NOAA Technical Memorandum NMFS-AFSC-267

We Are Not Asking Management Questions

by
C. W. Fowler and S. M. Luis

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Alaska Fisheries Science Center

January 2014

NOAA Technical Memorandum NMFS

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This document should be cited as follows:

Fowler, C. W. And S. M. Luis. 2014. We are not asking management questions. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-267, 48 p.

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January 2014

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Abstract

In today's world, humans face a myriad of serious problems. These problems are exemplified by the risks associated with the ongoing extinction crisis (including the risk of our own extinction), global climate change, oceanic acidification, overfishing, pollution, pandemics, and full-scale state-change in the biosphere. Our actions are, in varying ways, and to various degrees, contributing to such predicaments. We need guiding information to deal with the long-term consequences of our actions—consequences to our species' quality of life and survival as well as to that of various nonhuman systems (e.g., other species and ecosystems). A first step is that of asking management questions aimed at finding out how we can fit into our world sustainably, both as individual people and as a species—the human species. These questions must be asked, and they must be phrased specifically to guide and promote science that will produce clear, objective, and holistic answers that lead to effective action.

Are such questions being asked? In this paper, we report work in which we addressed this question by examining a randomly selected sample of 100 peer-reviewed papers. The six journals in which these papers were published were chosen because the journals state within their missions or objectives the importance of making scientific information available for use in management as action taken in regard to human interactions and impacts on other species, ecosystems or the biosphere. In each paper, we searched for evidence of a stated management question (involving appropriate decisions and action, as distinct from a research question involving the focus of science) and found none. Most of the papers made substantive contributions to understanding the general principle of complex interconnectedness as it applies to the reality of which everything is a part. However, when considering management implications, the majority of papers used terminology more consistent with management that ignores this principle. Instead, suggested action (management), whether overt or implied, almost always seemed to accept the objective of manipulating nonhuman systems without regard to the sustainability of the relevant impacts. There was little, if any, evidence of trying to find a sustainable mode of interacting with, and participating in, such systems to include the sustainability of these systems.

Asking proper management questions is one of the first steps toward finding the kind of information that will guide us toward realistic interactions and participation. Thus, we strongly recommend extensive changes in educational, managerial, and scientific realms to promote the asking of proper management questions. Such questions must meet the criteria of embracing the principle of complex interconnectedness, by accepting the responsibility of finding sustainable ways for humans to fit into, and interact with, nonhuman systems across all temporal, spatial, and hierarchical scales. Questions must be specific, avoid manipulation, seek holistic sustainability, and lead to measurable goals. For example, "At what rate can we sustainably harvest walleye pollock from the Eastern Bering Sea?" is far superior to "How can we manage walleye pollock to maximize profits?" Good management questions define the science that will provide answers that account for things holistically, objectively, and consistently.

CONTENTS

Introduction

Why is it important to address the issue of appropriately asking questions? We currently face serious challenges caused by human impacts on nonhuman systems. These issues need to be addressed in order to achieve sustainable impacts if we want to continue to exist as part of this planet's ecosystems and biosphere. The long list of serious problems that we face in today's world count as one set of prominent motivating factors emphasizing the importance of obtaining appropriate guidance for how to sustainably interact with other species, ecosystems and the biosphere. Such problems include the ongoing extinction crisis (Hoffmann et al. 2010), overfishing (Coll et al. 2008), climate change (IPCC 2007), ocean acidification (Turley et al. 2010), the major threat of global pandemics (e.g., Knobler et al. 2005), and ecosystems that are seriously damaged or totally destroyed (e.g., streams and rivers such as the Colorado River, and growing numbers of lakes that are completely devoid of water much of the time; Glennon [2002], Postel [2003]). An increasing number of scientists are seriously concerned about a major change (state shift) or collapse of the biosphere (e.g., Barnosky et al. 2012), collapse of civilization (Ehrlich and Ehrlich 2013), and human extinction (e.g., the auto-extinction mentioned by Hern [1993]; see also Leslie [1998][1]). We need guidance for sustainable human relationships with, and participation in, the numerous systems with which we interact. It is important that this guidance lead to action that relieves other systems of human influence insofar as it is contributing to these problems—especially problems in the form of risks to our species (e.g., extinction) via systemic feedback.

Without effective guiding information, decisions are, by default, subject to severe bias, and often lead to disastrous results. It is of vital importance that we ask management questions that lead to a very specific form of information—information that provides realistic guidance and that results in decisions devoid of errors, misconceptions, and fallacy (Fowler and Hobbs 2011). The best management questions are those that promote science which provides holistically objective guiding information (Fowler 2009). There are numerous steps in this process; the first

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[1]The risk of the extinction of the human species is of growing concern to a number of scientists (e.g., Boulter 2002). It is a topic of consideration for a growing number of groups such as Oxford University's Future of Humanity Institute (Bostrom 2013). See Fowler (2003) and Bostrom (2013) for other references to published work expressing concern regarding human extinction.

is that of asking the management questions themselves. An important part of this step is making sure that the questions are posed to meet specified standards. These standards are based on basic principles, tenets, and criteria recognized widely[2] as important in setting policy and making decisions in management.

One of the basic principles is that of interconnectedness—a well-accepted aspect of reality. The research conducted in virtually all fields of science substantiates the notion that we are part of a universal system within which the various parts interact to varying degrees and in innumerable ways. Owing to the ubiquitous nature of relationships among entities (e.g., subatomic particles, chemicals, cells, individuals, species, ecosystems, planets, and galaxies), it is impossible to exist without having impacts. The principle of interconnectedness acknowledges that there will be numerous effects at a variety of levels often far removed from the immediate and direct effects that we see in everyday life. In this respect, we cannot prevent having systemic influence with all of its repercussions, including those that affect humans—such things are beyond our control. We need to ask management questions that lead to guidance regarding the magnitude of sustainable influence.

A second basic principle is that of complexity—science substantiates the complex nature of reality with a growing list of things that have been identified, named, explained, and described. Our libraries and languages provide superficial listings of the parts of reality and a glimmer of understanding of the immense number of such parts. These huge numbers include the number of elements, the number of atoms of each element, the number of chemical compounds made up of these elements, and the number of molecules of each. At higher levels of hierarchical complexity, we have the numbers of individuals of every species and the communities, ecosystems, and the biosphere in which they occur. The basic principle of complexity is brought to bear in knowing that our influence involves an essentially infinite set of relationships, not only with all entities in the physical environment, but also with the entire biosphere, all ecosystems,

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[2]The accumulation of principles and tenets seen as important to management involves a large body of literature. Examples include Christensen et al. (1996), Mangel et al. (1996), Lackey (1998), Foster et al. (2000), and Francis et al. (2007). See Fowler (2003, 2009) for further examples and for overviews of such tenets and principles with references to many more examples from the literature.

all species, and every individual within each species. At the minimum, such relationships are well beyond anything that can be represented in any simulation model in which we try to include such relationships. The principle of complexity acknowledges that our impacts involve numerous pathways (in reality, it is a set of innumerable pathways).

