Using Anecdotal Occurrence Data for Rare or Elusive Species: The Illusion of Reality and a Call for Evidentiary Standards

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Anecdotal occurrence data (unverifiable observations of organisms or their sign) and inconclusive physical data are often used to assess the current and historical ranges of rare or elusive species. However, the use of such data for species conservation can lead to large errors of omission and commission, which can influence the allocation of limited funds and the efficacy of subsequent conservation efforts. We present three examples of biological misunderstandings, all of them with significant conservation implications, that resulted from the acceptance of anecdotal observations as empirical evidence. To avoid such errors, we recommend that a priori standards constrain the acceptance of occurrence data, with more stringent standards applied to the data for rare species. Because data standards are likely to be taxon specific, professional societies should develop specific evidentiary standards to use when assessing occurrence data for their taxa of interest.

Keywords: anecdotal, evidentiary standards, fisher, ivory-billed woodpecker, wolverine

In conservation and wildlife biology, establishing the presence of rare or elusive species, including some that have long been considered extinct, can become a near-mythic quest. Because the occurrence of a rare species—or even one that has recently been declared extinct—seems plausible, we tend to believe anecdotal observations (i.e., observations that lack conclusive physical evidence) despite widespread understanding of the intrinsic problems associated with such data. Just as it is difficult to doubt the veracity of a detailed and seemingly reliable statement from an eyewitness in a court of law, it is also difficult to discount a visual observation of a rare, elusive, or extinct species when it is reported by a trained and experienced biologist. Compounding this problem, anecdotal data are often accompanied by inconclusive physical evidence, such as castings or pictures of tracks, fuzzy or distant photographs, or nondiagnostic acoustic recordings. Unfortunately, such weak corroborative data are often treated as confirmatory. Consequently, anecdotal occurrence data continue to be used for making important conservation decisions, such as delineating the current geographic range or deriving rudimentary estimates of abundance for species of concern.

For these reasons, we argue that the use of anecdotal data to establish the presence or geographic range of rare or elusive species is inherently unreliable and can lead to errors with substantial negative impacts on conservation decisionmaking and resulting conservation efforts. This is not to say that anecdotal data cannot provide useful preliminary information for conservation. The multitude of citizen scientists who provide anecdotal observations serve as important sentinels for detecting potential changes in the status of species of concern. For example, anecdotal information can provide early warnings of population declines when numerous observers report that once-common organisms now appear scarce. Alternatively, repeated sightings of species of concern in a given area can be used to identify high-priority areas for

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initiating systematic surveys or new research. However, we argue that conclusions regarding the presence of rare or elusive species must be based on verifiable physical evidence. We present three case histories to illustrate how the use of anecdotal data to assess the current distribution or population status of species of concern can adversely affect conservation goals. Our examples include delays in obtaining needed habitat protections (the fisher [*Martes pennanti*] in the Pacific states), delays in initiating reintroductions or other conservation actions (the wolverine [*Gulo gulo*] in California), and the misallocation of scarce resources for conservation (the ivory-billed woodpecker [*Campephilus principalis*] in the southeastern states). We then show how evidentiary standards for species' occurrence data could be delineated using a gradient of reliability based on current knowledge of the species' status.

Case history 1: The fisher in the Pacific states

Fishers once occurred in most coniferous forest habitats in the Pacific states of Washington, Oregon, and California (Aubry and Lewis 2003). Perceived range losses and potential threats to their primary habitat resulted in the submission of two petitions during the 1990s to list the fisher in the Pacific states under the Endangered Species Act (Beckwitt 1990, Carlton 1994). Both petitions were denied, the first because reliable information on the status of fisher populations was lacking (USFWS 1991) and the second because anecdotal occurrence data indicated that fishers were distributed continuously across much of their historical range (figure 1a, map at left; USFWS 1996).

