Photo: Torrey Ritter

Photo: Adam Grove

Recommendations for Managing Mountain Goats in Montana: *Executive Summary*[1]

Management outcomes for mountain goats in Montana have fallen short when compared to other big game species. Commonly-brainstormed fixes such as protecting habitat and managing harvest have worked with elk and deer but are proving to be incomplete solutions for mountain goat restoration. Mountain goat herds in western Montana are still struggling despite their general alignment with protected areas and a long history of varied harvest strategies. Herein, Montana Fish, Wildlife & Parks (FWP) reports on a focused effort to reach beyond brainstorming by investing in a rigorous process of structured decision-making, wherein management considerations are drawn from multiple biological and social inputs, while explicitly accounting for uncertainty. The result identifies the strategies within management control that have the best chance of supporting mountain goats in the coming years and are most practical for being put into action.

[1] *This is a summary meant to serve the day-to-day needs of management. For a complete description of the decision analysis and a list of references cited refer to: Gude, J., N. DeCesare, K. Proffitt, S. Sells, R. Garrott, I. Rangwala, Q. Kujala, M. Biel, J. Coltrane, J. Cunningham, T. Fletcher, J. Golla, K. Loveless, R. Mowry, J. Newby, M. O'Reilly, R. Rauscher, K. Rose, M. Thompson, and J. Vore. 2020. Recommendations for managing mountain goats in Montana: a decision analysis approach. Technical Report, Wildlife Division, Montana Fish, Wildlife & Parks, Helena, Montana. 68 pp.*

Recommended Management Strategies:

- Introduce and establish new mountain goat populations on native ranges where populations have been extirpated as well as in historically unoccupied, suitable habitats.
- Augment mountain goat numbers and reduce carnivore numbers in remnant mountain goat populations that are at risk of extirpation, and do so only in a research and learning context, to further our understanding of how these actions affect mountain goat populations.
- Projects involving the translocation of mountain goats should acknowledge and transparently communicate the risk of disease transmission from source to recipient mountain goat or sympatric bighorn sheep populations.
- Continue to curtail hunter harvest, especially nanny harvest, in struggling populations.
- Increase knowledge about mountain goat population sizes and dynamics.
- Increase knowledge about pneumonia pathogens in mountain goats.
- Increase knowledge about public and decision makers' risk tolerance toward the potential pathogen spread that could occur from translocated mountain goats to resident mountain goats and bighorn sheep.
- Continue and expand ongoing efforts:
  - Provide sustainable public opportunity to view and hunt mountain goats.
  - Translate public opportunities to appreciate mountain goats into outreach and public support for conservation.
  - Foster cooperative working relationships within and among agencies.
  - Avoid or mitigate effects of human development or recreation.
  - Minimize mountain goat habituation.
  - Manage conifer encroachment in goat habitat where possible.

Mountain Goat Working Group

FWP convened a working group to develop management guidance for mountain goats in Montana and identify priority monitoring and research needs tied directly to mountain goat management. Beginning in May 2018, the working group met for two days on each of four occasions, plus a 1-day video conference in December 2019 to complete the task. The group employed a Structured Decision Making (SDM) process to extract the most predictive power from the knowledge of assembled individuals. SDM is a way of formalizing common sense, designed to ensure that all components of a decision are thoroughly considered in complex situations. Most importantly, SDM is a learning process, wherein assumptions, risks and probabilities are tested, evaluated and adapted throughout, resulting in an original and supported product in the end.

Participants:

<u>FWP</u>

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CONFEDERATED SALISH AND KOOTENAI TRIBES
The Tribal Wildlife Program was kept apprised of progress and products.

