the foothills and baylands area of the district for **open space and recreational uses…parks, playgrounds, trails, parkways and other recreational facilities…"**

In 1976, voters in San Mateo County passed Proposition D the "San Mateo County Annexation," which mirrored Measure R's original language, to be added to the Midpen district. Proposition D states it, "will preserve open space in its natural state as "room to breathe" in our hills and baylands." It further states, "District lands will be held primarily as open space with light recreational use."

Based on the two voter-approved purposes the Midpen mission is "*To acquire and preserve a regional greenbelt of open space land in perpetuity, protect and restore the natural environment, and provide opportunities for ecologically sensitive public enjoyment and education.*"

In or around 2004, the Midpen Board of Directors voted to annex portions of San Mateo County along the coast. Since that time, the Midpen Board of Directors added a second-tier mission statement that supposedly only applies to coastal properties. The second-tier mission statement is "*To acquire and preserve in perpetuity open space land and agricultural land of regional significance, protect and restore the natural environment, preserve rural character, encourage viable agricultural use of land resources, and provide opportunities for ecologically sensitive public enjoyment and education.*"

Voter approval was never granted to change the scope of the mission of Midpen. In taking the unilateral action, without voter approval, the Midpen Board of Directors changed the scope of the mission thus departing from the voter-approved management mission "to protect and restore the natural environment" which had been in place for decades. It is our understanding that elected officials may not amend or repeal an approved measure without submitting the change to voters unless the change furthers the purpose of the initiative. The initiatives passed by the voters creating and expanding Midpen were very specific in location and purpose.

The Midpen Board of Directors entered into a for-profit business model by converting public lands, which voters had established would be protected and restored to the natural environment, and creating a private-corporate interest on the public lands managed by Midpen.

Creating a livestock operation, which Midpen spends tax dollars to support, is a stark departure from the voter-approved purpose to acquire property "*to protect and restore the natural environment*…" as outlined in the agency's mission statement.

<u>II. OVERVIEW</u>

The Toto Ranch RMP fails to adequately analyze the impacts of livestock grazing to the natural environment and fails to consider alternatives to mitigate those impacts. I, Deniz Bolbol, previously requested that Midpen notify me of all livestock grazing related actions. The only notification I received on this proposed RMP was the Midpen Board of Directors meeting agenda which I received via email on February 21, 2020.

The Proposed RMP has failed to consider significant and potentially substantial impacts affected by the proposed action to allow livestock grazing on Toto Ranch.

While the existence of public controversy over the environment effects of a project will not *require* preparation of an EIR, substantial evidence before the agency that indicates the project *may* have a significant effect on the environment mandates an EIR. Substantial evidence includes facts, reasonable assumptions predicated upon facts, and expert opinion supported by facts.

Midpen has failed to conduct thorough analysis and has proposed a Mitigated Negative Declaration (MND) which is in adequate for the proposed livestock grazing.

Mitigated Negative Declaration (MND) incorporates revisions (mitigation measures) in the proposed project that will avoid or mitigate impacts to a point where **clearly no significant impacts on the environment would occur.**

The lead agency shall provide a public review period of not less than 20 days for Mitigated Negative Declarations. 14 CCR § 15073

We, along with other interested parties, have not been notified of the public review period for the Toto Ranch RMP. We, along with other interested parties, wish to have time to review the proposed RMP and provide meaningful input.

The proposed RMP does not meet the criteria for an MND.

"Significant effect on the environment" means a substantial, or potentially substantial, *adverse change in any of the physical conditions within the area affected* by the project including land, air, water, minerals, flora, fauna, ambient noise, and objects of historic or aesthetic significance. An economic or social change by itself shall not be considered a significant effect on the environment. A social or economic change related to a physical change may be considered in determining whether the physical change is significant. 14 CCR § 15382. Section 21083, Public Resources Code. Sections 21068, 21083, 21100 and 21151, Public Resources Code; *Hecton v. People of the State of California*, 58 Cal. App. 3d 653.

If the project *may* cause significant adverse environmental impacts, the lead agency must prepare an Environmental Impact Report (EIR).

The proposed Toto Ranch RMP clearly outlines actions that will, or at minimum may, have significant adverse environmental impacts. Yet, Midpen has failed to consider alternative actions to mitigate the issues identified for justifying livestock grazing. Some of those adverse environmental impacts from livestock grazing and the management of livestock grazing are outlined below.

III. PROPOSED RMP FAILS TO ANALYZE COMPLETE DATA AND IMPACTS OF PROPOSED ACTIONS

The Proposed RMP fails to adequately address disclose or analyze impacts of:

- fencing (wildlife-friendlier and other) on wildlife, including but not limited to ground dwelling birds and other animals, impacts of "wildlife-friendlier" fencing on wildlife range usage patterns, etc.
- diverting water from streams, creeks and other water sources and the wildlife who rely on those water source in order to accommodate livestock usage (amounts of water, impacts to water tables, streams, creeds, etc.),
- livestock presence on wildlife habitat and wildlife,
- livestock presence on predators (illegal and legal killing of predators),
- all costs to tax payers for purchasing lands, managing livestock grazing (including staff time) and subsidies to the livestock industry including data and analysis conducted to establish the Midpen AUM rate,
- production of greenhouse gases, including methane, from livestock grazing
- water quality impacts from livestock grazing -- both on site and downstream,
- other pertinent issues pertaining to livestock grazing and public input on this highly controversial issue of livestock grazing on public lands.

If livestock grazing were to end on the Toto Ranch property, fencing would no longer be needed and as the area would be solely devoted to and managed as wildlife habitat. Fencing could be removed and the landscape could be united as one contiguous area as wildlife habitat.

In addition to the above-mentioned impacts, Midpen must disclose and analyze the short- and long-term cumulative impacts of the proposed RMP; Midpen allows livestock grazing on this parcel and 8 additional parcels, which Midpen states represents 40% of the coastal grazing lands, and must disclosure and consider the *cumulative* impacts resulting from all livestock grazing on Midpen-managed public lands.

Fencing

The proposed RMP fails to consider and analyze the impact that fencing (wildlife friend or not) has on wildlife – including ground-dwelling animals. Fences provide elevated hunting perches for avian predators at locations where none were historically observed. When fences are erected through intact natural habitats, they can extend the reach of avian predators into the bisected habitat. Fencing and habitat issues that threaten various species of grouse also apply to their smaller cousins, the quail. Members of the quail family are mostly non-migratory, ground-dwelling birds. Most inhabit early-successional brushy areas. Cover is needed for California Quail to roost, rest, nest, escape from predators, and for protection from the weather (Sumner 1935, Leopold 1977). Fencing lands for livestock increases the threat from avian predators.

The RMP fails to consider that wildlife interactions with fences can be direct (physical) or indirect (behavioral), and lead to positive or negative consequences. The RMP fails to consider any negative impacts of fencing. Fencing can be used to limit disease transmission by separating wildlife and livestock (Ver Cauteren et al.,2007; Lavelle et al., 2010). The rate of wildlife mortality and injury as a result of direct contact with fences is largely unknown because most cases go unreported or unnoticed. Indirect effects of fences on wildlife manifest themselves as changes in behavior and biology. Many of these indirect effects are difficult to observe, quantify, and fully evaluate. Additionally, fencing – wildlife-friendlier or not – can cause wildlife to run into the fencing causing either injury or death or behavioral changes. (Attachment 2)

While “wildlife-friendlier” fencing is supposed to be utilized, barbed wire and other fencing continue to be in use and lack of replacement has direct negative impacts on wildlife.

The proposed RMP fails to analyze important issues relating to environmental impact due to fencing and failed to consider removing livestock grazing in order to mitigate the need for the majority of fencing.

Livestock Grazing Impacts to Water Sources

Grazing animals and pasture production can negatively affect water quality through erosion and sediment transport into surface waters, through nutrients from urine and feces dropped by the animals and fertility practices associated with production of high-quality pasture, and through pathogens from the wastes.[1]

The effect of grazing animals on soil and water quality must be evaluated at both the field and watershed scales. Such evaluation must account for both direct input of animal wastes from the grazing animal and also applications of inorganic fertilizers to produce quality pastures. (Attachments 3, 4)

The proposed RMP fails to analyze important issues relating to environmental impact due to water usage for livestock and failed to consider removing livestock grazing in order to mitigate the need for diverting water for livestock use and the impact of livestock on water sources.

Adverse Impacts of Livestock Grazing on Native Wildlife

Livestock grazing can have direct and indirect impacts on wildlife. Direct impacts include the removal and/or trampling of vegetation that would otherwise be used for food and cover, and livestock-wildlife interactions that may result in wildlife displacement or disease transmission.

The pattern of use by livestock and the resulting increase or decrease in community diversity will depend upon the terrain (broken, flat, mixed) and availability of water in the area. While uniform use may be desirable from the standpoint of maximizing livestock production, it is generally undesirable to wildlife because of reduced habitat diversity, reduction of heavy escape cover, and greater interaction between domestic and wild species (Brown 1978; Mackie 1978).

Indirect impacts result from changes in vegetation due to livestock grazing. The diets of wild ungulates may decline in nutritive value as they are forced to be less selective when cattle grazing reduces plant diversity and causes a decline in range condition (Holechek et al. 1995). The continued heavy grazing or browsing by only one species tends to cause a trend away from one vegetation type to another type.

The proposed RMP fails to take a hard look at the following wildlife conflicts with livestock grazing and failed to consider ending livestock grazing in order to mitigate these impacts:

- reduced nest sites for ground-dwelling birds and wildlife

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[1] Hubbard RK1, Newton GL, Hill GM., *Water quality and the grazing animal.* J Anim Sci. 2004;82 E-Suppl:E255-263. https://www.ncbi.nlm.nih.gov/pubmed/15471806

- decreased water quality
- trampled nests for ground-dwelling birds and wildlife
- disturbance to wildlife during fawning seasons
- reduced cover that permits wildlife to hide from predators
- reduced biomass of desirable wildlife forage
- increased noxious weed populations
- decreased vegetative diversity for bird, mammal, and insect communities
- potential spread of parasites or disease

Adverse Impacts of Livestock Grazing on Native Predators
The Midpen "FACT SHEET: Mountain Lions" outlines that these predators have territories of up to100 square miles. The Fact Sheet also acknowledges that mountain lions rely on brush and other environmental conditions in order to successfully hunt. Ironically, the Midpen Fact Sheet recommends "Keep livestock in enclosed sheds and barns at night, and be sure to secure all outbuildings." Yet, Midpen has not implemented this on the public lands it manages. This is the primary action that is needed to prevent predator conflict with livestock grazing.

The proposed RMP refused to even consider this rational and reasonable management mechanism needed to protect predators and livestock. Instead, Midpen is considering killing predators or compensating ranchers for livestock loss due to predators instead of ensuring the public lands rancher is implements a safe operation for his/her livestock. Not requiring ranchers to keep livestock in enclosed barns at night is irresponsible and inevitably creates wildlife conflict with livestock grazing.

The proposed RMP fails to analyze important issues relating to the real and potential impact to livestock grazing on predators and failed to consider removing livestock in order to mitigate these real and potential impacts to predators.

Costs of Livestock Grazing
As per the proposed RMP: $5,000 per year[2] for 632 AUMs[3] - approximately $7.91 per AUM.

The Midpen rate is far below the Western state average of $23.40 per AUM. The Congressional Research Service, March 4, 2019, *Grazing Fees: Overview and Issues* report (Attachment 1) states, "*For grazing on private lands in 2017, **the average monthly lease rate for lands in 16 western states was $23.40 per head**. Fees ranged from $11.50 in Oklahoma to $39.00 in Nebraska…"* Assuming grazing in the Bay Area is not less expensive than grazing in Nebraska, the local rate may be significantly higher than the western state average.

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[2] Over the last two grazing seasons, this Lease has provided an average annual grazing rent per season of $4,695.00. The Lessee will continue to pay an annual grazing rent to the District estimated at $5,000.00 per year. Annual grazing rent can vary depending upon the average selling price of beef cattle as well as the quantity and age of the conservation cattle grazing on the property.

[3] The estimated stocking rate for an average forage production year is 632.0 Animal Unit Months (AUMs) or 53.0 animal units year round, but would significantly increase with a reduction in coyote brush in the grasslands. (RMP, page 5)

Based on the CRS estimated western state average rate of $23.40 per AUM and the Midpen Toto Ranch rate of $7.91 per AUM – the difference is $15.49 per AUM. Midpen is charging only 1/3 of the CSR-determined going rate to graze livestock.

Midpen's subsidy of the livestock industry is not disclosed or analyzed in the proposed RMP and is not in the best interest of the taxpaying citizens who fund the District.

IV. CLOSING COMMENTS

The following issues have a direct impact on the proposed actions and the proposed RMP fails to take a hard look at these important actions, fails to consider alternative actions to address environmental issues raised by livestock grazing and failed to disclose and consider the short- and long-term cumulative impacts of livestock grazing on Midpen-managed public lands. Midpen should conduct an EIR that includes analysis on the following and other pertinent issues raised:

1. Analyze how proposed grazing use may conflict with wildlife needs for habitat and other resources.
2. Provide and analyze any baseline data or understanding on how livestock presence may drive off native species, including but not limited to listing all predator conflicts that have occurred in the broader area (mountain lion territory range averages 100 square miles).
3. Analyze all fencing in relationship to water sources, wildlife movement and other intended or unintended impacts.
4. Test, analyze and disclose all water sources in the vicinity of the proposed livestock grazing. Analysis must include testing of ground water table, upstream and downstream water samples, impacts of livestock water usage on wildlife species, full disclosure of all water sources managed or controlled, etc.
5. Disclose and analyze data on the wildlife usage of Toto Ranch – number of predator encounters and deaths, wildlife (including bird) usage and deaths, wildlife migratory patterns, etc.
6. Specific analysis and disclosure of ground-dwelling bird species and other native animals on the proposed site – historic numbers and current numbers.

Midpen must prepare an Environmental Impact Report (EIR) and must address the issues identified herein. The draft EIR must provide supporting data to support its proposed actions for the Toto Ranch RMP.

As interested parties, we request that Midpen conduct the necessary EIR and associated public comment period for the Toto Ranch and all livestock grazing leases. Midpen must conduct the above requested analysis of new data in order to consider the impacts the proposed actions will have on wildlife, water sources, natural habitat, and the local citizens who voted to "protect and preserve the natural environment."

Thank you for your consideration.

Deniz Bolbol
San Mateo, CA
Email: [redacted]

Kathleen Yoon

Kathleen Yoon
Los Altos, CA
Email: [redacted]

Attachments:

1. Congressional Research Service, March 4, 2019, *Grazing Fees: Overview and Issues*
2. Jakes, A.F., Jones, P.F., et al, *A fence runs through it: A call for greater attention to the influence of fences on wildlife and ecosystems,* Biological Conservation 227 (2018) 310–318
3. Hubbard RK, Newton GL, Hill GM., *Water quality and the grazing animal.* J Anim Sci. 2004;82 E-Suppl:E255-263.
4. Roche LM, Kromschroeder L, Atwill ER, Dahlgren RA, Tate KW (2013) Water Quality Conditions Associated with Cattle Grazing and Recreation on National Forest Lands. PLoS ONE 8(6): e68127.

ATTACHMENT 1

Grazing Fees: Overview and Issues

Updated March 4, 2019

Congressional Research Service
https://crsreports.congress.gov
RS21232

CRS REPORT
Prepared for Members and
Committees of Congress

Summary

Charging fees for grazing private livestock on federal lands is a long-standing but contentious practice. Generally, livestock producers who use federal lands want to keep fees low, whereas conservation groups believe fees should be increased. The current formula for determining the grazing fee for lands managed by the Bureau of Land Management (BLM) and the Forest Service (FS) was established in the Public Rangelands Improvement Act of 1978 (PRIA) and continued by a 1986 executive order issued by President Reagan. The fee is based on grazing of a specified number of animals for one month, known as an animal unit month (AUM). The fee is set annually under a formula that uses a base value per AUM. The base value is adjusted by three factors—the lease rates for grazing on private lands, beef cattle prices, and the cost of livestock production.

For 2019, BLM and FS are charging a grazing fee of $1.35 per AUM. This fee is in effect from March 1, 2019, through February 29, 2020, and is the minimum allowed. Since 1981, when BLM and FS began charging the same grazing fee, the fee has ranged from $1.35 per AUM (for about half the years) to $2.31 per AUM (for 1981). The average fee during the period was $1.55 per AUM. In recent decades, grazing fee reform has occasionally been considered by Congress or proposed by the President, but no fee changes have been adopted.

The grazing fees collected by each agency essentially are divided between the agency, Treasury, and states/localities. The agency portion is deposited in a range betterment fund in the Treasury and is subject to appropriation by Congress. The agencies use these funds for on-the-ground activities, such as range rehabilitation and fence construction. Under law, BLM and FS allocate the remaining collections differently between the Treasury and states/localities.

Issues for Congress include whether to retain the current grazing fee or alter the charges for grazing on federal lands. The current BLM and FS grazing fee is generally lower than fees charged for grazing on state and private lands. Comparing the BLM and FS fee with state and private fees is complicated, due to factors including the purposes for which fees are charged, the quality of the resources on the lands being grazed, and whether the federal grazing fee alone or other non-fee costs are considered.

Unauthorized grazing occurs on BLM and FS lands in a variety of ways, including when cattle graze outside the allowed areas or seasons or in larger numbers than allowed under permit. In some cases, livestock owners have intentionally grazed cattle on federal land without getting a permit or paying the required fee. The agencies have responded at times by fining the owners, as well as by impounding and selling the trespassing cattle. BLM continues to seek a judicial resolution to a long-standing controversy involving cattle grazed by Cliven Bundy on lands in Nevada.

There have been efforts to end livestock grazing in specific areas through voluntary retirement of permits and leases and subsequent closure of the allotments to grazing. Congress has enacted some such proposals. Congress also has considered measures to reduce or end grazing in specified states or to allow a maximum number of permits to be waived yearly. Among other reasons, such measures have been supported to protect range resources but opposed as diminishing ranching operations.

Another issue involves expiring grazing permits. Both BLM and FS have a backlog of permits needing evaluation for renewal. To allow for continuity in grazing operations, P.L. 113-291 made permanent the automatic renewal (until the evaluation process is complete) of permits and leases that expire or are transferred. The law provided that the issuance of a grazing permit "may" be categorically excluded from environmental review under the National Environmental Policy Act (NEPA) under certain conditions. NEPA categorical exclusions have been controversial.

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Introduction

Charging fees for grazing private livestock on federal lands is statutorily authorized and has been the policy of the Forest Service (FS, Department of Agriculture) since 1906, and of the Bureau of Land Management (BLM, Department of the Interior) since 1936. Today, fees are charged for grazing on BLM and FS land basically under a fee formula established in the Public Rangelands Improvement Act of 1978 (PRIA) and continued administratively.[1]

BLM manages a total of 245.7 million acres, primarily in the West. Of total BLM land, 154.1 million acres were available for livestock grazing in FY2017.[2] The acreage used for grazing during 2017 was 138.7 million acres.[3] FS manages a total of 192.9 million acres. Although this land is predominantly in the West, FS manages more than half of all federal lands in the East.[4] Of total FS land, more than 93 million acres were available for grazing in FY2017, with 74 million used for livestock grazing.[5] For both agencies, the acreage available for livestock grazing reflects lands within grazing allotments. However, the acreage in those allotments that is capable of forage production is substantially less, according to the FS, because some lands lack forage (e.g., are forested or contain rockfalls). In addition, for both agencies, acreage used for grazing is less than the acreage available due to voluntary nonuse for economic reasons, resource protection needs, and forage depletion caused by drought or fire, among other reasons. Because BLM and FS are multiple-use agencies, lands available for livestock grazing generally are also available for other purposes.

On BLM rangelands, in FY2017, there were 16,357 operators authorized to graze livestock, and they held 17,886 grazing permits and leases.[6] Under these permits and leases, a maximum of 12,333,568 animal unit months (AUMs) of grazing potentially could have been authorized for use. Instead, 8,820,617 AUMs were authorized for use.[7] BLM defines an AUM, for fee purposes,

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[1] P.L. 95-514, 92 Stat. 1803; 43 U.S.C. §§1901, 1905. Executive Order 12548, 51 *Fed. Reg*. 5985 (February 19, 1986), at https://www.archives.gov/federal-register/codification/executive-order/12548.html. These authorities govern grazing on the Bureau of Land Management (BLM) and the Forest Service (FS) lands in 16 contiguous western states, which are the focus of this report. These states are Arizona, California, Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Utah, Washington, and Wyoming. Forest Service grasslands and "nonwestern" states have different fees. In addition, grazing occurs on some other federal lands, not required to be governed by PRIA fees, including certain areas managed by the National Park Service, Fish and Wildlife Service, Department of Defense, and Department of Energy.

[2] This figure was provided to CRS by BLM on December 10, 2018. It reflects BLM acreage within grazing allotments during FY2017.

[3] This figure was provided to CRS by BLM on December 10, 2018. It is an estimate of the acreage within BLM allotments for which BLM billed grazing permit and lease holders.

[4] *East* is used here to refer to all states except the following 12 states: Alaska, Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming. For more information on federal land ownership by state, see CRS Report R42346, *Federal Land Ownership: Overview and Data*, by Carol Hardy Vincent, Laura A. Hanson, and Carla N. Argueta.

[5] These figures were provided to CRS by FS on November 30, 2018. Nearly all of this acreage is in the 16 western states covered by this report. The acreage used for livestock grazing (74 million) reflects FS acreage in active allotments. Additional acres under other ownerships also were in active allotments. Active means that livestock use was permitted during the year.

