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Original Article

Distinguishing Values From Science in Decision Making: Setting Harvest Quotas for Mountain Lions in Montana

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ABSTRACT The relative roles of science and human values can be difficult to distinguish when informal processes are used to make complex and contentious decisions in wildlife management. Structured Decision Making (SDM) offers a formal process for making such decisions, where scientific results and concepts can be disentangled from the values of differing stakeholders. We used SDM to formally integrate science and human values for a citizen working group of ungulate hunting advocates, lion hunting advocates, and outfitters convened to address the contentious allocation of harvest quotas for mountain lions (*Puma concolor*) in west-central Montana, USA, during 2014. A science team consisting of mountain lion biologists and population ecologists convened to support the working group. The science team used integrated population models that incorporated 4 estimates of mountain lion density to estimate population trajectories for 5 alternative harvest quotas developed by the working group. Results of the modeling predicted that effects of each harvest quota were consistent across the 4 density estimates; harvest quotas affected predicted population trajectories for 5 years after implementation but differences were not strong. Based on these results, the focus of the working group changed to differences in values among stakeholders that were the true impediment to allocating harvest quotas. By distinguishing roles of science and human values in this process, the working group was able to collaboratively recommend a compromise solution. This solution differed little from the status quo that had been the focus of debate, but the SDM process produced understanding and buy-in among stakeholders involved, reducing disagreements, misunderstanding, and unproductive arguments founded on informal application of scientific data and concepts. Whereas investments involved in conducting SDM may be unnecessary for many decisions in wildlife management, the investment may be beneficial for complex, contentious, and multiobjective decisions that integrate science and human values.

KEY WORDS harvest quotas, human values, integrated population model, Montana, mountain lion, public working group, *Puma concolor*, science, structured decision making.

Decision making in wildlife management incorporates both human values and science (Riley et al. 2002). Management agencies are typically required to seek input about decisions from their constituencies; this input commonly reflects values of the diversity of stakeholders invested in outcomes of wildlife management. Within constraints of laws, regulations, and mandates, management agencies seek to combine stakeholder input with scientific information to make decisions. All decisions are ultimately based on human values (Keeney 1996, Gregory et al. 2012); scientific input is included in wildlife management decisions because scientists, managers, and many stakeholders value the assurance it offers that wild populations will be effectively managed (Runge et al. 2013). Science is therefore part of the decision-making

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process only because it is valued; because other, nonscientific values are also considered, science informs but does not dictate decisions on wildlife management.

Science can arbitrate among competing values. Scientific findings are rarely specific to a particular decision and include uncertainty, so they can be framed to advocate for specific management decisions based on competing human values. Integration of human values and science in decision making is generally informal (Runge et al. 2013); therefore, the potential for misunderstanding and conflict among decision makers, managers, and stakeholders can be strong. This can lead to intractable conflict where stakeholders with differing values can claim scientific support for their respective positions. To such groups, the expertise and experience of wildlife managers may hold limited credibility (Riley et al. 2002); without explicit application of science to a decision, managers can have considerable difficulty arbitrating among differing claims of scientific support for advocated positions and decisions. Further, decision makers are often challenged to interpret and incorporate input that may reflect undisclosed values outside the scope of the decision.

Structured Decision Making (SDM) is a formal decision-making process that can be used to address complex issues in wildlife management by explicitly integrating diverse, complex, and contradictory considerations that can make identification of optimal solutions difficult when using informal processes (Keeney 1996, Gregory et al. 2012, Runge et al. 2013). Products of the SDM process include decisions that are transparent, inclusive, replicable, and thus ultimately defensible in a public forum. Structured Decision Making is not appropriate to all settings in wildlife management; in particular, where conflict between parties involved in a decision is substantial, finding a solution may require other approaches (e.g., mediation, joint fact finding, or conflict resolution; Runge et al. 2013). Use of SDM can be highly effective, however, where single decision makers or a decision-making body (e.g., a fish and wildlife commission) must reach optimal solutions to the complex, multiobjective challenges common in wildlife management. In particular, SDM makes scientific information and human values involved in a decision explicit, allowing for formal evaluation of relative importance and tradeoffs between them. We illustrate how SDM was used to formally distinguish the roles of values and science for a contentious decision: setting regional harvest quotas for mountain lions (*Puma concolor*) in western Montana, USA.

