To Colorado Parks and Wildlife Commission members,

The undersigned address the two Colorado Parks and Wildlife (CPW) proposed mule deer strategy studies in the Piceance Basin[i] and Upper Arkansas River[ii]. We are concerned about the lack of "gold standard" for scientific inference, which is the "random assignment to control and treatment groups with experimental designs that avoid biases in sampling, treatment, measurement, or reporting," [1]. Neither of the proposed studies meets the gold standard, because (1) of a lack of proper control (zero cougar killing); (2) there is a risk of selection bias when treatments are not assigned randomly; and (3) the sample size is too small to make robust inferences. These factors preclude scientific conclusions from the studies. Moreover, the designs also raise (4) legal and ethical concerns.

While we understand that good experimental design is difficult, we also want to emphasize that ***poor design invalidates the conclusions and wastes taxpayer resources***. The references to the following fundamentals of research design are provided below our summary explanations.

1. Lack of proper control

(a) A proper set of controls and treatments would require at least 3 of each to achieve statistical robustness. Furthermore, the control sites must not experience cougar killing (legal and illegal take) and must experience every intrusion except cougars dying, e.g., the same number and intensity of intrusions as in treatment sites but no cougars killed. The current plan to allow ±10% cougar harvest in control areas is indefensible scientifically. Currently the design is flawed, just as if it were a biomedical clinical trial in which the researchers said, "experts don't know what effect this pill will have, so the control will be a low-dose and in the treatment will be a high dose."

(b) The Piceance Basin study, which involves killing black bears and mountain lions on one parcel of land and then comparing that to an area with no predator control from 2010-2012, is called a pseudo-control or false control. The other area was studied at a different time and place under very different conditions than today.

(c) Under the current design, each spatial unit is a single replicate. Events within a unit are not independent of other events within that unit. A more robust design would reverse-treatment within each unit, which receives a treatment by random-assignment, not by researcher selection of sites for treatments. Although the Arkansas River study looks more robust, it remains a sample size of 4 and the lack of a true control will make the results impossible to interpret scientifically.

2. Selection bias

The Upper Arkansas River proposal states, "Deer data analysis unit (DAU) D-16 (Figure 1) was identified as an area where cougar suppression could be beneficial to the deer population."[iii] This subjective decision will invalidate the scientific value of the proposed study in a single step. When treatments are assigned according to the response variable that one wishes to measure, you have guaranteed a sampling bias that would invalidate the study. Remember, a treatment is a hypothesized solution. If one designs a study with the assumption that the solution will work, one risks intentional bias in measurement and reporting. Random assignment is far easier and more robust to these biases and protects the researcher from claims of intentional bias.

3. Small sample size

With fewer than 6 study units (3 control and 3 treatment), there is no statistical test that can reliably confirm or reject the research hypothesis. That requirement for 6 or more arises because each unit is a single replicate. Events within a unit, such as the survival of a marked mule deer, are not statistically independent of other events (i.e., another mule deer's survival) in that same unit. They have all experienced the same treatment and confounding variables associated with that unit. We suggest a reverse-treatment design to increase the sample size but that recommendation MUST be accompanied by random-assignment or it can produce another form of bias (treatment bias). Although the Arkansas River study looks more robust because of the crossover design (reverse-treatment), it does not have random assignment and the low-level of cougar killing throughout both units and throughout the study creates a pseudo-control that invalidates the experiment.

Given the four units chosen for the studies, the CPW could achieve a sample size of 8 if they are willing to assign treatment and control randomly and then reverse the treatment in each unit in the following phase of the study.

References to research design and narrative explaining the principles:
In 1964, in the journal *Science*, Platt hypothesized about scientific progress with the deceptively simple title "Strong Inference" [2]. Platt hypothesized that certain fields advance slowly and others quickly because their practitioners varied in the efficiency with which they tested between alternative, opposed hypotheses. He observed that the slower fields of his time had become bogged down by the perception that their topic was too complex for simple tests. Platt [2] anticipated the argument and countered that their models were becoming too complex to be falsifiable. Falsifiability is a foundational principle of good science. Platt also predicted that slower fields had become bogged down by a focus on methods, as opposed to rapidly advancing fields that had focused on incisive experiments that forced alternative hypotheses into divergent predictions [2]. Subsequent writers have echoed his views in their particular fields (biomedical research, paleo-sciences, and population biology, among others) [3-6].