[6] BLM uses both permits and leases to authorize grazing. Permits are used for lands within grazing districts (under Section 3 of the Taylor Grazing Act, 43 U.S.C. §315b). Leases are used for lands outside grazing districts (under Section 15 of the Taylor Grazing Act, 43 U.S.C. §315m).

[7] Statistics in this paragraph were taken from U.S. Department of the Interior (DOI), BLM, *Public Land Statistics, 2017*, Table 3-8c and Table 3-9c, at https://www.blm.gov/sites/blm.gov/files/PublicLandStatistics2017. The numbers of operators and animal unit months (AUMs) used are reported as of September 30, 2017, and the number of permits and

as a month's use and occupancy of the range by one animal unit, which includes one yearling, one cow and her calf, one horse, or five sheep or goats.[8]

On FS rangelands, in FY2017, there were 5,725 permit holders permitted (i.e., allowed) to graze commercial livestock, with a total of 6,146 active permits. A maximum of 8,238,429 head-months (HD-MOs) of grazing were under permit and thus potentially could have been authorized for use. Instead, 6,803,425 HD-MOs were authorized for use.[9] FS uses HD-MO as its unit of measurement for use and occupancy of FS lands. This measurement is nearly identical to AUM as used by BLM for fee purposes. [10] Hereinafter, *AUM* is used to cover both HD-MO and AUM.

BLM and FS are charging a 2019 grazing fee of $1.35 per AUM. This annual fee is in effect from March 1, 2019, through February 29, 2020. This is the minimum fee allowed. (See "The Fee Formula" section, below.) BLM and FS typically spend more managing their grazing programs than they collect in grazing fees.[11] For example, $79.0 million was appropriated to BLM for rangeland management in FY2017. Of that amount, $32.4 million was used for administration of livestock grazing, according to the agency. The remainder was used for other range activities, including weed management, habitat improvement, and water development. For the same fiscal year, BLM collected $18.3 million in grazing fees.[12] The FY2017 appropriation for FS for grazing management was $56.9 million. The funds are used primarily for grazing permit administration and planning.[13] FS collected $7.6 million in grazing fees during FY2017.[14]

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leases and maximum AUMs are reported as of January 3, 2018.

[8] Specifically, BLM regulations at 43 C.F.R. §4130.8-1 provide that in general, "[f]or the purposes of calculating the fee, an animal unit month is defined as a month's use and occupancy of range by 1 cow, bull, steer, heifer, horse, burro, mule, 5 sheep, or 5 goats: (1) Over the age of 6 months at the time of entering the public lands or other lands administered by BLM; (2) Weaned regardless of age; or (3) Becoming 12 months of age during the authorized period of use."

[9] Statistics in this paragraph were provided to CRS by FS on November 30, 2018.

[10] Specifically, FS regulations at 36 C.F.R. §222.50 provide that "[a] grazing fee shall be charged for each head month of livestock grazing or use. A head month is a month's use and occupancy of range by one animal, except for sheep or goats. A full head month's fee is charged for a month of grazing by adult animals; if the grazing animal is weaned or 6 months of age or older at the time of entering National Forest System lands; or will become 12 months of age during the permitted period of use. For fee purposes 5 sheep or goats, weaned or adult, are equivalent to one cow, bull, steer, heifer, horse, or mule."

[11] Past estimates of the cost of livestock grazing have varied considerably for a number of reasons, including the following. Some estimates might reflect the entirety of BLM and FS appropriations for rangeland management, whereas others might reflect the subset of these appropriations for administration of livestock grazing. Another variable is whether the estimates reflect any indirect costs to the federal government of livestock grazing, such as programs that might benefit livestock grazing or compensate for impacts of livestock grazing, or indirect costs to ranchers, such as for maintenance of fences and water sources. A 2015 study by the Center for Biological Diversity identifies BLM, FS, and other federal programs that might fund indirect costs of livestock grazing. The study also identifies potential nonfederal costs, such as at the state or local level. The study, entitled *Costs and Consequences: The Real Price of Grazing on America's Public Land*s," 2015, is available at https://www.biologicaldiversity.org/programs/public_lands/grazing/pdfs/CostsAndConsequences_01-2015.pdf. Another 2015 assessment, by the Public Lands Council, identifies the costs to ranchers of grazing on federal lands in addition to the grazing fee. See Public Lands Council, *The Value of Ranching*, 2015, at http://publiclandscouncil.org/wp-content/uploads/2015/07/ValueofRanching_Onesheet-1.pdf.

[12] The amount used for livestock grazing administration versus other rangeland management activities and the amount of fees collected were provided to CRS by BLM on December 10, 2018.

[13] The FS appropriation for grazing management was taken from appropriations documents. Other FS appropriations also support livestock grazing but are not separately identifiable. For instance, appropriations for vegetation and watershed management, within the National Forest System account, have been used for range improvements, restoration, and invasive species management. A total of $184.7 million was appropriated for vegetation and watershed management in FY2017, but the portion for activities that benefitted livestock grazing is not identifiable.

[14] The amount of grazing fees was taken from appropriations documents.

Grazing fees have been contentious since their introduction. Generally, livestock producers who use federal lands want to keep fees low. They assert that federal fees are not comparable to fees for leasing private rangelands because public lands often are less productive; must be shared with other public users; and often lack water, fencing, or other amenities, thereby increasing operating costs. They fear that fee increases may force many small and medium-sized ranchers out of business. Conservation groups generally assert that low fees contribute to overgrazing and deteriorated range conditions. Critics assert that low fees subsidize ranchers and contribute to budget shortfalls because federal fees are lower than private grazing land lease rates and do not cover the costs of range management. They further contend that, because some of the collected fees are used for range improvements, higher fees could enhance the productive potential and environmental quality of federal rangelands.

Current Grazing Fee Formula and Distribution of Receipts

The Fee Formula

The fee charged by BLM and FS is based on the grazing on federal rangelands of a specified number of animals for one month. PRIA establishes a policy of charging a grazing fee that is "equitable" and prevents economic disruption and harm to the western livestock industry. The law requires the Secretaries of Agriculture and the Interior to set a fee annually that is the estimated economic value of grazing to the livestock owner. The fee is to represent the fair market value of grazing, beginning with a 1966 base value of $1.23 per AUM. This value is adjusted for three factors based on costs in western states of (1) the rental charge for pasturing cattle on private rangelands, (2) the sales price of beef cattle, and (3) the cost of livestock production. Congress also established that the annual fee adjustment could not exceed 25% of the previous year's fee.[15]

PRIA required a seven-year trial (1979-1985) of the formula while BLM and FS undertook a study to help Congress determine a permanent fee or fee formula. President Reagan issued Executive Order 12548 (February 14, 1986) to continue indefinitely the PRIA fee formula, and established the minimum fee of $1.35 per AUM.[16]

The 2019 grazing fee of $1.35 per AUM represents a 4% decrease from the 2018 fee. Since 1981, BLM and FS have been charging the same fee, as shown in **Table 1**. The fee has ranged from $1.35 per AUM (for about half of the years during the 39-year period) to $2.31 per AUM (for 1981). The fee averaged $1.55 per AUM over the period.

Table 1. Grazing Fees from 1981 to 2019

(dollars per animal unit month)

1981.....................$2.31	1991.....................$1.97	2001.....................$1.35	2011.....................$1.35
1982.....................$1.86	1992.....................$1.92	2002.....................$1.43	2012.....................$1.35
1983.....................$1.40	1993.....................$1.86	2003.....................$1.35	2013.....................$1.35
1984.....................$1.37	1994.....................$1.98	2004.....................$1.43	2014.....................$1.35

[15] 43 U.S.C. §1905.

[16] The executive order is available at https://www.archives.gov/federal-register/codification/executive-order/12548.html.

1981.....................$2.31	1991.....................$1.97	2001.....................$1.35	2011.....................$1.35
1985.....................$1.35	1995.....................$1.61	2005.....................$1.79	2015.....................$1.69
1986.....................$1.35	1996.....................$1.35	2006.....................$1.56	2016.....................$2.11
1987.....................$1.35	1997.....................$1.35	2007.....................$1.35	2017.....................$1.87
1988.....................$1.54	1998.....................$1.35	2008.....................$1.35	2018.....................$1.41
1989.....................$1.86	1999.....................$1.35	2009.....................$1.35	2019.....................$1.35
1990.....................$1.81	2000.....................$1.35	2010.....................$1.35	

Sources: Data for 1981-2005 are primarily derived from p. 83 of a 2005 Government Accountability Office report, GAO-05-869, at https://www.gao.gov/products/GAO-05-869. Data for 2006-2019 are primarily derived from annual BLM press releases. See for instance the 2019 press release containing the 2019 fee, at https://www.blm.gov/press-release/blm-and-forest-service-grazing-fees-lowered-2019.

Distribution of Receipts

Fifty percent of grazing fees collected by each agency, or $10.0 million—whichever is greater—go to a range betterment fund in the Treasury. BLM and FS grazing receipts are deposited separately.[17] Monies in the fund are subject to appropriations. BLM typically has requested and received an annual appropriation of $10.0 million for the fund. FS generally requests and receives an appropriation that is less than the $10.0 million minimum authorized in law. For instance, for FY2017, the agency received an appropriation of $4.2 million, roughly half the fees collected.[18]

The agencies use the range betterment fund for range rehabilitation, protection, and improvement, including grass seeding and reseeding, fence construction, weed control, water development, and fish and wildlife habitat. Under law, one-half of the fund is to be used as directed by the Secretary of the Interior or of Agriculture, and the other half is authorized to be spent in the district, region, or forest that generated the fees, as the Secretary determines after consultation with user representatives.[19] Agency regulations contain additional detail. For example, BLM regulations provide that half of the fund is to be allocated by the Secretary on a priority basis, and the rest is to be spent in the state and district where derived. Forest Service regulations provide that half of the monies are to be used in the national forest where derived, and the rest in the FS region where the forest is located. In general, FS returns all range betterment funds to the forest that generated them.[20]

[17] 43 U.S.C. §1751(b)(1).

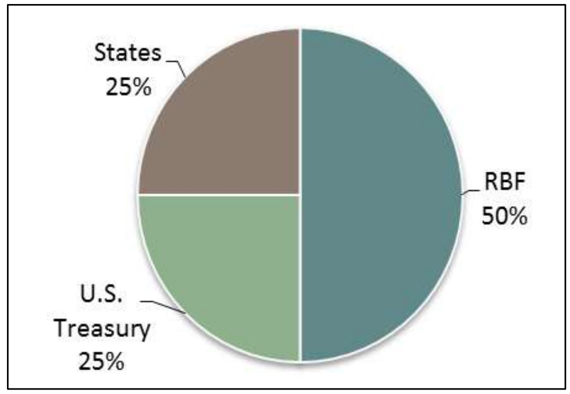
[18] This amount is the actual appropriation based on collections. It differs from the amount the agency requested and received in the appropriations law ($2.3 million), which was an estimate. See USDA, FS, *FY2019 Budget Justification*, p. 110, at https://www.fs.fed.us/sites/default/files/usfs-fy19-budget-justification.pdf.

[19] 43 U.S.C. §1751(b)(1).

[20] For BLM, see regulations at 43 C.F.R. §4120.3-8. For FS, see regulations at 36 C.F.R. §222.10.

The agencies allocate the remaining 50% of the collections differently.[21] For FS, 25% of the funds are deposited in the Treasury and 25% are subject to revenue-sharing requirements. The revenue-sharing payments are made to states, but the states do not retain any of the funds. The states pass the funds to specified local governmental entities for use at the county level (16 U.S.C. §500; see **Figure 1**).[22] For BLM, states receive 12.5% of monies collected from lands defined in Section 3 of the Taylor Grazing Act and 37.5% is deposited in the Treasury.[23] Section 3 lands are those within grazing districts for which BLM issues grazing permits. (See **Figure 2**.) By contrast, states receive 50% of fees collected from BLM lands defined in Section 15 of the Taylor Grazing Act. Section 15 lands are those outside grazing districts for which BLM leases grazing allotments. (See **Figure 3**.) For both agencies, any state share is to be used to benefit the counties that generated the receipts.

Figure 1. Distribution of Forest Service Grazing Fees



Source: CRS.

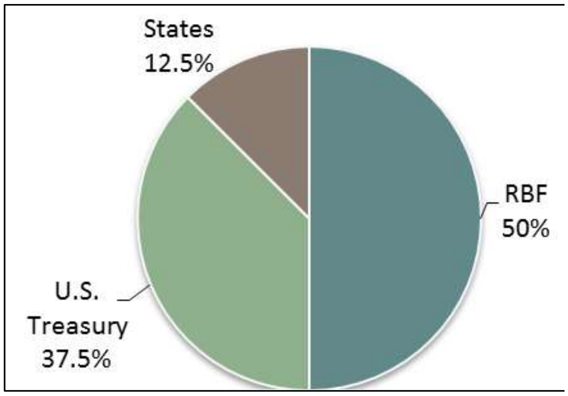
Note: RBF = Range Betterment Fund.

[21] The allocations described in this paragraph are made regardless of the amount of fees collected by an agency, including whether the total collection is less than the $10.0 million authorized for the range betterment fund (described above).

[22] More specifically, FS is required to share the annual average of 25% of the revenue generated on NFS land over the previous seven fiscal years with the counties containing those lands. Starting in 2000, however, Congress has at times authorized counties containing national forest system lands to receive revenue-sharing payments through an alternative payment program called Secure Rural Schools (SRS) payments. Payments made through SRS are based not on current revenue but on a formula that accounts for historic revenue. For more information, see CRS Report R41303, *Reauthorizing the Secure Rural Schools and Community Self-Determination Act of 2000*, by Katie Hoover. Under separate provisions of law (16 U.S.C. §501), 10% of monies received from national forests are to be allocated to the National Forest Roads and Trails Fund. However, these funds sometimes have stayed in the Treasury, as directed by recent annual Interior appropriations laws.

[23] Taylor Grazing Act of June 28, 1934; ch. 865, 48 Stat. 1269. 43 U.S.C. §§315, 315i.

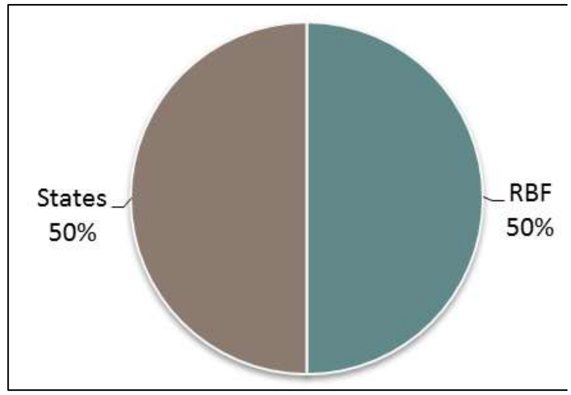
Figure 2. Distribution of BLM Grazing Fees: Section 3



Source: CRS.

Note: RBF = Range Betterment Fund.

Figure 3. Distribution of BLM Grazing Fees: Section 15



Source: CRS.

Note: RBF = Range Betterment Fund.

History of Fee Evaluation and Reform Attempts

PRIA directed the Interior and Agriculture Secretaries to report to Congress, by December 31, 1985, on the results of their evaluation of the fee formula and other grazing fee options and their recommendations for implementing a permanent grazing fee. The Secretaries' report included (1) a discussion of livestock production in the western United States; (2) an estimate of each agency's cost for implementing its grazing programs; (3) estimates of the market value for public rangeland grazing; (4) potential modifications to the PRIA formula; (5) alternative fee systems; and (6) economic effects of the fee system options on permittees.[24] A 1992 revision of the report updated the appraised fair market value of grazing on federal rangelands, determined the costs of range management programs, and recalculated the PRIA base value through the application of economic indexes. The study results, criticized by some as using faulty evaluation methods, were not adopted.

In the 1990s, grazing fee reform was considered by Congress but no change was enacted. In particular, in the 104th Congress (1995-1996), the Senate passed a bill to establish a new grazing fee formula and alter rangeland regulations. The formula was to be derived from the three-year average of the total gross value of production for beef and no longer indexed to operating costs and private land lease rates, as under PRIA. By one estimate, the measure would have resulted in an increase of about $0.50 per AUM. In the 105th Congress (1997-1998), the House passed a bill with a fee formula based on a 12-year average of beef cattle production costs and revenues. The formula would have resulted in a 1997 fee of about $1.84 per AUM. Since the 1990s, it appears that no major bills to alter the grazing fee have passed the chambers.

Also in the 1990s—and in subsequent years—certain Presidents proposed changes to grazing fees and related policies. However, these changes were not adopted. As one example, in 1993, the Clinton Administration proposed an administrative increase in the fee and revisions of other grazing policies. The proposed fee formula started with a base value of $3.96 per AUM and was

[24] U.S. Department of Agriculture, Forest Service, and U.S. Department of the Interior, Bureau of Land Management, *Grazing Fee Review and Evaluation*, A Report from the Secretary of Agriculture and the Secretary of the Interior (Washington, DC: February 1986).

to be adjusted to reflect annual changes in private land lease rates in the West (called the Forage Value Index). The current PRIA formula is adjusted using multiple indexes. As a second example, for some fiscal years (e.g., FY2008), President George W. Bush proposed terminating the deposit of 50% of BLM's grazing fees into the range betterment fund. The fee collections would have gone instead to the General Fund of the U.S. Treasury. As a third example, for some fiscal years, President Obama proposed a grazing administrative fee for BLM and FS (e.g., of $1.00 per AUM in FY2015 and $2.50 per AUM in FY2017). These administrative fees would have been additional to the annual grazing fee, and the agencies would have used them to offset the cost of administering the livestock grazing programs.

Current Issues

Fee Level

There is ongoing debate about the appropriate grazing fee, with several key areas of contention. First, there are differences over which criteria should prevail in setting fees: fair market value; cost recovery (whereby the monies collected would cover the government's cost of running the program); sustaining ranching, or resource-based rural economies generally; or diversification of local economies. Second, there is disagreement over the validity of fair market value estimates for federal grazing because federal and private lands for leasing are not always directly comparable. Third, whether to have a uniform fee, or varied fees based on biological and economic conditions, is an area of debate. Fourth, there are diverse views on the environmental costs and benefits of grazing on federal lands and on the environmental impact of changes in grazing levels. Fifth, it is uncertain whether fee increases would reduce the number of cattle grazing on sensitive lands, such as riparian areas.[25] Sixth, some environmentalists assert that the fee is not the main issue, but that all livestock grazing should be barred to protect federal lands.

As noted, there have been proposals to alter the grazing fee in recent years, but these proposals have not been adopted. For example, the Obama Administration's proposed grazing administration fee of $2.50 per AUM in 2017 would have been in addition to the annual fee of $2.11 per AUM. The monies would have been used for administering grazing to shift a portion of the costs to permit holders. Use of the fees would have been subject to appropriations. BLM estimated that the proposed administrative fee would have generated $16.5 million in FY2017, and FS estimated revenues of $15.0 million in FY2017.[26] Livestock organizations, among others, opposed the proposal as an unnecessary and burdensome cost for the livestock industry. The Administration had included similar proposals in earlier budget requests; none of these proposals were enacted.

As another example, in 2005, several groups petitioned BLM and FS to raise the grazing fees, asserting that the fees did not reflect the fair market value of federal forage. When the agencies did not respond to the petition, the groups sued.[27] In addition to asserting that BLM and FS

[25] As described in a BLM glossary, riparian areas are "[l]ands adjacent to creeks, streams, and rivers where vegetation is strongly influenced by the presence of water." See DOI, BLM, *Public Land Statistics, 2017*, p. 247, at https://www.blm.gov/sites/blm.gov/files/PublicLandStatistics2017.

[26] DOI, BLM, *Budget Justifications and Performance Information, Fiscal Year 2017*, p. II-6 and VII-35 – VII–36, athttps://edit.doi.gov/sites/doi.gov/files/uploads/FY2017_BLM_Budget_Justification.pdf. USDA, FS, *FY2017 Budget Justification*, pp. 39-40, at https://www.fs.fed.us/sites/default/files/fy-2017-fs-budget-justification.pdf.

[27] Center for Biological Diversity v. U.S. Department of the Interior, No. 10-CV-952 (D.D.C. *Complaint filed* June 7, 2010).

unreasonably delayed response to their petition, the petitioners argued that the agencies were required to conduct a study under the National Environmental Policy Act (NEPA) to determine the environmental impacts of the current grazing fee rate. In January 2011, BLM and FS responded to the petition, denying the request for a fee increase, and the lawsuit was settled.[28]

State and Private Grazing Fees

The BLM and FS grazing fee has generally been lower than fees charged for grazing on other federal lands as well as on state and private lands, as shown in studies over the past 15 years. For instance, a 2005 Government Accountability Office (GAO) study found that other federal agencies[29] charged $0.29 to $112.50 per AUM in 2004, when the BLM and FS fee was $1.43 per AUM. While BLM and FS use a formula to set the grazing fee, most agencies charge a fee based on competitive methods or a market price for forage. Some seek to recover the costs of their grazing programs. GAO also reported that in 2004, state fees ranged from $1.35 to $80 per AUM and private fees ranged from $8 to $23 per AUM.[30]

In 2010, when the BLM and FS fee was $1.35 per AUM, state grazing fees continued to show wide variation. They ranged from $2.28 per AUM for Arizona to $65-$150 per AUM for Texas. Moreover, some states did not base fees on AUMs, but rather had fees that were variable, were set by auction, were based on acreage of grazing, or were tied to the rate for grazing on private lands.[31] Further, a 2018 study of state grazing fees in 11 western states continued to show widely differing fees, ranging from $3.50 per AUM for New Mexico to $65-$100 per AUM for Texas. Fees for these states were higher than the 2018 BLM and FS fee ($1.41 per AUM).[32]

For grazing on private lands in 2017, the average monthly lease rate for lands in 16 western states was $23.40 per head. Fees ranged from $11.50 in Oklahoma to $39.00 in Nebraska.[33] For comparison, in 2017, the BLM and FS grazing fee was $1.87 per AUM.