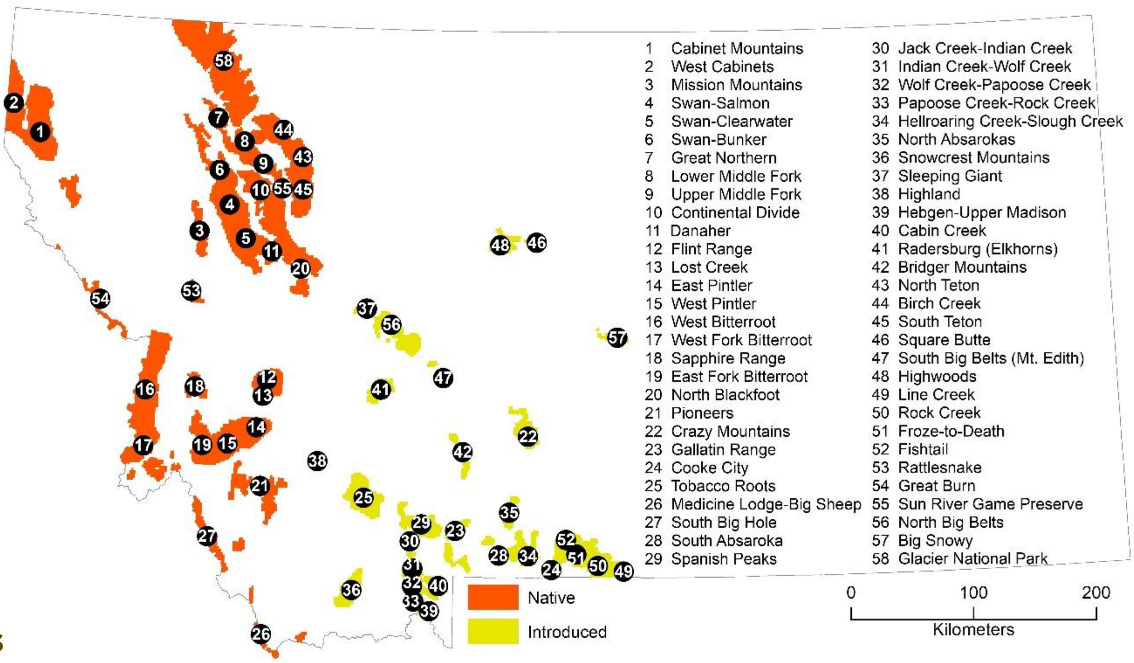
Issue Statement

The working group began by brainstorming and crafting specific statements about the issues to be addressed in this process, which may be categorized as status, needs and challenges.

Status

The mountain goat is an iconic and ecologically important species that contributes to the quality of life for present and future generations of Montanans. Mountain goats have declined across much of their native range in Montana (Figure 1), raising concerns for their present and future status, and for lost outdoor experiences involving mountain goats, including hunting.

Figure 1 Below: *Current mountain goat distribution in Montana, divided into 58 population units existing within native ranges (orange) and introduced outside of native ranges (yellow).*



Needs

FWP is charged with the stewardship of Montana's wildlife. Management of mountain goats is hampered by a lack of information on abundance, vital rates, population boundaries, effects of ecological processes and predation, climate change, and effects of respiratory pathogens shared with bighorn sheep. FWP needs a better understanding of these uncertainties to effectively manage mountain goats.

Challenges

Additional challenges to mountain goat management include inadequate funding linked with limited public advocacy compared with other big game or carnivore species. Limited FWP resources for research and monitoring flow logically toward the highest priority species and to projects with a high likelihood of success. Difficulties and added expenses of working in goat terrain burden cost/benefit analyses of proposed projects. Compounding these uncertainties and challenges, Montana lacks a statewide management plan for mountain goats.

Fundamental Objectives

After articulating the issues to be addressed, the working group devised fundamental objectives. Fundamental objectives are the measurable outcomes that an ideal management strategy would achieve.

1. Maximize the square kilometers of suitable habitat that mountain goats occupy in 50 years.
2. Maximize the number of mountain goat population units meeting population trend objectives one goat-generation from now. Trend objectives reference the desired direction (increasing, stable, or decreasing) for each mountain goat population (Gude et al. 2020).
3. Minimize negative effects of mountain goats on the ecosystems they inhabit by minimizing disease risks to bighorn sheep from shared respiratory pathogens.
4. Minimize disease risks to mountain goats from respiratory pathogens shared by mountain goats and bighorn sheep.
5. Minimize predicted annual costs of management.
6. Minimize human social conflict resulting from mountain goat management.