To investigate the reliability of these anecdotal data, Aubry and Lewis (2003) mapped the geographic distribution of anecdotal observations of fishers in the Pacific states

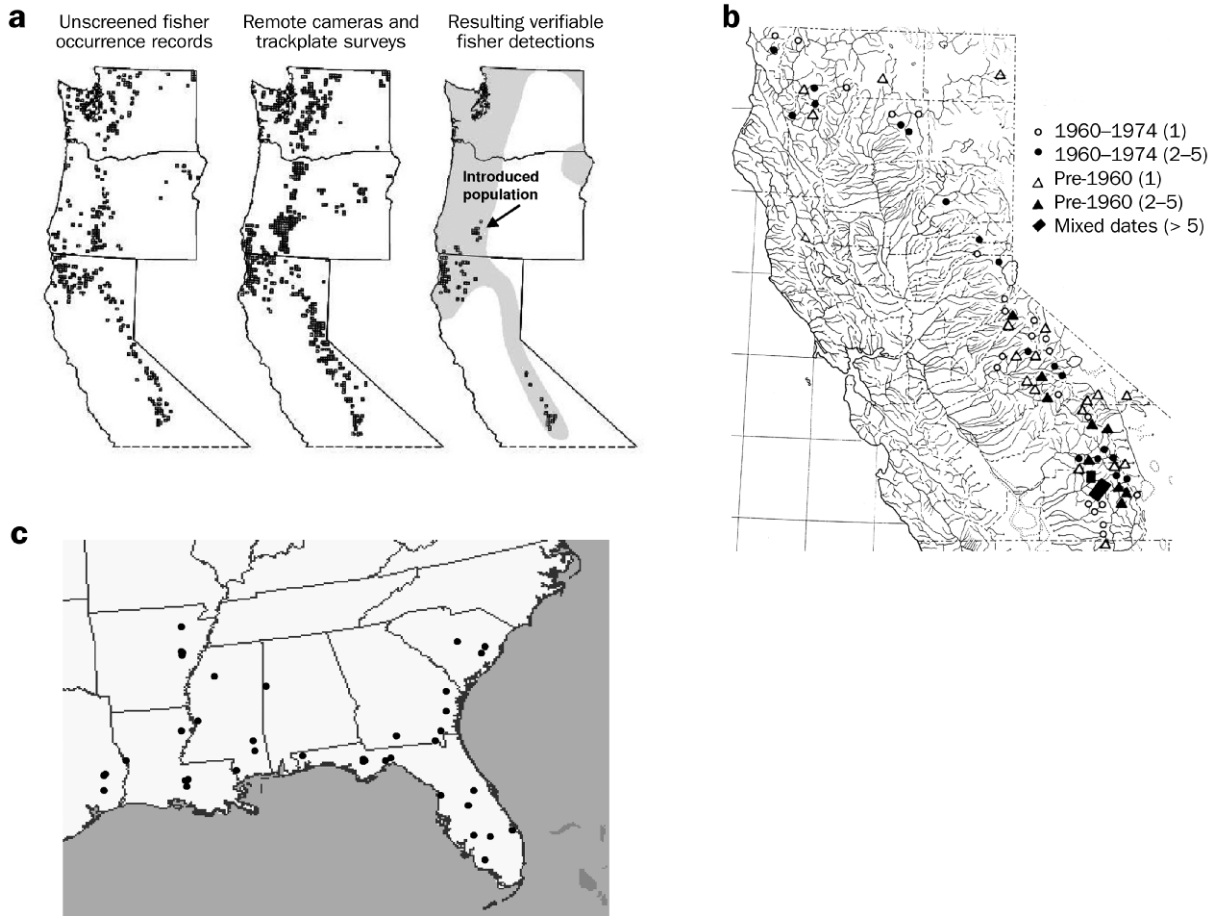

Figure 1. Recent occurrence records for (a) fisher in the Pacific states (1954–1992; map reproduced from Aubry and Lewis [2003]), (b) wolverine in California (ca. 1960–1974; map reproduced from Schempf and White [1977]), and (c) ivory-billed woodpecker in the southeastern states (1944–2005; modified from* www.fws.gov/ivorybill/IBW-range-map.pdf*). The locations of standardized surveys conducted from 1989 to 2000 for fishers in the Pacific states are shown in (a), center map ("Remote camera and trackplate surveys"); verifiable fisher detections obtained during those surveys and the presumed historical range (gray shading) of the fisher in the Pacific states are shown in (a), map at right ("Resulting verifiable fisher detections"). The arrow in this map points to an introduced population from sources in Minnesota and in British Columbia, Canada. In (b), numbers in parentheses are the number of occurrences associated with each symbol. In (b) and (c), all occurrences are anecdotal.