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[28] Center for Biological Diversity v. U.S. Department of the Interior, No. 10-CV-952 (D.D.C. *Order filed* February 23, 2011).

[29] Other federal agencies covered by the GAO study included the Department of Energy, agencies (in addition to BLM) within the Department of the Interior, and agencies within the Department of Defense.

[30] GAO, *Livestock Grazing: Federal Expenditures and Receipts Vary, Depending on the Agency and the Purpose of the Fee Charged*, GAO-05-869 (Washington, DC: September 2005), pp. 37-40, at http://www.gao.gov/products/GAO-05-869. Hereinafter cited as GAO, *Livestock Grazing*, 2005.

[31] These figures and information are derived from an April 2011 study by the Montana Department of Natural Resources and Conservation. The report is at https://web.archive.org/web/20120930233640/http:/dnrc.mt.gov/Trust/AGM/GrazingRateStudy/Documents/GrazingReviewByBioeconomics.pdfhttps://web.archive.org/web/20150301051054/https:/dnrc.mt.gov/Trust/AGM/GrazingRateStudy/Documents/GrazingReviewByBioeconomics.pdfhttp://dnrc.mt.gov/Trust/AGM/GrazingRateStudy/Documents/GrazingReviewByBioeconomics.pdf. In particular, Table 1 (p. 9) compares fees on state lands in 17 western states. https://web.archive.org/web/20150301051054/https:/dnrc.mt.gov/Trust/AGM/GrazingRateStudy/Documents/GrazingReviewByBioeconomics.pdfhttp://dnrc.mt.gov/Trust/AGM/GrazingRateStudy/Documents/GrazingReviewByBioeconomics.pdf

[32] Holly Dwyer, WY Office of State Lands & Investments, 2018, *State Trust Land Grazing Fees*, at https://www.wyoleg.gov/InterimCommittee/2018/05-20180927StateLandsGrazingFees.pdf.

[33] Statistics on grazing fees on private lands were taken from U.S. Department of Agriculture, National Agricultural Statistics Service, *Charts and Maps, Grazing Fees: Per Head Fee, 17 States*, January 2018, at https://www.nass.usda.gov/Charts_and_Maps/Grazing_Fees/gf_hm.php. Including Texas, which also had a fee of $11.50, the 17-state average fee was $20.60 in 2017. For many years, the National Agricultural Statistics Service has published fees for grazing on private lands.

Comparing the BLM and FS grazing fee with state and private fees is complicated due to a number of factors. One factor is the varying purposes for which the fees are charged. Many states and private landowners seek market value for grazing. As noted above, PRIA established the BLM and FS fee in accordance with multiple purposes. They included preventing economic disruption and harm to the western livestock industry as well as being "equitable" and representing the fair market value of grazing. While the base fee originally reflected what was considered to be fair market value, the adjustments included in the formula have not resulted in fees comparable to state and private fees. According to GAO's 2005 study, "it is generally recognized that while the federal government does not receive a market price for its permits and leases, ranchers have paid a market price for their federal permits or leases—by paying (1) grazing fees; (2) nonfee grazing costs, including the costs of operating on federal lands, such as protecting threatened and endangered species (i.e., limiting grazing area or time); and (3) the capitalized permit value."[34] Regarding the latter, the capitalized value of grazing permits typically is reflected in higher purchase prices that federal permit holders pay for their ranches.

A second factor is the quality of resources on the lands being grazed and the number and types of services provided by the landowners. For example, in its 2005 study, GAO noted advantages of grazing on private lands over federal lands. They included generally better forage and sources of water; services provided by private landowners, such as watering, fencing, feeding, veterinary care, and maintenance; the ability of lessees to sublease, thus generating revenue; and limited public access. With regard to state lands, the study indicated that states also typically limit public access to their lands, while the quality of forage and the availability of water are more comparable to federal lands.[35]

A third factor is whether the federal grazing fee alone or other non-fee costs of operating on federal lands are considered in comparing federal and nonfederal costs. Some research suggests that ranchers might spend more to graze on federal lands than private lands when both fee and non-fee costs are considered. Non-fee costs relate to maintenance, herding, moving livestock, and lost animals, among other factors. [36]

Grazing Without Paying Fees

Unauthorized grazing occurs on BLM and FS lands in a variety of ways, including when cattle graze outside the allowed areas or seasons or in larger numbers than allowed under permit. According to GAO, the frequency and extent of unauthorized grazing is not known, because many cases are handled informally by agency staff. However, during the five-year period spanning 2010 to 2014, BLM and FS documented nearly 1,500 instances of unauthorized grazing, some of which involved the livestock owners having to pay penalties and, less frequently, livestock impoundment.[37]

In many cases the unauthorized grazing is unintentional, but in other cases livestock owners have intentionally grazed cattle on federal land without getting a permit or paying the required fee. The livestock owners have claimed that they do not need to have permits or pay grazing fees for

[34] GAO, *Livestock Grazing*, 2005, pp. 49-50, at http://www.gao.gov/products/GAO-05-869.

[35] GAO, *Livestock Grazing*, 2005, p. 49, at http://www.gao.gov/products/GAO-05-869.

[36] Neil Rimbey and L. Allen Torrell, *Grazing Costs: What's the Current Situation?*, University of Idaho, March 22, 2011.

[37] GAO, *Unauthorized Grazing: Actions Needed to Improve Tracking and Deterrence Efforts*, GAO-16-559 (Washington, DC: July 2016), pp. 12-13, at http://www.gao.gov/products/GAO-16-559.

various reasons, such as that the land is owned by the public; that the land belongs to a tribe under a treaty; or that other rights, such as state water rights, extend to the accompanying forage.

A particularly long-standing controversy involves cattle grazed by Cliven Bundy in Nevada.[38] After about two decades of pursuing administrative and judicial resolutions, in April 2014, BLM and the National Park Service began impounding Mr. Bundy's cattle on the grounds that he did not have authority to graze on certain federal lands and had not been paying grazing fees for more than 20 years. BLM estimated at that time that Mr. Bundy owed more than $1 million to the federal government (including grazing fees and trespassing fees) as a result of unauthorized grazing. However, the agencies ceased the impoundment of the cattle due to fears of confrontation between private citizens opposed to the roundup and federal law enforcement officials present during the impoundment. Mr. Bundy had not been paying grazing fees to the federal government primarily on the assertion that the lands do not belong to the United States but rather to the state of Nevada, and that his ancestors used the land before the federal government claimed ownership.[39] However, courts determined that the United States owns the lands, enjoined Mr. Bundy from grazing livestock in these areas, and authorized the United States to impound cattle remaining in the trespass areas.[40] BLM continues to seek to resolve the issue through the judicial process.

BLM estimated that during the two decades prior to the 2014 intended impoundment of Mr. Bundy's cattle, the agency had impounded cattle about 50 times. The operation to remove Mr. Bundy's cattle from federal lands in Nevada was the biggest removal effort, in terms of the number of cattle and the area involved, according to BLM.[41] It was also one of the most controversial, in part because of the number and role of law enforcement officials and the temporary closures of land to conduct the impoundment.[42]

Voluntary Permit Retirement

There have been efforts to end livestock grazing on certain federal lands through voluntary retirement of permits and leases and subsequent closure of the allotments to grazing. This practice is supported by those who view grazing as damaging to the environment, more costly than beneficial, and difficult to reconcile with other land uses. This practice is opposed by those who support ranching on the affected lands, fear a widespread effort to eliminate ranching as a way of life, or question the legality of the process. In some cases, supporters seek to have ranchers relinquish their permits to the government in exchange for compensation by third parties, particularly environmental groups. The third parties seek to acquire the permits through transfer, and advocate agency amendments to land use plans to permanently devote the grazing lands to other purposes, such as watershed conservation.[43]

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[38] Except where otherwise noted, information in this paragraph was derived from information provided to CRS by BLM on April 24, 2014, and information formerly on BLM's website (since removed).

[39] See for example, CBS/AP, CBS News, "Nevada Rancher Cliven Bundy: 'The Citizens of America' Got My Cattle Back," April 13, 2014, at http://www.cbsnews.com/news/nevada-rancher-cliven-bundy-the-citizens-of-america-got-my-cattle-back/.

[40] For example, court orders were issued on July 9, 2013, and October 9, 2013.

[41] Telephone communication between BLM and the Congressional Research Service, April 23, 2014.

[42] Jon Ralston, "Former BLM Director: Bundy is Not a Victim but BLM Mishandled Roundup," *Ralston Reports*, April 14, 2014, at http://www.ralstonreports.com/blog/former-blm-director-bundy-not-victim-blm-mishandled-roundup.

[43] The third parties would not pay grazing fees under their permits if they opt not to graze during the amendment process, because fees are paid for actual grazing,

Legislation to authorize an end to grazing in particular areas through voluntary donations of the permits by the permit holders has been introduced in recent Congresses. These measures generally provide for the Secretary of the Interior and/or the Secretary of Agriculture to accept the donation of a permit, terminate the permit, and end grazing on the associated land (or reduce grazing where the donation involves a portion of the authorized grazing). Provisions authorizing such voluntary permit donations in specific areas have sometimes been enacted.[44]

Other bills have sought to establish pilot programs for livestock operators to voluntarily relinquish permits and leases in particular states. Still other measures have proposed allowing the Secretary of the Interior and the Secretary of Agriculture to accept a certain number of waived permits, such as a maximum of 100 each year. Under both types of measures, when the Secretaries accept waived permits, they would permanently retire such permits and leases and end grazing on the affected allotments (or reduce grazing where the relinquishment involves a portion of the authorized grazing). Provisions authorizing such pilot programs for particular states or authorizing acceptance of a certain number of waived permits have not been enacted.

In earlier Congresses, legislation was introduced to *buy out* grazing permittees (or lessees) on federal lands generally or on particular allotments.[45] Such legislation provided that permittees who voluntarily relinquished their permits would be compensated at a certain dollar value per AUM, generally significantly higher than the market rate. The allotments would have been permanently closed to grazing. Such legislation, which had been backed by the National Public Lands Grazing Campaign, was advocated to enhance resource protection, resolve conflicts between grazing and other land uses, provide economic options to permittees, and save money. According to proponents, while a buyout program would be costly if all permits were relinquished, it would save more than the cost over time. Opponents of buyout legislation include those who support grazing, others who fear the creation of a compensable property right in grazing permits, some who contend that it would be too costly, or still others who support different types of grazing reform.

Extension of Expiring Permits

The extension, renewal, transfer, and reissuance of grazing permits have been issues for Congress. Both BLM and FS have a backlog of permits needing evaluation for renewal. For instance, BLM's backlog has been increasing for more than a decade, with a backlog of more than 7,000 permit renewals as of September 30, 2017.[46] To allow for continuity in grazing operations, Congress had enacted a series of temporary provisions of law allowing the terms and conditions of grazing permits to continue in effect until the agencies complete processing of a renewal. The most recent provision, P.L. 113-291 (Section 3023), made permanent the automatic renewal (until the renewal evaluation process is complete) of grazing permits and leases that expire or are transferred.[47]

[44] See, for example, P.L. 114-46, Section 102(e), for certain wilderness areas in Idaho and P.L. 112-74, Section 122, for the California Desert Conservation Area.

[45] For example, see H.R. 3166 in the 109th Congress.

[46] DOI, BLM, *Budget Justifications and Performance Information, Fiscal Year 2019*, p. VI-37, at https://www.doi.gov/sites/doi.gov/files/uploads/fy2019_blm_budget_justification.pdf. The figure in the document shows grazing permits processed by BLM, and permits in an unprocessed status, annually from FY1999-FY2017.

[47] This provision was enacted as an amendment to portions of the Federal Land Policy and Management Act (specifically 43 U.S.C. 1752) pertaining to livestock grazing on BLM and FS lands in 16 contiguous western states, which is the focus of this report. Annual appropriations laws for Interior, Environment, and Related Agencies have continued to provide automatic extension of grazing permits on other FS lands.

Agency decisions regarding permit issuance are subject to environmental review under the National Environmental Policy Act (NEPA). That environmental review would include the identification of any additional state, tribal, or federal environmental compliance requirements, such as the Endangered Species Act (ESA), that would apply to a permitted grazing operation. P.L. 113-291 provided that the issuance of a grazing permit "may" be categorically excluded from this NEPA requirement under certain conditions.[48] Provisions regarding categorical exclusions have been controversial. Supporters assert that they will expedite the renewal process, foster certainty of grazing operations, and reduce agency workload and expenses. Opponents have expressed concern that categorical exclusions could result in insufficient environmental review and public comment to determine range conditions.

Author Information

Carol Hardy Vincent
Specialist in Natural Resources Policy

Disclaimer

[48] For information about the various levels of environmental review required under NEPA, see CRS Report RL33152, *The National Environmental Policy Act (NEPA): Background and Implementation*, by Linda Luther.

ATTACHMENT 2

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Perspective

A fence runs through it: A call for greater attention to the influence of fences on wildlife and ecosystems

Andrew F. Jakes[a,*,1], Paul F. Jones[b], L. Christine Paige[c], Renee G. Seidler[d,2], Marcel P. Huijser[e]

[a] *Wildlife Biology Program, Department of Ecosystem and Conservation Sciences, W. A. Franke College of Forestry and Conservation, University of Montana, 32 Campus Drive, Missoula 59812, MT, USA*
[b] *Alberta Conservation Association, 817 4th Avenue S. #400, Lethbridge T1J 0P3, Alberta, Canada*
[c] *Ravenworks Ecology, 962 Dusty Trail Rd., Driggs, ID 83422, USA*
[d] *Wildlife Conservation Society, North America Program, Teton Field Office, PO Box 936, Driggs, ID 83422, USA*
[e] *Western Transportation Institute, Montana State University, PO Box 174250, Bozeman 59717, MT, USA*

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ABSTRACT

Fencing is a nearly ubiquitous infrastructure that influences landscapes across space and time, and the impact of fences on wildlife and ecosystems is of global concern. Yet the prevalence and commonness of fences has contributed to their “invisibility” and a lack of attention in research and conservation, resulting in a scarcity of empirical data regarding their effects. Stakeholders, including scientists, conservationists, resource managers, and private landholders, have limited understanding of how fences affect individual animals, populations, or ecosystem processes. Because fences are largely unmapped and undocumented, we do not know their full spatial extent, nor do we fully comprehend the interactions of fences with wild species, whether positive or negative. To better understand and manage fence effects on wildlife and ecosystems, we advocate for an expanded effort to examine all aspects of *fence ecology*: the empirical investigation of the interactions between fences, wildlife, ecosystems, and societal needs. We first illustrate the global prevalence of fencing, and outline fence function and common designs. Second, we review the pros and cons of fencing relative to wildlife conservation. Lastly, we identify knowledge gaps and suggest research needs in fence ecology. We hope to inspire fellow scientists and conservationists to “see” and study fences as a broad-scale infrastructure that has widespread influence. Once we better understand the influences and cumulative effects of fences, we can develop and implement practical solutions for sustaining wildlife and ecosystems in balance with social needs.

1. Introduction

Globally, wildlife contend with shrinking natural habitats in landscapes dominated by an expanding human footprint and the accumulating influence of infrastructure (Sanderson et al., 2002; Johnson et al., 2005; Leu et al., 2008). Linear transport and energy infrastructures (e.g., roads, pipelines, power lines, canals) often have negative impacts on native wildlife and ecological processes through direct mortality, creating barriers and hazards, or altering behavior (Bevanger, 1998; Lemly et al., 2000; Trombulak and Frissell, 2000; Taylor and Knight, 2003; Benítez-López et al., 2010). The resulting habitat fragmentation, population declines, and disrupted ecosystem processes (e.g., seasonal migrations (Berger, 2004)), have broad-scale effects on wildlife and natural ecosystems and have prompted substantial investment in research and mitigation.

Fencing is nearly ubiquitous yet has received far less research attention than roads, powerlines, and other types of linear infrastructure. Worldwide, lands are laced with countless kilometers of fences erected by diverse stakeholders at different scales for widely varying purposes. Collectively, fences form extensive and irregular networks stretching across landscapes, and their influence on wildlife and ecosystems is likely far-reaching. Yet fencing is largely overlooked and is essentially “invisible” in terms of systematic research and evaluation.

We see parallels with road ecology in the widespread influence of fences. In recent decades, substantial investment into the study of road ecology has driven its advancement as a science, leading to improved public safety and wildlife conservation. Yet in many landscapes fences are more prevalent than roadways. Unlike roads, fences have vertical

* Corresponding author at: National Wildlife Federation, Northern Rockies, Prairies & Pacific Region, 240 North Higgins Ave., Suite 2, Missoula, MT 59802, USA.
E-mail address: jakesa@nwf.org (A.F. Jakes).
[1] Present address: National Wildlife Federation, Northern Rockies, Prairies & Pacific Region, 240 North Higgins Ave., Suite 2, Missoula, Montana, USA, 59802.
[2] Present address: Idaho Department of Fish and Game, 4279 Commerce Circle, Idaho Falls, Idaho, USA, 83401.

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Fig. 1. Fence densities vary widely in difference landscapes. (a) Roadside boundary/livestock fence in rural landscape; (b) pasture fence in exurban landscape; (c) yard fence in suburban landscape.

structure that imposes unique hazards and barriers for wildlife, are typically unregulated, are constructed and maintained largely by private landholders, but we may be able to mitigate some of their ecological effects in a cost-effective manner.

To date, most empirical research on wildlife-fence interactions and fence systems has been limited in scope, often focused on single species at local spatial scales. Existing studies have largely addressed fence impacts on ungulates or at-risk species, often motivated by mortalities and barriers to known movements (e.g., Mbaiwa and Mbaiwa, 2006; Harrington and Conover, 2006). Large gaps exist in the empirical science on wildlife-fence interactions and we need more information to support wildlife conservation and resource management. We lack knowledge on the broad-scale and cumulative effects of fence infrastructure on a multitude of species, population demographics, and ecosystem processes. We do not know the longer-term or ecosystem-level consequences of fences, even of those fences erected for specific conservation objectives.

There is a fledgling but growing movement in North America and elsewhere to install wildlife friendlier fence designs (Paige, 2012, 2015), now advocated by many conservation groups and government agencies. Yet most of the practical experience with fences—their design, utility, installation, and modifications—resides among private landholders and government resource managers, whose knowledge is built on field trials and circulated via peers. Private landholders, including livestock growers, construct and maintain most fences, are familiar with their location and structure, and need them to be functional. Working with these stakeholders represents an excellent opportunity to develop effective fence solutions that maintain local economies, reduce impacts to wildlife, and sustain dynamic ecosystems. Without a systematic understanding of fences—their purpose, design, extent, and ecological effects—we cannot communicate or collaborate effectively for conservation goals, nor create more sustainable landscapes where people and wildlife can co-exist.

Therefore, we advocate for a greater focus on *fence ecology*: the empirical investigation of the interactions between fences, wildlife, ecosystems, and societal needs. In nearly every fenced landscape, there are opportunities to study and better understand the influence of fences on wildlife populations and ecological processes at multiple scales. In addition, there is an urgent need to examine alternative fence designs and systems that are more sustainable for people and wildlife and to provide a clearer understanding of the use of fencing in the context of wildlife conservation and management.

In this essay, we first illustrate the prevalence of fencing and offer a brief overview of contemporary fence functions and typical designs. Second, we review the positive and negative effects of fencing as it relates to wildlife conservation. Lastly, we identify knowledge gaps and suggest research opportunities in fence ecology. We examine our current level of knowledge, which is largely limited to wildlife-fence interactions at small spatial scales. We advocate for interdisciplinary research that examines issues at larger spatial scales and with a larger suite of stakeholders—shifting focus from studying effects on individual animals or small groups of wildlife to entire populations and ecosystem processes. Because the influence of fences on nature applies globally, we invite specialists worldwide to pursue a better understanding of fence ecology within their own ecological and social setting. A better understanding of the full ramifications of fence infrastructure will inform conservation decision-making and encourage creative alternatives.

2. Fence functions and types

Fences serve to protect and manage resources, delineate land ownership, and define political boundaries (Kotchemidova, 2008). The first fences were constructed of readily available natural materials at relatively small scales, and required considerable investment in labor (Baudry et al., 2000; Woods et al., 2017). The invention of barbed wire in 1874 made it possible to fence vast areas with little cost and effort (Liu, 2009). Barbed wire and other mass-manufactured materials bolstered a rapid proliferation of fencing, which has fundamentally altered landscapes and cultures worldwide.

Today, fences continue to proliferate as land uses shift, natural and rural areas are developed or exploited, and transportation networks multiply (Linnell et al., 2016; Li et al., 2017; Løvschal et al., 2017). The design, density, and extent of fencing are highly variable between urban, rural, and open or natural landscapes. For example, Fig. 1 illustrates the dissimilarity in fence type and density in three landscapes of western North America—each area presents different challenges and consequences for wildlife and conservation.

Fences are spatially extensive, creating vertical obstacles for wildlife to cross, and are constructed with varying degrees of permeability. In many rural areas, fencing far exceeds roads in linear extent. We compared fencing spatial data from Seward et al. (2012) to available road spatial data for southern Alberta, Canada (Alberta Base Features Data - Spatial Data Warehouse© 2017). We found that the linear extent of fences was twice that of all roads per township, 16 times the extent of paved roads, 7 times the extent of two-track roads, and 4 times the extent of gravel roads (Fig. 2).