Difficulties and added expenses of working in goat terrain burden cost/benefit analyses of proposed projects. ***Above: Bitterroot Mountains, photo by Rebecca Mowry.***

Alternative Strategies

The working group then developed a toolbox of 7 detailed strategies for achieving the fundamental objectives, which prompted analysis and comparison of best-to-worst case scenarios when each strategy was paired with each fundamental objective.

1. Status quo: focusing on population monitoring and conservative harvest management.
2. Top-down mortality management: further limiting mortality from predation and hunting.

3. Introducing new mountain goat populations (where goats currently do not exist).

4. Augmenting struggling mountain goat herds with translocations.

5. Habitat protection: protecting important mountain goat habitats from human use.

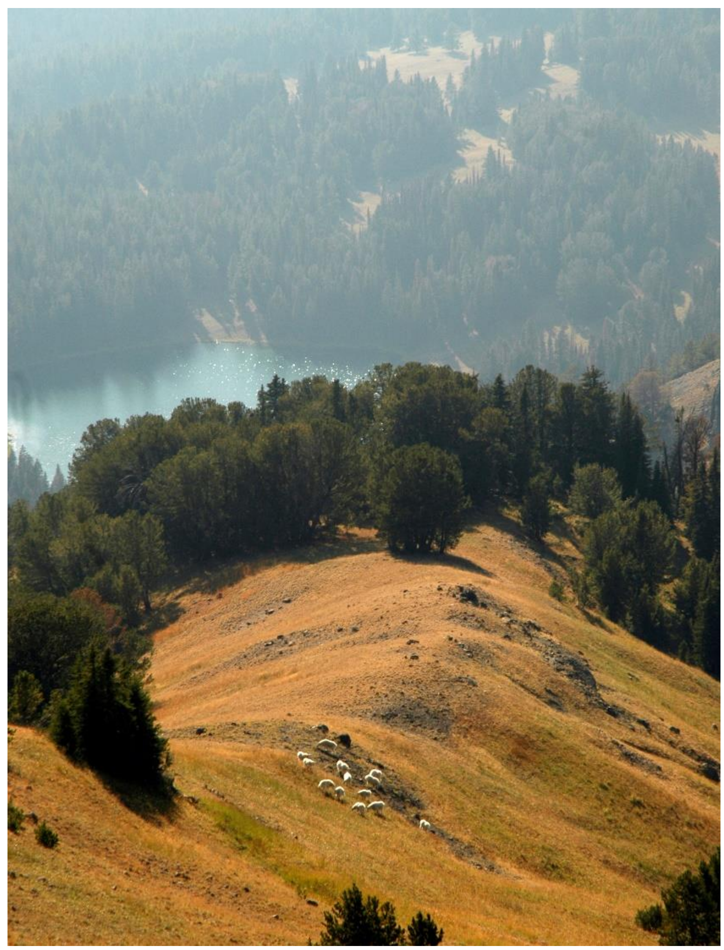
6. Combined, with augmentations: including elements from strategies 1-5.

7. Combined, without augmentations: same as strategy 6, but without augmentations.

Consequence Predictions

Decision analysis requires explicit predictions of the effect of each alternative strategy on each fundamental objective. Few mountain goat data are available in Montana, and considerable uncertainty surrounds most mountain goat ecological and disease processes. The working group's science team constructed multiple alternative models to predict the effects of different actions toward achieving the fundamental objectives. In each alternative model, the science team estimated uncertainty around the action and the projected outcome. For each fundamental objective where uncertainty was incorporated into the consequence predictions, the working group also had to specify a belief (or probability) weight on the predictions from each alternative model.

Research in Glacier National Park suggests that mountain goats use snow to slow their respiration during summer. ***Clockwise from top left: Glacier National Park, photo by Wesley Sarmento. Great Burn Proposed Wilderness, photo by Liz Bradley. Beartooth Mountains, photo by Mike Thompson. Great Burn Proposed Wilderness, photo by Liz Bradley.***



The existence of mountain goat populations in some warmer and drier parts of Montana adds uncertainty to the prediction of negative climate change effects. ***Clockwise from top left: Big Belt Mountains, photo by Adam Grove. Square Butte, photo by Cory Loecker. Gallatin Range, photo by Torrey Ritter. Square Butte, photo by Cory Loecker.***

Influence of Climate Change

The primary uncertainty concerning Fundamental Objective 1 is the impact that climate change will have on the amount of habitat occupied by mountain goats.