In ecology today, we see examples of both of Platt's hypothesized brakes on progress when one hears that ecosystems are too complex to manipulate experimentally, rather than calls for elegant ecological experiments as we saw decades ago [7-10]. The field of predator ecology is at that crossroads. The traditional hypothesis is that killing predators equals more prey. That view has been disputed as long ago as Leopold (1949) who proposed the alternative that functional predator populations keep ecosystems healthier. CPW is facing this question today. However salutary efforts emerged recently by predator-prey ecologists who had conducted careful experimental manipulations to exclude or include predators from complex ecological systems [11]. We see the salutary effects today in important arguments over whether wolves – and other large carnivores such as big cats – strongly shaped biodiversity by scaring herbivores and feeding on herbivores [12-14]. Resolving that scientific debate will demand strong inference. The strong inference espoused by Platt [2] is best served by gold standard experiments using random assignment to control and treatment with sufficient sample sizes to overcome random variation that may confound an elegant test of an important hypothesis.

4. Legal and ethical considerations

Wildlife are a public trust asset and the proposed studies preferentially serve a narrow community of mule deer hunters and cougar hunters, while ignoring the broad public interest in healthy ecosystems, unimpaired wildlife populations, and transparent accounting for wildlife assets. If CPW is held accountable in court or by the legislature for its management of cougars and black bears, the proposed studies will not survive the legal test for a prudent trustee of the public interest in wildlife.

The Colorado Supreme Court characterized the public trust in wildlife, and the privilege of hunting wildlife granted by the state, in similar language:

The ownership of wild game is in the state for the benefit of all the people. The right to kill game is a boon or privilege granted, either expressly or impliedly, by the sovereign authority, and is not a right inhering in any individual. The power of the state to make regulations tending to conserve the game within its jurisdiction is based largely on the circumstance that the property right to the wild game within its borders is vested in the people of the state in their sovereign capacity; and, as an exercise of its police powers and to protect its property for the benefit of its citizens, it is not only the right but it is the duty of the state to take such steps as shall preserve the game from the greed of hunters.[iv]

For these reasons, we conclude that these two studies be denied in their current state by the CPW Commission and drastically reexamined to implement the gold standard for scientific inference. As is, these studies will offer no valid conclusions and misuse already limited funds.

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[i] http://cpw.state.co.us/Documents/Research/Mammals/Piceance-Basin-Predator-Management-Plan-Overview.pdf
[ii] http://cpw.state.co.us/Documents/Research/Mammals/Upper-Arkansas-River-Predator-Management-Plan-Overview.pdf
[iii] http://cpw.state.co.us/Documents/Research/Mammals/Upper-Arkansas-River-Predator-Management-Plan-Overview.pdf
[iv] Maitland v. People, 93 Colo. 59, 62, 23 P.2d 116, 117 (1933).

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Piceance Basin[1] Predator Management Plan Overview

ADDRESSING EARLY MULE DEER FAWN SURVIVAL IN THE PICEANCE BASIN

The Piceance Basin in northwest Colorado (GMU 22) represents winter range supporting the largest migratory mule deer population in Colorado. This area has been the focus of research and monitoring efforts since the late 1940's and represents one the best documented mule deer populations in North America. Previous CPW Research efforts conducted during the 1980s through mid-1990s documented a high density population (mean winter density = 63/km^2) that appeared to be primarily limited by winter severity and forage conditions on winter range. During the early 1990s, this population declined to about 1/3 of the previous winter range density (mean winter density = 23/km^2), likely due to exceeding the forage capacity on winter range to support the previously high deer densities.

Thirteen years later (January 2008), another CPW research effort was initiated to address mule deer/energy development interactions in the Piceance Basin, where similar information is now being collected to provide comparisons to mule deer demographic data from the 1980s and early 1990s. In comparing data between the 2 time periods (1982-1990 before the decline and 2008-present), December fawn weights have increased (averaging 8.6 lbs heavier), winter fawn survival (December - June) has more than doubled (averaging 0.716 versus 0.351), and winter starvation has become rare (<3% of collared fawns), which was common during the 1980s (averaging 33% annually), but early winter fawn recruitment (December fawn counts) has declined from about 73 fawns/100 does to 49 fawns/100 does. Higher winter fawn weights, survival, and low starvation frequency suggests mule deer in the Piceance Basin are no longer limited on winter range, but lower December fawn counts has limited this populations ability to recover to historic levels. Similarly high fawn survival and low winter fawn counts have also been documented in other Colorado mule deer DAUs that have experienced previous population declines.

Because winter fawn survival is high, but overall fawn recruitment (# of fawns becoming adults) is low, CPW proposes to understand early fawn survival from birth until December. CPW has been addressing newborn (neonate) fawn survival in the Piceance Basin the past 4 years. Thus far, neonate survival has been relatively low (~40%) and largely due to predation (44% of collared fawns), but managers have been unable to confirm whether predation is limiting overall fawn survival or fawns dying from predation are weaker, on average, and would otherwise likely have died prior to adulthood. To address the reason for lower December fawn counts in the Piceance Basin and identify potential management options, CPW proposes to continue monitoring newborn fawn survival for another 3 years and reduce predator densities (black bears and cougars) during the spring fawning period to evaluate this approach for increasing early fawn survival. This information will indicate if predation is most limiting or if maternal or fetal condition predisposes fawns to lower survival and ultimately reduces their recruitment as adults. Conditions in the Piceance Basin are comparable to other western Colorado mule deer populations and this information will likely be applicable to declining deer herds in the western third of the state.

