Exhibit A

Center for Environmental Science, Accuracy & Reliability

Science or Advocacy?

ECOLOGY AND CONSERVATION OF GREATER SAGE-GROUSE: A LANDSCAPE SPECIES AND ITS HABITATS

An analysis of the four most influential chapters of the monograph.

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Introduction

An Endangered Species Act (ESA) listing of the greater sage grouse could result in myriad adverse effects on the economies of affected states and counties. Since virtually all economic activities in the affected states are identified as threats to the sage grouse's continued existence, ESA inclusion of the sage grouse will inevitably result in vast, costly economic disturbances. The U.S. Fish and Wildlife Service (FWS) has explicitly identified oil and gas related activities, power transmission and distribution, wind power production, urbanization, recreation, farming and ranching among activities threatening the grouse. FWS has also identified fencing, roads, and power transmission lines as contributing to the bird's decline.

Limitation or cessation of these activities will fundamentally change human and animal lives throughout the west. Removal of fences, roads and livestock will have a profound effect on economic activity as well as quality of life. The effects of an ESA listing of the sage grouse will occur in all eleven states where the bird is found, determining to a notable extent how and where food is grown, water is used, resources are extracted, and even where citizens can enjoy the beauty of natural resources.

Given the tremendous impact of an ESA listing to the human

Economic and social dislocations as profound as these are justified only if based on data demonstrating the accuracy and reliability of the FWS's assessment of the status of the sage grouse.

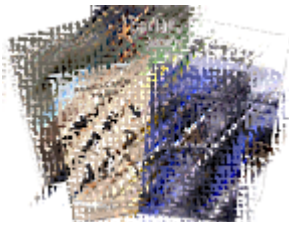
environment, a listing must be the result of a systematic consideration of all threats based solely on scientific data. Otherwise, the law does not authorize it. The Center for Environmental Science, Accuracy and Reliability (CESAR) is dedicated to ensuring that the ESA is fully and uniformly enforced, without bias. CESAR acts on the principle that accurate scientific data and thorough examination of its implications result in the conservation of natural resources and a thriving society. To this end, CESAR undertook an examination of the data supporting the FWS listing determination. Our intent is to lend insight into the scientific foundation for the determination in order to better understand any necessary conservation actions.

A listing must be the result of a systematic consideration of all threats based solely on scientific data

Our review focused primarily on the Cooper Ornithological Society's Monograph: *Studies in* Avian *Biology.* This monograph/volume is unusual in that it was written specifically as a primary resource document for the FWS's 2010 decision on greater sage grouse. Based on the information in the monograph, FWS determined the grouse was warranted for listing as "threatened" under the ESA but its listing was "precluded by other priorities." The decision was in part a result of repeated, and ultimately successful, litigation by various corporations invested in the issue.

A cursory review reveals a limited variety of sources and lack of adherence to standard peer-review protocols. Over one third of the authors were federal biologists (12 from the USGS, 1 from BLM, and 1 from USFWS, out of 38 authors).

However, when all authors were totaled across all papers, the proportion of federal authors was even higher (44%).



Studies in Avian Biology, Knick (USGS) and Connelly (Idaho Game and Fish), were also authors on multiple chapters (nine and seven papers respectively out of 25 chapters total). These numbers indicate that the editors were essentially reviewing, editing, and approving their own work for publication.

At least six months prior to being made available to the public, near-final chapters of *Studies in Avian Biology* were provided to the FWS as they were completed. These chapters were central in the FWS decision-making process regarding the potential ESA listing of the sage grouse. Information contained within the 25 chapters was distilled into a PowerPoint presentation by Carol Schroeder (Director, Forest and Rangeland Ecosystem Science Center, USGS) and presented to staff and decision-makers at the Department of Interior in Washington, DC on 31 July 2009. However, neither the chapters, nor the USGS presentation, were available for public review until November 2009, when the documents were posted on the USGS Sagemap website. This transparency was forced by repeated requests, including Freedom of Information Act requests. The chapters were then removed from the Sagemap website after publication in *Studies in Avian Biology* in July 2011.

These chapters were central in the FWS decision-making process regarding the potential ESA listing of the sage grouse…

USGS provided logistical support for the publication, and underwrote the financial costs including payment of page charges to the Cooper Ornithological Society (COS), the publisher of *Studies in Avian Biology*.

After being paid once by USGS for the project, *Studies in Avian Biology* became a profit center of the Cooper

Ornithological Society (COS) and is available for US$95.00 (hard copy or e-book format). The public cannot copy any text from COS's e-book version nor print any of its contents. This effectively limits distribution and restricts independent review while securing and increasing COS's profit. Compare this to the .pdf versions available temporarily on the USGS website at http://sagemap.wr.usgs.gov/monograph.aspx, documents that were easily accessed by the taxpayers who paid for their production at USGS and at COS.

This raises the question of whether the documents are a private product or a U.S. Government product since the taxpayers undoubtedly supported the production and publication.

We found only minor editorial changes between the final drafts posted online and used by the FWS for the listing decision and those included in the final *Studies in Avian Biology* monograph. However, the chapter numbers and order were changed, eliminating direct comparisons by chapter. Therefore, this review uses citations by year and chapter number (e.g. 2009 for the original posted chapters cited by the FWS (2010), and 2011 for the final version published in *Studies in Avian Biology*).

A quantitative measure of the importance of this monograph in the FWS's decision-making process can be found through a review of the 2010 sage grouse ESA-listing determination (FWS 2010). Three chapters in particular were cited numerous times (48 to 65 citations). We therefore review here: the introductory chapter and the three chapters most important to the listing determination. First we review the introductory chapter, *Greater sage-grouse and sagebrush: an introduction to the landscape* (Knick and Connelly 2009, 2011) because it sets the context for all of the chapters that follow. Next, we review the top three chapters cited by the FWS in its 2010 'warranted but precluded' decision on sage grouse. These are, in order of importance (the number of times they

were cited by FWS):

- 65 citations: Greater Sage-Grouse population dynamics and probability of persistence.
- 58 citations: Ecological influence and pathways and land use in sagebrush.
- 48 citations: West Nile virus ecology in sagebrush habitat and impacts on greater sage-grouse populations.

Finally, the recent questions raised regarding the scientific rigor and integrity of the science supporting other FWS regulatory actions[1] convinced us of the necessity for a thorough review of the data underlying the sage grouse science used for the listing status review.

We were unable to replicate the analyses published in the monograph as neither the data used in the analysis, nor the algorithms used for Population Viability Analysis are publicly available. This made it impossible for us to directly evaluate or replicate results independently. Thus, since the results are neither reproducible nor verifiable, the study fails the fundamental litmus test of sound science.