- Research in Glacier National Park suggests that mountain goats use snow to slow their respiration during summer, and researchers in southeast Alaska have predicted that mountain goat habitat is likely to shrink due to climate change.

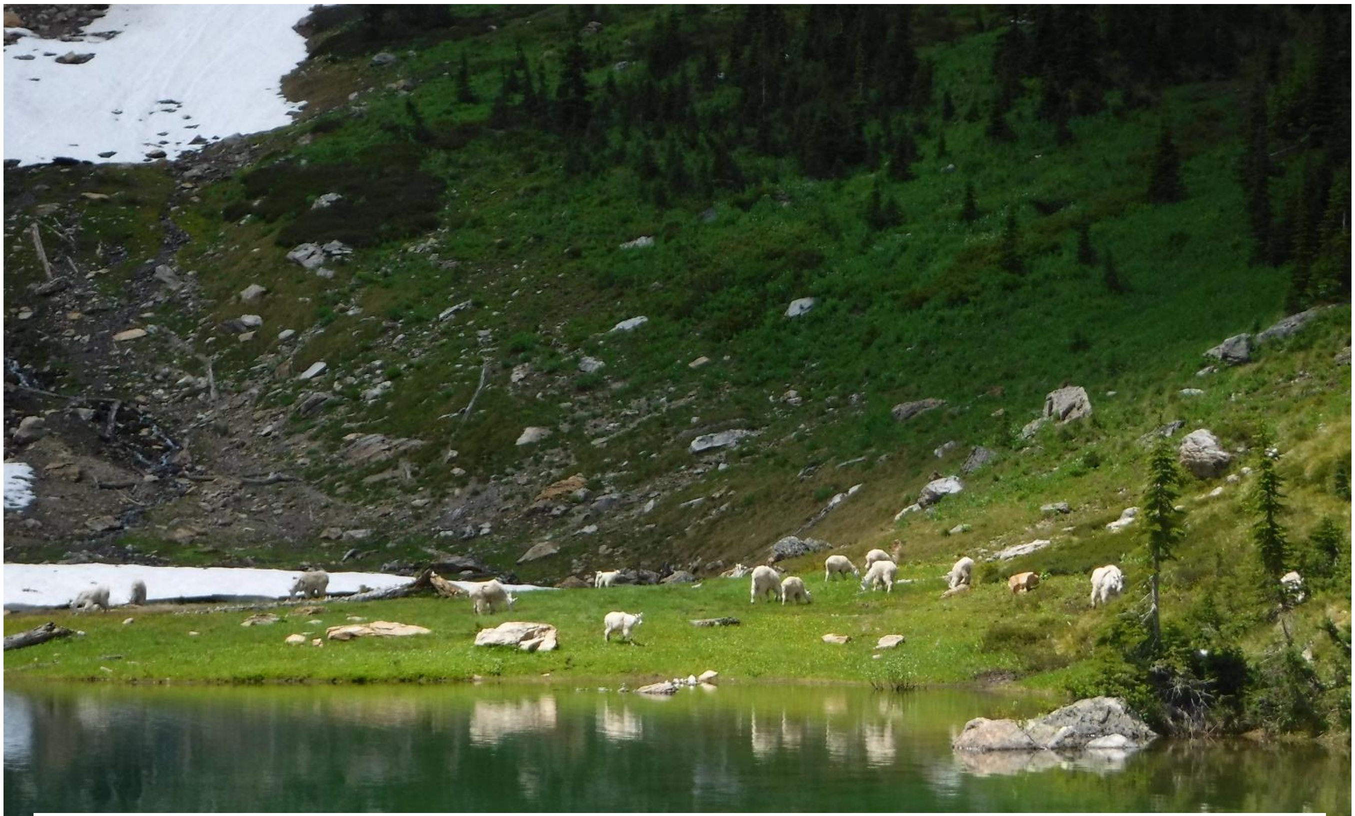
- The existence of mountain goat populations in some warmer and drier parts of Montana (e.g., Square Butte) and elsewhere (e.g., the Black Hills in South Dakota and several herds in Nevada) adds uncertainty to the prediction of negative climate change effects implied from the studies in specific herd ranges.
- The climate-driven habitat model for mountain goats in Montana included the following covariates: canopy cover, slope, precipitation, growing degrees days, and potential vegetation.
- To forecast mountain goat habitat conditions over the next 50 years by incorporating future climate change uncertainty, we considered 3 divergent future climate scenarios based on regionally representative Global Climate Models.
- A fourth scenario contained no climate-related covariates and represented the hypothesis that climate change will not limit the distribution of mountain goat populations in Montana.
- Goat habitat modeling suggested that projected increases in precipitation and growing degree days will compensate to some degree for lost summer snowpack in goat habitat.
- Regardless of which climate scenario becomes more likely, the introduction strategy is always predicted to result in more area occupied by mountain goats than other alternatives.

