RESEARCH ARTICLE | APPLIED ECOLOGY

# Hallmarks of science missing from North American wildlife management

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## Distinguishing science from “fact by assertion” in natural resource management

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Nichols et al. (1) offer an optimistic counter-perspective to our recent study that assessed the scientific basis of wildlife management in North America (2). We are encouraged to see the discussion on this important topic progressing. We note that their response agrees with most of our findings and conclusions,

specifically that most North American hunt management systems could improve, and that the hallmarks framework we provided could help.

The aim of our publication was to advance dialogue about the role of science in natural resource management, and to provide a repeatable and transparent means to test the veracity of science-based claims and assumptions commonly asserted by agencies. We offered a Hallmarks of Science framework, based on a foundation of four hallmarks: clear objectives, evidence, transparency, and independent review, as a generalizable approach for assessing (and ideally evolving) the scientific basis of any natural resource management system (2).

Nichols et al.'s letter suggests that migratory waterfowl management systems could make excellent candidates for further study. If their assertions of that system's scientific basis are substantiated through future systematic assessment, such as the one we provided for species managed by states, provinces, and territories across Canada and the US, this system could offer insight for improving the scientific foundation for other taxa and locations.

Although the response provided by Nichols et al. might suggest promising avenues for future work, many of the assertions and criticisms do not withstand scrutiny. We focus on two primary foci of their critique: 1) operational definitions and hallmarks for assessment of science-based approaches to management, and 2) whether the exclusion of migratory waterfowl management challenges the conclusions of our study. We end with a cautionary note about 'fact through assertion', a phenomenon that motivated our study and that is exhibited in Nichols et al.'s description of waterfowl management.

Alternative definition of science and its role in management
Nichols et al. provide the following definition of science: "a process by which humans reduce uncertainty and learn". Whereas this might describe some aspirations of science, especially in a management context, it neither describes the process of science, nor does it provide any reasonable critique of our Hallmark approach.

Nichols et al. suggest that hypotheses, models, and monitoring programs should be used as alternatives to the hallmarks that we tested. These are components of management-related research (and adaptive management [3, 4]), which nests within the Evidence hallmark of our broader framework. We note that Mangel (5–7) has provided a comprehensive treatment of scientific research hallmarks in a management context, through testimony and supporting documents provided in an international review of Japanese Whaling programs.

Instead of a focus on management research, our attention was on the process of science-based management. We note that the primary objective of management agencies might simply be achieving goals determined by society, not advancing knowledge broadly about the taxa subject to management. We were motivated by the pressing need to confront claims of a 'scientific basis' to policy, given the power this term might hold in suggesting to the public that a given activity is rigorous, credible, and buffers against error.

Nichols et al. state that our hallmarks are "not indicative of the presence or absence of science". We agree that these hallmarks are not necessarily indicative of the presence of science, but we question how science-based management could operate in their absence. By analogy, a house might have a robust foundation, but without proper walls and a dependable roof, the edifice

might still be compromised. In the absence of a proper foundation, however, a robust edifice is not possible. Similarly, without the foundational hallmarks of science we offer, we suggest that a scientific approach to management is not possible. Moreover, although they do not alone ensure a fully scientific process, these hallmarks can certainly help facilitate progress. For example, our hallmarks of transparency and independent review could help identify areas for improvement in specific management systems.
Nichols et al. additionally propose that we do not understand the "nature of science and its role in management" because of our statement that, “we do not suggest that a scientific basis is required for all management systems or decisions, but that it ought to be present when it is expected by the public or claimed by agencies“. Although we agree with their statement that science might be particularly valuable in cases when evidence is scarce, our point was that science does not (and cannot) solely drive wildlife management; although it can predict outcomes of management actions, what society ought to do is ultimately decided by values. We emphasize that good governance requires a clear distinction in where the science begins and ends in decision-making.

Exclusion of waterfowl
Nichols et al. express concerns about cases that were excluded from this assessment. They state, for example, that, “Artelle et al. (1) specified exclusion of federal management programs and migratory birds from their assessment”. Our wording might have contributed to some confusion about how we handled federal lands in our analyses. We stated that we “…excluded assessment of hunting on parcels of federal and tribal lands”, but hunting of most species on these lands is usually guided by management plans of the states in which such parcels are found (8 and https://www.fws.gov/refuges/hunting/getting-licensed/). Thus, these systems were captured by most of our state-level assessments.