Approach: CPW proposes to monitor fawn survival on two adjacent birthing (parturition) areas over the next 3 years, one receiving predator reduction and the other without any predator reduction efforts (Figure 1).

To be most effective in applying predator reduction to sufficiently reduce predation rates the Western Association of Fish and Wildlife Agencies Mule Deer Working Group (2012) suggests focusing on relatively small areas during critical survival periods when habitat and climate factors are non-limiting. Thus, CPW proposes to focus predator control efforts on a relatively small summer range parturition area on the Roan Plateau (1,277 km^2) during May and June just prior to and during the fawn birthing period. CPW will compare survival rates to an un-manipulated parturition area to the east between Meeker and Rifle; newborn mule deer fawn survival in the absence of predator control has been documented in these areas from 2010 - 2012. Because the predator reduction area consists primarily of private lands (mostly energy companies) and hunting seasons are not available during the spring, specialized contractors will conduct predator control efforts. Predator control efforts will focus on black bears and mountain lions because these species have been connected to predation of at least 25% of the collared fawns monitored since 2010; predation from all other predators is typically ~10%. Cougar and black bear removal methods employed will consist of cage traps, culvert traps, foot snares, and trailing hounds for capture and a firearm will be used for euthanasia. Predator control personnel will make every effort to salvage all black bear and cougar carcasses for CPW disposal (gall bladders, skulls, claws and hides) or distribution (meat). CPW anticipates predator removal levels to range between 5-10 cougars and 10-15 black bears annually. Higher removal levels are possible and could be as high as 15 cougars and 25 black bears. While the objective is to reduce cougar and black bear densities in this focal area, overall densities at the Data Analysis Unit scale should be minimally influenced. The proposed reductions in predator densities also coincide with the current management objectives in this rural area to maintain relatively low predator densities for enhancing big game populations and reducing livestock conflicts. CPW will consider predator reduction effective if fawn predation rates from black bears and mountain lions is reduced to ≤10% and a subsequent increase in fawn survival is documented.

[1]Between Meeker and Rifle

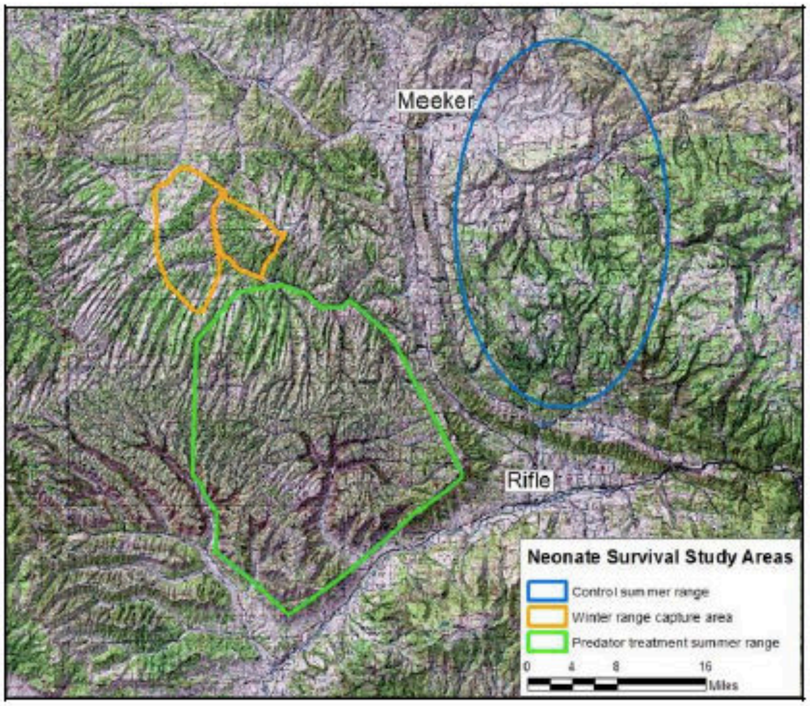

Figure 1. Mule deer winter and summer ranges, Piceance Basin, northwest Colorado. Pregnant adult females on winter range (orange boundary) will receive vaginal implant transmitters to facilitate neonate capture and collaring efforts in the predator treatment area (green boundary). Neonates in the control area (blue boundary) will be opportunistically captured to provide survival rate comparisons between summer ranges with and without focused predator reduction.