Data on mountain goat population sizes and age structure are very limited in Montana. ***Above: Glacier National Park, photo by Wesley Sarmento.***

Influence of Uncertainty about Population Dynamics

Uncertainty about mountain goat population demography and population dynamics has a large effect on management effectiveness concerning Fundamental Objective 2.

- Data on mountain goat population sizes and age structure are very limited in Montana, so we simulated these values from distributions representing confidence ranges provided by local biologists and using published mountain goat vital rates.
- We relied on vital rate data from Alberta and Alaska, the only two areas where long-term studies of mountain goat population dynamics have been conducted.
- Vital rates estimated from mountain goats in Alberta were divided into 3 trend scenarios, including periods when the population was increasing (1993-2003), declining (2004–2017) and stable (1993–2017 overall).
- We used vital rate values and their variances from each of these 3 study periods to model Montana populations deemed to be declining, stable, or increasing according to the biologist trend estimates.
- To represent vital rates for Montana mountain goat populations with uncertain trends based on the professional judgment of biologists, we created an uncertain category for vital rates with mean vital rates equivalent to those from a stable population but larger confidence intervals that fully spanned the range of values from all study periods, including declining to increasing values (Table 1).
- Our predictions range from 3% to 95% of mountain goat population units in Montana meeting population trend objectives one goat-generation from the present, depending on the uncertainty, modeling assumptions, and management alternatives we included.



More information about mountain goat population size, demography and population dynamics would improve mountain goat management. ***Above: Dalton Lake in the Great Burn Proposed Wilderness, photo by Liz Bradley.***

- The optimal alternative choice is affected by the lack of information on mountain goat demography and population dynamics.
- More information about mountain goat population size, demography, and population dynamics would therefore improve mountain goat management.
- Alternative strategies that included augmentation of existing mountain goat populations may do the best at achieving Fundamental Objective 2, but these alternatives also increase disease risks for mountain goats and bighorn sheep the most.
- Alternative strategies that involve reducing harvest and predation effects in populations may also contribute toward achieving Fundamental Objective 2, but the effects of carnivore density reductions on mountain goat populations are unknown and may create social conflicts.

Table 1. Vital rate scenarios (mean and 95% Confidence Intervals) for adult females and newborns used to represent declining, stable, increasing, and uncertain population trends in the Leslie matrix population model for mountain goats in Montana. These vital rates were taken or derived from the Caw Ridge population in Alberta, one of the only long-term studies of mountain goat population dynamics ever undertaken.

	Adult female survival		Newborn survival		Adult female fecundity	
	Mean	95% CI	Mean	95% CI	Mean	95% CI
Declining	0.87	(0.85,0.90)	0.48	(0.39,0.56)	0.38	(0.30,0.46)
Stable	0.92	(0.89,0.95)	0.59	(0.48,0.70)	0.67	(0.58,0.76)
Increasing	0.94	(0.90,0.99)	0.62	(0.49,0.75)	0.75	(0.65,0.85)
Uncertain	0.92	(0.85,0.99)	0.59	(0.39,0.75)	0.67	(0.30,0.85)

Influence of Uncertainty about Pneumonia Pathogens

Uncertainty about pneumonia pathogens and risk of mixing pathogens among herds during translocations has a large impact on management effectiveness concerning Fundamental Objectives 3 and 4.