This SDM process took place in west-central Montana, in administrative Region 2 of Montana Fish, Wildlife and Parks (MFWP; Fig. 1), which included the city of Missoula. As the agency responsible for wildlife management in Montana, MFWP recommends harvest regulations (e.g., seasons, quotas, etc.) to the Montana Fish and Wildlife Commission, the decision-making body. Mountain lion populations in west-central Montana have grown in recent years (Robinson et al. 2013, 2015) and were recently identified as a primary source of mortality and limiting factor for survival and recruitment of elk (*Cervus canadensis*) calves (Eacker et al. 2016, 2017). As a result, managers and ungulate hunters became increasingly concerned about possible declines in populations of elk, mule deer (*Odocoileus hemionus*) and white-tailed deer (*O. virginianus*). Accordingly, MFWP established a harvest management plan with the intent to reduce the mountain lion population by 30% over two-thirds of Region 2 during 2012–2014, followed by a recovery period of undetermined length. Justification for this plan included increasing ungulate recruitment and populations and thereby satisfaction of deer and elk hunters. This decision was contentious when it was made in 2011; ungulate hunting advocates felt the quotas were too low and therefore unlikely to positively affect deer and elk recruitment, whereas mountain lion hunting advocates felt the quotas were too high and put the mountain lion population at risk of extirpation. The mountain lion harvest prescription implemented by MFWP was based on a density estimate of 2.87/100 km^2 extrapolated from Robinson et al. (2013, 2015). When a greater estimated mountain lion density of 5.12/100 km^2 was released (Proffitt et al. 2014, 2015), divisions among stakeholders were exacerbated and public debate about mountain lion harvest became highly rancorous, pitting 2 sets of stakeholders against each other: ungulate hunting advocates that wanted greater quotas and used the relatively high density estimate of Proffitt et al. (2014, 2015) to bolster their arguments, and mountain lion hunting advocates who wanted lower quotas, mistrusted the high density estimate, and bolstered their arguments with the relatively low density estimates of Robinson et al. (2013, 2015).

The resulting dispute about harvest levels for mountain lions in west-central Montana was such that MFWP was unlikely to have a publicly vetted proposal for harvest quotas for 2014 (the third year of the original harvest plan) for approval by the Fish and Wildlife Commission. To reconcile the strongly opposing stakeholder interests within the hunting community, MFWP convened a citizen working group comprising 12 resident mountain lion and ungulate hunters, including mountain lion hunting outfitters, non-outfitting mountain lion hunters, and deer and elk hunters and outfitters, some of whom had affiliations with local advocacy or sportsman groups. The 12 members were selected from applicants based on a clear commitment to a collaborative approach for achieving consensus, to balance opposing stakeholder values, and because of their ability to influence others within their stakeholder group. Because differing density estimates and predicted effects of different mountain lion quotas were central to debates about 2014 quotas in public meetings, a science team was assembled to estimate outcomes of different quotas considered by the working group. The science team consisted of wildlife scientists with expertise in mountain lions and population modeling. The task of the working group, supported by the science team, was to use the SDM process to develop a proposed harvest quota (i.e., distribution of quotas for lion harvest across the 27 hunting districts and Missoula special management area in west-central Montana) that was as acceptable as possible to both the ungulate and mountain lion constituencies.