These two basic principles (complexity and interconnectedness) can be combined into one: complex interconnectedness. This principle is about a reality that is beyond our control; we have no control over the fact that our impacts involve innumerable pathways, through multiple kinds of connections, affecting innumerable entities, beings or things around us, and ultimately giving rise to consequences that impact us humans.

Thus, another basic principle involves our lack of control over reality—a principle related to, dependent on, and involving complex interconnectedness. We cannot change the fact that there is unimaginable interconnectedness and complexity. We cannot alter the fact that we will have influence, whether we like it or not; this fact is beyond our control. We cannot alter the fact that this influence permeates among the innumerable systems that are interconnected in the reality of which we are a part—both as individuals and as a species. As such, one criterion for a good management question is that of being restricted to asking what we (as humans) can do to be, or participate, *sustainably* within the systems of which we are parts, and systems with which we interact (Box 1, Sustainability). Management questions should ensure that their answers lead to action involving influence that is, in fact, holistically sustainable. In other words, guidance must involve action to achieve sustainability for each of us as individuals, the human species, all systems with which we interact and all of the interrelationships involved. Sustainability must involve all time frames, all spatial scales, and all levels of organizational complexity.

Box 1: Criteria to be Met by Management Questions

1. Sustainability - Management questions must seek an answer that will lead to sustainability, not only for humans, but for all systems that we influence and with which we interact. Seeking simple maintenance of the status quo is not an option; the answer to a good management question will often expose the fact that what is currently being done is unsustainable. Sustainability involves long time scales and includes accounting for the risk of human extinction.

2. Specificity - Management questions must provide clear focus on a specific form of interaction with, influence on, or participation in, a specific nonhuman system. Clear identification of the individual form of interaction/influence/participation is crucial as is clear identification of the nonhuman system with which we are interacting or in which we are participating.

3. Intransitivity - Management questions must be restricted to finding guidance for the regulation of human activities at sustainable levels rather than for the manipulation of nonhuman systems to maintain the status quo. Sustainably fitting into, and sustainably interacting with, nonhuman systems is the goal of management and confining human activities to such ends is of primary importance. We cannot control the fact that management will result in systemic reactions involving innumerable consequences.

4. Measurability - Management questions must provide the option of measurable goals for sustainability. Specific metrics can be left to scientists who make the measurements that lend themselves to guidance, but the specific form of interaction or influence must be defined such that it can be measured. This allows for establishing clear goals, monitoring progress, and evaluating current status.

As we have attempted to make clear above, a major part of the generic form of sustainability is sustainability, not only for humans, but also for the systems in which we participate as well as those with which we interact. This involves two more basic principles, both involving normalcy (in contrast to abnormality or pathology) and pertinent to the concept of health: 1) variability and change are characteristic of nearly everything and, 2) variability is subject to limits (variability is not infinite). Change resulting in variability beyond those limits, as empirically observable, can be measured by scientists as anomalous, atypical, aberrant or pathological. Guidance is thus inherent to patterns that help define health (Fowler 2003, 2009)—each pattern being very specific to one particular aspect of being part of, and interacting with other systems. Thus, a second criterion for a good management question is one of identifying a very specific form of sustainable influence, participation, or mode of being (Box 1, Specificity). It is important that we ask management questions to carefully identify a specific aspect of fitting into, interacting with, and influencing nonhuman systems. This specificity identifies the pattern scientists can focus on in characterizing variability with its limits and provide measures of any abnormality (lack of sustainability) discovered. As such, a good management question directs us toward an individual facet of health, or sustainability; many such questions are needed to deal with the complexity involved in the numerous ways in which we influence and interact with nonhuman systems. The concept of health is broadly applicable—normal variation applies to all systems (both human and nonhuman) and all forms of interaction.

In focusing on one element of the complexity of reality, action is confined to that undertaken as management; management involves action on our part (decisions, policy, and accomplishments by humans). As specified above, there are aspects of reality over which we have no control, as a matter of principle. This gives rise to a third criterion for a good management question (Box 1, Intransitivity). A good management question must be confined to finding guidance for the control of human action (intransitivity) as management that we undertake to find sustainability in our participation in, and interaction with, nonhuman systems.[3] Abnormality (or pathology) found in nonhuman systems (rather than human systems or human interactions with the nonhuman) is grounds for asking management questions regarding any of the infinite ways human influence might be contributing to such problems. Thus, abnormal concentrations of CO_2 in the atmosphere is motivation for asking a good management question such as "*At what rate can the human species sustainably produce CO_2*?"

To set the stage for the study that we are reporting in this paper, consider the question: *"Are the patterns of density-dependence in productivity ecologically or evolutionarily determined?"* This question exemplifies questions asked in science but is not a management question; it does not specify sustainability for human activities or influence. It is perfectly acceptable as a science question; we seek understanding, and explanation and science contributes to progress toward both. Now consider a different question: *"How much biomass can we humans consume (or harvest) sustainably from the California Current ecosystem each year?"* This is a bonafide management question. It involves a particular aspect of human participation/influence and seeks sustainability for that influence. The particular aspect of population dynamics of the first question is undoubtedly a relevant factor[4] in regard to the answer of the second question, but, considered in isolation, does not answer such questions.

An important aspect of the second question (the management question) in the last paragraph is that of asking "how much". Answers to this question will be expressed in units of mass per unit time (e.g., metric tons per year or kilograms per month); these are units of measure that are essential to management. Without such metrics, management is subject to guesswork. Thus, a fourth criterion for a good management question is that of lending itself to measurements that can be specified by scientists (Box 1, Measurability). Quantification is an essential element

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[3]The distinction between intransitive and transitive management must be clear. We can't avoid (or control the fact) that we have impacts on the nonhuman but we can regulate (intransitively) our interactions so as to achieve holistic sustainability in such relationships. The transitive manipulation of other (nonhuman) systems without holistic regard for the complexity of reality is typified by most management carried out today—manipulation of various systems to meet human needs without questioning the sustainability of those needs.

[4]Owing to the principle of complex interconnectedness, virtually everything bears some form of relevance—some minuscule, some extensive.

to management questions. Thus, questions that do not have measurements involved (such as *"Should we humans be harvesting biomass from the California Current evosystem?"*) can be reformulated to ensure something measurable (such as *"What portion of the resources humans use can be extracted sustainably from the California Current evosystem?"* or *"From what portion of the Earth's surface can we humans sustainably extract resources?"*).

Further consideration of what constitutes an appropriate management question (with examples) is found in Fowler (2003, 2009) and Fowler and Hobbs (2009, 2011). The kind of science brought to bear in answering such questions is exemplified in Fowler (2008), wherein abnormality on the part of humans is identified and measured so that management action is provided with quantitative objectives. More details are presented below.