- Only 2 mountain goat herds in Montana have been evaluated for their respiratory pathogen communities using a statistically-robust sample size; both herds were found to carry pneumonia-associated pathogens, and 1 of these herds currently occupies a range overlapping a bighorn sheep herd.

Montana currently has 29 mountain goat herds that occupy ranges overlapping bighorn sheep herds, and 22 of these bighorn sheep herds are known to carry pneumonia-associated pathogens. ***Above: Glacier National Park****, photo by Wesley Sarmento.*

- Both mountain goat herds, as well as other goat herds from outside of Montana that are known to harbor pneumonia-associated pathogens, would be involved in translocations under some of the management alternatives considered in this process.

- The working group used three hypotheses to capture the considerable uncertainty about the number of bighorn sheep and mountain goat herds with pneumonia-associated pathogens.
    - The first hypothesis states that the herds currently known to carry pneumonia-associated pathogens are the only such cases in Montana.
    - The second states that all bighorn sheep and mountain goat herds in Montana carry pneumonia-associated pathogens.
    - The third hypothesis states that the bighorn sheep and mountain goat herds with pneumonia-associated pathogens are those that can be historically traced to range overlap with domestic sheep herds, via direct overlap or translocations of mountain goat or bighorn sheep with ranges overlapping domestic sheep.

- All 29 mountain goat herds currently overlapping bighorn sheep herds and all the mountain goat herds that would be sources for the translocations considered by the working group can be historically traced to range overlap with domestic sheep.

- We predict that somewhere between 3-100% of current bighorn sheep herds overlapping mountain goat herd units will be exposed to mountain goat populations with pneumonia-associated pathogens under the models and alternatives we considered.

- We predict that somewhere between 41-100% of current mountain goat herds harbor pneumonia-associated pathogens or will be exposed to bighorn sheep populations with pneumonia-associated pathogens under the models and alternatives we considered.

- In addition to the disease risk stemming from the presence of pneumonia pathogens, the working group was concerned with risk stemming from mixing the microbial communities living in transplanted mountain goats with those living in resident mountain goats or bighorn sheep.

- Efforts to increase information about which mountain goat and bighorn sheep herds harbor pneumonia-associated pathogens will affect the optimal decision about which mountain goat herds and new population areas should be involved in translocations.

- Alternatives that do not involve translocations of mountain goats result in fewer bighorn sheep and mountain goat herds exposed to mountain goat populations with pneumonia-associated pathogens, under every model we considered.

- Accounting for low risk tolerance for mixing microbial communities results in alternatives with new introductions outperforming alternatives with augmentations in every model we considered.

- Risk tolerance for pneumonia epizootics in bighorn sheep and mountain goat herds therefore plays a large role in deciding among management actions. While public tolerance for taking such risks is likely higher in struggling populations, more information on the risk tolerance of the public and decision makers is needed.

In 2002, Bob Henderson (left) and Shawn Cleveland reintroduced mountain goats from the Crazy Mountains to Red Mountain in the Scapegoat Wilderness Area. Photo by Pat Shanley, Helena National Forest.

Conclusions

The decision analysis identified introductions to establish new mountain goat populations as a strategy resilient to climate-change that should be pursued. The amount of future gain in area occupied by mountain goat populations may be small, in part due to uncertainty in future climate conditions and their effects on mountain goat habitat, but gains in area occupied are predicted from alternatives with new population introductions under the full range of future climate scenarios we considered. New population introductions could be done within a research design that will help reduce uncertainty about their effects on the area occupied by mountain goats over the next 50 years. New population introductions could also be combined with other management actions that were well-supported in the decision analysis. For example, education and community involvement campaigns could be established to foster local buy-in for a newly introduced population. New introductions could be paired with temporary, short-term efforts to reduce carnivore densities before and during the introduction to facilitate population establishment.

Predictions show that augmentations of struggling mountain goat herds might also have a large, positive effect on the number of mountain goat populations reaching trend objectives.