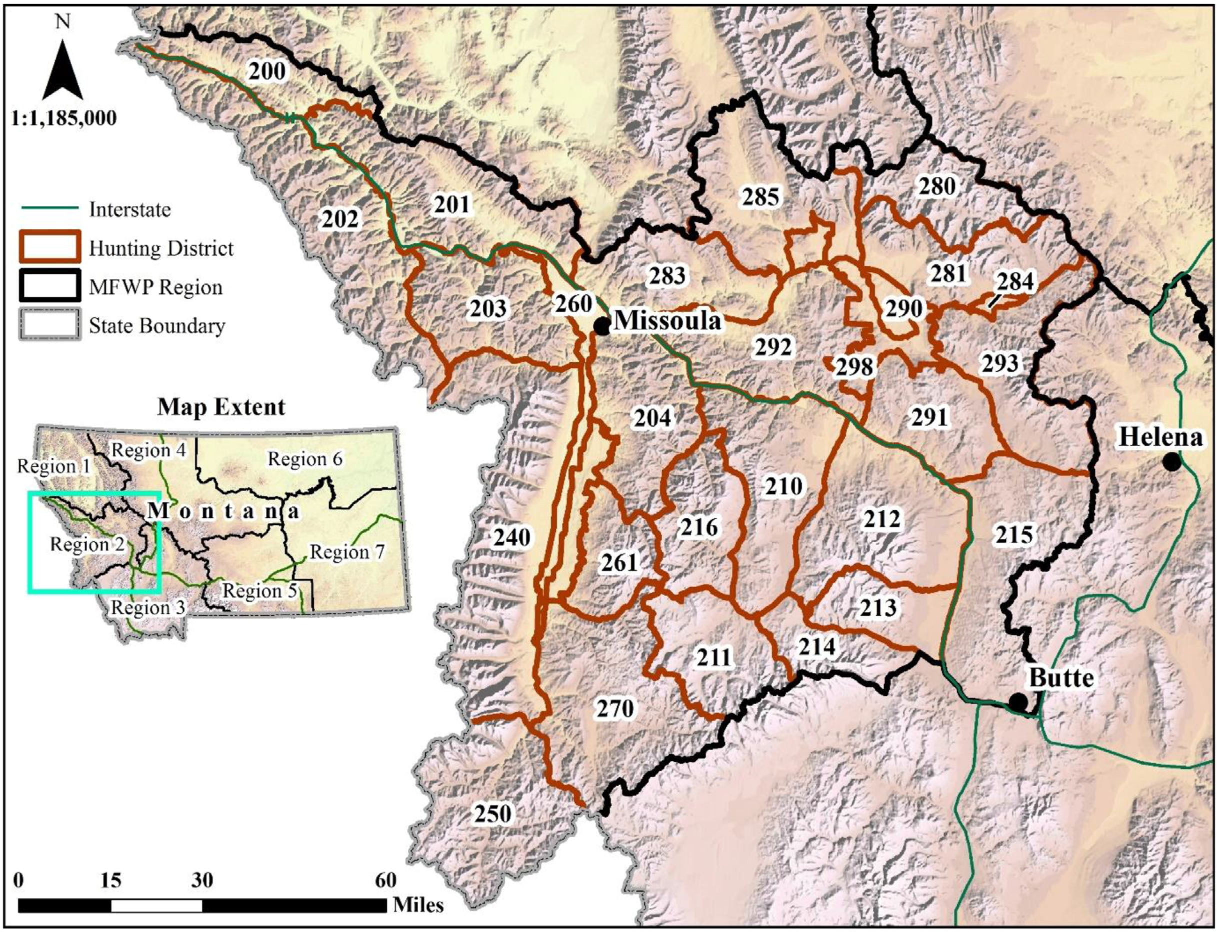

Figure 1. A Structured Decision Making process was used to develop recommended harvest quotas for mountain lions in west-central Montana, USA, in 2014 that included 27 hunting districts and the Missoula special management area located in Administrative Region 2 of Montana Fish, Wildlife and Parks (MFWP).

Application of Structured Decision Making

Structured Decision Making consists of value-focused thinking and logical decomposition of a decision problem. Because all decisions are inherently based on human values, discussion of those values should precede other analysis (Keeney 1996). Decomposition of a problem breaks a decision into logical components to create an explicit, transparent, and replicable framework for making optimal decisions that are less likely to be challenged. These components include defining the problem, identifying objectives, defining alternative actions, estimating consequences of those actions, and evaluating trade-offs among them (Table 1; Hammond et al. 1999, Gregory et al. 2012, Runge et al. 2013, Sells et al. 2016).

The citizen working group met for 4 days to participate in the SDM process. The group developed a problem statement, objectives, and alternative harvest quotas in the first 2 days. The group adjourned for 2 weeks thereafter, allowing the science team to predict the consequences for each of the alternative harvest quotas on mountain lion abundance for the following year (because quota decisions are made annually by the Fish and Wildlife Commission) and 5 years into the future (to better illustrate effects of the alternative quotas). The working group then reconvened for 2 days to hear results from the science team, evaluate the merits and trade-offs for each harvest quota based on those results, and determine a harvest quota they would recommend to MFWP.

Problem statement.—The problem statement developed by the group specified that differing expectations of mountain lion hunters and ungulate hunters were in conflict, where mountain lion hunters were concerned about a potentially declining mountain lion population and ungulate hunters were concerned about the effects of a potentially growing mountain lion population on ungulates. This conflict had produced strong disagreements, including 1) desired density and demographic structure of the mountain lion population; 2) harvest levels, and sex and age structure of the harvest needed to achieve the desired outcomes; and 3) effect of mountain lion predation on ungulate population dynamics.

Objectives.—The working group decided on a set of objectives that should be addressed by any harvest quota alternative:

1. Maximize satisfaction of resident mountain lion hunters.
2. Maximize satisfaction of nonresident mountain lion hunters.

Table 1. Steps of Structured Decision Making (Hammond et al. 1999, Gregory et al. 2012, Runge et al. 2013, Sells et al. 2016).

Step	Description	Input
Problem statement	Defines the context for a decision, identifying goals that need to be met, legal considerations, actions that need to be taken, why taking action is difficult, and the role of uncertainty.	Mandates, laws, policies, preferences
Objectives	Represent what might ideally be accomplished by resolving the problem. No decision alternative is likely to meet each objective equally. Variation in the degree to which alternatives meet objectives allows evaluation of tradeoffs and identification of optimal solution.	Mandates, laws, policies, preferences
Alternatives	Options the decision maker can choose from to address the objectives; they should be unique, encompass a diversity of possible actions, and be financially, legally, and politically reasonable.	Management actions, uncertainty
Consequences	Predicted consequences of each alternative for each objective. Predicted consequences are numerical (e.g., population estimates, constructed scores based on professional opinion), allowing for quantitative analysis.	System understanding, research, monitoring, public surveys
Trade-offs and optimization	Analysis of predicted consequences quantifies tradeoffs among alternatives for satisfying individual objectives and the extent to which each alternative satisfies the full set of objectives.	Values, preferences, objective weights, risk attitudes, quantitative analyses