With an increasingly clear idea of what constitutes a bonafide management question, we can proceed to the focal point of this paper: Are such questions being asked? Fowler and Hobbs (2009) found that most scientists fail to ask management questions even when requested to do so by administrative officials.[5] In view of these results, it seems unlikely that management questions would be found in general peer-reviewed scientific papers—the translation of science to practical application is often left to people who are not scientists. However, it seemed likely that we might find management questions in journals with stated objectives of being published in the service of application. Do management questions occur in journals with missions of publishing applicable information? This is the central question being addressed by the study reported in this paper—a research question. Another question involves awareness of the basic principles we have described. Specifically, does the published literature reflect awareness of the complex interconnected nature of reality and the impossibility of controlling nonhuman systems

[5] In preparation for a center-wide planning meeting, scientists working for the National Marine Fisheries Service at the Alaska Fisheries Science Center (primarily program leaders) were asked to pose management questions. Only 9 of the 102 questions actually involved management and only 5 of those met the four criteria listed in this paper.

without consequences (some of which we may never identify or understand[6])? In other words, do the authors of papers published in the applied literature understand the distinction between transitive and intransitive management and the importance of confining ourselves to the intransitive?

In this context, our paper addresses two null hypotheses. The first is the hypothesis that papers published in applied journals pose a management question. The second is that usage of management terminology is confined primarily to the intransitive aspects of management.[7]

Methods

We randomly selected 100 papers published in six different journals to serve as the raw material for our analysis. Each journal was chosen based on its stated mission: publishing information considered to be useful for management. We assumed that the journals (and their editors) considered management to involve the various aspects of human impacts on nonhuman systems (an example of which would include our use, or consumption, of resources from other species and their ecosystems, the use of fertilizers, producing CO_2, or using pesticides).

The first 75 papers were selected independent of the words in the title. Preliminary results based on this initial selection were presented to colleagues who recommended that we choose papers with the word "management" in the title (at least hypothetically, this might increase the chances that a bonafide management question would be posed). Following this suggestion, we selected 25 additional papers. For the first 75, we randomly chose page numbers (within randomly chosen issues and randomly chosen journals from the six we

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[6]Some might think that these circumstances would preclude asking management questions entirely. We are left, however, with the viable option of asking management questions that involve controlling human enterprise (i.e., intransitive action, Criterion 3, Box 1) using guiding information that takes advantage of the principle of complex interconnectedness to be integrative of all things (holistic so as to account for the unknown and unknowable; see Fowler, 2009 and Appendix 3 of Fowler et al. 2013).

[7]That is, published works acknowledge that we do not have control over the complex interconnectedness of reality and view management as primarily a matter of controlling our (human) influence so as to achieve normalcy in our relationships with the nonhuman.

selected—journals were assigned numbers to enable random selection). Using those pages, we selected the corresponding article. The first 75 papers were published between 2006 and mid-2008; the next 25 papers were published before mid-2008 without an early time-limit. All papers were otherwise selected randomly. For the last 25, a full list of papers that met our criteria (results of searches for titles with the word "management") were numbered and selected randomly. The random selection of the first 75 papers required ignoring cases where selected pages corresponded to editorials, book reviews, advertising, or other material that was not part of a peer-reviewed article. In the case of the last 25 papers, it involved rejecting titles that did not contain a form of the word "management". The corresponding pdf file was then downloaded and read with specific focus on determining whether or not a management question was asked. Bibliographic information was maintained using Procite[8] software.

We made sure that all papers were searchable with Adobe[8] software. This required that a few of the papers published early in the history covered by our study be scanned to enable the implementation of optical character recognition (OCR).

For the first part of our study, each of the 100 papers in our sample was searched for question marks (the "?" character). A count was then recorded for each paper indicating the number of these characters found, but only if they were in the main text or title and if they followed a posed question. In other words, questions in literature cited sections were not counted, nor were question marks in tables to indicate lacking information or indeterminate results. The resulting counts were then subdivided into three groups: a) those that were management questions (as described above; i.e., met the criteria listed in Box 1), b) those that were research (or science) questions, and c) questions falling into other categories.

Owing to previous experience with scientists failing to ask management questions (Fowler and Hobbs, 2009) we also undertook a rather subjective search for evidence that there were identifiable management questions that might have been in the minds of the authors (i.e., questions that they may have been thinking about but did not put into words). We report the

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[8]The use of brand names does not imply endorsement by the National Marine Fisheries Service, NOAA.

results of this phase of our work in the next section, but emphasize that other scientists will undoubtedly differ with us in their opinions.

A second part of our work involved scanning each published paper for the term "manage" and for the term "control" (along with their derivatives, such as "management" and "controlling"). This was done to determine if the authors recognized the distinction between transitive management (controlling or manipulating the nonhuman without full regard to consequences) and intransitive management (limiting ourselves to the magnitude of influence that we humans can sustainably exert). Thus, use of the term "control" when referring to experimental design and to ecological forces (e.g., top-down control in food webs) were ignored. Terminology such as "predator control" and "species management" (when the species is not the human species) exemplify transitive management.

Results

The six journals that we chose for the purposes of this study are listed in Table 1 with corresponding quotes from the websites where their objectives are stated. The journal number (JNu) was used in randomly selecting journals to find the first 75 papers used in our study.

The 100 papers that we randomly chose for this study are listed in the Citations section of this paper with corresponding numbers (in alphabetic order by senior author). Data regarding the simple matter of asking questions as they correspond to these papers are presented in Table 2. Most of the first 75 papers (as described in the Methods section) are represented by blanks in the 5th and 10th columns. The 25 papers chosen because they had the word "management" in their titles have an "m" in the 5th and 10th columns (columns labeled M).

In addition to the 25 papers specifically chosen to have the word "management" in their title, there were also 6 papers in the original 75 that contained this word in their title (8.0%). Thus, we had a total of 31 papers for which evaluations were possible after being identifiable as related to management in two ways; they were in journals that deal with management and they had the word "management" in their title. The six additional papers (from the original 75) are identified with an "m*" in the fifth and tenth columns of Table 2. Sixty-nine papers did not have the word "management" in their title.

Table 1. -- A list of six journals (journal number = JNu) from which a sample of 100 papers was randomly chosen to determine if management questions were asked.

JNu	Journal name	Stated objective
1	Conservation Biology	.... encourages the communication of results to facilitate their application in conservation decision-making ...
2	Journal of Applied Ecology	.... papers that apply ecological concepts, theories, models and methods to the management of biological resources in their widest sense ...
3	Ecological Applications	.... concerned broadly with the applications of ecological science to environmental problems ...
4	Ecology of Freshwater Fish	.... conservation, development and management of recreational and commercial fisheries ...
5	Ecological Management and Restoration	.... dedicated to promoting improved ecosystem management and restoration within the context of ecologically sustainable utilization ...
6	Fisheries Management and Ecology	.... all aspects of the management, ecology and conservation of inland, estuarine and coastal fisheries ...

In our sample of papers, a total of 69 questions were asked, 55 (78%) of which were categorized as research questions (regarding things like explanation, description, establishing connections, characterization, and measuring). No questions met the criteria listed in Box 1. In other words, no questions were asked that required answers involving quantitative guiding information for management in regard to human interactions with anything nonhuman (e.g., other species, ecosystems, or the biosphere; i.e., following our definition of a management question).

Table 2.-- List of references (R, identified by numbers in the Citations) showing the number of questions asked (QA), and, of those, the number that were management questions (MQ), and the the number that were research questions (RQ). Papers with the word “management” in the title are identified by “m” in the M columns.