However, Nichols et al.’s more specific concern, that excluding waterfowl might be construed as misleading, is somewhat perplexing. We were transparent about this exclusion throughout our paper. For example, we were unambiguous in explaining that “[w]e excluded polar bears, waterfowl, and migratory birds … because their management differs from most terrestrial species by being governed through a mix of federal and state/province/territory-level laws and regulations.” The authors’ soccer analogy implies that we had a selection bias against ostensibly well-performing management systems. Instead, we made the a priori decision to exclude systems subject to different “rules” (e.g. national and international treaties) than those managed exclusively by states, provinces, and territories. As such, the excluded systems are analogous not to different “teams”, but different “leagues”. We agree that further study into these and other systems might yield additional insight into determinants of robust science-based management, but do not agree that their exclusion compromises our conclusions.

The most pointed opposition by Nichols et al. seems to target our title, “Hallmarks of science missing from North American wildlife management”. Their criticism is that our survey did not include all hunted species. Given this rationale, we are surprised that their letter, which provides assertions about a single group of species, is titled "Science alive and well in North American Wildlife Management". A more appropriate title (if the assertion is accurate) might instead be, “Science alive and well in waterfowl (especially mallard [Anas platyrhynchos]) management of Canada and the USA”.

Fact by assertion

Finally, we note Nichols et al. display 'fact by assertion'. This is a somewhat common pattern in ostensibly science-based natural resource management that in fact inspired our original work. For example, Nichols et al.'s claim that "North America has been a clear leader in the incorporation of science into ongoing programs of wildlife management", and "The best examples of scientific wildlife harvest management, in our opinion, have been developed for North American waterfowl by federal and state agencies in the U.S. and Canada". These assertions are not defended with evidence, so we do not have sufficient information to dispute or substantiate them. Instead, we reiterate that careful independent analysis of these systems might yield important insights.

Moving forward

We think there is great value in further assessing the waterfowl management system Nichols et al. have described to determine whether it does provide a 'best-practice' example of science-based management. As we suggested in Artelle et al. (2018), using our approach to assess management systems such as this could quantify the extent to which a scientific basis is substantiated, offering insight into what factors might encourage robust decision-making processes. We hope that the conversation sparked by our paper continues in a constructive fashion, and encourage further productive discussions with managers, scientists, and practitioners.

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## RE: Science Alive and Well in North American Wildlife Management

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(3 April 2018)

Artelle et al. (1) entitled a recent article with the provocative claim: “Hallmarks of science missing from North American wildlife management”. Although we agree with some of the concerns and recommendations of Artelle et al. (1), we believe that the article is misleading about the distinction between science and management, the role of science in wise management, and the degree to which science is used in North American wildlife management. Here we distinguish between science and management, specify an appropriate role of science in management, and document the explicit use of science in at least some programs of North American wildlife management.

Management is a process by which actions are taken in order to influence a system to meet specified objectives. Management thus requires knowledge, or at least hypotheses, about the influence of available actions on system dynamics and other variables associated with objectives. Science is a process by which humans reduce uncertainty and learn. In the absence of uncertainty about effects of management actions, science may not be needed for effective management (although prior science is the usual reason for absence of uncertainty). In the face of uncertainty, science can play an important role in management by comparing observed system behavior with predictions from competing hypotheses about such behavior.

Artelle et al. (1) listed four “hallmarks of science relevant to natural resource management”: measureable objectives, evidence, transparency and independent review. They went on to list indicator criteria for each hallmark. We agree that these hallmarks and associated criteria are reasonable expectations for any informed management process. However, they are not indicative of the presence or absence of science. Instead, hallmarks of science in management would include the specification of hypotheses about the effects of management actions on system dynamics and other variables associated with objectives, the development of corresponding models to predict consequences of different actions, the existence of a monitoring program to provide data for use in testing predictions, and the specification of some means of tracking the predictive performance of the hypotheses (i.e., learning).