3. Improve ungulate numbers in at-risk hunting districts in Region 2.
4. Maintain acceptable densities of mountain lions for
   a. ungulate hunters
   b. landowners
   c. mountain lion hunters
   d. outfitters
   e. nonhunters
   f. nonresidents
   g. people inhabiting the urban–wildlife interface around Missoula
5. Improve support of all hunters for mountain lion hunting.
6. Improve public support for mountain lion hunting.

The group considered no alternative that would have arguably put the lion population at risk of extirpation, negating the need for an objective for preventing extirpation. The group defined satisfaction of lion and ungulate hunters as how each stakeholder group likely perceived hunting opportunity based on regulations (e.g., quota allocations that decreased opportunity for ungulate hunters would reduce satisfaction). The group used objectives for acceptable densities to reflect how different stakeholder groups perceived the mountain lion population. Objectives were not equally important to group members; therefore, each group assigned a weight to each objective on a scale of 0 (least important) to 1 (most important).

Alternatives.—The working group developed 5 alternative harvest quotas for the 27 hunting districts and the Missoula special management area in west-central Montana (Supporting Information, Table S1). Each represented a different strategy for mountain lion management, according to the different priorities of group members:

1. Status quo—Maintain original plan to reduce mountain lion population in two-thirds of the region for 1 more year, followed by an undefined period of population recovery.
2. Maintain the population—Keep the mountain lion population at current levels.
3. Reduce the population where ungulate populations are of concern—Increase harvest of female mountain lions in hunting districts where ungulate populations are below objective or trending downward.
4. Increase the population—Harvest fewer female mountain lions.
5. Increase the number of trophy animals in the population—Harvest fewer male mountain lions.

Estimation of consequences for alternatives.—Members of the working group predicted consequences for objectives by assigning a score representing stakeholder satisfaction from 1 (complete dissatisfaction) to 5 (complete satisfaction) to each objective for each alternative harvest quota. Prediction of consequences was based on perceptions of group members; numbers derived from formal public surveys would have been ideal but such surveys could not have been conducted before a decision on harvest quotas needed to be made. Group members assigned scores to objectives 3 and 4 based on estimates of population consequences for ungulates and mountain lions generated by the science team. To reflect the importance individual group members placed on each objective, member scores for each harvest quota for each objective were multiplied by the objective weights they assigned.

The science team predicted effects of each alternative harvest quota on the ungulate and mountain lion populations for 5 years following quota implementation. Consequences for the status quo alternative were predicted in 2 ways: 1) population reduction for a 5-year period, to illustrate long-term consequences if such a harvest strategy was maintained; and 2) elimination of adult female harvest after 1 year of reduction, consistent with the original plan of allowing population recovery following reduction. These estimates allowed the group to predict consequences for each harvest quota for objectives 3 and 4. Limited data available on ungulate populations and scientific understanding of how reduction of mountain lion densities can affect ungulate populations did not allow quantitative prediction of ungulate population responses to changes in the mountain lion population brought about by harvest. The science team therefore made qualitative predictions of negative, neutral, or positive effects of increased or decreased mountain lion densities on ungulate populations.

The science team estimated effects of each harvest quota on the mountain lion population in west-central Montana using integrated population modeling (IPM). Integrated population models combine multiple sources of demographic data to fit one overall population trajectory with associated measures of precision (White and Lubow 2002, Schaub and Abadi 2011). Primary data sources for these analyses included the number of animals harvested annually, age-at-harvest, abundance estimates, and telemetry data. Harvest data facilitated abundance estimation via age-at-harvest population reconstruction methods (Conn et al. 2008). Multistate survival models provided estimates of survival, harvest mortality, and other mortality from telemetered animals. Primary literature was also used to build informative prior distributions for pregnancy rates and litter size. The process model took the form of a matrix projection model with 4 age classes and 2 sexes. The 4 age classes included kittens (0–6 months), juveniles (6–18 months), subadults (18–30 months), and adults (30+ months). These classifications allowed age classes to experience differential vital rates and harvest, which increased consistency with previously published work and harvest regulations. Assumptions included equal sex ratio at birth and that kittens would achieve independence at 18 months of age. The first day for the model's annual population cycle was set to 1 December because this is the beginning of the harvest season; therefore, kittens were not exposed to harvest. Harvest regulations for lions in Montana specify that females accompanied by spotted kittens are protected; we therefore assumed collateral mortality of kittens orphaned by harvest was minimal. Harvest was incorporated by subtracting the observed or postulated harvest from the age- and sex-specific abundance at the biological beginning of each year, thereby treating harvest as fully additive (Robinson et al. 2014).