In addition to our own independent scientific review, CESAR also considered reviews conducted by scientists commissioned by the State of Colorado whose comments were ignored by the publishers and editors of the monograph. These scientists identified most of the same flaws in the work identified by our staff. Where appropriate, the pertinent comments are included. Where the content of one of these reviews is used, it is clearly indicated.

1 In re Consol. Delta Smelt Cases, 1:09-CV-00407 OWW, 2011 WL 3875512 (E.D. Cal. Aug. 31, 2011)

Chapter Analysis: Greater sage-grouse and sagebrush: an introduction to the landscape [2].

This introductory chapter provides background on sagebrush and sage grouse, summarizes previous research, and provides the context for chapters of the monograph. The authors, Knick and Connelly, assign considerable importance to their own research. Over one third of the citations in this chapter are papers or reports that Knick or Connelly have authored.

Further, peer review of this chapter was not independent: the three listed peer reviewers of this chapter (Naugle, Rotenberry, and Dobkin) were either coauthors on other papers in this monograph (Naugle was author on three papers, including a paper on which he was a coauthor with Knick and Connelly), or coauthors of previous papers with Knick and Connelly. The close collaborative relationship of the authors and coauthors clearly undermines the peer review process which requires independent peer reviewers with no real or perceived conflict of interest.

The authors state that harvest (from hunting) and predation are not significant factors affecting on sage grouse population trends. However, they present no data or quantitative analysis to support this supposition. Further, the accuracy of this claim is doubtful given that 207,433 sage grouse were harvested between 2001 and 2007 alone (Reese and Connelly (2009, 2011), and the level of predation on sage grouse reported by other authors. It is particularly questionable given the significance assigned to various threats for which there is little data on actual mortality,

2 Knick and Connelly 2009, 2011

such as livestock grazing, farming, or oil and gas development. Nevertheless the authors dismiss mortalities from hunting and predation, estimated to be as high as 10% of the population annually.

Knick and Connelly describe their rationale for delineation of a "Sage Grouse Conservation Area" to include a much larger area than that which sage grouse are currently or historically found. The area includes a 50km buffer surrounding a hypothetical "pre-European sage grouse distribution" and large areas within "historic range", but the authors provide no data or evidence of historic or current sage grouse populations (e.g. the desert of southeastern Utah). The 50km buffer increases the area of the author's proposed "Sage Grouse Management Area" by over 450,000km2. However, they provide no basis historical or otherwise to justify this change or reconcile their exclusion of areas where sage grouse are found and inclusion of areas where they have not been

found (historically or currently). No data is provided to support the rationale.

Knick and Connelly state that sagebrush ecosystems are naturally complex, hierarchically organized, and have an "integrated" structure and function:

"The model of sagebrush systems as a hierarchical organization arranged along spatial and temporal scales is one of the unifying concepts underlying the information presented in this volume (Fig. 4). This model presents ecological systems as an integrated assemblage of patterns and processes at smaller scales enclosed within successive levels at larger scales."

This approach evidences a belief that natural phenomena are governed by a predetermined purpose as opposed to blind natural laws. For such views to be expressed as a "unifying concept" by the editors and authors of an influential scientific monograph is highly unusual. The use of this approach would require experimental or empirical data to support the hypothesis and no such evidence is presented or referenced to support this model.

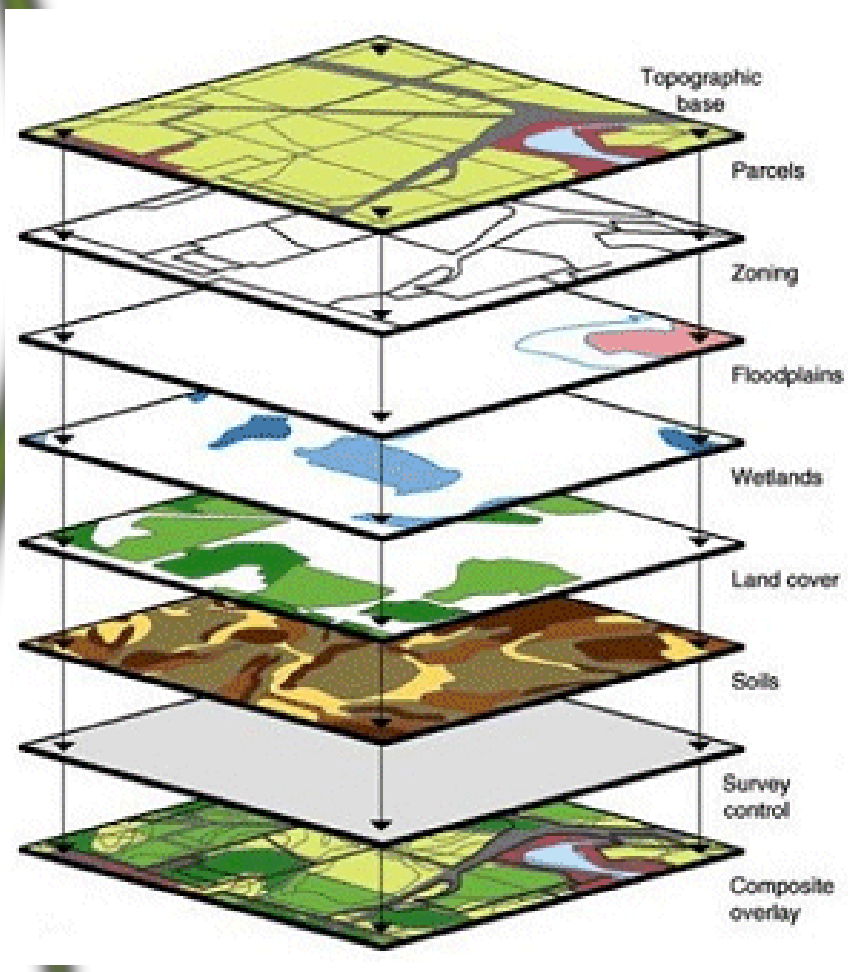
Knick and Connelly present an extensive list of potential threats to sage grouse, including:

- The conversion of sage brush to croplands (resulting in the reduction, elimination or fragmentation of sagebrush);
- Development of oil and gas resources;
- Exploration and development of wind and geothermal energy;
- Livestock grazing;
- Urbanization and increasing human densities ("as people choose to live near wilderness and recreation areas
- New corridors proposed for energy transmission;
- Roads;
- Increasing outdoor recreation (including off-highway vehicles and hiking); and,
- The "human footprint" (which "influences the landscape structure of sagebrush-dominated habitats for sage-grouse."

Oddly, hunting mortality and predation, two threats for which extensive data documenting their effects are available, were not included in this list. The authors do not explain exclusion of these threats.

Based on the opinions summarized above, the authors then conclude by translating this opinion into an unsupported policy rationale for federal regulation across eleven states, via federal law, the ESA.