However, augmentations increase the number of overlapping mountain goat and bighorn sheep herds, and therefore have high potential for mixing of pneumonia-associated pathogens and other microbial communities. The strong disease risk aversion that was revealed within the working group had its largest dampening effect on the overall weight of support for alternatives involving augmentations. Therefore, mountain goat herd augmentations should only be contemplated in a research or learning context. If pursued, augmentations should be designed and carried out in a manner that reduces uncertainties about their effects on mountain goat populations. Augmentations should be pursued in areas where there is already an identified risk of extirpation in the recipient herd, such that tolerance for the additional disease risks is higher. Augmentations could also be paired with temporary, short-term efforts to reduce carnivore densities before and during the introduction to facilitate an immediate population increase.

Mountain goats were transplanted from Round Butte in 2008 and the Crazy Mountains in 2009 to augment the population on Ear Mountain, where this collared goat was photographed in 2012. Photo by James Marlen.

New population introductions also have the potential to overlap the distribution of bighorn sheep herds, and therefore can pose a risk of pneumonia-associated pathogen transmission to bighorn sheep. Given the disease risk aversion in the working group, any new population introductions should overtly consider disease transmission risks, mitigate them where possible, and ensure that affected stakeholders and agencies are willing to take the risks.

Reducing hunter harvest in small populations of mountain goats could have a large, positive effect on the number of populations meeting trend objectives. Harvest opportunity has already been substantially reduced in many areas and should be considered in other areas. Recent hunting regulation changes in Montana have also focused on reducing harvest of adult female mountain goats in some areas, and this should also be considered in other areas that are not meeting an increasing population trend objective. However, in introduced populations with high productivity, higher harvest rates may be useful for managing population sizes below carrying capacity to prevent forage over-utilization, population crashes, and population dynamics similar to those of long-established, native herds.

Using hunter harvest to reduce carnivore density is predicted to reduce predation on mountain goats and have a large positive effect on the number of mountain goat populations reaching population trend objectives. However, lacking empirical evidence, there is high uncertainty about whether the effect would be realized, or whether the effect would be large or small. Reducing predation should therefore be contemplated in a research or learning context that would reduce uncertainty about population dynamics and the effects of the action. An increased carnivore harvest strategy would also generate public conflict, so if pursued it should be done in a manner that maximizes public involvement, where there is a likelihood of success, and with uncertainty in the outcome being transparently communicated.

Mountain goats are accessible as prey for large carnivores on winter range in Trout Creek, near the Great Burn Proposed Wilderness. ***Photo by Liz Bradley.***

Area closures of important mountain goat habitats to human activities should only be considered in areas where impacts of human activities on mountain goat populations are relatively clear, because area closures are not predicted to have a substantial effect on the number of mountain goat populations meeting trend objectives. Montana has yet to see the level of human disturbance, and the associated impacts to mountain goat populations, that other states and provinces have, but the working group recommends being ready to pursue this action where it is needed. Area closures are predicted to increase social conflict more than any other action that was evaluated. If pursued in Montana, area closures should be pursued in a publicly transparent way that clarifies the intention to protect struggling mountain goat herds for the public and decision makers to weigh against the human opportunities that would be lost. Further, the effects of area closures on mountain goat population trends are based on model structure and assumptions for which empirical data do not exist. If area closures are undertaken, the effects on mountain goat populations should be monitored to evaluate model assumptions and inform future actions.

We identified two priority information needs for mountain goats in Montana: 1) to learn about mountain goat population dynamics and 2) to learn about pneumonia-associated pathogens in mountain goats and bighorn sheep. Decreasing uncertainty estimates will affect our predictions and selection of optimal management strategies related to increasing the number of mountain goat herds meeting their trend objectives.