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Upper Arkansas River[1] Predator Management Plan Overview

ADDRESSING COUGAR PREDATION ON MULE DEER IN DATA ANALYSIS UNITS D-16 AND D-34

The recently adopted Colorado mule deer strategy identifies predation as one of the potential factors limiting Colorado mule deer populations. Since the adoption of the mule deer strategy by the Parks and Wildlife Commission, CPW developed a plan for the implementation of the strategy. As part of the implementation strategy, staff examined existing predator and deer research and monitoring data to identify areas where predation may be most limiting to mule deer, which in turn could be used to inform predator harvest/management decisions. In June 2015, CPW personnel met to explore the concept for a project that examines how deer populations may respond to cougar suppression.

Deer data analysis unit (DAU) D-16 (Figure 1) was identified as an area where cougar suppression could be beneficial to the deer population. Beginning in 1999, D-16 was added as one of 5 intensive deer monitoring DAUs in the state. From 1999-present, averaging across all years, the leading known cause of both doe (6.4%) and fawn (7.5%) mortality has been cougar predation. Cougar predation has averaged 28% of the total mortality for does and 32% of the total mortality for fawns. Currently, the population is below the long-term population objective (current objective 16,000-20,000 deer) and based on survival data, population growth may be limited to some extent by cougar predation on fawns and adult does.

A research project is proposed, beginning in the winter of 2016/2017, to examine the mule deer population response to cougar suppression. The study would be conducted in D-16 and the adjacent DAU, D-34. Harvest levels in these two DAUs would be used to create different cougar densities to examine the effects of cougar suppression in three stages. In stage one (years 1-3), cougar populations in D-16 will be suppressed (~50% harvest and human caused mortality), while cougar populations in D-34 will be allowed to increase towards habitat potential (~10% harvest). Stage 2 (years 4-6) represents a recovery stage where both populations will be allowed to increase towards habitat potential (10% harvest). The final stage (years 7-9) represents the crossover where D-34 cougar populations will be suppressed (~50% harvest and human caused mortality), while D-16 will continue to be allowed to increase towards habitat potential (~10% harvest).

CPW believes this is the first study that will examine the mule deer response to cougar population density in such a controlled experiment with significantly different cougar densities. These two disparate cougar densities should result in significantly different levels of predation mortality and an understanding of how predation impacts survival within the mule deer population. Through this manipulation we will also gain a better understanding of cougar harvest management and potential impacts on cougar populations.

The impact of cougar hunting on cougar populations, especially high levels designed to suppress populations, can be varied and is not well understood. A Wyoming study demonstrated that a cougar population could be significantly suppressed through 2 years of heavy harvest. Harvest rates of approximately 12% to 18% of the population have generally been shown as the tipping point between maintaining stable populations and decreasing populations. However, the percent adult female harvest is the crucial factor in population change. Understanding harvest structure as populations are manipulated throughout the experiment will provide critical information for management in the future as decisions are made about suppressing, maintaining or increasing cougar populations.

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One aspect of this study will be to closely examine cause-specific mortality of cougars and develop a thorough understanding of levels of mortality in relation to population size and hunting pressure. The progression of this study will enable us to directly measure cause-specific survival during declining and increasing phases of a cougar population and under heavy and light harvest scenarios. This will allow a clear examination of non-hunting mortality rates, such as disease, intra-specific strive, or other natural mortality.

Similarly, cause-specific survival of kittens throughout the stages of the project will provide essential information for management as this directly relates to population growth and recovery. Past research has suggested that increased harvest has actually led to decreased kitten survival because of infanticide (kittens being killed by other cougars). Increased infanticide has been suggested to relate to high male harvest as this leads to an increase in subadult males in the population and territorial instability. However, recent cougar research in Colorado has shown higher infanticide rates during a 5-year non-hunting period than the subsequent 5-year hunting phase of the study.

There is also the perception that high immigration rates of subadult males will lead to increases in human conflict and livestock depredation. Some studies have indicated that harvest and subsequent increases in subadult males have correlated with human-cougar conflict. However, others have found that demographic class did not relate to human-cougar interaction. This management experiment will provide direct information on human-cougar interactions with respect to changes in cougar populations, age structure, and immigration rates.

The objectives of this study are first to evaluate the effects of cougar population density on mule deer populations. In conjunction with this, CPW hopes to evaluate the effectiveness of sport hunting to achieve high rates of cougar harvest. In addition to evaluating the mule deer response, we will also examine the structure of the cougar harvest and the cougar population responses to harvest levels. Cougar demographic rates (cause-specific mortality, reproduction, immigration/emigration) will be estimated relative to population density and harvest level.

CPW is proposing this research project to examine deer population response to changes in cougar density to gain an understanding of how cougar harvest could be used as a deer management tool. A critical component of this includes understanding how the cougar population responds to various harvest levels so that CPW can balance deer management with cougar management.

[1]Leadville to Cañon City (D-16) and Poncha Springs to Walsenburg (D-34)

Figure 1: Study areas D-16 and D-34