The monograph relies critically on extensive GIS analysis to translate speculative habitat conditions into theoretical historical habitat, which is then compared to current potential sage grouse habitat. The theoretical habitat loss since European settlement is calculated through this exercise. As mentioned previously, areas known to be historically occupied by sage grouse were not included, and areas where there is no data of sage grouse occupancy are included. Speculative models are substituted for lack of historic data on sagebrush extent and sage grouse distribution, and are the basis of postulated historic habitat in the monograph. Thus, the "results" of this modeling exercise are misleading, as are the subsequent analyses that rely on it. In sum, it is not a scientific assessment relying on best available scientific data, but rather an advocacy document expressing the authors' preference for sagebrush ecosystem protection.



It is also worth noting that the scientific method was not used (no hypothesis testing) by any of the authors in this 25-chapter monograph. Instead, the authors rely on *post hoc* interpretation of results or purely descriptive approaches. The terms 'hypothesis' and 'hypotheses' appear only six times in the 25 chapters, and only to describe the work of cited authors. At the end of this review, we have included a chart identifying the data used to arrive at the conclusions in the report.

Chapter Analysis: Greater Sage-Grouse Population Dynamics and Probability of Persistence[3]

This paper was highly influential. The FWS relied on this chapter heavily in its 2010 sage grouse listing decision. Cited 65 times in that decision, the highest number of any chapter from the sage grouse monograph, it figured prominently in the FWS conclusion that the greater sage grouse deserved "threatened" status under the ESA. However, a close review of the analysis and data demonstrates flaws significant enough to completely undermine its conclusions. Specifically, both Garton et al. (2009, 2011) and the FWS (2010) downplayed or ignored known issues with the data provided in this paper, errors in formulas used, errors of omission, and bias with their analytical method. These errors were exposed when the Colorado Division of Wildlife, commissioned independent scientists to review its contents. These comments, which were formally submitted to the FWS, were uniformly ignored.

3 Garton et al. 2009, 2011

Sage grouse are ground dwelling, secretive birds with cryptic coloration, making census difficult. However, during the spring breeding season, sage grouse congregate at leks where the male sage grouse display conspicuously to attract potential mates. Beginning in the 1940's and 1950's, to gain information for setting hunter harvest levels, state biologists began counting adult male sage grouse attending the largest and most accessible leks. Over the next four decades, the number of leks counted increased approximately ten-fold.

Although male leks counts have been conducted by thirteen states and provinces for many years, there are numerous, well-known problems with this method, and these render it statistically invalid for estimating population number or trend. For example, the data gathered are a non-random sample of sage grouse leks and do not account for male sage grouse at unknown leks. Males move between leks which violates assumptions. Further, only males are counted at leks, and no provision is made for counting females or juveniles. As a result, the male lek count data represent an unknown proportion of total sage grouse.

Compounding the problem is the fact that thirteen different states and provinces collected data, often using different methods and unequal levels of effort. Repeated pleas from multiple authors to replace this traditional method with a statistically valid one have been ignored. As a result, determining population number and long-term trends across the entire range of sage grouse is not currently possible, no matter what analyses are applied to the data.

Despite these fundamental limitations, three attempts have been made to conduct range-wide analyses of male lek count data obtained from states and provinces: Connelly et al. (2004), Western Association of Fish and Wildlife Agencies (WAFWA 2008), and Garton et al. (2009, 2011). Each group employed different methods, including undocumented and subjective methods, for defining what constituted a “lek” and including/excluding lek counts obtained from them. As a result, even though each study used the same raw data provided by the states, the number of leks selected for analysis differed nearly three-fold (3,419 - 9,789 respectively) between WAFWA 2008 and Garton et al. (2009, 2011). A fundamental problem with this approach is that even if the raw lek-count data were publicly available (which it is not), subjective criteria were used to select the final data sets used in analyses, and therefore the analyses themselves, would not be reproducible.

The three studies also differed in their analytical methods and acknowledgement of the limitations of their data and analyses in inferring sage grouse population numbers or trends. While both Connelly et al. (2004) and WAFWA (2008) used a justifiably cautious approach and were unwilling to overstate the significance of their results to infer sage grouse population numbers or trends, the monograph authors[4] took the opposite approach. After acknowledging the potential limitations, these authors then use their analyses to make predictions of past and future population trends in sage grouse, and their probabilities of extinction, thirty and one hundred years into the future (from 2007) and emphasize the precision of their predictions.

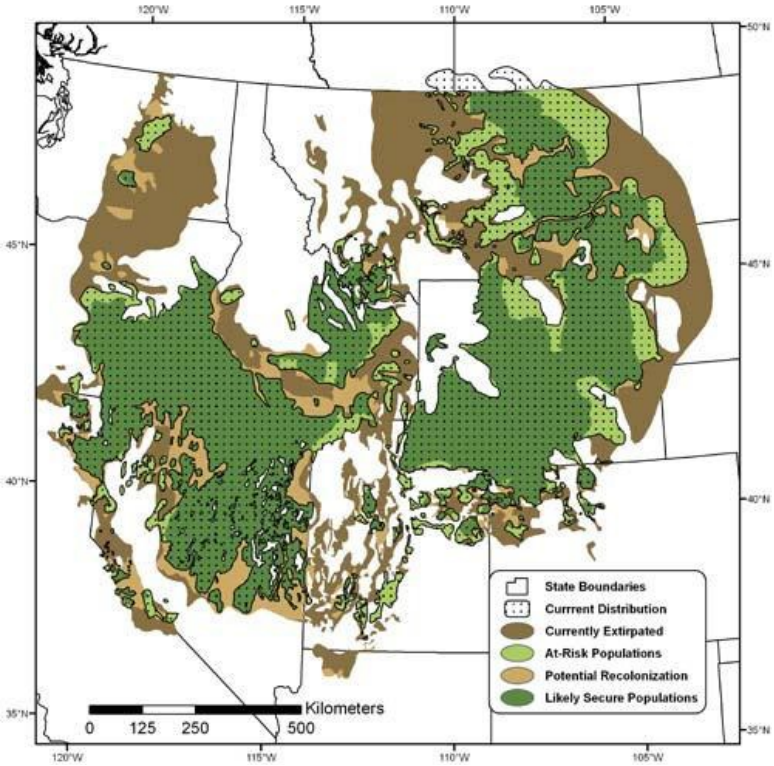
Specifically, the authors use lek count data to:

1) Estimate current population sizes (not valid for reasons discussed above);

2) Estimate past population sizes or "reconstructed population estimates" (backwards from 2007 to 1965);

3) Fit population growth models to these "reconstructed population estimates" (which

4 Garton et al. (2009, 2011)



are estimates and not empirical data); and 4) Forecast future population estimates and trends from the growth models, along with the probabilities of population persistence in the years 2037 and 2107. Probabilities of population persistence were based upon the proportion of model replicates where effective population size was above 50 or 500. Below these numbers, populations were considered extinct. (Note that future population estimates were based upon the earlier "reconstructed population estimates", and are not real data.)