Area closures of important mountain goat habitats to human activities should only be considered in areas where impacts of human activities on mountain goat populations are relatively clear. ***Above: Glacier National Park, Wesley Sarmento photo.***

Better population data on mountain goats has been an information need for over 5 decades in Montana and is also a central part of mountain goat management plans in neighboring jurisdictions. This information need includes developing improved, Montana-specific estimates of mountain goat population sizes, vital rates, and age structures; and inferences regarding the effects of carnivore harvest, protection of habitat from human use, and translocations on mountain goat populations. Several strong, simplifying assumptions were included in our predictive population model. These assumptions lead to predictions of positive effects of taking certain management actions, yet no empirical mountain goat data exist to support these assumptions.

FWP and the U. S. Forest Service are partnering to avoid or mitigate effects of human development or recreation on mountain goats and to minimize habituation. ***Above: Heart Lake Trail in the Great Burn Proposed Wilderness, photo by Liz Bradley.***

Relatedly, analyses are needed to determine the viability of struggling mountain goat herds across western Montana, and whether some of these herds are at risk of extirpation. We assumed that small, struggling mountain goat herds will not become extirpated within our prediction time frame of 50 years for occupied mountain goat habitat. This critical assumption likely results in positive bias in our predictions for alternatives that do not involve taking action to improve population trends in small, struggling herds. High probabilities of extirpation would likely increase the tolerance of decision makers for taking actions and risks, such as population augmentations, to forestall extirpation of smaller herds.

The second priority information need that we identified is for information about pneumonia pathogens in mountain goats. This includes estimates of the pneumonia-associated pathogen communities in Montana mountain goat herds and quantification of the health and population effects of mixing pathogen communities when mountain goat and bighorn sheep herds are mixed during translocations. If mountain goat translocations are not going to be implemented, this information need is not critical. However, if mountain goat translocations to establish new herds or to augment existing herds, or translocations of bighorn sheep into mountain goat herd units, will be implemented, disease risks can be reduced with more information about the pathogen communities of mountain goat and bighorn sheep herds with a focus on source and recipient areas first. More information on the biological effects of mixing microbial communities among mountain goat and bighorn sheep herds would be of great worth to informing mountain goat management going forward. Establishing a biological rationale for the actual risk associated with mixing microbial communities when mountain goats or bighorn sheep are transplanted will be pivotal in decision analyses. Nevertheless, uncertainty about disease processes and pathogens in mountain goat and bighorn sheep herds is going to remain into the foreseeable future. A better understanding of the risk tolerance among wildlife managers, decision makers, and the engaged public for pneumonia epizootics in bighorn sheep or mountain goat herds that arise from management actions is therefore also needed.

FWP Region 3 and Wildlife Health Program staff conducted a helicopter capture of mountain goats in the Crazy Mountains in February 2016 to test the herd for exposure to pneumonia-associated pathogens that mountains goats share with bighorn sheep and domestic sheep. Photo by Jennifer Ramsey.

Both biological information needs that we identified, related to uncertainties in population dynamics and disease risks in mountain goats, affect achievement of fundamental objectives and are affected by the management actions included in our alternatives. Because the management actions we included are likely to be repeated in time or across the state, these uncertainties could be reduced through development of an adaptive management program. Focused research and monitoring programs could be implemented in concert with management actions in a way that decreases these uncertainties and improves the achievement of fundamental objectives in the future or in other areas. These information needs are closely related; for example, Montana-specific mountain goat population dynamics data will be key to understanding the effects of pneumonia pathogens and management actions such as translocations that create disease risks. These uncertainties might therefore be reduced in concert with one another in a carefully designed adaptive management program.

If priority information needs were addressed in succession, focusing on understanding pneumonia pathogens in mountain goats first would make the most sense because this information has the largest effect on the overall decision. The optimal choice among management actions is affected by the goal of minimizing disease risks, disease risk tolerance, and associated biological and social information needs. Disease risk tolerance has a strong effect on the weight of support for mountain goat translocations, and translocations potentially have the largest effects on the fundamental objectives of increasing area occupied and number of herds meeting population trend objectives. Therefore, a greater understanding of pneumonia pathogens in mountain goats has the highest potential to influence informed decision-making and achievement of fundamental objectives for mountain goat conservation.

Mountain goats have declined across much of their native range in Montana, raising concerns for their present and future status, and for lost outdoor experiences involving mountain goats, including hunting. ***Above: Bridger Mountains, photo by Torrey Ritter.***