obtained during the last several decades (figure 1a, map at left), and compared their geographic extent with that of verifiable occurrence records obtained during the most recent decade using standardized detection protocols (figure 1a, center map; Zielinski and Kucera 1995). Compared with anecdotal records, the results of recent standardized survey efforts revealed a dramatically different assessment of the current distribution of fishers in the Pacific states (figure 1a, map at right). Although standardized surveys have been conducted throughout most forested areas in that region (figure 1a, center map), and many were intentionally located in areas where multiple anecdotal observations of fishers had been made, fishers were detected only in restricted portions of southwestern Oregon and in several disjunct areas in California (figure 1a, map at right). These findings revealed extensive range losses in Washington and Oregon (figure 1a, map at right) and the isolation of extant fisher populations in the Pacific states from other populations in North America (Aubry and Lewis 2003). These results were supported by genetic studies demonstrating that fishers occurring in the southern Cascade Range in Oregon were introduced from British Columbia and Minnesota (Drew et al. 2003), and that populations in the Siskiyou Mountains of northwestern California and southwestern Oregon are indigenous and isolated from the introduced population in the Oregon Cascades (figure 1a, map at right; Aubry et al. 2004, Wisely et al. 2004). Based partly on these findings, a third petition submitted in 2000 (Greenwald et al. 2000) resulted in Pacific Coast fishers being declared "warranted but precluded" for listing under the Endangered Species Act (USFWS 2004), meaning that the US Fish and Wildlife Service (USFWS) acknowledged the need for federal protection, but listing was precluded by higher priorities.

For the Pacific fisher, the use of anecdotal occurrence data led to a significant overestimation of the species' current distribution and a failure to recognize the extent to which range losses had occurred. The 2004 designation of "warranted but precluded" further demonstrated the need for conservation actions to protect fisher populations on the Pacific Coast and initiated a wide array of conservation and management activities, including the establishment of an international team of biologists charged with developing a conservation assessment and strategy for fishers in the Pacific states and British Columbia. Thus, it is likely that misconceptions created by the acceptance of anecdotal occurrence data as empirical evidence delayed the initiation of conservation actions for Pacific Coast fishers by at least a decade.

Case history 2: The wolverine in California

Grinnell and colleagues (1937) described the California wolverine as being confined to the southern Sierra Nevada and on the verge of extinction. However, from the 1950s to the 1970s, numerous anecdotal occurrence records were compiled and reported in both primary (Ruth 1954, Jones 1955, Cunningham 1959) and gray literature sources (Bruce and Weick 1973, Schempf and White 1977, CDFG 1978, Kovach 1981). In particular, relying entirely on anecdotal data, Schempf and White (1977) arrived at the remarkable conclusion that wolverines were present throughout most of the mountainous regions of California. The authors claimed that the data they compiled left "no doubt" that wolverines were present in the North Coast and North Sierra regions, areas where wolverines were thought absent in Grinnell's time (figure 1b). Subsequently, a status report published by the state of California stated, "Available information suggests that wolverine numbers are increasing in California" (CDFG 1978, p. 66). The broad, contiguous geographic range described in Schempf and White (1977), and expanded by Kovach (1981) to include the White Mountains, has been accepted and repeated by others (Banci 1994) and is still California's official position (CDFG 2008).

Beginning in the late 1980s, a series of survey efforts were initiated to verify wolverine presence using remote cameras, bait stations, and helicopter surveys in many areas of California (Kucera and Barrett 1993, Zielinski et al. 2005). People continue to claim that they have seen wolverines in California, and our molecular genetics facility (*www.fs.fed.us/rm/wildlife/genetics/index.php*) is often called upon to analyze feces and hair samples collected in California near putative wolverine dens or observations. To date, however, none of these surveys or DNA (deoxyribonucleic acid) analyses has detected wolverines in California; the last verifiable evidence of wolverine occurrence in California was obtained in 1922 (box 1; Aubry et al. 2007).

Aubry and colleagues (2007) conducted a detailed analysis of historical patterns of wolverine distribution throughout the contiguous United States. Considering historical records and the current distribution and extent of suitable habitat conditions for wolverines, they concluded that wolverines most likely never occupied montane areas that lacked extensive alpine habitat conditions, such as the North Coast region of California. Schwartz and colleagues' (2007) genetic analyses provided empirical support for these conclusions, indicating that wolverines in the Sierra Nevada of California were isolated from other populations in North America. Thus, the assertion that the wolverine was rapidly expanding its range in California during the 1970s was clearly inaccurate. Most likely, wolverines were extirpated in California early in the 20th century, as Grinnell and colleagues (1937) anticipated.