As land use change transformed once contiguous landscapes, the proliferation of fences has accelerated the fragmentation of ecosystems. For example, in the eastern Qinghai-Tibetan Plateau region of China, the rapid spread of fences created ecosystem-level impacts due to a shift from traditional pastoralism to land privatization (Li et al., 2017.) The erection of fences altered the grazing behavior of yaks (*Bos grunniens*), which increased grazing intensity, degraded pastures, and changed the vegetation community and ecological regime (Li et al., 2017). In the Greater Mara ecosystem of East Africa, rapid proliferation of fencing threatens the region's great animal migrations and traditional Maasai pastoralism (Løvschal et al., 2017). In Asia, Europe, and North America, shifts in global politics have resulted in an increase in impermeable boundary fences erected along international borders, fragmenting landscapes and presenting barriers to animal movements (Lasky et al., 2011; Linnell et al., 2016).

Contemporary purposes of fencing fall into four categories, which often overlap: (1) livestock (i.e., pasture or range) fence to control domestic livestock; (2) exclusion fence to protect public safety and private or public resources; (3) boundary fence to delineate landholdings or political boundaries; and (4) conservation fencing to protect at-risk species. Worldwide, these fence categories employ a wide variety of construction designs, materials, and spatial distribution across the landscape (Table 1). The impact that fence designs have on wildlife varies from positive (e.g., protection from poaching), in the case of conservation fences, to primarily negative (e.g., barriers to movement) in the case of the other three types of fences (Table 1). However, even fences designed to have positive benefits for focal species may have negative consequences for other species.

3. The dichotomy of fences: conservation tool or ecological threat?

Within the world of conservation, debate about fences stems from the equivocal nature of an infrastructure that can be a valuable instrument for management and protection or cause wildlife mortality and ecological tragedy—or both (Pfeifer et al., 2014; Woodroffe et al., 2014). Fences are often erected to safeguard threatened species, sensitive habitats, or to manage vegetation objectives using livestock grazing as a tool. Conversely, many managers and conservationists promote removal or modification of existing fences to increase ecological connectivity and reduce harmful impacts to wildlife. In light of this dichotomy, we provide a schematic interpretation (Fig. 3) to illustrate the far-reaching interactions that fences have on wildlife. This schematic is not exhaustive, but provides a framework for discussion.

Wildlife interactions with fences can be direct (physical) or indirect (behavioral), and lead to positive or negative consequences (Fig. 3). On the positive side, fencing designed specifically for conservation can reduce mortality of target species, help restore ecosystem connectivity across transportation corridors by guiding wildlife to safe crossing

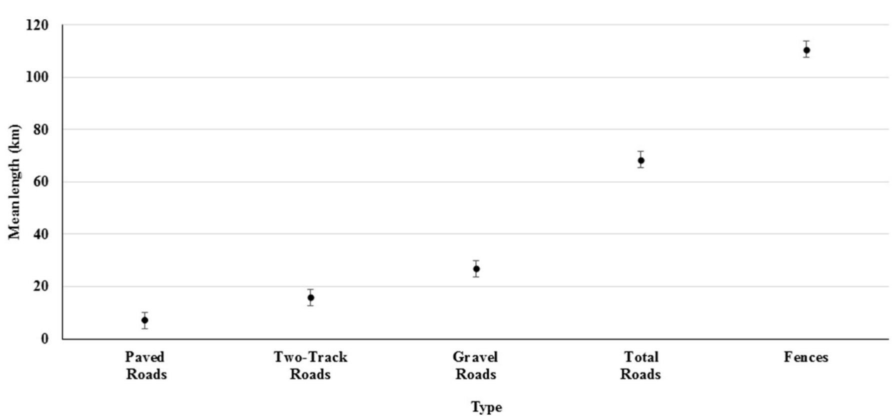

Fig. 2. The extent of fences on a landscape may far exceed that of roads. Comparison of the mean kilometers of fences per township to the mean kilometers of three types of roads per township in southern Alberta, Canada. Each error bar was constructed using the 95% confidence interval of the mean. Fence data obtained from Seward et al. (2012); road data obtained from the Alberta complete road layer of the Alberta Base Features Data (©Spatial Data Warehouse Ltd., 2017). (Disclaimer: *The Minister and the Crown provides this information without warranty or representation as to any matter including but not limited to whether the data/information is correct, accurate, or free from error, defect, danger, or hazard and whether it is otherwise useful or suitable for any use the user may make of it*).

Table 1
Design, distribution, and general impact to wildlife of the various fence types found around the world.

Type	Purpose	Ownership	Spatial extent	Primary design	Impact to wildlife
Livestock (pasture or range) fence	Control domestic livestock distribution	Private	Extensive	Barbed wire usually 3–5 strands (contain large domestic animals) Woven wire (contain small to medium domestic animals)	Semi-permeable to all wildlife Impermeable for medium and large mammals
Exclusion fence	Protect social or natural resources.	Local government	Restricted (e.g., right-of-way fences along highways)	Woven wire topped with barbed wire	Impermeable for medium and large mammals Semi-permeable to small mammals, birds, and reptiles
Boundary fence	Control movement of people or wildlife across political or landholder boundaries	Federal government	Restricted (e.g., USA/Mexico border fence)	Variable based on location (e.g. country) and purpose	Impermeable to all wildlife except species that can fly over
Conservation fence	Protect imperiled species and wildlife communities	Environmental non-government organizations	Limited (e.g. Scotia Sanctuary, Australia)	Woven wire fencing averaging 2 m in height and usually with electrified wires	Positive for the species trying to protect Potential barrier or impediment to other wildlife in the area

opportunities, and reduce wildlife-human conflict, thus increasing social acceptance of wildlife. When employed as a tool in wildlife management, fences may deliver positive results for target species and habitats (Hayward and Kerley, 2009). Fencing can contain and protect sensitive natural areas, particularly within areas heavily modified by habitat loss and degradation (Homyack and Giuliano, 2002; Miller et al., 2010), deter poaching (Dupuis-Désormeaux et al., 2016), and protect sensitive species by reducing predation (Young et al., 2013; Cornwall, 2016; Ringma et al., 2017). Fencing can also limit disease transmission by separating wildlife and livestock (VerCauteren et al., 2007; Lavelle et al., 2010), stem encroachment of invasive and non-native species into protected areas (see Hayward and Kerley, 2009, for review), and minimize crop and livestock depredation conflicts, fostering greater social tolerance of wildlife (Huygens and Hayashi, 1999; King et al., 2017). Fences are increasingly used to keep wild and domestic animals off transportation corridors and guide them towards safe crossings (Leblond et al., 2007; Huijser et al., 2016), which increases human safety, reduces wildlife mortality, and maintains connectivity for wildlife (Beckmann et al., 2010). Fences will continue to be an important and effective management tool—the challenge is to recognize their full ecological context and potential adverse effects.

Negative consequences of wildlife-fence interactions can be classified as direct or indirect. Direct effects involve physical contact between the individual and the fence. These include direct mortality, injuries, and hair loss, which can result in reduced individual- or population-level fitness. The most observable impact is direct mortality, which can happen immediately when an animal collides with fencing or slowly when animals are caught in fences and die from exposure, starvation, or predation. Direct mortality of a wide range of birds and mammals from fence collisions and entanglements has been documented worldwide (Allen and Ramirez, 1990; Baines and Andrew, 2003; Harrington and Conover, 2006; Booth, 2007; Rey et al., 2012). More difficult to measure are injuries and hair loss that occur from encounters with fences while crossing. Jones (2014) documented hair loss in pronghorn (*Antilocapra americana*) as a result of crossing barbed wire fences and postulated the implications. The rate of wildlife mortality and injury as a result of direct contact with fences is largely unknown because most cases go unreported or unnoticed, or the carcasses are scavenged.

Indirect effects of fences on wildlife manifest themselves as changes in behavior and biology. These include heightened stress of negotiating fences, separation of neonates from mothers (Harrington and Conover, 2006), obstructed movements, habitat loss, and fragmentation. Stress occurs when animals are temporarily entangled, search frantically for a place to cross by pacing up and down the fence (Seidler et al., 2018), or must negotiate multiple fences in a landscape. These impacts can accumulate over time and contribute to increased energy expenditure, higher mortality rates, and decreased overall fitness of individuals. Young that cannot negotiate a fence and are separated from adults can die of dehydration, exposure, or predation (Harrington and Conover, 2006), and the loss of neonates reduces recruitment and potentially population size. Many of these indirect effects are difficult to observe, quantify, and fully evaluate.

Fences often delineate and separate areas of modified terrain (e.g., tilled agriculture, grazed pasture, urbanization, etc.) and some, such as veterinary cordon or wildlife-proof fences, stretch for kilometers across large regions. Such fences act as barriers, isolate remnant habitats, and fragment landscapes (Hobbs et al., 2008). As barriers and obstacles, these fences limit or block wildlife movements and influence wildlife behavior, with potential individual- and population-level consequences that ultimately alter the ecological integrity of natural systems (Berger, 2004; Sawyer et al., 2013; Jakes et al., 2018). Impermeable fences or large-scale fence networks can jeopardize the fecundity and survival of individuals and populations, reduce genetic connectivity, and alter ecological processes such as herbivory and nutrient flow (Hilty et al., 2006; Taylor et al., 2006). When fences severely fragment an ecosystem, wildlife populations become isolated, reducing genetic

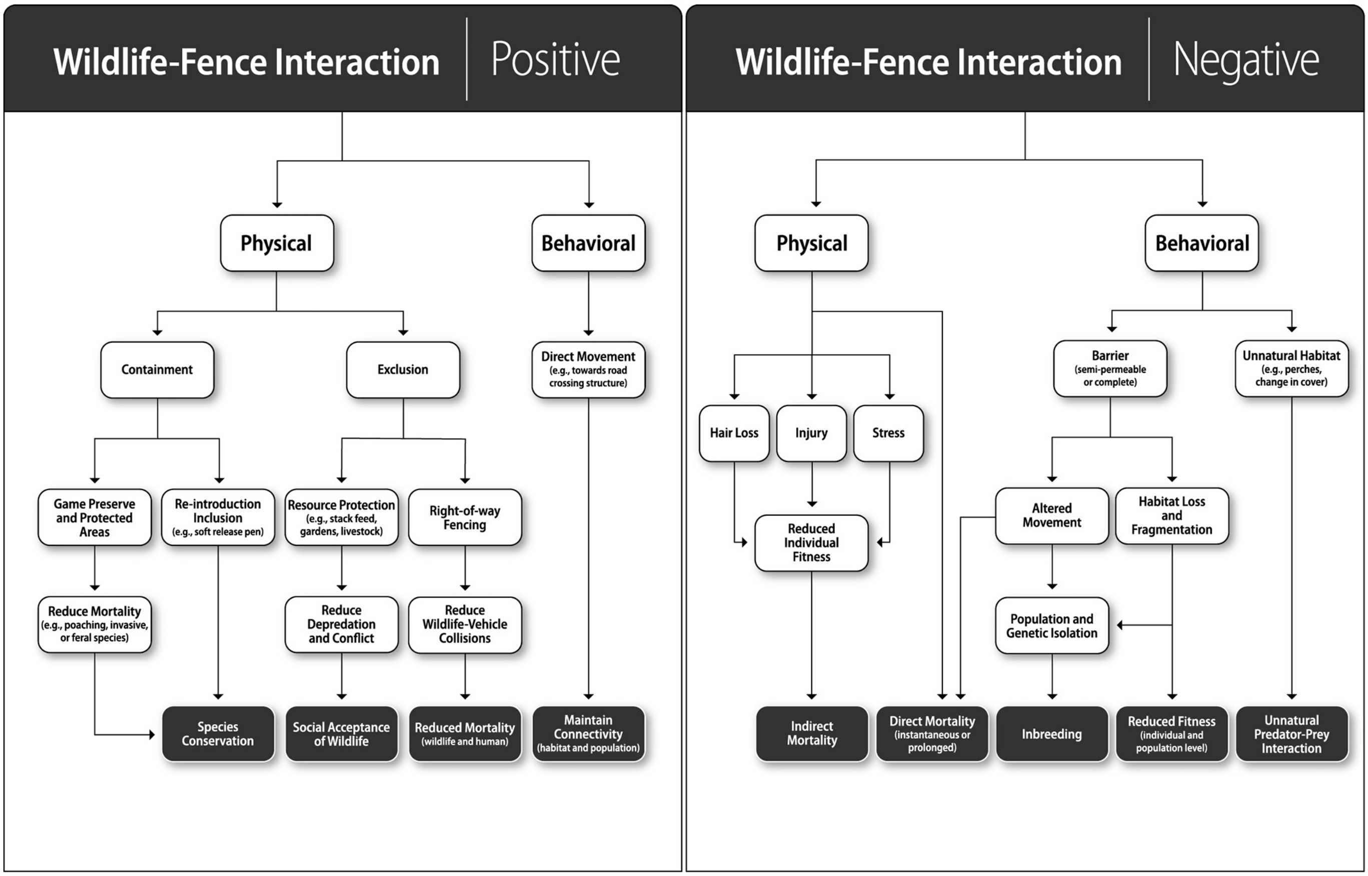

Fig. 3. Depiction of the positive and negative interactions between wildlife and fences. The shaded boxes represent outcomes of the various interactions.

exchange, diversity, and individual and population fitness (Jaeger and Fahrig, 2004; Ito et al., 2013).

In North America in recent decades, greater attention has been given to the effects of fences on wildlife, especially ungulates and grouse, with studies focused on the obstacles that fences pose for long distance migration and dispersal, and their effect on connectivity for wildlife across landscapes (Berger, 2004; Hilty et al., 2006; Taylor et al., 2006; Seidler et al., 2015). As a result, various fence modifications and crossings have been promoted to reduce animal injury, mortality, and ease animal passage (e.g., Paige, 2012, 2015). For example, in the United States, resource agencies have widely adopted fence markers to increase visibility for lesser prairie-chicken and greater sage-grouse, and smooth bottom wire to aid pronghorn passage. Many designs have been based on trial and error in the field, yet progressively more attention is being given to testing the effects of specific fence modifications on particular species (Stevens et al., 2013; Van Lanen et al., 2017; Burkholder et al., 2018; Jones et al., 2018). Although promoted by agencies and conservation organizations, the implementation of wildlife-friendlier fence designs across landscapes is patchy and by no means universal.

Even fences constructed for particular conservation purposes can produce unintended consequences. For example, veterinary cordon fences erected across Botswana to control disease transmission between livestock and wild ungulates led to dramatic and devastating declines in migratory ungulates (Williamson and Williamson, 1984; Mbaiwa and Mbaiwa, 2006). The extensive dingo (*Canis lupus dingo*) and rabbit-proof fences of Australia were erected to protect livestock and grazing lands, but altered predator-prey dynamics of endemic and introduced species with negative consequences for vegetation and ecosystems (Newsome et al., 2001; Johnson et al., 2007). Protected area and agricultural fences in east Africa fragment landscapes, alter ecological functions and wildlife movements, and can aggravate tensions between wildlife conservation and the livelihoods of local communities or nomadic pastoralists (Reid et al., 2004; Fynn et al., 2016). Depending on design, maintenance, and the social and ecological context, fences erected with the best of intentions may actually exacerbate conservation conflicts.

4. Knowledge gaps and research opportunities

The current empirical research on the interactions between fences, wildlife, and ecosystems, especially at broad scales, is slim. Opportunities for study range from fence design and efficacy, to biological and ecological influences, to understanding the social aspects of fence systems and adoption of change—topics that are often interwoven. Advancing our understanding of the influence of fence infrastructure begins with identifying knowledge gaps so that questions can be posed and tested. Fence-related empirical research can inform and shape solutions for conservation, on-the-ground mitigation actions, systematic monitoring, and adaptive management (Table 2).

4.1. Fence extent and design

Most linear anthropogenic features that cross landscapes are readily mapped and incorporated into spatial analyses. Fences are largely unmapped and undocumented: we do not know the full extent of where they are, and we do not have efficient methods or tools to catalogue their design, purpose, and condition. Assessment of fence influences at landscape and ecosystem scales is hampered by a lack of elementary data on the magnitude, type, condition, and density of existing fence infrastructure. Efforts to generate geospatial fence data have so far used modeling to approximate the density of fences at regional scales,

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Table 2
Suggested knowledge gaps and general research opportunities in fence ecology.

	Knowledge gaps	Research opportunities	Actions	Outcomes
Design & extent	Fence extent & condition	• Methods for geospatial analysis of fence distribution and condition.	• Test mapping methods using drone technology, or high-resolution aerial imagery with automated GIS processes. • Model fence types using land tenure records.	• Ability to map, quantify, and evaluate fence infrastructures for research and conservation.
	Efficacy of designs	• New designs for specific wildlife mitigations. • Efficacy of wildlife fence designs. • Biological & ecological costs/benefits of conservation fences. • Alternative methods to manage livestock distribution.	• Use trail cameras to assess wildlife and livestock fence interactions and response to modifications. • Conduct cost/benefit analyses of various designs incorporating ecological and biological factors.	• Improved designs to sustain wildlife and ecosystems while maintaining fence purpose. • Adapt fence systems to reduce unintended consequences. • Reduce the number of fences erected to control livestock.
Wildlife	Behavior & biology	• Species' perception, reaction to, and physical negotiation of various fence types. • Influence of fences on species' distribution. • Biological response to stress or energy loss due to fences.	• Use trail cameras to assess wildlife-fence interactions. • Use spatial fence layer data as a covariate in habitat and distribution modeling. • Compare stress and energy levels (e.g., corticosteroid levels, fat reserves) between individuals occupying areas with different fence densities or types.	• Designs and mitigations to ease animal crossing, movements, and reduce biological impacts.
	Population	• Rates of injury and mortality due to fences. • Physical and biological factors that contribute to injury, mortality, stress, population-level effects.	• Conduct transects to assess mortality rates. • Assess fence density and its relationship to range-wide population demographics, size, connectivity (genetic relatedness and movement rates).	• Designs and mitigations that reduce impacts on populations.
Ecosystems	Landscape-level effects	• Influence of fencing and distribution at landscape scales on species and ecosystems. • Fence hotspots that impede wildlife movements. • Influence of conservation fences on ecological communities or processes.	• Use spatial fence layer data as a covariate in habitat and movement modeling and assess influence of fences on migration pathways. • Utilize data from trail cameras to assess effects on multiple species or ecological processes.	• Alter fence systems to mitigate problem designs and locations. • Adapt fence systems and infrastructure to sustain the ecological community and functions.
	Soils	• Changes in soil chemistry, moisture regimes, soil microbiomes, compaction or erosion due to fences.	• Assess soil characteristics along and away from fence lines to determine similarities and differences	• Mitigate soil impacts; sustain healthy soils.
	Vegetation	• Fence effects on vegetation composition, condition, and succession.	• Assess vegetation community types along and away from fence lines.	• Sustain ecosystem functions, native species, and healthy vegetation communities.
	Ecological processes	• Fence effects on herbivory patterns (wild and domestic), seed dispersal, nutrient flow, or other ecosystem processes.	• Assess impacts of domestic and wild animals along fence lines towards changes in soil composition, seed dispersal, or nutrient flow.	• Mitigations to sustain or restore ecosystem processes.
Social dimensions	Local culture	Influence of land tenure systems on fence use and design. • Influence of values, traditions, and perceptions of wildlife on the adoption of conservation projects. • Social/cultural factors that contribute to wildlife conflict.	• Use surveys, public and private meetings with local stakeholders and community leaders to understand local concerns and collaborative opportunities.	• Incorporate local knowledge and perceptions and develop appropriate projects to balance conservation with local values and economies.
	Economic costs and incentives	• Social and economic incentives, risks, and rewards of adopting conservation fence systems. • Modes of collaboration and dissemination that promote conservation fence projects. • Value of socializing project costs (partnerships, cost-share, volunteer labor).	• Assess stakeholder perspectives on wildlife-fence interactions and conservation fence projects. • Evaluate efficacy of outreach and cost-share systems. • Assess cost-benefit of roadway fencing in terms of insurance savings.	• Increase adoption of fence alternatives to benefit wildlife and ecosystems.

combining field surveys with a synthesis of existing spatial data sets (Poor et al., 2014). An effort to map fence lines across southern Alberta with remote imagery was found to be 94% accurate, but the process was tedious and time consuming (Seward et al., 2012). In some landscapes, fence type and condition can be modeled based on land tenure records combined with ground-truthing (Poor et al., 2014). However, fence condition, permeability, and extent changes over time with maintenance and land use, so the shelf life of mapping data must be considered when weighing methods, effort, and accuracy. Any examination of fences across landscapes will greatly benefit from the development of more efficient methods and use of new technologies, such as drones or high resolution imagery (Table 2), to quantify and evaluate fence infrastructure at large scales for geospatial analysis.

Empirical studies of specific fence designs and their effects on wildlife are relatively sparse (Karhu and Anderson, 2006; Stull et al., 2011; Van Lanen et al., 2017; Burkholder et al., 2018; Jones et al., 2018). The basic specifications for wildlife-friendlier fence designs were conceived for adult ungulates in North America (Karsky, 1988) but do not account for the reduced abilities of juvenile, pregnant, stressed, or injured individuals, other species (e.g., large carnivores), or the effects of seasonal changes (e.g., snow, flooding) or topography (e.g., terrain, slope). Fence modifications to benefit multiple species must be tailored to the fence purpose, context, species present, and ecosystem (Paige, 2012, 2015). Practical testing of various types of fences, gates, wildlife crossings, funneling techniques, and other modifications intended for conservation objectives will provide insight into their efficacy and how wildlife respond. The use of non-invasive methods such as trail cameras can facilitate evaluation of various fence modifications and their efficacy in creating passage for wildlife (Table 2).