The authors concluded by emphasizing the precision of their results and downplaying the limitations, ignoring the likely inaccuracy of their data and analysis. Then, inappropriately relying on precision rather than accuracy[5], the authors overstate the significance of the results to the future of sage grouse management.

The analysis fails to address the inherent bias[6] which occurs as a result of the data and analysis used. There are questions regarding the mathematical choices the authors make and the unacknowledged propagation of error in their models, that put their extinction predictions on par with guesswork. The data available to the authors of this article is acknowledged to be inadequate for the task.

The analysis and results included in the chapter contain mathematical errors and fail to clearly identify where assumptions have been made and, in some cases where assumptions are identified, they are questionable.

The analysis fails to address the inherent bias which occurs as a result of the data and analysis used. There are questions regarding the mathematical choices the authors make and the unacknowledged propagation of error in their models. The data available to the authors of this article is acknowledged to be inadequate for the task.

The article makes neither mention nor any effort to account for hunting mortality, even though over 207,000 sage grouse were taken between 2001 and 2007.

5 Imagine a bulls-eye target where an archer hits the bulls-eye repeatedly; this archer is both precise and accurate. The archer who hits the same point on the outside edge of the target repeatedly is precise, but not accurate; as he misses the bull's eye repeatedly. In this case, the authors can claim precision, but they have no rational basis for asserting the accuracy of their results.

6 In statistical analysis, the term 'bias' is a term of art describing a particular type of error that can occur in any given analysis. In a statistical context, 'bias' improperly skews the outcome of analysis making it unreliable.

Identified Threat	Data Supporting Threat	Comment
Loss of half of the historic sagebrush habitat has been destroyed, leading to the surmise that as a result, sage grouse populations have declined as a result of a hypothetical loss of habitat.	None (extent of historic sagebrush habitat is entirely hypothetical). No data demonstrating a relationship between habitat extent and sage grouse population abundance or trends.	Data include observations from exploration occurring in the early 1800's. The explorers documented sparse sage grouse populations. The loss of historic habitat used in the monograph is based on imprecise, hypothetical reconstructions of potential climax vegetation, by Kuchler (1964 and later). Our research indicates that Kuchler did not base his maps on data. All subsequent GIS mapping of historic habitat is based on extrapolations of Kuchler's work. There is no analysis comparing sage grouse populations with habitat availability over time. None of the discussions of sage grouse population in the context of habitat availability use data, account for the cyclic nature of sage grouse populations, or consider the significant increase and decreases in sage grouse habitat availability over time.

Table 1-A, **The Present or Threatened Destruction, Modification or Curtailment of Habitat or Range of the Greater Sage-Grouse**

[A chart of those threats identified in Knick et al., along with any supporting data we could identify.]

This number does not account for unrecovered wounded grouse which can substantially increase mortality rates by as much as 50%.

In addition to these compounding issues and errors, the authors started with an obviously low number of male sage grouse upon which to base all other analyses, starting with an estimated 88,816 male sage-grouse in 2007. If one uses the same assumptions of sex ratio that Garton et al. did, this produces an estimate of the total number of sage grouse that is approximately 42% lower than the combined estimate of 535,542 sage grouse from all thirteen states and provinces in 2007.

Starting with such an obviously low estimate, the authors inevitably reach a biased conclusion that sage grouse are threatened.

Finally, the authors base their key finding, that of persistence prediction, on a 'rule of thumb' which has been repeatedly disproved and repudiated. The 50/500 "rule of thumb" used to predict quasi-extinctions is not based on credible evidence and had been deemed contrary to empirical results

obtained from the wild and laboratory and reported by multiple authors. Simply put, there is no evidence of a universal *number* or ratio, below which a population is doomed to extinction. As a result, extinction predictions based on the 50/500 "rule of thumb" are essentially no better than guesswork. And as pointed out below by the reviewers, Garton et al.'s (2009, 2011) extinction predictions are not only unreliable they are biased.

Samples of the biases, errors, and omissions identified by the Scientists retained by the State of Colorado:

"*The authors present an analysis modeling trends in the rate of change in lek counts and then use the best fitting model to forecast trends to determine the probability of existence for varying subgroups of Greater sage-grouse. It is an ambitious, but flawed analysis. Model assumptions are not always made clear and when they are they open doubt about the results and the authors'*

Table 1-B, **The Present or Threatened Destruction, Modification or Curtailment of Habitat or Range of the Greater Sage-Grouse** [A chart of those threats identified in Knick et al., along with any supporting data we could identify.]

Identified Threat	Data Supporting Threat	Comments
Effect of habitat loss is compounded by the fragmented nature of the remaining habitat, as fragmentation results in functional habitat loss for greater sage grouse even when otherwise suitable habitat is still present.	No precise definition of habitat fragmentation provided. No data supporting the population-level demographic effect of fragmentation. No data documenting the differences in productivity between suitable occupied habitat and unsuitable occupied habitat (caused by fragmentation). No data quantifying the loss of function in terms of sage grouse population abundance or trends.	The papers in the monograph recite many changes in land use, ownership, regulation and management. They also document physical changes in the landscape. However, these recitations are not linked in any meaningful way to sage grouse population fluctuations. Further, little data is provided to support the premise that sage grouse populations have declined from those extant prior to European settlement due to inadequate habitat, particularly in light of the very small numbers of sage grouse documented by the first Europeans exploring sage grouse

interpretations. The authors note the complications *and inaccuracy of lek counts, but then proceed to* use *the data ignoring the inherent biases and uncertainties. The authors repeatedly state that a problem with forecasting population trends is that the models assume everything stays the same; but the real problem with these forecasts is the data used in the model is not accurate or very precise making model forecasts uninterpretable.*"

"… the authors fail to provide the mathematical foundation for the method they used to estimate trend. Key mathematical*/statistical errors are made in the analysis as a result. These errors go far beyond the usual debates of the quality of lek data or what type of trend should be fit. The mathematical development of the trend analysis is* wrong*. Third, because of the mathematical problems with the analysis, results are not* interpretable*. It is impossible to know how to consider the results presented because all of the variances are mathematically wrong.*

Samples of comments made by the scientists retained by the State of Colorado on the inadequacy of the data used

We assumed all lek data used in this *analysis were obtained following these* [established] *procedures. This is a naïve statement, and absolutely untrue and the authors know it. It is a fatal assumption and needs to be acknowledged"*

> *."“No state uses a random* sample *of leks, therefore **all**, not 'most', leks are not from a random sample.”*

"Since each state collects lek data *quite differently it is essential that the analysis describe what data were* used *in each state when populations or management zones overlap states. Experts in Colorado have grave concerns regarding data collected prior to 1986 and excluded* [it] *from the WAFWA report. There are also large data gaps in the Colorado data and the authors must describe how those data were handled or censored. The authors gloss over the severe problems with lek counts and consistency among states. The quality of the data needs to be discussed in the report. There*

is an assumption of quality and consistency among states that is a dangerous and invalid assumption. In addition, Colorado was never contacted regarding any inaccuracies or problems with the data set (if in fact data prior to 1986 were used). We know problems exist with the dataset, and none of the authors contacted the State of Colorado for clarification or corrections. Therefore, we can only assume that the data quality control for the manuscript is suspect or assumptions were made that are erroneous."