Group members disagreed strongly about current mountain lion densities; therefore, the IPM was used to forecast the trajectory of the mountain lion population for each harvest quota based on 4 different, extrapolated mountain lion densities: 1) 2.87/100 km^2 (Robinson et al. 2013, 2015); 2) 3.1/100 km^2, the lower credible interval reported by Proffitt et al. (2014, 2015); 3) 3.5/100 km^2, an estimate based on expert opinion of a mountain lion hunter offered during testimony to the Montana Fish and Wildlife Commission that some group members deemed credible; and 4) 5.1/100 km^2, the median value reported by Proffitt et al. (2014, 2015).

The science team made predictions of the number (with 95% credible intervals) of mountain lions $\geq$18 months of age per 100 km^2, for 2000–2019 for each harvest quota and each density estimate. Whereas the decision focused only on setting harvest quotas for 2014, IPM predictions extended to 2019 to visualize the different effects of each season type because differences in predicted effects of the harvest quotas were very small after 1 year. Predictions of the IPM based on 4 different estimates of mountain lion density differed in magnitude, but for each density estimate the predicted population trajectories of the alternative harvest quotas differed minimally (Fig. 2). For example, alternative 3 (the harvest quota designed to reduce the mountain lion population where ungulate populations are below objective or trending downward) always resulted in a predicted decline of the mountain lion population in west-central Montana, regardless of which estimate of mountain lion density was used. The effect of mountain lion density on IPM predictions was largest for low densities (e.g., Robinson et al. 2013, 2015) and smallest for high densities (e.g., the median estimate from Proffitt et al. 2014, 2015), but the direction of predicted effects was always the same for each harvest quota.

Each member of the working group used IPM model predictions to predict the acceptability to different stakeholders of the mountain lion densities produced by implementation of each alternative harvest quota, using a scale of 1 (highly unacceptable) to 5 (highly acceptable), based on personal experiences and perceptions. The 4 different density estimates had limited influence, so each working group member was asked to rely on IPM predictions from only 1 of the 4 estimates for mountain lion density. Predicted consequences of each harvest quota for each objective, (adjusted for each group member by importance weights they assigned) were averaged across the group. Final consequences were calculated by normalizing estimated consequences and multiplying them by importance weights (Table 2).

Tradeoffs and optimization.—The summed consequences for each alternative harvest quota (Table 2; Fig. 3) suggested that alternative 3 (reduce all mountain lions where ungulate populations are of concern) best satisfied all objectives among the harvest quotas. Alternatives 1 (status quo) and 2 (maintain the mountain lion population) scored nearly equally with support lower than alternative 3 by 14% and 17%, respectively. Alternative 5 (increase the no. of trophy mountain lions in the population) had moderate support, scoring 40% lower than alternative 3. Alternative 4 (increase all mountain lions in the population) had little support, scoring 69% lower than alternative 3 (Fig. 3).

Although ranking highest among the 5 harvest quotas, alternative 3 ranked worst for meeting objectives of maximizing satisfaction of mountain lion hunters and maintaining densities of mountain lions acceptable to mountain lion hunters. Although this quota would have best addressed values of ungulate hunting advocates, the working group deemed that its failure to address the values of mountain lion hunting advocates required development of a new alternative that better satisfied both stakeholder groups. This is consistent with the process of SDM because it does not make decisions but clarifies them, allowing changes to each step of the process as more is learned about the problem being addressed (Hammond et al. 1999, Gregory et al. 2012, Runge et al. 2013). The working group decided to develop a new alternative by modifying alternative 2 (maintain mountain lion population). This process involved in-depth negotiation among group members about allocation of mountain lion harvest across the 27 hunting districts and Missoula special management area in west-central Montana (Supporting Information,