4.2. Biological and ecological effects of fences

Fence impacts on wildlife are usually observed at the individual or local group level, such as individual mortalities or barriers to herd movements. Some of these impacts may be dismissed as inconsequential, especially since rates (i.e., mortality) are usually unknown. These impacts are often dismissed because scientists, managers, and policymakers are most concerned with populations, meta–populations, and ecosystems for wildlife management and conservation. Unless cumulative effects of fences can be measured and understood, they are not addressed. Only a few studies have examined the influence of fences at large enough scales to generate meaningful knowledge at population levels. For example, both Rey et al. (2012), and Harrington and Conover (2006) measured mortality due to wire fences at landscape scales, finding dramatically higher annual mortality rates for juveniles versus adults. Fences are a major source of mortality for grouse species in Europe and North America and may be a factor driving population declines (Baines and Andrew, 2003; Wolfe et al., 2007; Stevens et al., 2013). In contrast, a survey of lions (*Panthera leo*) in 11 African countries showed populations were significantly closer to carrying capacities within fenced reserves than in unfenced regions (Packer et al., 2013).

However, these studies only scratch the surface. There are ample opportunities to examine fence influences on wildlife populations and ecosystems, including individual-level effects that may accumulate to influence population size, alter movements across landscapes, and affect vegetation communities or ecosystem processes such as nutrient flow. Many fence effects on individuals (e.g., injury, energy cost, or loss of fitness from navigating fences) are difficult to measure, which makes it difficult to determine if they scale up to influence population demographics. Research that examines cumulative effects of these impacts on populations across landscapes is sparse to nonexistent. Improved methods are needed to detect and quantify potential population consequences (Table 2).

Fences often induce a behavioral response in wildlife and we lack significant information on these responses—that is, how animals perceive, physically negotiate, and habituate to fences. A handful of studies have documented particular species' reaction to fences or fence modifications (e.g., Asian elephants (*Elephas maximus*, Chelliah et al., 2010), greater sage-grouse (Stevens et al., 2013), mule deer (*Odocoileus hemionus*) and white-tailed deer (*Odocoileus virginianus*, Burkholder et al., 2018), and pronghorn (Jones et al., 2018; Seidler et al., 2018)). However, the cumulative stress and behavioral outcomes from crossing multiple fences on a landscape is poorly understood. Most of our understanding of animal perception and interaction with fences is built on anecdote rather than empirical study. Advances in technology such as camera traps or fine temporal-scale GPS collars with accelerometers can be used to assess behavioral interactions of wildlife with fences (Table 2).

Fences for mitigation efforts may benefit some species at the expense of others or the larger ecosystem. For example, wildlife crossing structures and associated barrier fencing significantly reduces wildlife-vehicle collisions but animals must learn the location of crossing opportunities and that it is safe to use them (Huijser et al., 2016). It may also cause stress on animals as they learn to negotiate novel structures (Seidler et al., 2018). Investigating species' sensitivity to barriers and stress and whether such stress compromises fitness or has population-level effects will provide insight to improve conservation fence systems (Table 2).

Biodiversity and ecological processes (e.g., herbivory, seed dispersal, nutrient flow) can be affected by the shift, loss of, or increase of animal (both domestic and wildlife) movements that are shaped by fence infrastructures (Todd and Hoffman, 1999; Wu et al., 2009; Augustine et al., 2013). However, there is an immense lack of understanding relative to fence effects on community or ecological systems. Research can identify and target movement bottlenecks, barriers, and critical habitats at meaningful scales for functional and resilient ecosystems, which will inform biodiversity conservation. More studies using vegetation transects and soil assessments at and away from fences will provide information on the role fencing plays in shaping vegetation communities, moisture regimes, and nutrient cycling (Table 2).

4.3. Human dimensions of fence ecology

Often the easiest aspect of a conservation problem is the technical solution and the most difficult is the human factor. Conservation is a social issue, and empirical study of the social aspects of fence ecology can help improve outreach, innovation, adoption, and conservation. In any given cultural context, a better understanding of local norms, values, perceptions, and social influencers can provide insight into how best to implement conservation projects (Mulder and Coppolillo, 2005; St John et al., 2010).

Cultural, economic, and political factors influence the use of a particular fence system and the adoption of innovations for conservation. Land tenure systems, cultural traditions, experiences with wildlife conflict, and personal and community values regarding various species all feed into the acceptance of change for conservation. Cultural perceptions, values, and status of early adopters influence how conservation practices are understood and accepted (Mulder and Coppolillo, 2005). Conceptual application of social science research, such as diffusion of innovation theory, can provide a framework for examining the technical, cultural, and political characteristics that shape the adoption of conservation practices (Mascia and Mills, 2018).

Understanding the costs and benefits to stakeholders, individual or community autonomy and control, and the influence of peers and authority figures can provide insights into how fence innovations are perceived and adopted (St John et al., 2010; Knight et al., 2011). Socializing costs through partnerships and incentives can accelerate the acceptance of conservation projects in a community (Mascia and Mills, 2018). Some government agencies and conservation organizations offer incentives to cover the cost of fence materials or labor for conservation projects, yet there is rarely follow-up monitoring of such programs to determine if they achieve their objectives. Moreover, government incentive programs can at times work at cross-purposes. For example, a federal agricultural program in the United States heavily subsidizes pasture cross-fencing for livestock distribution, resulting in a proliferation of fencing in rangelands inconsistent with incentives from the same agency that promote conservation fence and habitat projects for wildlife (Toombs and Roberts, 2009; Knight et al., 2011). Ultimately, a deeper understanding of how to navigate the human dimensions of wildlife-fence issues is essential to implementing effective and successful conservation practices. Insights can be gained through stakeholder surveys and interviews that assess perspectives on wildlife-fence interactions and adoption of, or resistance to, conservation fence projects (Table 2).

5. Conclusions

Whether a fence is a tool or a problem for wildlife and ecosystem conservation is in the eye of the beholder. A landholder, producer, wildlife/habitat manager, or researcher will each have a different perspective on the utility and risk of fences for conservation. Fence ecology must be based on ecological concepts and science-driven results from empirical data. It must seek solutions to help balance the social needs for fencing with conserving wildlife and natural ecosystems. As a result, fence ecology can provide a clearer understanding of fence functions and impacts so that stakeholders can communicate effectively.

The impact of fences on wildlife and ecosystem processes is of global concern, but the study of fence influences on wildlife and ecological systems is in its infancy. Fences are largely taken for granted, which has led to their "invisibility" and lack of attention in conservation biology, leaving us with little empirical data regarding their effects on wildlife. Moreover, we have been left without a common understanding among stakeholders regarding the pros and cons of fencing. A more holistic understanding of fence ecology will open extensive opportunities to shape conservation at broad scales. Innovative research will provide better understanding of the cumulative and broad-scale influences of fences on populations and ecosystem processes, and help develop designs and mitigations that reduce fence impacts. Empirical study of fence ecology will advance conservation and management, with the ultimate goal of restoring functioning, intact, and resilient landscapes. We hope to inspire fellow scientists and conservationists around the world to "see" and study fences as a pervasive infrastructure that has profound influence on wildlife and ecosystems.

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Water quality and the grazing animal.

Hubbard RK[1], Newton GL, Hill GM.

Abstract

Grazing animals and pasture production can affect water quality both positively and negatively. Good management practices for forage production protect the soil surface from erosion compared with conventionally produced crops. Grazing animals and pasture production can negatively affect water quality through erosion and sediment transport into surface waters, through nutrients from urine and feces dropped by the animals and fertility practices associated with production of high-quality pasture, and through pathogens from the wastes. Erosion and sediment transport is primarily associated with high-density stocking and/or poor forage stands. The two nutrients of primary concern relating to animal production are N and P. Nitrogen is of concern because high concentrations in drinking water in the NO(3) form cause methemoglobinemia (blue baby disease), whereas other forms of N (primarily nitrite, NO(2)) are considered to be potentially carcinogenic. Phosphorus in the PO(4) form is of concern because it causes eutrophication of surface water bodies. The effect of grazing animals on soil and water quality must be evaluated at both the field and watershed scales. Such evaluation must account for both direct input of animal wastes from the grazing animal and also applications of inorganic fertilizers to produce quality pastures. Watershed-scale studies have primarily used the approach of nutrient loadings per land area and nutrient removals as livestock harvests. A number of studies have measured nutrient loads in surface runoff from grazed land and compared loads with other land uses, including row crop agriculture and forestry. Concentrations in discharge have been regressed against standard grazing animal units per land area. Watersheds with concentrated livestock populations have been shown to discharge as much as 5 to 10 times more nutrients than watersheds in cropland or forestry. The other major water quality concern with grazing animals is pathogens, which may move from the wastes into surface water bodies or ground water. Major surface water quality problems associated with pathogens have been associated with grazing animals, particularly when they are not fenced out from streams and farm ponds. This paper presents an overview of water quality issues relating to grazing animals.

Water Quality Conditions Associated with Cattle Grazing and Recreation on National Forest Lands

Leslie M. Roche[1]*, Lea Kromschroeder[1], Edward R. Atwill[2], Randy A. Dahlgren[3], Kenneth W. Tate[1]

1 Department of Plant Sciences, University of California, Davis, California, United States of America, **2** School of Veterinary Medicine, University of California University of California, Davis, California, United States of America, **3** Department of Land, Air, and Water Resources, University of California, Davis, California, United States of America

Abstract

There is substantial concern that microbial and nutrient pollution by cattle on public lands degrades water quality, threatening human and ecological health. Given the importance of clean water on multiple-use landscapes, additional research is required to document and examine potential water quality issues across common resource use activities. During the 2011 grazing-recreation season, we conducted a cross sectional survey of water quality conditions associated with cattle grazing and/or recreation on 12 public lands grazing allotments in California. Our specific study objectives were to 1) quantify fecal indicator bacteria (FIB; fecal coliform and *E. coli*), total nitrogen, nitrate, ammonium, total phosphorus, and soluble-reactive phosphorus concentrations in surface waters; 2) compare results to a) water quality regulatory benchmarks, b) recommended maximum nutrient concentrations, and c) estimates of nutrient background concentrations; and 3) examine relationships between water quality, environmental conditions, cattle grazing, and recreation. Nutrient concentrations observed throughout the grazing-recreation season were at least one order of magnitude below levels of ecological concern, and were similar to U.S. Environmental Protection Agency (USEPA) estimates for background water quality conditions in the region. The relative percentage of FIB regulatory benchmark exceedances widely varied under individual regional and national water quality standards. Relative to USEPA's national *E. coli* FIB benchmarks–the most contemporary and relevant standards for this study–over 90% of the 743 samples collected were below recommended criteria values. FIB concentrations were significantly greater when stream flow was low or stagnant, water was turbid, and when cattle were actively observed at sampling. Recreation sites had the lowest mean FIB, total nitrogen, and soluble-reactive phosphorus concentrations, and there were no significant differences in FIB and nutrient concentrations between key grazing areas and non-concentrated use areas. Our results suggest cattle grazing, recreation, and provisioning of clean water can be compatible goals across these national forest lands.

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* E-mail: lmroche@ucdavis.edu

Introduction

Livestock grazing allotments on public lands managed by the United States Forest Service (USFS) provide critical forage supporting ranching enterprises and local economies [1–3]. Surface waters on public lands are used for human recreation and consumption, and serve as critical aquatic habitat. Concerns have been raised that microbial and nutrient pollution by livestock grazing on public lands degrades water quality, threatening human and ecological health [4–7]. Some of the contaminants of concern include fecal indicator bacteria (FIB), fecal coliform (FC) and *Escherichia coli* (*E. coli*), as well as nitrogen (N) and phosphorus (P). FIB are regulated in an attempt to safeguard public health from waterborne pathogens such as *Cryptosporidium parvum* and *E. coli* O157:H7 and human enteroviruses including adenoviruses and coliphages [8]. Concerns about elevated N and P concentrations in surface water stem from the potential for eutrophication of aquatic systems [9].

The USFS must balance the many resource use activities occurring on national forests (e.g., livestock grazing, recreation). National forests in the western United States support 1.8 million livestock annually, provisioning 6.1 million animal unit months (AUM) of forage supply allocated through 5,220 grazing permits held by private ranching enterprises [10]. In California (USFS Region 5), 500 active grazing allotments annually supply 408,000 AUM of forage to support 97,000 livestock across 3.2 million ha on 17 national forests. With an annual recreating population of over 26 million [11], California's national forests are at the crossroad of a growing debate about the compatibility of livestock grazing with other activities (e.g., recreation) dependent upon clean, safe water.

There is a paucity of original research on water quality conditions on public grazing lands, and the conclusions of these reports are often inconsistent. For example, in California's Sierra Nevada, Derlet and Carlson [6] found surface water samples collected below horse and cattle grazing areas on USFS-administered lands were more likely to have detectable *E. coli* than non-grazed sites in national parks. Derlet *et al.* [12] reported algal coverage, algal-*E. coli* associations, and detection of waterborne *E. coli* to be greatest at sites below cattle grazing and lowest below sites experiencing little to no human or cattle activity, with human recreation sites being intermediate. Also in the central

Sierra Nevada, Myers and Whited [13] found FIB increased in surface waters below key grazing areas on USFS allotments following the arrival of cattle. However, Roche *et al.* [14] found no evidence of degradation of Yosemite toad breeding pool water quality in key grazing areas on three allotments in the Sierra National Forest of central California. Examining land-use and water quality associations in watersheds throughout the Cosumnes River Basin, Ahearn *et al.* [15] also reported water quality conditions in upper forested watersheds, which include USFS grazing allotments, to be well below levels of ecological concern.

The purpose of this study was to quantify microbial pollutant and nutrient concentrations during the summer cattle grazing and recreation season on 12 representative allotments across 5 national forests in northern California. Specific objectives were to 1) quantify FC, *E. coli*, total nitrogen, nitrate, ammonium, total phosphorus, and soluble-reactive phosphate concentrations in surface waters; 2) compare these results to a) water quality regulatory benchmarks, b) maximum nutrient concentrations recommended to avoid eutrophication, and c) estimates of nutrient background concentrations for this region; and 3) examine relationships between water quality, environmental conditions, and cattle grazing and recreation (i.e., resource uses).

Methods

Ethics Statement

Permission for site access was granted by the US Forest Service, and no permits were required.

Study Area

This cross sectional, longitudinal water quality survey was completed across 12 grazing allotments on USFS-managed public

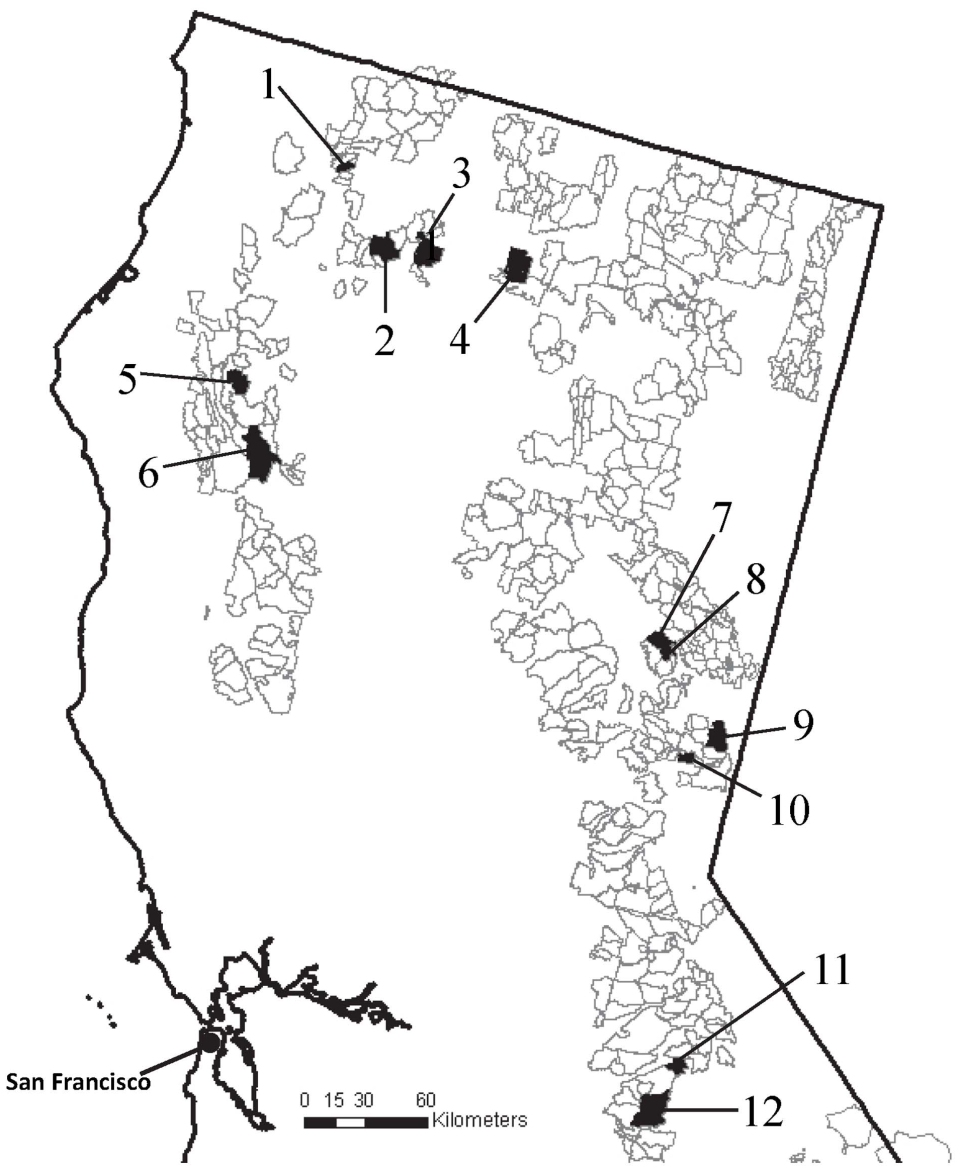

Figure 1. The 12 U.S. Forest Service grazing allotments (shaded polygons) in northern California enrolled in this cross-sectional longitudinal study of stream water quality between June and November 2011. Unshaded polygons are other U.S. Forest Service grazing allotments in the study area.
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Table 1. Concentrations of total nitrogen (TN), nitrate (NO_3-N), ammonium (NH_4-N), total phosphorus (TP), and phosphate (PO_4-P) for 743 stream water samples collected across 155 sample sites on 12 U.S. Forest Service grazing allotments in northern California.

Nutrient	Mean[a] ($\mu g\ L^{-1}$)	Median ($\mu g\ L^{-1}$)	Maximum ($\mu g\ L^{-1}$)	Below Detection[b] (%)	Eutrophication[c] ($\mu g\ L^{-1}$)	Background[d] ($\mu g\ L^{-1}$)
TN	58±2.7	33	675	5	–	60–530
NO_3-N	19±0.9	5	221	51	300	5–40
NH_4-N	11±0.4	5	146	61	–	–
TP	21±2.8	9	1321	32	100	9–32
PO_4-P	7±0.3	5	83	40	50	–

Published estimates of concentrations of general concern for eutrophication of stream water, and estimates of background concentrations for the study area are provided for context.

[a]The '±' indicates 1 standard error of the mean.

[b]Percentage of samples below minimum analytical detection limit. Limits were 10 $\mu g\ L^{-1}$ for nitrogen and 5 $\mu g\ L^{-1}$ for phosphorous. Observations below detection limit were set to one half detection limit (5 $\mu g\ L^{-1}$ for nitrogen and 2.5 $\mu g\ L^{-1}$ for phosphorus) for calculation of mean and median concentrations.

[c]Concentrations if exceeded indicate potential for eutrophication of streams [38–42].

[d]Estimated range of background concentrations for the three U.S. Environmental Protection Agency Level III sub-ecoregions (5, 9, 78) included in the study [43].

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lands in northern California, USA (Fig. 1). Allotments were selected to represent the diversity of climate, soil, vegetation, water quality regulatory agencies, and resource use activities found across this landscape. The study area ranged from 41°40′ to 37°55′ N latitude and 123°30′ to 120°10′ W longitude, and included national forests in the Klamath, Coast, Cascade, and Sierra Nevada Mountain Ranges. Allotments were located on the Klamath (Allotments 1, 2), Shasta-Trinity (Allotments 3–6), Plumas (Allotments 7, 8), Tahoe (Allotments 9, 10), and Stanislaus (Allotments 11, 12) National Forests (Fig. 1). The study area totaled approximately1,300 km^2 and elevation ranged from 207 to 3,016 m (Table S1). The prevailing climate is Mediterranean with cool, wet winters and warm, dry summers. The majority of precipitation falls as snow between December and April, with snow melt generally occurring between May and June. Soils in Allotments 1–2, 5–7, and 11 are dominated by Inceptisols; Allotments 3, 10, and 12 are dominated by Alfisols; Allotment 8 and 9 are dominated by Mollisols; and Allotment 4 is dominated by Andisols [16] (Table S1).

All allotments were located in mountainous watersheds with canopy cover of mesic and xeric forests ranging from 9 to 89 and 2 to 93% cover, respectively [17]. Cooler mesic conifer forests were dominated by white fir (*Abies concolor*), red fir (*Abies magnifica*), and Douglas fir (*Pseudotsuga menziesii*). The relatively drier xeric conifer forests were dominated by ponderosa pine (*Pinus ponderosa*) and Jeffrey pine (*Pinus jeffreyi*). Montane hardwood and shrub cover ranged from 0 to 20%, and grass and forb cover from 1 to 9%. Wet meadows and other riparian plant communities covered 1 to 5% of allotment areas, and were the primary forage source for cattle grazing in these allotments.