Artelle et al. (1) highlighted “the importance of disclosing the relative contribution of science compared with other considerations ….in management decision-making.” The central role and contribution of science to decision-making is the reduction of uncertainty, usually about effects of management actions on system behavior and other variables associated with management objectives. Such reduction of uncertainty leads to an increase in the ability to meet management objectives. Other components of informed decision processes, e.g., development of objectives and potential actions, are rooted in the values of decision-makers, stakeholders, and society in general. Scientific processes may sometimes be used to elucidate values and thus help develop objectives, but are not otherwise needed in the development of these other elements of a decision process.

Especially confusing was the statement by Artelle et al. (1) that “decision-making might be necessary when reliable evidence is limited or lacking….Hence we do not suggest that a scientific basis is required for all management

systems or decisions." It is our opinion that this statement reflects a misunderstanding about the nature of science and its role in management. Absence of reliable evidence, for example about effects of actions on systems and objective components, is exactly when science is most needed. Science provides the basis for developing such evidence.

The title of the Artelle et al. (1) article caught our eye, as we hold the view that North American wildlife management, especially North American wildlife harvest management (a focus of 1), has been a world leader in the application of science to management decisions (2, 3). Our perspective is based on a collective 130+ years of involvement in North American harvest management at state and federal levels. The best examples of scientific wildlife harvest management, in our opinion, have been developed for North American waterfowl by federal and state agencies in the U.S. and Canada. The first of these programs was the well-documented adaptive harvest management (AHM) program for mid-continent mallard ducks, Anas platyrhynchos (4-8), with similar programs now developed for other mallard populations and other duck species (9). These harvest management programs include not only the hallmarks of Artelle et al. (1), some of which are indicative of informed decision processes, but also the hallmarks of scientific management (4, 10).

For example, the mid-continent mallard AHM program is guided by four competing hypotheses about the effects of hunting on mallard populations. The explicit models corresponding to these hypotheses are used to determine the appropriate harvest regulations each year. Model-based predictions are compared against monitoring program population estimates annually in order to modify the relative degrees of confidence in the four models, i.e., to learn (4, 10). Specifically, degrees of confidence in the four models are updated using Bayes theorem, a process that has led to substantial support for one of the models, some support for another, and little for the remaining two (e.g., see 11). The inclusion of this scientific step in the management process has thus led to learning, and hence to the evolution of the relative influence of the different models on management decisions (4).

This embedding of science within a broader management program is occurring not only in North American waterfowl management (9), but in several other North American wildlife management programs as well (e.g., 12-15). However, we certainly do not claim that such management dominates North American wildlife programs. Indeed, we have been critical of North American wildlife management for being slow to adopt this approach to management in the face of uncertainty (e.g., 16). Nonetheless, it strikes us as inappropriate to single out, for absence of scientific management, the continent where such management was first implemented over two decades ago and where many other examples have been added over the years. In fact, the scientific waterfowl harvest management programs of North America have been used as a basis for developing similar programs in Europe (17) and have been singled out for emulation in other natural resource decision problems (18).

We acknowledge that despite a title critical of "North American wildlife management", the "Materials and Methods" section of Artelle et al. (1) specified exclusion of federal management programs and migratory birds from their assessment. This explicit exclusion does not diminish the misleading nature of the title and would be akin to an article "On the mediocrity of Spanish club football" that explicitly excluded from consideration F.C. Barcelona and Real Madrid!

In conclusion, we share the general opinion of Artelle et al. (1) that there is much room for improvement in North American wildlife management. We also agree that adoption of some of the hallmarks and criteria that they list would be useful. However, we believe that Artelle et al. (1) have confused science and decision analysis, and we have tried to clarify this distinction. We have also specified the key role of science in wildlife management as the reduction of uncertainties, usually about the effects of actions on managed systems. We have identified components of the scientific process (hypotheses and corresponding models, monitoring, comparison of observations with model-based predictions, a means of tracking results of these comparisons [learning]) and described how such a process can be embedded into wildlife management programs. Finally, we have noted that while scientific management is not as common as it should be in this continent, North America has been a clear leader in the incorporation of science into ongoing programs of wildlife management by governmental agencies.

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