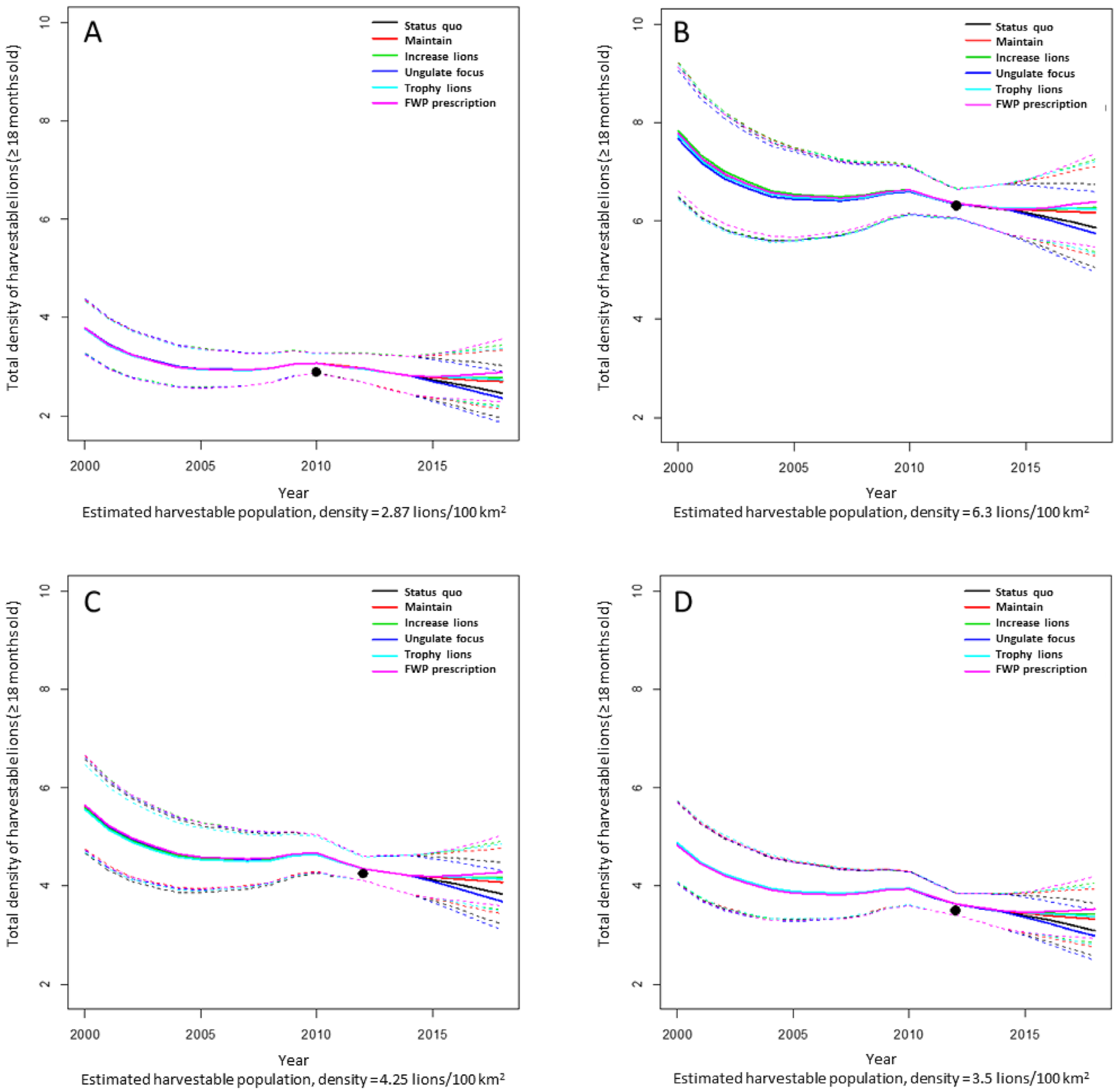

Figure 2. Predictions of integrated population models for 5 alternative harvest quotas based on 4 different estimates of mountain lion density (lions/100 km^2) in west-central Montana, USA. A = Robinson et al. (2013, 2015); B = median density from spatially explicit capture–recapture (SECR) analysis (Proffitt et al. 2014, 2015); C = lower confidence limit from SECR analysis (Proffitt et al. 2014, 2015); D = expert opinion of a lion hunter offered during testimony to the Montana Fish and Wildlife Commission, 2014. Dots represent the density estimates used to generate predictions, dashed lines represent credibility intervals.

Table S1). The process was contentious but collaborative among all members, involving compromise from all parties. The science team demonstrated that alternative estimates of density of the mountain lion population did not help distinguish among alternatives, so discussions revolved around acceptability of the different proposed harvest allocations among members, and ultimately to the hunting stakeholder groups represented.

The final recommendation from the working group differed from the status quo alternative originally proposed by MFWP by having 3 fewer total mountain lions but 20 fewer females in the allowable harvest (Supporting Information, Table S1). Compared with alternative 2 (maintain the mountain lion population), the final harvest quota allocated 12 additional females for harvest. This emphasis on harvesting females represented a strategy to reduce predation for a short-term benefit to ungulate populations without ultimately reducing growth of the mountain lion population due to harvest. Although the final recommendation for mountain lion harvest quotas from the working group differed little from the status quo proposed by MFWP, there was consensus among group members for the recommendation. Not all members of the group were equally satisfied by the recommendation, but all parties generally agreed that it was likely the best harvest quota achievable without alienating specific stakeholder groups.