Grazing Management

Cattle grazing management strategies on the study allotments reflect those widely found on western public grazing lands, such as those reviewed in Delcurto et al. [18] and George et al. [19]. Study allotments were grazed with commercial beef cow-calf pairs during the June to November grazing-growing season, following allotment-specific management plans designed to achieve annual herbaceous forage use standards (Table S1). Herbaceous use standards are set as an annual management target to protect ecological condition and function of meadow and riparian sites [20], and vary by national forest, allotment, and meadow ecological conditions [21–27].

Cattle stocking densities ranged from 1 animal unit (~450 kg cow with or without calf) per 18 ha to 1 animal unit per 447 ha (Table S1). Timing of grazing (turn on and turn off dates for cattle), duration of grazing season, and number of cattle are permitted by the USFS on an allotment-specific basis. Animal unit month (AUM) is the mass of forage required to sustain a single animal unit for a 30-day period, and is the standard metric of grazing pressure on USFS allotments.

Foraging, and thus spatial distribution of cattle feces and urine, is non-uniform across these allotments. Areas receiving relatively concentrated use by cattle are referred to as key grazing areas. Key grazing areas are often relatively small, stream-associated meadows and riparian areas that are preferentially grazed by cattle due to high forage quantity and quality and drinking water availability. For the most part, allotments are not cross-fenced to create pastures, which would improve grazing distribution. Where cross-fences exist, resulting pasture sizes are large (>2000 ha) with few pastures per allotment (<3).

Sample Site Selection

Key grazing areas and concentrated recreation areas within 200 m of streams in each allotment were identified and enrolled in the study in collaboration with local USFS managers and forest stakeholders. Water sample collection sites were established in streams immediately above, beside, and/or below sites with each activity to characterize water quality associated with these activities. Recreational activities included developed and undeveloped campgrounds, swimming-bathing areas, and trailheads used by hikers and recreational horse riders (i.e., pack stock). Key grazing areas were meadows and riparian areas that cattle were known to graze and occupy frequently and/or for extended periods throughout the grazing season. Additional sites were established at perennial flow tributary confluences with no concentrated use activities, enabling us to objectively include comparison sites across allotments with no concentrated grazing and/or recreation. While cattle use was concentrated primarily in key grazing areas, cattle grazing could occur throughout each allotment; therefore, it was not possible to determine water quality conditions in the complete absence of cattle.

A total of 155 stream water sample collection sites were identified and sampled monthly throughout the 2011 summer grazing-recreation period. Sample collection sites per allotment ranged from 7 to 18, depending upon the number of key grazing

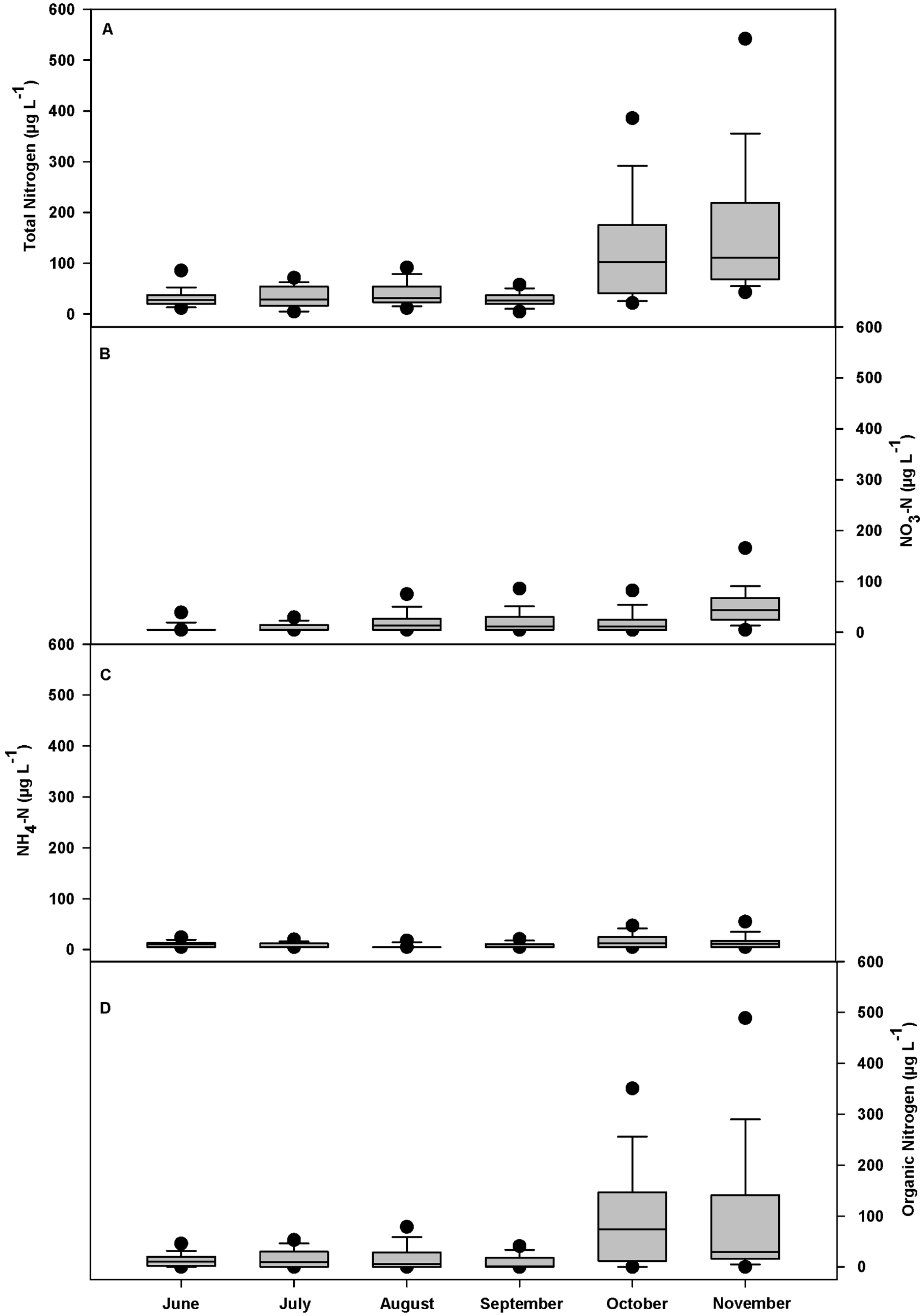

Figure 2. Overall monthly nitrogen concentrations for 743 stream water samples collected from 155 sample sites across 12 U.S. Forest Service grazing allotments in northern California enrolled in this cross-sectional longitudinal study between June and November 2011. (A) Total nitrogen, (B) nitrate (NO_3-N), and (C) ammonium (NH_4-N) were measured directly. (D) Organic nitrogen represents the difference between total nitrogen and NO_3-N plus NH_4-N. Bottom and top of shaded box are the 25^{th} and 75^{th} percentile of data, horizontal line within shaded box is median value, ends of vertical lines are 10^{th} and 90^{th} percentiles of data, and black dots are 5^{th} and 95^{th} percentiles of data. June $n = 135$; July $n = 150$; August $n = 178$; September $n = 120$; October $n = 127$; November $n = 33$.
doi:10.1371/journal.pone.0068127.g002

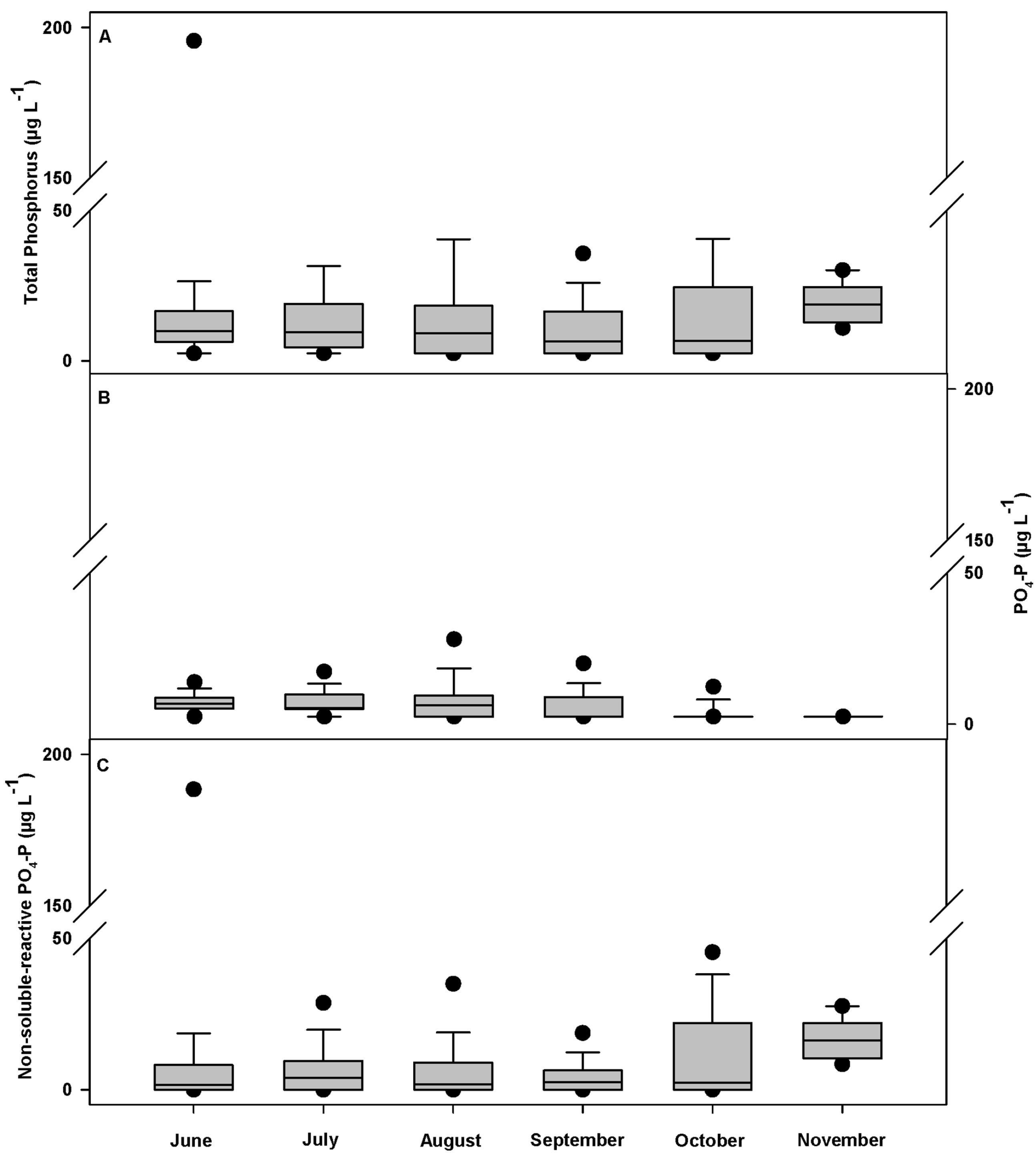

Figure 3. Overall monthly phosphorus concentrations for 743 stream water samples collected from 155 sample sites across 12 U.S. Forest Service grazing allotments in California enrolled in this cross-sectional longitudinal study between June and November 2011. (A) Total phosphorus (B) and soluble-reactive phosphorus (PO_4-P) were measured directly. (C) Non-soluble-reactive phosphorus represents the difference between total phosphorus (measured on unfiltered sample and treated with digesting agent) and soluble-reactive phosphorus. Bottom and top of shaded box are the 25th and 75th percentile of data, horizontal line within shaded box is median value, ends of vertical lines are 10th and 90th percentiles of data, and black dots are 5th and 95th percentiles of data. June $n = 135$; July $n = 150$; August $n = 178$; September $n = 120$; October $n = 127$; November $n = 33$.
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and recreation areas identified, and number of tributary confluences (Table S1). Sixty-three percent of sample sites were associated with key grazing areas, 17% were associated with recreation activities, and 20% were tributary confluences with no concentrated use activities.

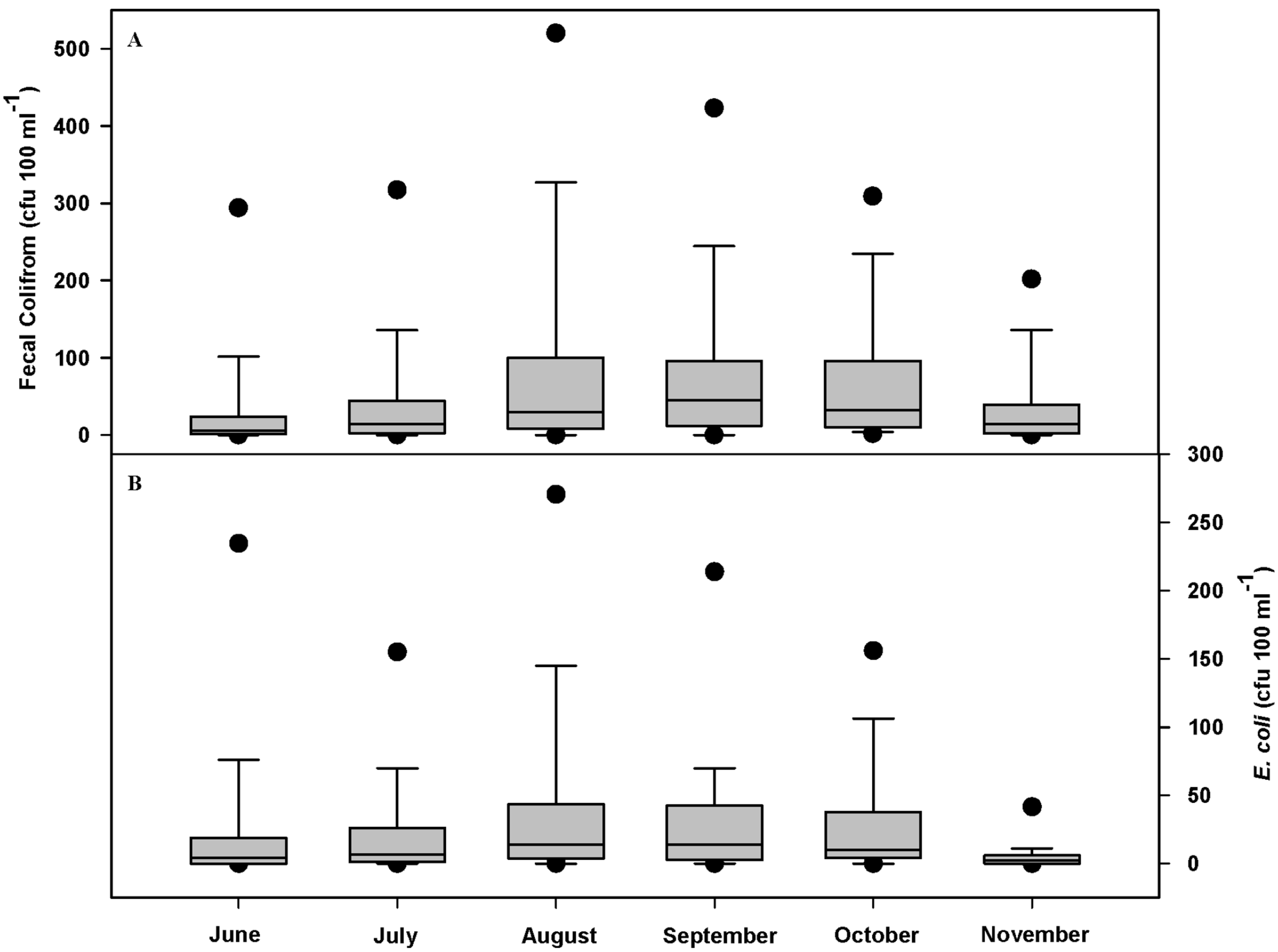

Figure 4. Overall monthly (A) fecal coliform and (B) *E. coli* concentrations for 743 stream water samples collected from 155 sample sites across 12 U.S. Forest Service grazing allotments in northern California enrolled in this cross-sectional longitudinal study between June and November 2011. Bottom and top of shaded box are the 25th and 75th percentile of data, horizontal line within shaded box is median value, ends of vertical lines are 10th and 90th percentiles of data, and black dots are 5th and 95th percentiles of data. June $n = 135$; July $n = 150$; August $n = 178$; September $n = 120$; October $n = 127$; November $n = 33$.
doi:10.1371/journal.pone.0068127.g004

Sample Collection and Analysis

In 2011, a total of 743 water samples were collected and analyzed during the June 1 through November 9 study period, which captured the period of overlapping cattle grazing and recreation activities across these allotments. On each allotment, sampling occurred monthly throughout the grazing-recreation season. All sites in an allotment were sampled on the same day. Total sample numbers per allotment ranged from 40 to 88 (Table S1).

At the time of sample collection, environmental conditions and/or resource use activities that may have affected water quality were recorded. Specifically, the following conditions were noted (yes/no): 1) stagnant-low stream flow (<2 liters per second); 2) turbid stream water; 3) recreation (i.e., swimming-bathing, camping, hiking, fishing, horse riding); 4) cattle; and 5) any activities (i.e., low stream flow, turbid water, precipitation, cattle, recreation users) observed that may affect water quality. If algae, periphyton, or other aquatic autotrophic organisms were present at high to moderate levels (>20% of substrate cover) at time of sampling, then these conditions were recorded.

A vertical, depth-integrated stream water collection was made at the stream channel thalweg [28]. Water was collected in sterilized, acid-washed one liter sample containers, which were immediately stored on ice. All samples were analyzed for FC and *E. coli* within 8 hours of field collection. A 250 ml subsample was taken from each sample, frozen within 24 hours of collection, and processed for nutrient concentrations within 28 days of field collection. FC and *E. coli* concentrations as colony forming units (cfu) per 100 ml of water sample were determined by direct one step membrane filtration (0.45 μm nominal porosity filter) and incubation (44.5°C, 22–24 hours) on selective agar following standard method SM9222D [29]. Difco mFC Agar (Becton, Dickinson and Company, Spars, MD, USA) and CHROMagar *E. coli* (ChromAgar, Paris, France) were used for FC and *E. coli*, respectively. Total N (TN) and total phosphorus (TP) were measured after persulfate digestion of non-filtered subsamples following Yu *et al.* [*30*] and standard method SM4500-P.D [29], respectively. Concentrations of nitrate (NO_3-N), ammonium (NH_4-N), and soluble-reactive phosphorus (PO_4-P) were determined from filtered (0.45 μm nominal porosity filter) subsamples following Doane and Horwath [31], Verdouw *et al.* [32], and Eaton *et al.* [29],

Table 2. Percentage of 743 stream water samples collected across 155 sample sites on 12 U.S. Forest Service grazing allotments in northern California which exceeded water quality benchmarks relevant to the study area, specifically, and the nation, broadly.

Benchmark	Overall (% of 743)	Key Grazing Area (% of 462)	Recreation Area (% of 125)	No Concentrated Use Activities (% of 156)
FC >20 cfu 100 ml^{-1} [a]	50	48	46	58
FC >50 cfu 100 ml^{-1} [b]	31	28	27	42
FC >200 cfu 100 ml^{-1} [c]	10	10	6	13
FC >400 cfu 100 ml^{-1} [d]	4	5	2	4
E. coli >100 cfu 100 ml^{-1} [e]	9	8	7	11
E. coli >126 cfu 100 ml^{-1} [f]	7	7	6	8
**E. coli* >190 cfu 100 ml^{-1} [g]	5	4	4	6
**E. coli* >235 cfu 100 ml^{-1} [h]	3	3	3	4
E. coli >320 cfu 100 ml^{-1} [i]	2	2	2	2
E. coli >410 cfu 100 ml^{-1} [j]	1	2	2	1
NO_3-N >300 μg L^{-1} [k]	0	0	0	0
TP>100 μg L^{-1} [l]	2	2	2	<1
PO_4-P>50 μg L^{-1} [m]	<1	1	0	0

Results are reported for samples collected across all sample sites (overall) as well as for samples collected at sample sites monitored to characterize specific resource use activities across the allotments.

*Indicates the most relevant and contemporary standards for this study.

[a]Fecal coliform (FC) benchmark designated by Lahontan Regional Water Quality Control Board (LRWQCB) (based on geometric mean (GM) of samples collected over a 30-day interval) [36].

[b]FC benchmark designated by North Coast Regional Water Quality Control Board (NCRWQCB) (based on a median of samples collected over a 30-day interval) [37].

[c]FC benchmark designated by Central Valley Regional Water Quality Control Board (CVRWQCB) (based on GM of samples collected over a 30-day interval) [35].

[d]FC benchmark designated by CVRWQCB and NCRWQCB (maximum threshold value not to be exceeded by more than 10% of samples over a 30-day interval) [35].

[e]*E. coli* benchmark designated by U.S. Environmental Protection Agency (USEPA) [34] for an estimated illness rate of 32 per 1,000 primary contact recreators (based on GM of samples collected over a 30-day interval).

[f]*E. coli* benchmark designated by USEPA [34] for an estimated illness rate of 36 per 1,000 primary contact recreators (based on GM of samples collected over a 30-day interval).

[g]*E. coli* benchmark designated by USEPA [34] for an estimated illness rate of 32 per 1,000 primary contact recreators (for a single grab sample, approximates the 75th percentile of a water quality distribution based on desired GM).