R	QA	MQ	RQ	M	R	QA	MQ	RQ	M
1	0	0	0	m	26	0	0	0	
2	0	0	0	m	27	0	0	0	
3	0	0	0	m	28	0	0	0	
4	0	0	0	m	29	0	0	0	
5	0	0	0	m	30	0	0	0	
6	0	0	0		31	3	0	3	
7	0	0	0	m	32	0	0	0	m
8	0	0	0		33	0	0	0	m*
9	0	0	0		34	0	0	0	
10	0	0	0	m	35	0	0	0	
11	0	0	0		36	5	0	0	
12	5	0	5	m	37	0	0	0	
13	0	0	0		38	0	0	0	m
14	1	0	0	m	39	2	0	2	
15	0	0	0	m	40	3	0	3	
16	1	0	0		41	1	0	0	m
17	0	0	0		42	3	0	3	m
18	0	0	0	m	43	1	0	1	m
19	0	0	0		44	3	0	0	
20	13	0	13	m	45	1	0	0	m
21	0	0	0		46	1	0	1	m*
22	0	0	0		47	0	0	0	m*
23	0	0	0		48	0	0	0	m*
24	0	0	0		49	0	0	0	
25	0	0	0		50	0	0	0	

Table 2. -- Continued.

R	QA	MQ	RQ	M	R	QA	MQ	RQ	M
51	0	0	0		76	0	0	0	
52	0	0	0		77	0	0	0	
53	0	0	0		78	0	0	0	
54	0	0	0		79	1	0	1	
55	0	0	0		80	0	0	0	
56	0	0	0		81	0	0	0	
57	0	0	0		82	0	0	0	
58	0	0	0	m	83	1	0	0	m
59	0	0	0		84	0	0	0	
60	0	0	0	m*	85	5	0	5	
61	0	0	0	m	86	0	0	0	
62	0	0	0		87	5	0	5	
63	0	0	0		88	1	0	0	
64	0	0	0		89	1	0	1	
65	5	0	5		90	0	0	0	
66	0	0	0		91	0	0	0	m*
67	0	0	0		92	0	0	0	
68	5	0	5	m	93	0	0	0	
69	0	0	0		94	0	0	0	
70	1	0	1		95	0	0	0	
71	0	0	0		96	0	0	0	
72	0	0	0	m	97	0	0	0	
73	0	0	0		98	1	0	1	
74	0	0	0	m	99	0	0	0	m
75	0	0	0		100	0	0	0	

* Papers with the word “management” in their titles that were not originally chosen to meet this criteria.

Of the 69 questions found in our sample of papers, 32 (~46%) were asked in the papers with the word "management" in the title. This represented a little over one question per paper (32/31) for papers in this category. By contrast, 37 (~54%) of the 69 questions were found in the 69 papers without the word "management" in the title or about 0.54 (37/69) questions per paper. In no category (or combination of categories) were any management questions asked so as to define research that would provide direct guidance (no questions met Criterion 4, Measurability, of Box 1). In other words, no questions were posed so as to lead to science (research) that would provide an answer with an objective quantitative goal for management action. The same was true for other criteria of Box 1. No questions were asked with the objective of achieving sustainability with regard to a specific mode of human interaction with any specific nonhuman system. As is thus clear, no questions were asked that simultaneously met all of the criteria of Box 1; the MQ column of Table 2 contained nothing but zeros.

Other types of questions were asked, in our sample of papers, but they did not fall in either the category of a management question (regarding appropriate human relationships or impacts on other things) or questions addressed in research as reported in the corresponding paper (regarding things like explanation, description, establishing connections, characterization, and measuring). These other questions involved a variety of things. For example, Boeken and Shachak (1994; paper 12) asked five questions in a list of research questions that they identify as questions that they did *not* address. Bradstock, et al. (2006; paper 14) posed a question about the impact of research on management (a question that possibly could have been considered a research question identifying an impact). The title of the paper by Broadhurst et al. (2006; paper 16) asked a question that contains certain elements of a management question ("*Should we be more critical of remnant seed sources being used for revegetation?*"). Although it involves specificity, it lacks attention to sustainability and the clarity needed to lead to research that will provide a quantitative answer. As posed, this question would not lead to establishing guidance for management with progress that can be measured and compared to desired standards (Criterion 4, Box 1). Groffman et al. (2006), asked questions related to methodology (primarily related to the methods of research rather than the methods of management). Hauser et al. (2008; paper 41) presented a question in their title which is related to the quality of management (a choice of management options). Hobbs and Hilborn (2006; paper 44) present a question regarding probabilities related to statistical procedures. Hughes and Morley (2000; paper 45) presented a question regarding the utility of prediction in management. Salick et al. (1995; paper 83) asked one question pertaining to the elements of management (procedural—regarding things that should be included in management). Finally, Solow and Smith (2006; paper 88) asked a question regarding procedures for describing/characterizing things in the past using statistical procedures (Markov chains).

The results reported in the last few paragraphs are the outcome of a somewhat mechanical objective process. However, the papers in our sample may have been reports of work that the authors thought would address a management question even though they did not pose the question. Was there evidence that the authors may have been thinking of a management question but did not express it in words? This topic proved to be too subjective for us to address clearly. We found that the various papers in our sample involved a wide range of clarity about management issues being addressed. For example, Whitney et al. (2007) were clearly aware that their work contributed to substantiating the general principle of interconnectedness (e.g., they state: "An extinction necessarily affects community members that have obligate relationships with the extinct species."). However, was there a management question in their minds? We could not be clear that there was.

We might guess that a question pertinent to the work by Whitney et al. (2007) could be "*What is a sustainable population size for the clapper rail in southern California and northern Mexico?*" But this would fail to specify intransitive management action on the part of humans that might to lead to conditions wherein such populations would emerge. This question mentions sustainability but not for human interactions with the rail; human interactions are not specified in ways that can be measured. This question fails to meet the criteria listed in Box 1. On the other hand, a different management question might have been something like: "*At what rate can humans sustainably cause extinctions?*" This would meet Criteria 1, 3 and 4 of Box 1 but would need specification regarding a particular contributing factor (e.g., production of any pollutant, or habitat degradation, contributing to reduced clapper rail abundance).

At the other extreme, Baxter et al. (2006) were clearly addressing issues related to human influence on survival and reproduction of endangered species. However, the kind of management question they seemed to have in mind involves choice of strategies based on economic considerations rather than sustainability. Work such as this exemplified the introduction of anthropogenic interconnectedness wherein economic factors were overtly woven into human interactions with the nonhuman—economic systems count among the forces contributing to what we see (Fowler et al. 2013). In the work of Baxter et al. (2006), the sustainability of nonhuman systems and the sustainability of human influence takes lower priority than economic factors and, as a result, their work does not meet Criterion 1 (Box 1, Sustainability).

Because one of the factors raised in their work was the protection of nests, Baxter et al. (2006) could have asked the management question: "*What portion of the geographic range of the helmeted honeyeater (*Lichenostomus melanops*) would be free of direct human influence to be sustainable?*" This question meets all four criteria in Box 1. Because the honeyeater is an endangered species, a question that fits in the background of this work, could be repeated from above: "*At what rate can humans sustainably cause extinctions?*" (With continuing need to break such questions down into more specific questions, and adhere to Criterion 2 of Box 1, to provide specificity regarding individual contributing factors that lend themselves to measurement).