Table 2. Consequences of alternative harvest quotas for mountain lions, estimated for management objectives identified and weighted for importance by a citizen working group as part of a Structured Decision Making process used to address harvest management of mountain lions in west-central Montana, USA, in 2014. Objectives and alternatives were developed by the working group and represent what would be accomplished by an ideal management strategy and alternative approaches to such a strategy, respectively. Weights represent relative importance of each objective, averaged across working group members. Estimated consequences, ranging from 1 (complete dissatisfaction) to 5 (complete satisfaction), were averaged across working group members and normalized. Colors reflect range of normalized, weighted values on a scale from red (lowest) to green (highest). Final score for each alternative is the sum of estimated consequences for all objectives.

		Alternatives				
Objectives	Weight	Alternative 1: status quo	Alternative 2: maintain lion population	Alternative 3: reduce all lions where ungulate pop. is of concern	Alternative 4: increase all lions	Alternative 5: trophy lions
Maximize satisfaction of resident lion hunters.	0.11	0.01	0.11	0.00	0.10	0.09
Maximize satisfaction of nonresident lion hunters.	0.05	0.05	0.00	0.05	0.01	0.05
Improve ungulate numbers in at-risk districts in R2.	0.10	0.10	0.04	0.10	0.00	0.00
Maintain acceptable densities of mountain lions for:						
Ungulate hunters	0.11	0.06	0.01	0.11	0.00	0.01
Landowners	0.06	0.05	0.02	0.06	0.00	0.00
Lion hunters	0.12	0.03	0.10	0.00	0.12	0.11
Outfitters	0.07	0.05	0.05	0.07	0.00	0.03
Nonhunters	0.05	0.03	0.05	0.00	0.00	0.01
Nonresidents	0.03	0.01	0.02	0.03	0.00	0.00
Urban–wildlife interface	0.08	0.07	0.02	0.08	0.00	0.02
Improve sportsman support for lion hunting.	0.11	0.09	0.07	0.11	0.00	0.05
Improve public support for lion hunting.	0.10	0.07	0.09	0.10	0.00	0.05
Final score		**0.62**	**0.58**	**0.71**	**0.23**	**0.42**

Outcome

Conflation of human values and science is inherent and common, perhaps unavoidable, when making decisions about wildlife management, where decision makers must strike a balance between best available science and public input. This balance is relatively easy to achieve when scientific results directly address clear, measurable objectives for a decision, but this situation is rare. More often, discerning the best available science requires a synthesis across a diversity of information resources, including expertise and studies that may be partially or tangentially related to the decision. This leaves room for subjectivity to influence alternative interpretations of applicable science because it is human nature to seek evidence to support existing beliefs (Kahneman 2011).

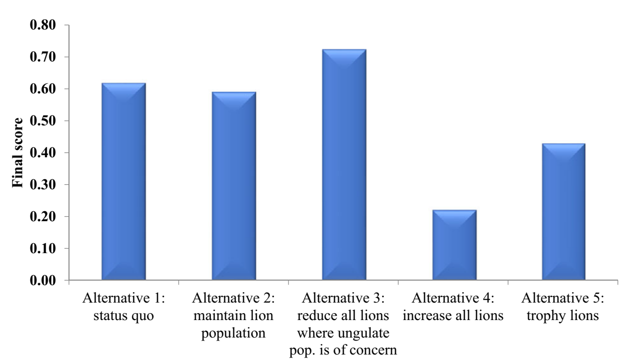

Figure 3. Decision support for 5 alternative harvest quotas for mountain lions in west-central Montana, USA, during 2014 generated through a Structured Decision Making process. Support was calculated by summing predicted consequences of each alternative for objectives designed to address social and biological considerations associated with allocating harvest quotas for mountain lions.

The SDM process sharpens focus of discussions inherent in complex decisions by clarifying values so there is little room for conflating them with science. Debate on the real issues underlying a decision can then proceed based on clear mutual understanding, if not agreement. The value placed on science is made explicit, so a false primacy and associated moral high ground of scientific contributions can be avoided. Further, SDM allows scientific contributions to be applied to decision making by using quantitative analyses to estimate biological and social consequences of potential actions. This process makes clear how science can and cannot inform a decision and minimizes debate about extrapolating science conducted in the past or elsewhere. Disagreement about the role of science can be addressed quantitatively and explicitly, minimizing effects of subjectivity. Importantly, uncertainty can be admitted openly so that all participants are aware of the limits of knowledge and its ability to foretell the future, despite having to make a decision now. This transparency allows the objectivity of science to be clear and thus more likely to be respected and valued by nonscientists.