*"Small sample sizes would aggravate the problems of biased/ non-*representative *samples resulting from absence of probability sampling or a real sampling frame. In addition, the great variation in sample sizes between populations, and across years, means that the reconstructed indices are wildly different in terms of their statistical reliability (see below)."*

Table 1-C, The Present or Threatened Destruction, Modification or Curtailment of Habitat or Range of the Greater Sage-Grouse. [A chart of those threats identified in Knick et al., along with any supporting data we could identify.]

Loss of habitat connectivity	Undefined, and no data supports the conclusion.	The papers do not define connectivity based on documented dispersal distances for sage grouse. There is no data or analysis relating loss of "connectivity", (however it may be defined) to reductions in populations or any recent loss of genetic diversity.
Conversion for agriculture	No data provided to support the premise that sage grouse populations are declining due to past agricultural conversion.	While agricultural conversion undoubtedly has taken place since European settlement, no data links sage grouse population declines to agricultural conversion. Predator control may have aided in sage grouse population growth in the mid to late 19th century.
Urbanization	No data demonstrating loss of sage grouse populations due to urbanization.	
Infrastructure (e.g., roads, power lines, fences) in sagebrush habitats	No data demonstrating loss of sage grouse populations due to infrastructure construction or existence.	There is documentation of increased avian predator density resulting from power poles and fence post being used as perches. However, there is no data identifying significant changes in sage grouse populations as a result of increased predation (beyond background levels) due to power poles and fence post construction
Fire	No data linking increased fire frequency to sage grouse population declines.	The papers assert increased fire occurrence as a result of invasive species (primarily cheat grass) replacing native species, which result in population level effects on sage grouse. However, this changed fire regime has been functioning for well over 100 years and its extent and the magnitude of the change is speculative at best. There is conflicting data on the effect of increased fire on sage grouse populations.
Invasive plants	No data directly linking increased fire frequency to sage grouse population declines.	Invasive plants have been credited with changes in the fire regime. The question of what quantifiable effect those changes have directly on sage grouse populations is not addressed using data.
Pinyon-juniper woodland encroachment	No data linking woodland encroachment directly to sage grouse population declines.	

"Unfortunately, the lek count data used in these analyses seem to be vulnerable to many if not most of the problems above, in spite of efforts to cull the worst of the data. Notably, for some unspecified fraction of the counts, it could not even be determined if acceptable protocols for counting were used. Nonetheless these data were used in modeling unless excluded for other reasons (e.g., extremely low numbers of leks counted). In some cases low numbers of leks (<10) and males (<50) were the basis of estimates … and in some pairs of years there were no doubt fewer leks sampled in each year than the average.

The scientists retained by the State of Colorado also noted the dangers in making inferences or assertions about sage grouse populations based on lek counts:

"How many (or what proportion) of counts were eliminated, how many were retained but could not be affirmed as having followed procedures?"

"An average of 1 – 6 leks per 5-year period is practically no data."

"One of my primary concerns is in using lek counts to make inferences about sage-grouse populations. This is obviously not a novel concern, as it has been pointed out repeatedly in the literature, but it is a fundamental one. Given the population ecology of this species, males are not the limiting resource demographically, females are. So, fluctuations in the population of males may or may not be indicative of fluctuations in the population as a whole. Further, it is not clear to what extent lek counts even fully represent the population of males."

"Given that there is apparently no knowledge of the relationship between lek counts and true abundance, it obviously cannot be asserted that the male lek counts constitute a reasonable index to minimum number of males on leks just because effort has increased in recent years. To make this claim requires some knowledge of a "saturation curve" for the index/ abundance relationship, and that seems nonexistent."

Table 1-D, The Present or Threatened Destruction, Modification or Curtailment of Habitat or Range of the Greater Sage-Grouse. [A chart of those threats identified in Knick et al., along with any supporting data we could identify.]

Grazing	No data linking grazing to sage grouse population declines.	Wild horse grazing was examined with no data evident to support grazing as a threat.
Energy development	Available data is conflicting. The highest density of leks and sage grouse populations occur in or near areas where energy development is most intensive. While there is data to support the premise that energy development can have an effect on sage grouse, few studies break threats down into cause and effect mechanisms	The net effect on sage grouse populations is not clearly identified by data. Energy development has been underway in sage grouse habitats for nearly a century, and yet the areas with significant development (even development with no mitigation) are sage grouse population strongholds. Studies of impacts to sage grouse have been based on evaluation of outdated technology and minimal mitigation, compared to what is now required.
Climate change	No data provided to support the existence of a threat.	Current arguments on climate assert that climate changes, rather than global warming is occurring and that this change will manifest differently in different parts of the world. No data on recent climate changes within the sage grouse habitat is identified. All threats are speculative and based on an unsupported assumption that temperatures will increase in a predictable manner.

"The data set from which this analysis and all other population analyses of sage-grouse are built appears to be deeply flawed, because the sampling scheme is not representative."

Samples of comments regarding invalid assumptions and analyses

The scientists *retained* by the State of *Colorado* question the authors' assumptions and conclusions based on a flawed sampling process:

"I disagree with the assertion (7th page of text) that even if the sampling is not random, if analyzed in a repeated measures framework, 'may provide unbiased and precise measures of the rate of change of populations.' If the leks surveyed are not a random sample, for example if they tend to be easier to access, hence closer to roads or other human establishments, you might be measuring trends in a sample that is specifically more at risk. To use this analysis to draw inference to the whole population, the assumption made is that the sampling is representative. I think that's a challenging assumption to make."

"The sampling bias has also changed over time. As the sampling intensity has *increased, new, active sites are added, while old sites may become inactive. The decrease in the percentage of active sites over time in most populations is more likely an indication of a change in the sampling scheme, than a change in the activity of sites. All this does is highlight the*

problems with an unspecified sampling frame and an ad hoc sampling scheme. This greatly undermines the ability to make inference to the population as a whole.