Because of the subjectivity involved in evaluating papers with regard to whether or not the authors might have been thinking of a management question, we failed to find clarity that could be replicated by a similar study conducted by other researchers. The guesswork behind such efforts would prevent meaningful consistency.

Our initial goals included that of categorizing papers in regard to the kind of science represented (e.g., revealing ecological relationships, characterizing human influence, improving methodology, offering explanation, discovery, and prediction). This proved to be more subjective than met our standards for reaching clear conclusions and was not considered the main goal of this paper. Therefore, results are not presented here. Our decision to not pursue this issue does not constitute an indictment of any of the papers we studied (nor of science in general); as is the case with most science, all 100 papers make meaningful contributions to the substantiation of important general principles, knowledge and understanding.

By comparison, there was greater clarity in regard to the more objective matter of which form of management (transitive vs. intransitive) seemed uppermost in the minds of the authors of our sample of papers. Thus, we could evaluate adherence to Criterion 3 (Box 1, Intransitivity).

To do so, we made a distinction based on the use of verbs associated with management; in most cases we could quite easily tell the difference between management perceived to be manipulative (transitive) in contrast to management seen as regulation of human activities (intransitive). Table 3 presents examples of wording that reflects the manipulative or transitive form of management wherein action involves control over the nonhuman (in contrast to action that involves placing limits on human influence—the intransitive form of management embracing the principle of complex interconnectedness).

We did find evidence that intransitive management is occasionally considered to be an option. For example, Adite et al. (2006; paper 2) mention restricting the harvest of fish (African bonytongue, *Heterotis niloticus*) as a form of management; this exemplifies the self-restraint of intransitive action (at the population or species level). In this example, humans would restrict, or regulate, their own harvest of fish. Broadhurst et al. (2006; paper 17) indicate that trawlers are managed and size selectivity is controlled—both examples of intransitive management (in a paper evaluating the effects of gear—substantiating the general principle that we impact the nonhuman). Mangi and Roberts (2007; paper 59) refer to the control of fishing effort and Rouget et al. (2006; paper 80) refer to land-use management. Overall, we found example of intransitive management mentioned in 15 of the 100 papers in our sample. Only three of these (papers 2, 17, and 53) were papers that did not *also* make clear mention of management in the transitive form (as listed in Table 3).

Table 3 presents a clear pattern with respect to the more explicit objective of this phase of our work. Here we are determining what portion of our sample of papers referred to management in the transitive form with the null hypothesis that less than half of the papers would use transitive terminology. We are addressing the research question: "What portion of our sample of papers showed a failure to meet Criterion 3—Intransitivity (Box 1)?" Our results showed that two-thirds (46 out of 69) of the papers without the word management in the title refer to management by using transitive terminology while 96.8% (30/31) of the papers with management in the title subscribed to transitive management in their use of management-related terminology. Overall, 76.0% (76/100) of the papers used transitive terminology exemplified by the words quoted in Table 3. Of the 78 papers containing the combination of characters for either “manage” or “control”, all but two (97.4%) made reference to the transitive form of management action.

We firmly reject our null hypotheses that management questions are being asked. We also reject the hypothesis that terminology involving intransitive management is more prominent than transitive terminology. Intransitive terminology occurs in less than half of the published literature as an indication that it is the least accepted form of management. Management questions are not being asked and transitive management is the prevalent form of management as it is currently perceived.

Table 3. -- List of references (identified by numbers in the Citation Section) with wording that is consistent with transitive rather than intransitive management action. Papers with the word “management” in the title are identified by m in the M column (m^1 for cases not specifically chosen for the word “management” in the title).

Reference	Transitive wording	M
1	...management of the Arctic charr... ...managers of aquatic ecosystems...	m
2		m
3	...grassland community [..] managed...	m
4	...control the [..] weed... ...management of the resources...	m
5	...management of gene diversity... ...[operational conservation unit] management... ...management of [..] populations... ...management of wildlife...	m
6		
7	...predator management... ...predator control... ...moors managed... ...land management...	m
8	...management of inland wetlands... ...wetland management...	
9		
10	...manipulation of vital rates... ...management of fecundity and survival... ...management of the helmeted honeyeater... ...koala management... ...population management... ...threatened species management... ...population management... .species management... ...removal of a predator or disease... ...managers of metapopulations...	m
11	...macrophyte control... ...macrophyte management... ..weed management...	
12	...landscape management... ...land management...	m
13	...management of Atlantic salmon...	
14	...fire management... ...wildfire control... ...management of [..] landscapes...	m
15	...dune management... ...management of [..] habitat...	m

Table 3. -- (Continued).

Reference	Transitive wording	
16	...land managers...	
17		
18	...pest control... ...management of soil organic matter... ...land management...	m
19	...water management... ...trees management... ...species management... ...livestock management... ...land management... ...weed control... ...herbivore control... ...predator control...	
20	...forest management... ...managed [..] stands...	m
21	...to manage species or their habitats...	
22	...manage the resources...	
23	...pest and weed control... ...management to control other grazers/browsers...	
24	...resource management... ...management of marine resources... ...management of the fish stocks...	
25	...agricultural management... ...manage vegetation composition... ...management of [..] fields and stage of vegetation development...	
26	(recommendations are for manipulation)	
27	...management of small captive populations... ...management of both captive and wild kestrels...	
28		
29	...management of [..] protected areas... ...manage resources...	
30	...forest management...	
31		
32	...management of stocks... ...stock management...	m
33	...management of an exploited species... ...management of marine reserves... ...resource manager...	m[1]
34	...management of the rare plants... ...management of populations... ...fields [..] managed... ...management of *Galeopsis angustifolia*... ...manage the site... ...management of the plant-pollinator communities... ...management of arable land... ...hedgerow management... ...manage [species]...	
35	...managed part of the study site... ...forest management...	
36		
37		
38	...population management... ...genetic management... ...management of endangered species' gene pools... ...individuals are [..] managed...	m
39	...bird groups [..] amenable to management... ...land managers... ...land management... ...farm properties managed... ...management of remnant natural vegetation... ...management of [..] trees...	
40	(recommendations are transitive)	
41	...pest control... ...management of water flows...	m
42	...salmon management...	m

Table 3. -- (Continued).