[h]*E. coli* benchmark designated by USEPA [34] for an estimated illness rate of 36 per 1,000 primary contact recreators (for a single grab sample, approximates the 75th percentile of a water quality distribution based on desired GM).[i] *E. coli* benchmark designated by USEPA [34] for an estimated illness rate of 32 per 1,000 primary contact recreators (approximates the 90th percentile of a water quality distribution based on desired GM).

[j]*E. coli* benchmark designated by USEPA [34] for an estimated illness rate of 36 per 1,000 primary contact recreators (approximates the 90th percentile of a water quality distribution based on desired GM).[k] Maximum concentrations of nitrate as nitrogen (NO_3-N) recommended by USEPA [38,39].

[l]Maximum concentrations of total phosphorus (TP) recommended by USEPA [39,40].

[m]Maximum concentrations of phosphate as phosphorus (PO_4-P) recommended by USEPA [39,41].

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respectively. Minimum detection limits were ~10 μg L^{-1} for TN, NH_4-N, and NO_3-N and ~5 μg L^{-1} for TP and PO_4-P. Organic nitrogen (ON) was calculated as *TN* – [*NO_3-N*+*NH_4-N*], and non-soluble-reactive PO_4-P was calculated as *TP* – *PO_4-P*. Laboratory quality control included replicates, spikes, reference materials, control limits, criteria for rejection, and data validation methods [33].

Data Analysis and Interpretation

Descriptive statistics were calculated for the overall dataset as well as by 1) key grazing areas, recreation areas, and sample sites with no concentrated resource use; 2) activity observed at time of sample collection; 3) and month. Results were compared to numerous FIB benchmark concentrations used in the formulation of contemporary microbial water quality standards, maximum nutrient concentrations recommended to avoid eutrophication, and background nutrient concentration estimates for surface waters across the study area. The United States Environmental Protection Agency (USEPA) nationally recommends and has provided guidance on *E. coli* FIB-based standards ranging from 100 to 410 cfu 100 ml^{-1}, dependent upon selected illness rate benchmarks and frequency of sample collection over a 30 day period [34]. The study area falls within the jurisdiction of three semi-autonomous California Regional Water Quality Control Boards (RWQCBs), each of which has established enforceable standards based on FC benchmarks [35–37] ranging from 20 to 400 cfu 100 ml^{-1}. We report study results relative to each of these benchmarks to allow for comparisons to the various national and regional policies. For our study, which is based on monthly monitoring of multiple land-use activity types and environmental conditions across a broad regional scale (spanning approximately1,300 km^2), the most relevant and contemporary comparisons are the national U.S. Environmental Protection Agency (USEPA) *E. coli* single sample-based [8,34] standards of 190 cfu 100 ml^{-1} (estimated illness rate of 32 per 1,000 primary contact recreators) and 235 cfu 100 ml^{-1} (estimated illness rate of 36 per 1,000 primary contact recreators).

General recommendations for maximum concentrations to prevent eutrophication of streams and rivers are 300, 100, and 50 μg L^{-1} for NO_3-N, TP, and PO_4-P, respectively [38–42]. The study area is within three USEPA Level III Sub-Ecoregions (5, 9, and 78), and estimated background concentrations for TN, NO_3-N, and TP in these sub-regions range from 60 to 530, 5 to 40, and 9 to 32 μg L^{-1}, respectively [43].

Table 3. Percentage of 155 stream water sample sites on 12 U.S. Forest Service grazing allotments in northern California which had at least one exceedance of water quality benchmarks relevant to the study area, specifically, and the nation, broadly.

Benchmark	Overall (% of 155)	Key Grazing Area (% of 97)	Recreation Area (% of 27)	No Concentrated Use Activities (% of 31)
FC >20 cfu 100 ml^{-1a}	83	82	81	87
FC >50 cfu 100 ml^{-1b}	65	61	63	81
FC >200 cfu 100 ml^{-1c}	34	36	22	39
FC >400 cfu 100 ml^{-1d}	18	20	11	19
E. coli >100 cfu 100 ml^{-1e}	29	31	22	29
E. coli >126 cfu 100 ml^{-1f}	25	28	19	23
**E. coli* >190 cfu 100 ml^{-1g}	17	16	15	19
**E. coli* >235 cfu 100 ml^{-1h}	14	13	11	16
E. coli >320 cfu 100 ml^{-1i}	8	6	11	10
E. coli >410 cfu 100 ml^{-1j}	6	6	7	3
NO_3-N >300 μg L^{-1k}	0	0	0	0
TP>100 μg L^{-1l}	8	10	7	3
PO_4-P>50 μg L^{-1m}	2	3	0	0

Results are reported for all sample sites (overall) as well as for sample sites monitored to characterize specific resource use activities across the allotments. *Indicates the most relevant and contemporary standards for this study.
[a]Fecal coliform (FC) benchmark designated by Lahontan Regional Water Quality Control Board (LRWQCB) (based on geometric mean (GM) of samples collected over a 30-day interval) [36].
[b]FC benchmark designated by North Coast Regional Water Quality Control Board (NCRWQCB) (based on a median of samples collected over a 30-day interval) [37].
[c]FC benchmark designated by Central Valley Regional Water Quality Control Board (CVRWQCB) (based on GM of samples collected over a 30-day interval) [35].
[d]FC benchmark designated by CVRWQCB and NCRWQCB (maximum threshold value not to be exceeded by more than 10% of samples over a 30-day interval) [35].
[e]*E. coli* benchmark designated by U.S. Environmental Protection Agency (USEPA) [34] for an estimated illness rate of 32 per 1,000 primary contact recreators (based on GM of samples collected over a 30-day interval).
[f]*E. coli* benchmark designated by USEPA [34] for an estimated illness rate of 36 per 1,000 primary contact recreators (based on GM of samples collected over a 30-day interval).
[g]*E. coli* benchmark designated by USEPA [34] for an estimated illness rate of 32 per 1,000 primary contact recreators (for a single grab sample, approximates the 75th percentile of a water quality distribution based on desired GM).
[h]*E. coli* benchmark designated by USEPA [34] for an estimated illness rate of 36 per 1,000 primary contact recreators (for a single grab sample, approximates the 75th percentile of a water quality distribution based on desired GM).[i] *E. coli* benchmark designated by USEPA [34] for an estimated illness rate of 32 per 1,000 primary contact recreators (approximates the 90th percentile of a water quality distribution based on desired GM).
[j]*E. coli* benchmark designated by USEPA [34] for an estimated illness rate of 36 per 1,000 primary contact recreators (approximates the 90th percentile of a water quality distribution based on desired GM).[k] Maximum concentrations of nitrate as nitrogen (NO_3-N) recommended by USEPA [38,39].
[l]Maximum concentrations of total phosphorus (TP) recommended by USEPA [39,40].
[m]Maximum concentrations of phosphate as phosphorus (PO_4-P) recommended by USEPA [39,41].
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At the sample site-scale, we used bivariate generalized linear mixed effects models (GLMMs) and zero-inflated count models to test for mean FIB and nutrient concentration (dependent variables were fecal coliform, *E. coli*, TN, NO_3-N, NH_4-N, TP, and PO_4-P)

Table 4. Mean concentrations for fecal coliform (FC) and *E. coli*, total nitrogen (TN), nitrate as nitrogen (NO_3-N), ammonium as nitrogen (NH_4-N), total phosphorus (TP), and phosphate as phosphorus (PO_4-P) for 743 total stream water samples collected across 155 sample locations on 12 U.S. Forest Service grazing allotments in northern California.

	Key Grazing Area	Recreation Area	No Concentrated Use Activities
	(462 samples)	(125 samples)	(156 samples)
FC (cfu 100 ml^{-1})	87±12 a	55±9 b	90±12 a
E. coli (cfu 100 ml^{-1})	42±6 a	29±7 b	43±8 a
Total N (μg L^{-1})	61±4 a	38±3 b	64±6 a
NO3-N (μg L^{-1})	17±1 ab	16±1 a	25±2 b
NH4-N (μg L^{-1})	11±0.6 a	10±1 a	10±0.7 a
Total P (μg L^{-1})	24±4 a	14±4 a	17±2 a
PO4-P (μg L^{-1})	7±0.3 a	5±0.2 b	8±0.6 a

Results reported are mean concentration for each resource use activity category. The '±' indicates 1 standard error of the mean. Different lower case letters indicate significant ($P<0.05$ with Bonferroni-correction for multiple comparisons) differences between resource use activity categories.
doi:10.1371/journal.pone.0068127.t004

Table 5. Mean concentrations for fecal coliform (FC) and *E. coli*, total nitrogen (TN), nitrate as nitrogen (NO_3-N), ammonium as nitrogen (NH_4-N), total phosphorus (TP), and phosphate as phosphorus (PO_4-P) for 743 total stream water samples collected across 155 sample locations on 12 U.S. Forest Service grazing allotments in northern California.

	Low Stream Flow[a]		Turbid Water[b]		Cattle Present[c]		Recreation[d]		Activities Observed[e]	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
No. Occurrences	51	692	37	706	130	613	28	715	341	402
FC (cfu 100 ml^{-1})	216±67**	72±7	212±64**	76±8	205±39**	56±5	36±13	84±8	115±16**	54±6
E. coli (cfu 100 ml^{-1})	114±45*	35±3	142±56**	35±3	115±21**	24±3	14±5*	41±4	61±9*	23±3
Total N (μg L^{-1})	87±16	55±3	95±12	56±3	44±4	60±3	27±3**	59±3	48±3	65±4
NO_3-N (μg L^{-1})	17±3	19±1	19±1	16±3	19±2	18±1	16±3	19±1	17±1	20±1
NH_4-N (μg L^{-1})	15±3	10±0.4	10±0.4	13±2	9±1	11±0.5	7±0.7**	11±0.4	10±0.6	11±0.5
Total P (μg L^{-1})	30±5	20±3	107±37**	16±2	20±3	21±3	10±2	21±3	27±6*	15±1
PO_4-P (μg L^{-1})	13±2**	7±0.2	11±2**	7±0.2	10±1*	6±0.2	6±0.5**	7±0.3	7±0.5	5±0.3

Results are reported by category of field observation of resource use activities and environmental conditions observed at the time of sample collection. The '±' indicates 1 standard error of the mean, * indicates different at $P<0.05$ (Bonferroni-adjusted), and ** indicates different at $P<0.01$ (Bonferroni-adjusted).
[a]Stagnant or low stream flow (<2 liters per second).
[b]Stream water turbid.
[c]Cattle observed.
[d]Recreational activities only (i.e., no cattle present) observed.
[e]Any activities (low stream flow, turbid water, precipitation, cattle, or recreation) observed that potentially impact water quality.
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differences between 1) key grazing areas, recreation areas, and sample sites with no concentrated resource use; and 2) occurrence of stagnant-low stream flow, turbid stream water, cattle, and recreation at the time of sample collection. We used GLMMs to analyze dependent variables with overdisperison (i.e., greater variance than expected) (fecal coliform, *E. coli*, TN) using the Poisson probability distribution function with robust standard errors [44]. For the GLMMs, we specified allotment identity and sample site identity as sequential random effects to account for hierarchical nesting and repeated measures [44,45]. Data with evidence of both overdispersion and zero-inflation can be produced by either unobserved heterogeneity or by processes that involve different mechanisms generating zero and nonzero counts [46–48]. For dependent variables with apparent overdispersion and zero-inflation (>25% zeros; NO_3-N, NH_4-N, TP, and PO_4-P), we used likelihood ratio tests to evaluate relative fits of zero-inflated negative binomial versus zero-inflated Poisson models [46–48]; we used simple Vuong tests [49] to evaluate relative fits of zero-inflated versus standard count models; and we used either likelihood ratio tests or Akaike Information Criterion (AIC), as appropriate, to compare relative fits between negative binomial and Poisson models. To account for the within-cluster correlation due to repeated measures, we specified sample site identity as a clustering variable in the final models to obtain robust variance estimates [50].

We also examined allotment-scale relationships of FIB and nutrient concentrations with environmental conditions and grazing management. We used bivariate zero-truncated count models to test associations between mean allotment values of response variables (fecal coliform, *E. coli*, TN, NO_3-N, NH_4-N, TP, and PO_4-P; mean of all samples collected for each allotment) and cattle grazing duration, animal unit months (AUM) of grazing, cattle density as cow-calf pairs 100 ha^{-1}, mean allotment elevation, and 2011–2012 water year precipitation [42] (independent variables). We used likelihood ratio tests to compare Poisson and negative binomial models [48]. For all analyses, when multiple response variables were predicted with the same independent variables, we interpreted significance levels using Bonferroni corrections to safeguard against Type I errors. Bonferroni adjusted p-values were considered significant at 0.0071 (dividing $P = 0.05$ by the 7 water quality indicators tested) and 0.0014 (dividing $P = 0.01$ by the 7 water quality indicators tested). All statistical analyses were conducted in Stata/SE 11.1 [48].

Results

Surface Water Quality and Weather Conditions Observed during Study

Precipitation during the 2010–11 water year ranged from 88 to 173% of the 30-year mean annual precipitation for each allotment, with 11 of 12 allotments receiving over 100% of mean annual precipitation (Table S1). Overall, nutrient concentrations were low across the study area (Table 1). With the exception of TN, over 32% of samples were below minimum detection limits for all nutrients (<10 μg N L^{-1} and <5 μg P L^{-1}). Nitrogen concentrations increased in October and November with the onset of fall rains (Fig. 2), and phosphorus concentrations showed no seasonal patterns (data not shown). The sum of NO_3-N and NH_4-N concentrations was lower than organic N ($TN - [NO_3\text{-}N + NH_4\text{-}N]$) concentrations throughout the sampling season (Fig. 2), suggesting that the majority of nitrogen was in organic forms. Additionally, PO_4-P concentrations were much lower than TP (Table 1; Fig. 3), suggesting that the majority of phosphorus was either organic or inorganic P adsorbed to suspended sediments. Mean and maximum FC and *E. coli* concentrations per allotment ranged from 30 to 255 and 17 to 151 CFU 100 ml^{-1}, and from 248 to 3,460 and 74 to 1,920, respectively (Table S2). FIB concentrations were highest from August through October (Fig. 4).

Nutrient and FIB Concentrations Relative to Water Quality Benchmarks

Mean and median NO_3-N, TP, and PO_4-P concentrations were at least one order of magnitude below nutrient concentrations recommended to avoid eutrophication (Table 1). No samples exceeded the NO_3-N maximum recommendation (Table 1). Overall, less than 2% of samples exceeded eutrophication

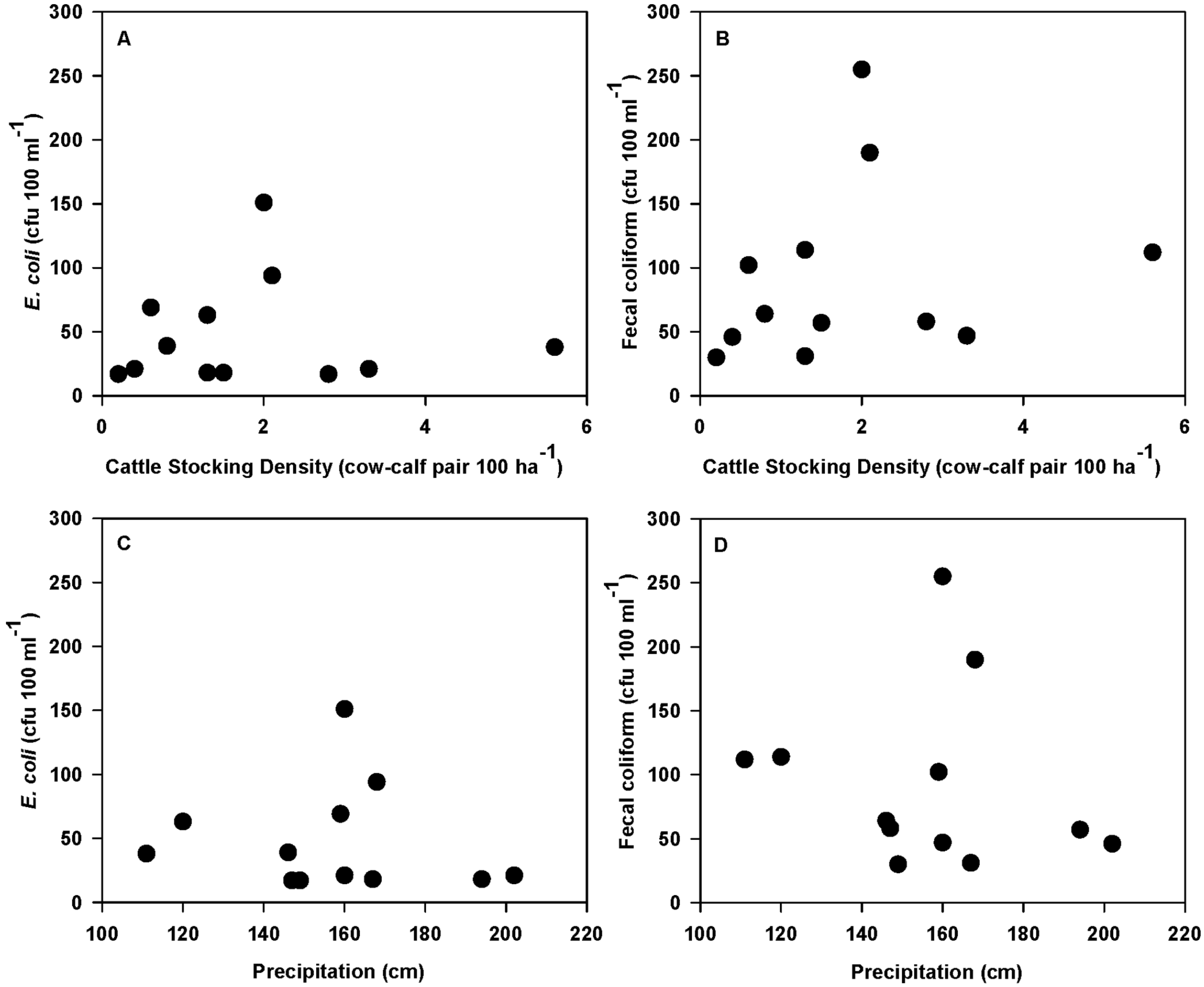

Figure 5. Trends in overall mean fecal indicator bacteria concentrations across sample sites during the June through November 2011sample period on 12 U.S. Forest Service grazing allotments in northern California enrolled in this cross-sectional longitudinal study. There were no significant relationships between allotment cattle stocking density and mean allotment concentrations of (A) *E. coli* ($P>0.9$) and (B) fecal coliform ($P>0.3$). During the study period, there were also no significant relationships between 2010–2011 water year precipitation and mean allotment concentrations of (C) *E. coli* ($P>0.6$) and (D) fecal coliform ($P>0.5$).
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benchmarks (Table 2), and less than 8% of sites exceeded these benchmarks at least once (Table 3). Mean and median TN, NO_3-N, and TP concentrations were at or below estimated background concentrations for the study area (Table 1). The percentage of all samples (Table 2) exceeding FIB benchmarks ranged from 50% (benchmark FC = 20 cfu 100 ml^{-1}) to 1% (benchmark *E. coli* = 410 cfu 100 ml^{-1}), while the percentage of sites (Table 3) that exceeded a FIB benchmark at least once ranged from 83% (benchmark FC = 20 cfu 100 ml^{-1}) to 6% (benchmark *E. coli* = 410 cfu 100 ml^{-1}).

Nutrient and FIB Concentrations Relative to Grazing, Recreation, and Field Observations

Nutrient concentrations were at or below background levels, and only 0–10% of sites within each resource use activity category (i.e., key grazing areas, recreation areas, and non-concentrated use activities) had at least one nutrient benchmark exceedance (Table 3). The relative percentage of samples and sites exceeding FIB benchmarks for key grazing areas, recreation areas, and non-concentrated use areas varied by the individual benchmarks (Tables 2 and 3).

We found significantly ($P<0.002$) lower FC, *E. coli*, TN and PO_4-P concentrations at recreation areas than at key grazing areas and areas with no concentrated use activities (Table 4). Mean NO_3-N concentrations were also significantly lower ($P<0.001$) at recreation sites than at areas with no concentrated use activity; however, it is important to note that all nutrient concentrations were at or below background levels (Table 1), and none of the sites sampled ever exceeded the maximum recommended NO_3-N concentrations during the study (Tables 3).

Relative to conditions at time of sample collection, FC, *E. coli*, and PO_4-P concentrations were significantly ($P<0.0071$) higher when stream flow was low or stagnant, stream water was turbid, and when cattle were actively observed (Table 5). TP concentrations were also significantly higher ($P<0.001$) under turbid water conditions. *E. coli*, TN, NH_4-N, and PO_4-P concentrations were significantly lower ($P<0.006$) when recreation activities were observed at time of sampling, compared to sample events when recreation was not occurring (Table 5). Occurrence of high to moderate cover (>20% of substrate cover) of algae, periphyton, and other aquatic organisms at time of sampling was low (<2% of samples).

Allotment-scale Nutrient and FIB Concentrations Relative to Grazing Management and Environmental Conditions

Mean allotment-scale nutrient concentrations were not significantly related (at Bonferroni adjusted $P<0.0071$) to cattle density (TN: $P=0.3$; NO_3-N: $P=0.2$; NH_4-N: $P=0.2$; TP: $P=0.3$; PO_4-P: $P=0.1$), precipitation (TN: $P=0.09$; NO_3-N: $P=0.07$; NH_4-N: $P=0.73$; TP: $P=0.3$; PO_4-P: $P=0.04$), mean allotment elevation (TN: $P=0.02$; NO_3-N: $P=0.4$; NH_4-N: $P=0.07$; TP: $P=0.5$; PO_4-P: $P=0.2$), AUM (TN: $P=0.6$; NO_3-N: $P=0.5$; NH_4-N: $P=0.9$; TP: $P=0.1$; PO_4-P: $P=0.6$), or grazing duration (TN: $P=0.02$; NO_3-N: $P=0.5$; NH_4-N: $P=0.03$; TP: $P=0.6$; PO_4-P: $P=0.6$).