"Small sample sizes would aggravate the problems of biased/ non-representative samples resulting from absence of probability sampling or a real sampling frame. In addition, the great variation in sample sizes between populations, and across years, means that the reconstructed indices are wildly different in terms of their statistical reliability."

"My concern regarding the first consequence is that by failing to account for the serially induced

Table 2, Overutilization For Commercial, Recreational, Scientific or Education. [A chart of those threats identified in Knick et al., along with any supporting data we could identify.]

Identified Threat	Data Supporting Threat	Comments
Hunting	Current data support an estimated loss of up to 9% of the total population rangewide.	Hunting results in disproportionate killing of females.[1] Hunting is the highest documented source of mortality for sage grouse. The first extirpations of sage grouse populations occurred during the early 1900's and were attributed primarily to hunting[1].

variance in the indices, fit of the time series of indices to alternative models could be overstated, and comparisons between alternative models of density dependence questionable. My concern about the second is that the way the indices are constructed might itself have induced patterns in these data that appear to represent density dependence but in fact are artifacts of the process of construction via backwards induction."

The scientists retained by the State of Colorado also draw attention to inherently flawed formulae and mathematical approaches resulting in unreliable results and conclusions:

"Because the quantity [equation here] *appears on the left (prediction) and on the right (predictor) side of this equation as a reciprocal, we should expect support for b <0 even in the absence of density dependence."*

"The estimate of the total number of males is algebraically circular."

"Results indicate the reconstructed index values can be expected to exhibit high variability, with values in the first decades of the reconstructed period extremely variable. Depending on numbers of leks counted (which in the study data varied over the time horizon) coefficients of variation approaching 100% with correspondingly huge confidence/ credibility intervals should be expected. Apparently, however, these values (on the original abundance or log scale) were used as predictors in the Ricker/ Gompertz models (see below) without accounting for this sample variation."

"The results suggest to me that there is a real issue with 'built in' patterns in these reconstructed data that may create the appearance of density dependent effects where in fact none occur."

"On face value, the above is a reasonable approach. However, as I've already indicated, I have serious misgivings about the validity of the reconstructed index approach. AIC and other approaches fundamentally depend on the likelihood, and in this case, the likelihood has been filled with numbers that are not really data—the constructed index values. By treating these index values are known predictors, the residual variability in the models is being underestimated, and relative differences between models inflated. Furthermore, simple analytical considerations (the earlier algebra) and numerical simulations suggest that statistical patterns in the 'data' may introduce spurious interpretations about the effects of density and misleading inference about quasi-equilibrium."

"The process of reconstructing population sizes based on the 2007 count and the [?]produces a string of correlated estimates. If all leks were surveyed in all years, then the covariance [the extent to which variables are correlated or change

together] *would be zero because the counts from interim years cancel out. Given that different leks are included in different pairs of years the*

covariance is not zero. Deriving a mathematical formulation of the covariances among reconstructed population sizes is not simple given the convoluted definition of the reconstruction. Therefore, I have provided R code for a simulation to demonstrate the problem …"

"All of the data issues aside, parametric uncertainty (or if you will, confidence interval length) needs to be taken into account, and properly estimated (as already noted, it has surely been underestimated here)."

"This is a strange assertion. It is not clear how a nonrandom sample would be likely to provide an unbiased estimate of population trend. Only in the case that all leks are tracking the overall population trajectory would this be true. It is particularly worrisome in that some lek count comparisons are made on the basis of small numbers of sampled leks (n< 10)."

"I do not favor 'reconstructing' population numbers and then using these as data in statistical models as if these are observations. Likelihoods are based on sample data, and the sample data here are the lek counts (warts and all) and (possibly) the baseline index value. Retaining this distinction is important, because a key part of the statistical likelihood is the model for the sampling process — and that seems to have been completely lost in the model fitting, where the index values apparently are treated equally as data."

"The population growth models are fit to the reconstructed population indices. How was the induced covariance handled? These models typically assume the data are independent, these data are not independent."

"*It makes no sense to me to assert that any stochastic outcome has 0 (or 1) probability of occurrence. The probability (maybe) is quite low, but it cannot be zero until it has not happened."*

The scientists retained by the State of Colorado explain over-arching bias problems in the authors' approaches, conclusions, and underlying assumptions:

"Why do a population-by-population analysis at all? Why not analyze all populations within an SMZ (e.g., via a hierarchical metapopulation analysis)? Interest seems to focus at the level of the SMZ anyway, and many of these individual populations do not really support model building on their own."

"How then can it be asserted a couple lines later that this is 'remarkably precise index'? First, we know that the index's variance is guaranteed to expand in reverse time, even if we have decent sample sizes (numbers of leks counted) and meet assumptions of random sampling, unbiasedness, etc., which assuredly are not being met. Second, the index's precision (or lack thereof) seems to have been ignored in the model fitting exercise.

[Note: In other words, the confidence intervals in the reconstructed population estimates are so large that virtually no trend can be reported at the usual 95% confidence intervals. Garton et al. (2009) used a less rigorous 90% confidence interval.]

"They [the *reconstructed population* estimates] *are only 'remarkably precise' if one ignores the propagation of error in the index construction."*

"In addition, use of the lek counts both to reconstruct index values and to estimate population growth rates creates a dependency in these quantities that appears to bias conclusions in favor of negative density-dependence."

"In addition, treatment of populations as completely independent entities fails to take advantage of apparent correlations between populations, at least within SMZs. I recommend that (1) estimation and modeling be based only on actual sampled (and not reconstructed) data, (2) sampling variation from lek counts or other monitoring data be properly incorporated into model construction and inference, (3) data be integrated into a common modeling framework that takes advantage of spatial autocorrelations, (4) projections be based on short-term predictions of local occupancy and related parameters rather than long-term predictions of abundance and quasi-extinctions, with rapid feedback from monitoring, and (5) monitoring and modeling be explicitly connected to well-defined management objectives."

Table 3, Disease or Predation

[A chart of those threats identified in Knick et al., along with any supporting data we could identify.]

Identified Threat	Data Supporting	Comments
West Nile Virus	Data supports the existence of WNV effects on sage grouse mortality.	The data in the cited papers are not consistent with the CDC reported data. Data used to support WNV population level effects is suspect and out-dated by nearly 5 years. Habitat conditions affecting WNV are misstated. (See earlier chapter for a more in-depth discussion)
Predation	Data supports adverse effects of predation on nests and chicks.	The effect of ravens, foxes, and other predators is well documented. Anthropogenic influence on the incidence, variety, and number of predators is less well documented

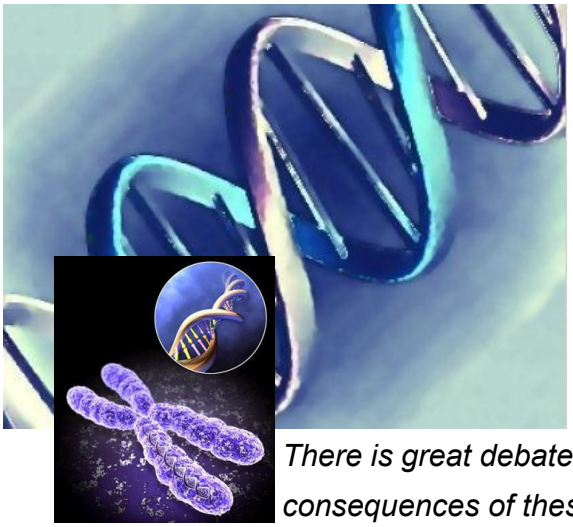
"'Even if the detection probability is unknown…' this statement is not defensible. It is simply a set of unquantifiable statements."