Reference	Transitive wording	
43	...endangered species management... ...land managers...	m
44	...management of natural resources...	
45	...water resources management... ...manage water resources... ...water management......reservoir management... ...physical habitat and river management... ...measures to control or mitigate change...	m
46	...forest stands under control... ...forest management... ...stand management... ...plantation management...	m[1]
47	...land management... ...vegetation management... ...ecosystem management... ...wildlife management... ...management of landscapes... ..natural resource management... ...resource management..	m[1]
48	...resources whose management... ...resource management...	m[1]
49		
50		
51	...forest management... ...biodiversity management... ...landscape management...	
52	...ecological management... ...pest management... ...farmland managed for...	
53		
54	...manipulate soil biology...	
55	...water management... ...landscape management...	
56	...natural resource management... ...fire management... ...managed [..] lands...	
57		
58	...management of habitat... ...habitat management...	m
59	...habitat manipulation...	
60	...management of native wildlife... ...species management... ...wildlife management... ...management of a species... ...wildlife managers... ...natural resource management...	m[1]
61	...management of species... ...park managers...	m
62	...management of protected areas... ...management of [..] ecosystems... ...management of the oldest marine park...	
63	...management of [..] populations... ...management of this species...	
64	...resource management...	
65	...managed threatened natural resources... ...land management...	
66	...population control... ...females number [..] controlled... ...deer management... ...cervid management... ...game management...	
67		

Table 3.-- (Continued),

Reference	Transitive wording	
68	...ecosystem management... ...management of [..] mistletoes... ...control of [..] mistletoe... ...fox and rabbit [..] control... ...pest control... ...range management... ...management of possums and predators... ...land management... ...pest management... ...forests [..] managed... ...resource management... ...brush management... ...pasture management... ...landscape management...	m
69		
70	...predator conservation management...	
71		
72	...refuge management... ...refuges [..] managed... ...grassland management... ...goose management... ...pasture management...	m
73		
74	...sward management... ...grassland management...	m
75	...management of native fishes... ...management of warmwater stream systems... ...natural resource management...	
76		
77	...coastal management...	
78	...river flow management... ...resource managers... ...flow-managed rivers...	
79	...habitat management...	
80	...management of natural resources... ...land management... ...properties [..] be managed...	
81		
82	...managed fields... ...managed landscapes... ...managed land... ...land is managed...	
83	...forest management... ...timber management... ...management of [..] species...	m
84	...management of stocks...	
85	...management of the countryside... ...countryside [..] can be enhanced...	
86	...weed control... ...controlling herbaceous plants...	
87	...weed communities that are more difficult to manage... ...agriculturally managed systems... ...chemical management... ...weed control...	
88		
89	...management of many waters... ...lake management... ...management [..] of ecosystems... ...management of freshwater fish species... ...river basin management... ...control programmes...	
90	...forest management... ...stand management... ...land management... ...Landscape Management... ... Manage” species...	
91	...controlling large mature females... ...control of common carp... ...manage common carp... ...population management... ...management of common carp...	m[1]

Table 3. -- (Continued),

Reference	Transitive wording	
92		
93		
94	...fish biodiversity management...	
95		
96		
97	...ecosystem management... ...forests managed for... ...manage to reduce densities...	
98		
99	...environmental management... ...management of [..] population...	m
100	...forest management... ...managed forests...	

Discussion

Consistent with earlier work (Fowler and Hobbs 2009, 2011), the sample of papers we studied showed no evidence of management questions[9] being asked in the field of applied ecology. Based on this work, it does not seem unrealistic to conclude that management questions are not being asked.[10] This is a serious shortcoming from several points of view. At worst, the failure to ask management questions promotes aimless actions with serious consequences. Slightly better, but highly problematic, it opens the door for action that serves human causes at the expense of nonhuman systems (anthropocentrism with ultimate peril for humans—i.e., little or no long-term sustainability). At best, and very misleading, the lack of asking good management questions has resulted in superficial actions taken in attempts to serve the well-

[9]Specifically as defined by the criteria in Box 1 so as to embody or implement well known, easily understood, and widely accepted basic principles.

[10]One possible reaction to this conclusion might be to counter with the argument that "because we are managing, we must be asking management questions". There is nothing about management (especially conventional management) that requires (or even implies) that management questions must be asked. It is the objective of work such as that by Fowler and Hobbs (2009, 2011) to link the two (management and questions) so that management questions will always be asked. The empirical evidence of this paper (and Fowler and Hobbs, 2009) shows that management is proceeding without questions that are asked to meet the criteria of Box 1 so as to incorporate well recognized general principles.

being of nonhuman systems (provided actions are not too costly in short-term human value systems—again involving anthropocentrism). In all cases, the consequences often involve dramatic long-term, large-scale problems of staggering magnitude (at least some of which are being observed[11]).

The consequences of not asking management questions are one thing; the failure to promote science that can provide realistic advice is another.

How does the failure to ask good management questions prevent the production of realistic advice? Obviously, if managers were asking: "*How many metric tons of red salmon (*Oncorhynchus nerka*) can be sustainably harvested in Bristol Bay, Alaska each year?*" and scientists conducted research that provided an answer of 100,000 metric tons (as an answer that accounted for everything holistically), managers would have what they needed (especially if they implemented the advice directly rather than yield to the pressures of economic, political, or other special interests). To our knowledge, this never happens. Why? The impediment comes from the fact that the vast majority of the kind of information that scientists provide involves estimates, characterization, explanation, or identification of things that are related to the answer but are not the answer[12]—especially not an answer that involves holism. Based on the principle of complex interconnectedness, virtually anything will bear some level of relevance to the answer. This results in a situation wherein the information scientists produce has to be *converted* to an answer. In conventional management, this inherently makes the process one that is subject to serious

[11]Witness the list of problems identified in the introductory section: the extinction crisis, overfishing, climate change, ocean acidification, the threat of global pandemics, ecosystems that are totally destroyed, the risk of global collapse, and human extinction.

[12]An example of this in fisheries management is the production of biomass estimates for the standing stock of a resource species as information used in establishing harvest levels (e.g., quotas). Standing stock is one thing and harvests are another. Standing stock is very relevant and valuable information. However its use in conventional management is subject to the bias of economic factors, politics, and human limitations in general. Estimated harvests by other species provides the consonance (harvests are harvests) not found in estimates of standing stock.

problems (basically the suite of human limitations[13]; Fowler 2009; Fowler and Hobbs 2011). Economic factors, for example, are often legislatively required as elements of the conversion; if economic factors are not used to modify advice coming from scientists, it certainly plays a role in final decisions regarding actions carried out as management. The reality of the full set of ecological, evolutionary, and other systemic factors/consequences goes largely ignored by default; the collective set of unknown/unknowable cannot be incorporated holistically and objectively through conventional means.

The apparent impasse we confront here is one that is solved, not by working to improve the conversion process[14], but by recognizing it for what it is and replacing it completely. In other words, we stop making attempts at anthropogenic conversion entirely and adopt a totally different process. This replacement requires that good management questions be asked so that the science (including the research question being addressed), and information are defined by the management question; conversion (as conventionally attempted) is not required. As explained in Fowler (2003, 2009) and Fowler and Hobbs (2011), this is achieved by a strict congruence, match, and isomorphism between the management question and science question (Fig. 1). This congruence (consonance) proceeds to the kind of information revealed by research and from there to management action.

[13]The list of human-related factors that give rise to serious problems as they are involved here is huge but includes: emotions, belief systems, values, governance, politics, conventional thinking, economics, greed, misapplication of science, ignorance, educational systems, and evolution (i.e., the selfish gene).

[14]For example, progress toward better management is often believed to be possible through better training to perpetuate the conversion process (e.g., see Brosnan and Groom 2006).