Structured Decision Making provided a venue for disentangling problems contributing to a highly contentious issue within the hunting public that made making an effective decision about managing mountain lions in west-central Montana intractable. Specifically, arguments based loosely on science about mountain lion and ungulate populations obscured the true impediment to making a decision about mountain lion quotas, which was disagreement among hunting stakeholders about the desired trajectory of mountain lion populations, combined with a lack of acknowledgement and respect for differing opinions on the subject. Debate among hunting stakeholders prior to the application of SDM had been misdirected to a disagreement about the science and whether scientific findings from other locations or times were applicable to the decision. Personal opinions and advocacies for different scientific findings had become just as entrenched in the discourse between hunting stakeholders as the value-based positions held by many of the participants. In such cases, people are generally more willing to debate science rather than expose their core values to scrutiny and question. Using SDM to include science where it was appropriate to the decision forced group members to think about and articulate to each other the core values driving their advocacy. It would have been difficult to reach that point otherwise. Once the working group learned that neither density estimates nor the alternative harvest quotas made substantive differences to management outcomes, dynamics within the working group changed considerably. Group discussion pivoted sharply to allocation of harvest quotas among hunting districts based only on social acceptability to different working group members.

A member of the working group presented the group's recommended harvest quota to the Montana Fish and Wildlife Commission in 2014 and the quota was implemented for that hunting season. The benefits of the working group outlasted the proximate goal of setting harvest quotas for mountain lions for a single season. As part of the SDM process, the group concluded that a longer term plan was needed, recommending that Montana develop a statewide mountain lion management plan. Based on that recommendation, MFWP has been developing a statewide plan with broad public involvement. In the years since the working group's recommendation for a single year of harvest quotas, mountain lion and ungulate constituencies have generally agreed to maintain the recommended harvest quota as the new status quo.

Not all decisions in wildlife management necessarily benefit from an SDM process as in-depth as the one we present, which required a commitment of 4 days by 12 volunteers from the public, 5 scientists, and 2 facilitators, as well as several local biologists, managers, and decision makers. Additionally, concerted effort of facilitators, the science team, and working group members was required prior to, during, and following the SDM process. This represents a considerably greater investment of resources than what is normally required for most decisions about harvest management (but see Robinson et al. 2016). Although a typical process for making decisions about harvest management does not necessarily elicit the clarity and candor exhibited by our working group, most harvest management decisions are not as contentious and existing public processes are probably sufficient for making them. Application of SDM is commonly considered an upfront investment that reduces ultimate costs of making poor decisions (Runge et al. 2013). This investment is difficult to demonstrate given the hypothetical outcomes of decisions not made but can be warranted for difficult, complex, and intractable decisions. Assessment is needed prior to embarking on SDM to determine whether it is likely to be a more efficient use of time, money, and energy than existing (or alternative) processes.

For SDM processes involving working groups, selection of group members and relative representation of opposing viewpoints can have a critical effect on the outcome of the process. This can be particularly true where working groups consist of stakeholders drawn from the public, where failure to include a key viewpoint has the potential to produce an outcome that is later subverted or produces conflict with those who feel excluded. For example, our SDM process addressed a strong dispute among hunting stakeholders and did not include representatives of nonhunting stakeholders that were not heavily involved in the dispute but certainly had a stake in lion management. The outcome of our process therefore was not universally accepted by nonhunting stakeholder groups. Further, the outcome was not accepted by all members of advocacies that were represented in the working group. It was therefore critical that our working group members had influence and credibility within and outside their stakeholder groups to ensure group decisions were ultimately supported. When selecting working group members, there is also a fundamental question about whether represented stakeholder values should proportionally match the composition of those in the public, or whether opposing viewpoints should be given sufficient (and likely disproportionate) representation so the group can reach reconciliation on a key impediment to a decision. In our application of SDM, the quantitatively supported alternative (reduce mountain lions where ungulate populations are of concern) was not advanced because it did not maximize acceptability and satisfaction for mountain lion hunting advocates, who made up a large portion of the working group. In Montana, ungulate hunters (>200,000/yr) vastly outnumber mountain lion hunters (<5,000/yr). Had the working group been made up of representative proportions of ungulate and mountain lion hunters, the quantitatively supported outcome may have advanced without the support of mountain lion hunting advocates. Had this occurred, public contention would likely have returned to the impasse that existed prior to our SDM process. To avoid this, our working group members were selected to include both the influence of the mountain lion and ungulate hunting advocacies to help ensure that the primary decision-making impediment created by disagreement between these groups could be resolved to each group's satisfaction. Conceivably, including nonhunting stakeholders in our working group could have created broader acceptance of the outcome of our process by the general public, but the impetus for a SDM process was the intractable disagreement among hunting stakeholders. Objectives defined by the working group included satisfaction of nonhunters, but no representatives of nonhunting stakeholders were included in the group to ensure consequences accurately reflected their perspectives for that objective. The inclusion of nonhunting stakeholders in the group, however, would have introduced advocacies that had been only tangentially involved in the dispute, displaced hunting stakeholders that were strongly invested, and likely only marginally increased acceptance of the outcome by the general public.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of this article at the publisher's website.

Table S1. Alternative harvest quotas for mountain lions proposed in west-central Montana, USA, by a citizen working group as part of a Structured Decision Making workshop, 2014.