"The author's description of 'metapopulation' is inadequate for proper interpretation. It is questionable if the authors are using the concept correctly. A metapopulation is a collection of population linked by interdependent colonization and extinction probabilities. It appears the authors only go so far as to incorporate a probability of connectivity based on a GIS analysis (not dispersal or movement patterns)."

"If 44% of populations show a declining carrying capacity, that seems to imply that 56% are stable or increasing. Wouldn't you expect about half of the populations to be declining?"

The scientists retained by the State of Colorado raised questions regarding extinction predictions using the outdated and erroneous "50/500 rule of thumb"

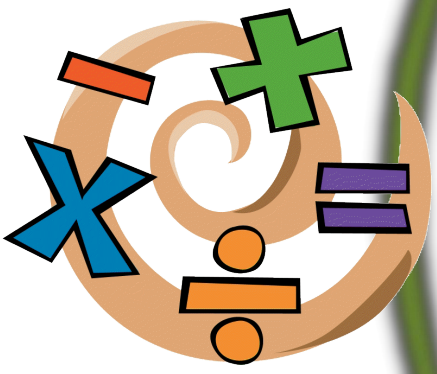
"The selection of effective population sizes are inconsistent and arbitrary… Unfortunately, they do not explain why they consider these thresholds relevant to their analyses. The numbers are based on general theory that states that populations with < 50 individuals are more likely to see the expression of deleterious alleles and inbreeding depression; while populations with < 500 individuals are more likely to see decreased genetic diversity due to increased rates of mutation and



genetic drift. The authors fail to discuss how this relevant to their analysis of lek counts. There is great debate about the consequences of these factors on the demography and long-term persistence of populations."

"For the uses in this paper, I'm not sure that effective population size (Ne) is the appropriate measure. Ne is important when talking about genetics and the preservation of genetic diversity within a population, but those dynamics tend to operate on the time scale of many generations, not years. The emphasis here is on the demographic, not the genetic, dynamics. That said, I cannot follow the calculations in the paper that link a lek count of 20 to an effective population size of 50. First, the equation on page 19 is incorrect; the numerator should be 4, not 1 (I think this is just a typo, not an error in calculation). Second, if there are 280 females and 140 males (46% of which successfully breed), the effective population size is 209, not 228, but maybe there's an assumption I'm missing. Third, Garton et al. mention a sex ratio of 1:2.5, but I cannot tell if that was used in their calculations."[7]

"…those dynamics tend to operate on the time scale of many generations, not years."

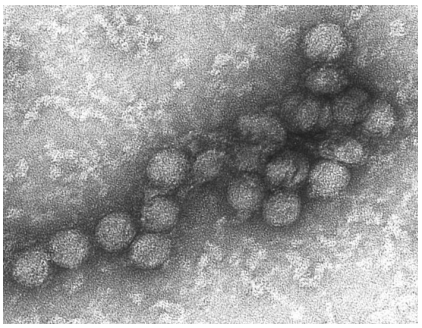


7Such errors lead to extinction predictions being grossly over-inflated by Garton et al. (2009, 2011).

"This is not a valid estimate of the variance of the probability of extinction. It fails to include the parameter uncertainty in the population models."

Chapter Review: West Nile Virus Ecology in Sagebrush Habitat and Impacts on Greater Sage-Grouse Populations[8].

This paper summarizes the literature published in 2008 or prior as well as unpublished information regarding West Nile



Virus (WNV) and its effects on sage grouse. Due to new regulations, much has changed since 2008. An example is the regulations introduced by BLM *in* 2009, which were designed to reduce or eliminate mosquito breeding *habitat* in artificial water impoundments, including those used by the oil and gas industry. Also, more advanced mitigation measures and technology have been developed for controlling mosquitoes. More advanced treatment options for produced water have also been developed, including the use of reverse osmosis, which allows water to be discharged into natural waterways without harm to the environment. Thus, Walker and Naugle's paper is based on outdated information and, in light of recent changes, overstates the influence of oil and gas development in providing mosquito breeding habitat *contributing* to

8 Walker and Naugle 2009, 2011

the threat of WNV to sage grouse. [9] Although the authors model three different scenarios of potential *demographic* impact to sage grouse populations, they devote only one paragraph to summarizing their results, and those results are not mentioned in the subsequent discussion or recommendations. As a result, the discussion is disconnected from the methods and results. Rather than an informed discussion of how their research results inform the management of sage grouse, the discussion and recommendations of the paper are composed of the authors' personal opinions regarding the severity of impacts to sage grouse, and surmises regarding potential strategies for mitigating the impacts of WNV to sage-grouse populations. There is no data or analysis presented that supports the recommendations.

The authors acknowledge that "marked spatial and annual fluctuations in nest success, chick survival, and other sources of adult mortality are likely to mask population-level impacts in most years." ***In other words, potential population-level effects of WNV on sage grouse may not be detectable because other sources of mortality tend to have a larger effect in any year.***

However, the *authors* do not *acknowledge* the well-documented fact that lek counts are not a reliable method for estimating population trends. And although Walker and Naugle suggest that "intensive monitoring of radio-marked birds" is needed to document the effects of low to moderate mortality due to WNV, that approach is severely limited, since WNV is highly variable in its spatial and temporal occurrence (see discussion below). It is also limited by practical constraints such as recovering carcasses from the field in time to determine cause of death (e.g. within 24 hours).

9This information was readily available to FWS when it undertook its 2010 listing determination since BLM is a sister Bureau under the Agency umbrella of the Department of the Interior.

A more appropriate methodology and one consistent with the best available science used in modern epidemiological studies would employ random sampling design across multiple *populations* for detecting the occurrence of WNV, followed by an intensive monitoring of individuals (via satellite GPS telemetry) within an affected population(s), once WNV has been detected above a certain threshold.