Mean allotment *E. coli* and FC concentrations showed increasing trends with increasing cattle densities and AUMs, and decreasing trends with increasing precipitation; however, these relationships were not statistically significant ($P>0.2$; Fig. 5). Mean allotment elevation ($P>0.8$), and cattle grazing duration ($P>0.7$) were also not correlated to mean allotment FIB concentrations (data not shown).

Discussion

Nutrient Conditions Relative to Water Quality Benchmarks

Mean and median nutrient concentrations observed across this grazed landscape were well below eutrophication benchmarks and background estimates (Table 1) [38–43]. Observed peak values in nitrogen and phosphorus concentrations were largely organic (or inorganic P adsorbed to suspended sediments) (Figs. 2 and 3), which are not considered readily available to stimulate primary production and eutrophication [39,51]. These results do not support concerns that excessive nutrient pollution is degrading surface waters on these USFS grazing allotments [4,12]. Our nutrient results are consistent with other examinations of surface water quality in similarly grazed landscapes. In the Sierra Nevada, Roche *et al.* [14] found nutrient concentrations of surface waters within key cattle grazing areas (mountain meadows) to be at least an order of magnitude below levels of ecological or biological concern for sensitive amphibians. On the Wallowa-Whitman National Forest in northeastern Oregon, Adams *et al.* [52] also reported nutrient levels to be at or below minimum detection levels in surface waters at key grazing areas.

Our results also agree with other studies of nutrient dynamics in the study area [53,54]. Headwater streams, such as those draining the study allotments, typically make up 85% of total basin scale drainage network length, have high morphological complexity, and high surface to volume ratios–which make them particularly effective at nutrient processing and retention [55]. Leonard *et al* [54] found that drainages in the western Tahoe Basin recovering from past disturbances and undergoing secondary succession tend to act as sinks for nutrients. Several studies have reported nutrient limitations across montane and subalpine systems resulting in low riverine nutrient export [56].

FIB Concentrations Relative to Water Quality Benchmarks

Overall mean and median *E. coli* were 40 and 8 cfu 100 ml^{-1}, and mean and median FC were 82 and 21 cfu 100 ml^{-1} (Table S2)– indicating that the nationally recommended *E. coli* FIB-based benchmarks would be broadly met, and that the more restrictive, FC FIB-based regional water quality benchmarks would be commonly exceeded across the study region. Clearly, assessments of microbial water quality and human health risks are dependent upon which FIB benchmarks are used for evaluation (Tables 2 and 3).

The scientific and policy communities are currently evaluating the utility of, and guidance for, FIB-based water quality objective effectiveness for safe-guarding recreational waters. As reviewed in Field and Samadpour [8], *E. coli* and FC are not always ideal indicators of fecal contamination and risk to human health from microbial pathogens. Poor correlations between bacterial indicators and pathogens such as *Salmonella* spp., *Giardia* spp., *Cryptosporidium* spp., and human viruses undermine the utility of these bacteria as *indicators* of pathogen occurrence and human health risk [8]. The ability of FIB to establish extra-intestinal, non-animal, non-human associated environmental strains and to grow and reproduce in water, soil sediments, algal wrack, and plant cavities also erodes their utility as *indicators* of animal or human fecal contamination [8]. Citing scientific advancements in the past two decades, the USEPA now recommends adoption of an indicator *E. coli* water quality objective as an improvement over previously used general indicators, including FC [34]. This guidance is based, in part, on *E. coli* exhibiting relatively fewer of the fecal indicator bacteria utility issues listed above, and on evidence that *E. coli* is a better predictor of gastro-intestinal illness than FC. Therefore, comparing our results to the most relevant and scientifically defensible *E. coli* FIB-based recommendations, 17% of all sites exceeded the 190 cfu 100 ml^{-1} benchmark, and 14% of all sites exceeded the 235 cfu 100 ml^{-1} benchmark [34]. This analysis, based on the best available science and USEPA guidance, clearly contrasts with the FC FIB-based interpretations currently in use by several regional regulatory programs, which suggest that as many as 83% of all sites in our study present potential human health risks.

Temporal Patterns in Water Quality

We observed a marked increase in total nitrogen concentrations in October and November, driven primarily by increased organic nitrogen, and to a lesser extent NO_3-N (Fig. 2). This coincided with the first rainfall-runoff events of fall that initiated flushing of solutes and particulates. The annual fall flush occurs subsequent to the summer drought and base flow period during which organic and inorganic nutrient compounds accumulate in soil and forest litter [54,57–60]. The disparity between TN and inorganic nitrogen (NO_3-N+NH_4-N) indicates the majority of flushed nitrogen was either particulate or dissolved organic nitrogen (Fig. 2). Consequently, most of the nitrogen flushed was likely in a relatively biologically unavailable form [51], with limited risk (relative to inorganic forms) of stimulating primary production and eutrophication. However, in nitrogen limited systems, increased biological utilization of organic nitrogen can occur [61].

FIB concentrations were highest from August through October (Fig. 4), which coincides with the period of maximum number of cattle turned out (Table S1). There is clear evidence that FIB concentrations increase with the introduction of cattle into a landscape, and increase with increasing cattle numbers [62–65]. The observed seasonal pattern of peak FIB concentrations also tracks the progression of stream flow from high, cold spring snowmelt to low, warm late-summer base flow conditions. Warm, low-flow conditions have been associated with elevated FIB [66–68]. Across this region, stream water temperatures are at their annual maximum in August and stream flows are at their annual minimum in September [69,70]. We observed stagnant-low flow conditions to be significantly associated with increased FIB concentrations (Table 5). It is likely that the seasonal peak of FIB concentrations is driven by timing of maximum annual cattle numbers, as well as optimal environmental conditions for growth and in-stream retention of both animal-derived and environmental bacteria (e.g., wildlife sources) [71–73]. Similar temporal trends in FIB concentrations have been observed in surface waters of Oregon, Wyoming, and Alaska [65,74,75].

Water Quality, Grazing, Recreation, and Environmental Conditions

Mean FIB concentrations at key grazing and non-concentrated use areas were higher than recreation sites, but did not exceed USEPA *E. coli* FIB-based benchmarks (Table 4). Mean FIB concentrations for all resource use activity categories exceeded the most restrictive regional FC FIB-based benchmarks of 20 and 50 cfu 100 ml^{-1}. *E. coli* FIB-based benchmark comparisons were generally comparable across sites, with recreation sites exhibiting overall lower numbers of exceedances; however, the different FC FIB-based benchmark comparisons indicated inconsistent results for water quality conditions across sites (Table 3). Similar to other surveys in the region [6,12,13], FIB concentrations were significantly greater when cattle were present at time of sample collection (Table 5). Tiedemann *et al.* [65] observed the same trend, with higher stream water FC concentrations on forested watersheds experiencing relatively intensive cattle grazing compared to ungrazed watersheds. Gary *et al.* [63] found grazing to have relatively minor impacts on water quality, though a statistically significant increase in stream water FC concentrations was induced at a relatively high stocking rate.

Mean allotment FIB concentrations showed apparent increasing trends with greater cattle densities (Fig. 5A and 5B); however, these allotment-level relationships were not statistically significant. Decreasing cattle density lowers fecal-microbial pollutant loading [76], which has been shown to reduce FIB concentrations in runoff from grazed landscapes [77]. Decreasing cattle density may also reduce stream bed disturbance and re-suspension of FIB-sediment associations by cattle [78–82]. Attracted to streams for shade, water, and riparian forage, cattle have been shown to spend approximately 5% of their day within or adjacent to a stream [63], depositing about 1.5% of their total fecal matter within one meter of a stream [83]. In a comprehensive review, George et al. [19] found that management practices that reduce livestock densities, residence time, and fecal and urine deposition in streams and riparian areas can reduce nutrient and microbial pollutant loading of surface water.

Samples associated with turbid stream water at the time of sample collection had significantly higher mean FIB concentrations than samples associated with non-turbid conditions (Table 5). It has been well documented that stream sediments contain higher concentrations of FIB than overlying waters [78–80,82], and that re-suspension of sediments in the water column by factors such as cattle disturbance or elevated stream flow is associated with elevated water column FIB concentrations [81]. FIB concentrations were also significantly higher under stagnant-low flow conditions (Table 5). Schnabel *et al.* [75] found a negative correlation between stream discharge and FIB concentrations at some sites, possibly due to the absence of a dilution effect under low flow conditions.

Although not statistically significant, we observed decreasing mean allotment FIB concentrations with greater precipitation during the 2010–2011 water-year (October 1 to September 30) (Fig. 5C and 5D). It is likely that precipitation during the 2010–2011 water-year is primarily reflecting snowpack, which supported higher than historical stream flow volumes during the study period. This potential relationship possibly reflects capacity of higher base flow volumes to dilute FIB concentrations. Lewis *et al.* [84] observed a similar negative correlation between surface runoff FC concentrations and annual cumulative precipitation on California coastal dairy pastures. Our observation that maximum FIB concentrations occurred under stagnant-low flow conditions (Table 5) also supports the potential for a negative relationship between FIB concentrations and annual precipitation.

Our results do not support previous concerns of widespread microbial water quality pollution across these grazed landscapes, as concluded in other surveys [6,12,13]. Although we did find apparent trends between cattle density and FIB concentrations (Figs. 5A and 5B) and significantly greater FIB concentrations when cattle were actively present, only 16% and 13% (Table 3) of key grazing areas ($n = 97$) exceeded the *E. coli* FIB-based benchmarks of 190 cfu 100 m^{-1} and 235 cfu 100 m^{-1}, respectively. Only 5 and 3% of total samples collected exceeded the *E. coli* FIB-based benchmarks of 190 cfu 100 m^{-1} and 235 cfu 100 m^{-1}, respectively (Table 2). In contrast, Derlet et al. [6] reported 60% and 53% of cattle grazing sites ($n = 15$) exceeded the 190 cfu 100 m^{-1} and 235 cfu 100 m^{-1} benchmarks, respectively. We also found no significant differences in FIB concentrations among key grazing areas and areas of no concentrated use activities (Table 4), which contrasts with previous work in the Sierra Nevada [6,12]. Finally, in this landscape of mixed livestock grazing and recreational uses, we found FIB concentrations to be lowest at recreation sites, indicating that water recreation objectives can be broadly attained within these grazing allotments. There are three important distinctions that separate our study from previous work: 1) in reaching our conclusions, we compared our study results to regulatory and background water quality benchmarks, which are based on current and best available science and policy; 2) these co-occurring land-use activities were directly compared on the same land units managed by a single agency (USFS), as opposed to previous comparisons between these land-uses occurring on different management units administered by different agencies with very different land-use histories and policies (e.g., USFS and U.S. National Park Service); and 3) to date, this study is the most comprehensive water quality survey in existence for National Forest public grazing lands, including an assessment of seven water quality indicators at 155 sites across five National Forests.

Conclusions

Nutrient concentrations observed across this extensively grazed landscape were at least one order of magnitude below levels of ecological concern, and were similar to USEPA estimates for background conditions in the region. Late season total nitrogen concentrations increased across all study allotments due to a first flush of organic nitrogen associated with onset of fall rainfall-runoff events, as is commonly observed in California's Mediterranean climate. Similar to previous work, we found greater FIB concentrations when cattle were present; however, we did not find overall significant differences in FIB concentrations between key grazing areas and non-concentrated use areas, and all but the most restrictive, FC FIB-based regional water quality benchmarks were broadly met across the study region. Although many regional regulatory programs utilize the FC FIB-based standards, the

USEPA clearly states–citing the best available science–*E. coli* are better indicators of fecal contamination and therefore provide a more accurate assessment of water quality conditions and human health risks. Throughout the study period, the USEPA recommended *E. coli* benchmarks of 190 and 235 cfu 100 ml^{-1} were met at over 83% of sites. These results suggest cattle grazing, recreation, and clean water can be compatible goals across these national forest lands.

Supporting Information

Table S1 Geographic characteristics, study year precipitation, cattle grazing management, and water quality sample collection sites and sample numbers for 12 U.S. Forest Service grazing allotments in northern California enrolled in this cross-sectional longitudinal study of stream water quality between June and November 2011.
(DOCX)

Table S2 Mean, median, and maximum fecal coliform (FC) and *E. coli* concentrations for 743 stream water samples collected across 155 sample sites on 12 U.S. Forest Service grazing allotments in northern California. All concentrations are reported as colony forming units per 100 ml of sample water (cfu 100 ml^{-1}).
(DOCX)

Acknowledgments

We thank Anne Yost, Barry Hill, and staff from the Klamath, Shasta-Trinity, Plumas, Tahoe, and Stanislaus National Forests for their assistance with study plan development and field data collection; Tom Lushinsky, D.J. Eastburn, Natalie Wegner, Donna Dutra, Mark Noyes, and Xien Wang for lab sample processing; University of California Cooperative Extension and USFS District Rangers and Forest Supervisors who provided lab space; and Anne Yost, Barry Hill, and three anonymous reviewers for their valuable and constructive comments on this manuscript.

Author Contributions

Conceived and designed the experiments: KWT ERA RAD. Performed the experiments: KWT. Analyzed the data: LMR KWT. Contributed reagents/materials/analysis tools: KWT RAD. Wrote the paper: LMR LK ERA RAD KWT.

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Subject: FW: All Board Members - Board Contact Form

From: [redacted]
Sent: Tuesday, February 25, 2020 4:56 PM
To: Clerk <clerk@openspace.org>; General Information <info@openspace.org>
Subject: All Board Members - Board Contact Form

EXTERNAL

Name *	Erin Tormey
Select a Choice *	All Board Members
Email *	[redacted]
Location: (i.e. City, Address or District Ward)	San Mateo County

Comments: *

February 25, 2020

Mid-Peninsula Regional Open Space
330 Distel Circle
Los Altos, CA 94022-1404

Dear MROSD,

The San Mateo Food System Alliance (SMFSA) would like to express its support for the Grazing Management Policy Amendment, incorporating conservation grazing to help maintain and restore native grasslands, biodiversity, manage vegetation to reduce wildfire risk, and support agriculture in San Mateo County. As part of conservation grazing, SMFSA supports grazers like Erik and Doniga Markegard who utilize holistic management and regenerative grazing practices to improve soil health, climate stability, conserve water, support wildlife, animal welfare, economic prosperity, and biodiversity.

Formed in 2006, the SMFSA is a community-based collaborative of farmers, ranchers, fishermen, farmers' market managers, public health and environmental professionals, garden-based educators, distributors, and residents seeking to promote, enhance and support an enduring and interdependent food system that is economically viable, environmentally sound, and socially equitable. The Food System Alliance seeks to increase access to healthy, local food for all residents, support rural economies, and ensure that land and waterways are not just maintained, but are preserved for future generations.

Ranchers that graze their cattle in a way that mimics nature and supports
a natural environment--one that includes both grazers and predators. This holistic method of grazing provides ecosystem services with multiple stewardship benefits and is a cost-effective method for maintaining healthy grasslands on the San Mateo County coast. Additional benefits of holistic, regenerative grazing include:

Soil Health--Improve soil health and fertility and reduce topsoil loss. Planned adaptive grazing can help slow or reverse topsoil loss by building organic matter and reducing compaction. (Byrnes, et al, 2018; Conant, et al, 2017; Pilan, et al, 2017; Teague, et al, 2011)

Biodiversity--Steward ecosystems to be productive and diverse. Regenerative ranching can support native plants, songbirds, and listed vertebrates and control invasive plants. (Gennet, et al, 2017; Marty, 2005; Henneman, et al, 2014; Stahlheber and D'Antonio, 2013; D'Tomasco, et al, 2007)

Food Security--Increase net productivity and resilience of our working lands. Meat provides 18% of the calories and 25% of the protein in global diets. 85% of livestock feed uses crop residues and byproducts unsuitable for humans. (Mottet, et al, 2017)

In summary, SMFSA fully supports the Grazing Management Policy Amendment, and more specifically the grazing lease for Toto Ranch operated by Markegard Family Grass Fed and the benefits of grazing on local, public grasslands.

Sincerely,

Erin Tormey

Proprietor, Farm Fatales on Irish Ridge Ranch

2017 Farmer of the Year

Founder, Coastside Farmers' Markets

On behalf of the San Mateo Food System Alliance

February 26, 2020

President Karen Holman and Board Members
Midpeninsula Regional Open Space District
330 Distel Circle
Los Altos, CA 94022-1404

Re: Item #4 on the February 26, 2020 Agenda: Toto Ranch Rangeland Management Plan and Grazing Lease in Tunitas Creek Open Space Preserve

Dear President Holman and Board Members,

On behalf of Green Foothills, I write in support of the staff recommendation to adopt the Toto Ranch Rangeland Management Plan and to enter into a new five-year lease at Toto Ranch with Erik and Donega Markegard.

Green Foothills has worked since our founding in 1962 to protect open space, farmland, and natural resources in San Mateo and Santa Clara Counties for the benefit of all. We have a long-standing and abiding interest in the rural San Mateo County coast, and have supported agricultural uses and practices that are consistent with our mission.

Green Foothills was instrumental in the successful extension of the District boundaries to include the San Mateo County coast in 2004. As part of that effort, the District adopted a Coastside Mission Statement: ***"To acquire and preserve in perpetuity open space and agricultural land of regional significance, protect and restore the natural environment, preserve rural character, encourage viable agricultural use of land resources, and provide opportunities for ecologically sensitive public enjoyment and education."***

The Toto Ranch Rangeland Management Plan includes prescriptions to meet the District's conservation grazing goals that help maintain and enhance the biodiversity of native grasslands, manage vegetation to reduce wildfire risk, and that will also support local, viable agricultural uses.

As part of conservation grazing, Green Foothills commends livestock grazers like the Markegards who use holistic management and regenerative grazing practices to improve soil health, conserve water, support diverse wildlife species, and help achieve climate stability. Their current lease should be extended, per the Staff Recommendation.

Sincerely,

Lennie Roberts

Lennie Roberts, Legislative Advocate, Green Foothills

From:	[redacted]
Sent:	Wednesday, February 26, 2020 12:32 AM
To:	Clerk; General Information
Subject:	All Board Members - Board Contact Form

EXTERNAL

Name *	Cynthia Fan
Select a Choice *	All Board Members
Email *	[redacted]
Location: (i.e. City, Address or District Ward)	Los Gatos

Comments: *

Re: agenda item 4 of the 2/26/20 Midpen board meeting, "Toto Ranch Rangeland Management Plan and Grazing Lease in Tunitas Creek Open Space Preserve"

To the MidPen Board:

I am writing to express strong support for you to continue to utilize well-managed cattle grazing on MidPen's public lands. Specifically, I urge you to approve the renewal of Doniga and Erik Markegard's grazing lease for Toto Ranch.

You are able to use data gathered from the land this family has leased to inform your decisions. The scale and practices of the Markegard's operation are not representative of those used in poorly-managed grazing operations. It is evident that the land leased to the Markegards does not suffer from the ecological and environmental damages that result from poorly-managed grazing operations.

The rangeland management plan being proposed formally addresses areas of concern to ensure continued conservation of our grasslands while minimizing negative impacts. Maintaining balance (in an ecosystem or in anything else), by definition, requires constant adjustments; MidPen's Grazing Plan allows for this.

In the context of the big picture, the pros of well-managed cattle grazing on public lands outweigh the cons. Well-managed cattle grazing helps maintain the ecosystem needed to support the native plants and wildlife that MidPen is dedicated to preserving. Well-managed cattle grazing helps maintain critical biodiversity above and below the ground. Well-managed cattle grazing builds healthy soils, soils that can absorb water like a sponge to give our area climate resilience in the face of flooding and drought. In the big picture, all these environmental benefits make it worth the investment of addressing the inevitable yet manageable challenges that arise.

And when it comes to food production, here is the big picture:
Most of the beef and dairy products consumed in our country come from the industrial food system, a system that is highly extractive and destructive rather than regenerative. To address the climate crisis and support true environmental stewardship in a country not ready to wholly give up beef and dairy, we must urgently and drastically change the model of animal agriculture used in our country's food system. How do we do that? We support the viability of local operations like Erik and Doniga Markegard's, operations that represent the antithesis of the horribly broken industrial food system.

The Markegards are well-recognized and highly-respected leaders in the movement away from the industrial food system. They demonstrate that ethical animal agriculture and environmental stewardship are practical and achievable. And they do so while offering full transparency. Because of these things, they are invaluable models for other producers and they are invaluable to conscious consumers like my family who want to ensure we are supporting good, clean, fair food. In a foodscape dominated by highly-profitable multinational corporations deceptively greenwashing consumers while externalizing the true costs to our soil, air, water, and biodiversity, it is more imperative than ever that we maintain the viability of ethical small- and mid-scale producers that are offering full transparency like the Markegards.

Our food system and environment currently suffers greatly from the dearth of small- and mid-scale values-based producers. Because land scarcity, especially in California, is one of the greatest challenges to successfully reforming our food system, it is critical that our public lands continue to be shared with values-based agricultural producers like the Markegards.

So thank you for collaborating with the Markegards, and other like-minded producers, on supporting the conservation of our grasslands while ALSO preserving responsible animal agricultural operations on Midpen-owned lands. This is the clear path to upholding Midpen's mission. Thank you for being leaders in land management.

–Cynthia Fan

resident of Los Gatos and

consumer advocating for the viability of good, clean, and fair agricultural production