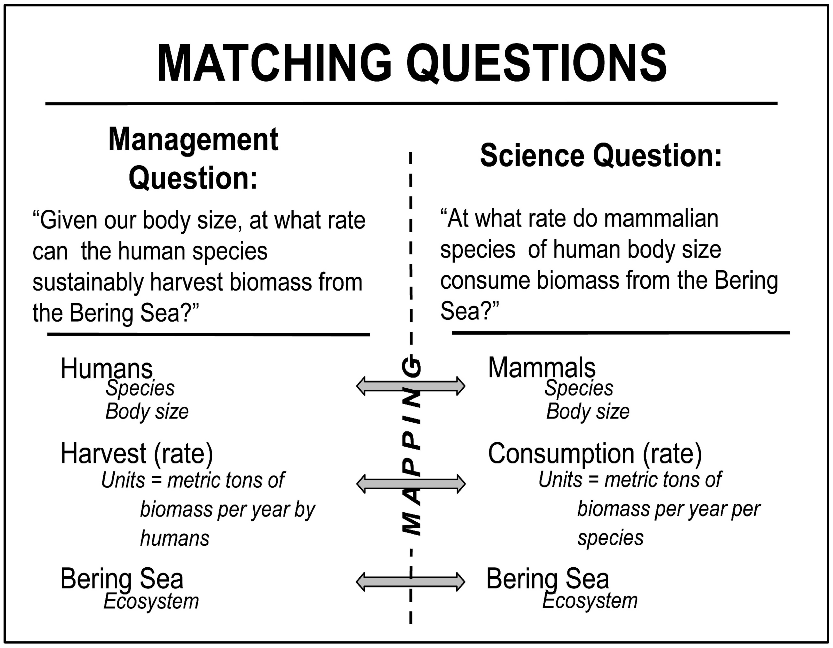

Figure 1. -- Illustration of the concept of mapping a management question into the consonant question for researchers to address in their application of science. The answer to the science question would reveal a pattern measured in units defined by the management question so that an answer to the management question can be provided in statistical terms (or, to maximize the biodiversity within the consonant empirical pattern; Fowler 2008)

Thus, only a minuscule part of the information produced by science meets the criteria necessary for actually answering a specific management question. The overwhelming majority of information pertains to explanation, prediction, discovery, and characterization/description of things that are not consonant with the management question in hand (but all with varying degrees of relevance[15]). Only a very tiny fraction of the information produced by scientists of the world is consonant with a specific management question (and, currently, this information is largely ignored). Almost all (if not all) of the products of science involves information that is relevant (owing to the principle of complex interconnectedness), but not consonant; the degree of relevance varies from factor to factor and is often the source of heated debate among scientists. When consonant, the information itself accounts for everything that is relevant—in

[15]Much of this information can be used objectively in correlative analysis when the consonant information is shown to be correlated with the nonconsonant information.

proportion to its actual importance, directly, accurately, and objectively; the information is infinitely integrative (Fowler 2009; see also: Appendix 3 of Fowler et al. 2013).

Although, in the work we are reporting here, we failed to objectively categorize individual papers in our sample of 100 publications with regard to the kinds of science they represented, the research reported in these papers, along with the research conducted by science in general, contributes to the formation of very valuable general principles such as those behind the criteria listed in Box 1. However, principles do not constitute management advice, even though they do provide invaluable help in defining (and asking) good management questions. A prime example involves the principle of complex interconnectedness; it exposes the unrealistic nature of transitive management[16] and forces us to confine our management questions to those seeking sustainable human interactions and influence on nonhuman systems—sustainable participation by humans in the universe.

The results of our study, however, indicate that the majority of scientists (and by association, most probably managers as well), at least passively, continue to accept the concept of manipulating nonhuman systems to meet perceived human needs (and maintain the status quo) rather than addressing questions of ways we can sustainably participate in, and interact with, nonhuman systems (and particularly whether or not what we are doing now is sustainable). This conclusion is not based solely on the results of our analysis of the use of management-related verbs in the papers we sampled. Referring back to Table 1, we note that the stated objective for the *Journal of Applied Ecology* includes transitive verbiage ("management of biological resources") rather than intransitive[17] (i.e., something like "management to achieve

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[16]Another general principle is that of human limitations: we cannot know or understand everything. Failure to combine this principle with that of complex interconnectedness leads to the perpetuation of the problem that Dante recognized several centuries ago: we continue making decisions and taking management action without full consideration of reality (Meeker 1997).

[17]Readers might react with the thought that this is merely a matter of semantics: "What people really mean when they say 'management of biological resources' is the management of peoples actions." In some cases this might be the case. However, two important points must be made. First is the need for a reversal of the burden of proof; is that (the intransitive) really what is meant (rather than the transitive as stated)? Second, scientists are increasingly aware that language is important in the way that we think (e.g., Boroditsky 2011; Thibodeau and Boroditsky 2013) and invoking the results of such work makes it difficult to conclude that what is said is not what is meant—in many, if not most, cases.

sustainable human influence on systems serving as sources of resources"). The same applies to *Ecological Management and Restoration*; their objectives include "ecosystem management". For this journal, however, there is also an example of the intransitive as seen in the words: "ecologically sustainable utilization".

The acceptance of transitive management is also seen in the names of many journals. Example include the *Journal of Wildlife Management* (rather than something like the *Journal of Sustainable Impacts on Wildlife*). *Regulated Rivers: Research and Management* is the name of a journal that has two word-combinations that are transitive. Other journals that have similar transitive terms in their names include: *Journal of Aquatic Plant Management*; *Journal of Environmental Management*; *International Journal of Pest Management*; *Forest Ecology and Management*; *Agricultural Water Management*; *Coastal Management*; *Tropical Coastal Area Management*; *Biological Control*; *AI Applications in Natural Resource Management*; *Journal of Range Management*; and *Wetlands Ecology and Management*. In defense of at least some of these journals, it should be pointed out that a few mission statements include intransitive terminology. For example the *Journal of Environmental Management* includes "the sustainable use of environmental resources" as one of the concerns of readers and contributors. Nevertheless, the presence of transitive terminology remains obvious among management-oriented journal titles and appears to be much more prominent than the intransitive.

Transitive terminology in management is also found in the titles of many books. *Analysis and Management of Animal Populations* (Williams et al. 2002) is an example. Other examples include: *The Science of Overabundance: Deer Ecology and Population Management* (McShea et al. 1997), *Game Management* (Leopold 1933), *Forest Insects: Principles and Practice of Population Management* (Berryman 1986), *Population Management for Survival and Recovery: Analytical Methods and Strategies in Small Population Conservation* (Ballou et al. 1995), *Ecological Integrity and the Management of Ecosystems* (Woodley et al. 1993), and *Forest Management: Technology, Practices and Impact* (Cruz and Correa 2012). This list is extensive with terminology involving expressions much like those listed in Table 3 (e.g., "wildlife management", "natural resource management", "population management", "game management", "ecosystem management" and "species management").

The titles of books, papers, and journals are not isolated cases where the frequent use of transitive terminology can be found. The titles of agencies, departments, and programs also contain words involving the transitive. In this case, the numerous examples include: *Wild Fire Management Branch* (Forests and Range, British Columbia); *Department of Forestry and Wildlife Management* (University of Massachusetts, Amherst) ; *Wildlife Management Institute*; *Department of Natural Resource Ecology and Management* (Iowa State University); and *Department of Ecosystem Management* (University of New England; Kiel University).