The authors' data and conclusions on WNV occurrence are immediately questionable because their map does not correspond with maps and data collected and produced by the Centers for Disease Control (CDC). These data and maps show a much more *heterogeneous* temporal and spatial distribution for WNV, and show a decline in WNV incidence in Montana and Wyoming since 2007. The data included in Figure 1 of Walker and Naugle combined data across multiple years, so no trend is discernible. Further, the data did not extend beyond 2007, although the data was clearly available to the FWS during their status review of the sage grouse[10].

In some cases, Walker and Naugle presume that some die-offs were the result of WNV, although no samples were taken. The authors do not provide their criteria for determining whether mortality was due to WNV, other factors, or simply unknown.

Although the authors cite several published sources on WNV occurrence, an undisclosed amount of data was *obtained* from "unpublished data provided by state agencies and researchers." It is unacceptable that the entire data set on WNV occurrence used by Walker and Naugle is not publicly available. Further, its provenance is uncertain. Since the CDC requires reporting of all cases of potential WNV due to public health concerns, all reputable data

[10] CDC WNV occurrence maps by state, county, year, and host (birds, humans, mosquitoes, sentinels, and veterinary), may be found on CDC's Arbonet at: www.cdc.gov/ncidod/dvbid/westnile/USGS_frame.html.

concerning WNV should and would have been reported to the CDC and included in their data sets.

The authors suggest that "Impacts from WNV in some populations such as northeastern Wyoming may act synergistically with other stressors like 'energy development and tillage agriculture'" to substantially reduce population size, distribution, or persistence. This statement is unsupported by data regarding relative mortalities associated with threats from energy development and tillage agriculture. As well, the authors did not mention or analyze the synergistic effects of one of the best documented sources of sage grouse mortality, hunting harvest, which can result in removal of up to 10% of the population annually. [11]

The authors state that: "Increasing temperatures associated with changing climate may exacerbate WNV risk for sage-grouse." They do not, however, present any data to support an actual or predicted rate of regional temperature increase, nor do they discuss which precipitation changes (i.e. drought) are likely to result from climate changes and why those changes could be more (or less) favorable to the proliferation of mosquitoes and transmission of WNV. Instead, despite the fact that global warming is now more properly acknowledged by proponents as climate change, recognizing the fact that climates the world over will *change*, rather than simply *warm*, the authors assume warming will invariably occur and its effects will lead to greater spread of WNV to sage grouse. This assumption is not accompanied by supporting data.

Chapter Review: Ecological Influence and Pathways of Land Use in Sagebrush (Knick et al. 2009, 2011).

Knick et al. (2009, 2011) discuss and analyze the effects of nearly every conceivable human activity on sage grouse distribution, including hypothetical ones, which the authors assume have a negative effect. Conspicuous in its absence is hunting harvest, which is the source of sage grouse mortality supported by mortality data rather than speculation and supposition (Reese and Connelly 2009, 2011).

Citing the work of previous authors, Knick et al. (2009, 2011) quantify the "effect area" around various types of development for their GIS analysis. However, Knick et al. do not accurately represent the results of cited authors but rather substitute their own values to delineate the effect area for each type of human activity: “We used an ecological rationale for estimating the area around points, lines, or polygons from which land use potentially influenced land cover or sage-grouse populations. Estimates for effect sizes into surrounding areas were based on foraging movements of human-subsidized predators, distance of exotic plant species spread, or on distribution data relative to land use." For oil and gas wells, the effect area used in the authors’ analysis includes a 3km

> **…do not accurately represent the results of cited authors but rather substitute their own values to delineate the effect area for each type of human activity…**

buffer around each oil or gas well pad, and in each direction from pipelines, roads, and transmission lines, regardless of their size or mitigation measures used. However, none of the cited three papers for oil and gas disturbance made such 3km recommendations, nor produced data that could be used to support such a buffer. The only mention of an effect at 3km in these papers had to do with cultivation rather than oil and gas development, or roads and powerlines. Those authors reported that "In 2001, cheatgrass was 20% more likely to be found within 3 km of cultivation, 13% more likely to be found within 700 m of a road, and 15% more likely to be found within 1 km of a power line." Again, no data support the use of a 3km buffer.

Similarly, another paper reported, "…we observed anecdotally that sites isolated (1000 m) from roads tended to contain fewer exotic species than sites near (50 m from) road," adding the caveat regarding their conclusions, “Exotic species richness tended to be greater and native species richness tended to be lower next to more improved roads, although we caution that our measurements of richness were a snapshot."

In summary, none of the studies cited by Knick et al. (2009, Chapter 13) justify their uniform 3km “effect area” around development and no other data is presented which supports this buffer.

The pre-European sage grouse distribution, as delineated by Schroeder et al. (2004), already includes large areas of non-habitat with no records of sage grouse occupancy. It also excludes areas of documented historic sage grouse occupancy that were clearly outside of identified sagebrush habitat. Using Schroeder et al. (2004) as a starting point, Knick et al. subsequently surround this "pre-settlement" range of sage grouse of within a 50km "buffer". There is no credible data that sage grouse ever occupied this buffer or that their populations were severely affected by activities within this buffer. Knick et al. thereby greatly *overestimate* the area in which sage grouse have been negatively affected by human development.

According to Knick et al., "All nonproprietary and nonsensitive spatial data sets used in our analysis are available for download on the SAGEMAP website http://sagemap.wr.usgs.gov; United States Department of the Interior 2001a)[?]. Each data set is accompanied by a metadata record documenting original source and GIS procedures." A search through this website, even searches using the term "sage grouse," does not yield the data sets used by Knick et al. in their analysis. Since the data used is deemed "proprietary" and "sensitive, and therefore withheld from the public" it is not possible to replicate the results of Knick et al. Thus, this study also fails the litmus test of sound scientific research since the results are not repeatable and verifiable. We question the use of 'secret' data for decision-making not involved with national security.

Conclusions and Recommendations

This and other reviews of the contents of the four key chapters of the highly influential monograph on sage grouse relied upon by the FWS in its 2010 listing decision identifies:

- significant mischaracterization of previous research,
- substantial errors and omissions,
- lack of independence in authorship and peer review,
- methodological bias, and
- a lack of reproducibility.

To ensure that the FWS upcoming sage grouse listing determination avoids these shortcomings and is based on an objective review of threats supported by data and demonstrated to affect sage grouse population trends, we recommend that the FWS undertake the following:

- Address the issues of omission, and mischaracterization identified in this review;
- Address issues identified by the scientists retained by the State of Colorado and quoted in this review;
- Require that for any studies used in the listing decision, authors make their data, analyses, and assumptions public and post the information in order to ensure their results are substantially reproducible;
- Post all peer review comments, in their entirety, from the editors of this volume, as well as future products, to elucidate issues for the public.

We note that had the FWS adhered to the Office of Management and Budget's Guidelines under the Information Quality Act many of the issues and errors identified in this review would not exist.