Thus, the prevalence of transitive terminology is observed in published papers (as shown in our study), in the mission statements of journals, in the names of journals, in the titles of books, and in the names of organizations. Is this a product of grammatical shorthand (is it easier to write "wildlife management" than "management of our interactions with wildlife")? Or is it a reflection of the way we think—specifically the way we think about management? In this regard, is our thinking about management impacted by our use of words; does the prevalence of transitive terminology prevent intransitive option? Definitive answers to these questions may not be possible. However, the consistency of action and terminology in conventional management seems to us to lead to the inescapable conclusion that complex interconnectedness may well be accepted in a principle but is largely denied in management. Criterion 3 (Box 1, Intransitivity) is largely ignored. This happens to our peril if the feedback of our actions includes an elevated risk of human extinction (not to mention the laundry list of problems with which we are surrounded).

It seems imperative to us that the asking of good management questions requires that they be expressed in intransitive terms. Consider, for example, paper 37 (Haegen 2007), which deals with effects of agriculture on birds in eastern Washington state. This work substantiates the principle that things are interconnected (and humans have impacts on birds). The author might have made use of the principle of complex interconnectedness to mention that his work gives rise to the management question: "*How many tons of wheat per square kilometer can be harvested sustainably from the shrubsteppe of eastern Washington?*" Multiple questions with this wording can be asked (with other crops substituted for wheat). There are other obvious questions stimulated by this paper (all relevant to the sustainability of all species and their ecosystems): "*To achieve sustainability, what portion of the shrubsteppe of eastern Washington should be protected from the direct effects of humans (set aside in protected status)?*" "*At what* *rate can pesticide X be applied sustainably in the shrubsteppe of eastern Washington?*" "*At what rate can irrigation water be extracted sustainably from the watersheds of the shrubsteppe of eastern Washington?*" All such questions should be asked and answered with management action taken on the basis of the answer.

Every paper in our sample can serve as the starting point for asking numerous management questions based on the principle of complex interconnectedness. Paper 56 (Leroux et al. 2007) for example, contains a list of some of the known elements involved in ecosystems as factors that should be taken into account in reserve design. One aspect of reserves involves the portion of a particular ecosystem that should be designated for protected status: "*In order to achieve sustainability, what portion of ecosystem X should be designated as areas free of the direct effects of humans?*" Within a large ecosystem this same question can be asked for smaller ecosystems (such as the area within the larger ecosystem that is occupied by a particular species). The multitude of questions of this type are treated by Fowler and Johnson (in prep.). In the areas that are not subject to complete protection, other questions apply (and have relevance to the protected areas because of the principle of complex interconnectedness—ecosystems interact with each other): "*What is a sustainable population density for humans?*" "*At what rate can humans sustainably produce carbon dioxide on each square kilometer of habitat?*"

Asking management questions is the first step. To provide realistic guidance for management, management questions must be posed so as to define corresponding research/science questions that can lead to research that provides the information needed as guidance. This is accomplished by a strict match between the two questions (Fig. 1). With a well-defined research question, research can reveal the natural pattern consonant[18] with the management question. This pattern will provide a holistic objective answer to the management question and management action can be taken to achieve numerous goals (e.g., health, sustainability, normalcy and improved biodiversity). The details regarding these steps may be found in Fowler (2003, 2009) and Fowler and Hobbs (2011). Our point here is that management questions must be asked to initiate any management process; without the management question

[18]The concept of consonance is treated in detail in Fowler (2003, 2009) and Fowler and Hobbs (2011). In essence, it involves an isomorphism or congruence that removes conceptual ambiguity. A pattern consonant with the management question reveals the information that answers the management question through empirically observed sustainability.

we proceed with business as usual and continue doing things with the increasingly obvious consequences.

The initial steps made in our study have their obvious extensions for future work. In addition to categorizing papers according to whether or not they had the word "management" in the title, we could have divided (and compared) the papers into groups according to whether the lead authors were associated with universities compared to those with lead authors associated with government agencies. Comparisons based on the continent in the address of the lead author could have been made; others could involve profit versus non-profit organizations (and government agencies) as sources of funding for the research being reported. With regard to such options in the work we are reporting, every category from these examples would be represented by published works in which no management questions were asked in our sample of papers.

Recommendations

What can be done to rectify the lack of asking bonafide management questions (and the undesirable consequences)?

One of the most obvious recommendations stemming from our work is to begin asking management questions:

1. Managers should pose management questions so that scientists can choose which ones to address.
2. Scientists should state the management questions that they believe to be the one(s) that they are addressing in their research and resulting published works.
3. Editors of journals with applied missions should require that people who publish in their journals state the management question being addressed.
4. Educators at all levels (but especially at the college and graduate level) should provide clear training in the asking of management questions (e.g., including how to meet the criteria of Box 1).
5. Everyone should be aware of the distinction between the transitive and intransitive forms of management so that the management questions can be posed to supply information for intransitive action.

6. Everyone should confine their asking of management questions to the intransitive so as to fully accept and incorporate the principle of complex interconnectedness in both the science conducted and published, and in management action.
7. Scientists who review papers submitted with the claim to having practical relevance should demand that the author(s) state one or more management question(s) to which their work applies.
8. Management questions should be posed so that answers provided by science is quantitative in nature (including the binary aspects of "should we" or should we not" be involved in a particular direct interaction), to adhere to Criterion 4 (Box 1, Measurability).

In all phases of management it is critically important to emphasize the merit of intransitive management questions compared to the risks associated with transitive management questions. A realistic management question has to take into account the complex interconnected nature of reality as a general principle that makes transitive management unrealistic.

Summary

We randomly sampled 100 peer-reviewed papers from six journals which have stated missions of publishing work pertinent to management in regard to species, ecosystems, and other nonhuman systems. We analyzed these papers with regard to whether or not management questions were posed and whether or not the general principle of complex interconnectedness was acknowledged to avoid transitive management action. None of these papers presented a management question; readers and managers are left to guess how the work being reported contributes to providing guidance. Virtually all of the papers (as with most of the products of science) help substantiate the general principle of complex interconnectedness. However, this principle was largely ignored (or even denied) as made evident in the use of transitive management-related terminology (also prevalent in journal titles, names of agencies/departments, and titles of books).

We urge systematic changes in publishing, education, and management to promote a requirement that good management questions be asked. Such questions must be asked so as to lead to very specific kinds of science. The research involved would then provide objective holistic answers to those questions (with very specific consonant information as defined by the management question). These answers would take the form of information that would not require conversion of the type that makes today's management so very deeply vulnerable to human limitations. Owing to the problems identified by scientists (e.g., extinction, climate change, ocean acidification, and the risk of human extinction), these recommendations are, in our view, essential steps toward averting long-term consequence of our actions that lead to further intensification of the challenges facing humanity.

Acknowledgments

We extend our sincere thanks to Jean Fowler, Susanne McDermott and Kim Shelden for their helpful reviews of previous versions of this paper—complete with invaluable comments and suggestions that substantivally improved our work.

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