Case history 3: The ivory-billed woodpecker in the southeastern states

The last verifiable evidence of the ivory-billed woodpecker was obtained in 1944 in northeastern Louisiana (Fitzpatrick et al. 2005). Since then, however, many people have claimed to have seen the bird. The USFWS has compiled records of these sightings (figure 1c), and they display two traits that are associated with many anecdotal occurrence records: (1) they are located in areas where the sighting is plausible, according to historical information on the organism's distribution and ecological relations; and (2) they show that the species is well distributed within this area of plausibility. Recently, there has been a spate of ivory-bill sightings in Arkansas.

Box 1. Wolverine recently found in California: Remnant native, natural disperser, or transplant?

On 28 February 2008, a wolverine was photographed near Lake Tahoe in the north-central Sierra Nevada by a remotely triggered camera. The camera was deployed during a study of the American marten (*Martes americana*) by Katie Moriarty of the US Department of Agriculture (USDA) Forest Service's Pacific Southwest Research Station and Oregon State University. This record represents the first confirmed occurrence of the wolverine in California since 1922 (Aubry et al. 2007). The photograph, and others taken of the same individual at nearby camera stations, was diagnostic; there was no doubt that the organism was a wolverine.

The discovery made the national news and generated a great deal of excitement in California and elsewhere. However, uncertainty remained concerning the wolverine's origin. It could have been a member of a previously undetected population of California wolverines that had persisted since 1922, a natural immigrant from populations in the northern Cascade Range or Rocky Mountains, or a released or escaped captive. Thus, the next step for evaluating the biological significance of this record was to identify the wolverine's source population. The historical population of California wolverines had unique mitochondrial haplotypes substantially different from other haplotypes in North America (Schwartz et al. 2007); consequently, DNA (deoxyribonucleic acid) analysis could determine whether the animal was part of a remnant population of California wolverines. Furthermore, some haplotypes found in northern populations (i.e., Alaska and northern Canada) are absent from extant populations in northern Washington, central Idaho, and northwestern Wyoming. Thus, if the wolverine had any of these exclusively northern haplotypes, it would be reasonable to conclude that it was translocated. If, however, its haplotype occurred in the Cascade or Rocky Mountains, then it could have either dispersed naturally or been translocated.

Noninvasive sampling (hair and scats) was initiated by a group including the USDA Forest Service's Pacific Southwest Research Station, Oregon State University, Tahoe National Forest, and the California Department of Fish and Game, and samples were quickly obtained. The wolverine was haplotype "A" (Wilson et al. 2000), a genetic group that occurs throughout the Rocky Mountains, Alaska, and Canada (USFS 2008). A gender test (Hedmark et al. 2004) revealed that the animal was a male. Thus, although researchers were able to determine that the animal was not a native California wolverine, its exact origins and means of arrival in California remain unknown. These results did, however, have significant implications for wolverine conservation in the contiguous United States, and exemplify the kind of empirical evidence needed to determine appropriate responses to extralimital occurrence records for rare and elusive species. The photographic evidence was diagnostic, but additional DNA evidence was necessary to determine the biological significance of this record.

Fitzpatrick and colleagues (2005) claimed that at least one male ivory-billed woodpecker persisted in the Big Woods region of eastern Arkansas, reversing the common belief that the species became extinct in continental North America in the mid-1900s. Their announcement was based on inconclusive physical evidence and on seven anecdotal visual observations made by individuals whom the authors believed to be experienced and knowledgeable.

Fitzpatrick and colleagues (2005) present two pieces of equivocal physical data: first, acoustic recordings that they acknowledge "cannot be positively distinguished from exceptional calls by blue jays," and second, the "blurred and pixilated" video footage taken by David Luneau in April 2004. Despite the authors' assertions, the video evidence is not diagnostic of the ivory-bill and may represent the pileated woodpecker (*Dryocopus pileatus*), which is similar in appearance and occurs throughout the historical range of the ivory-billed woodpecker (Sibley et al. 2006, Collinson 2007). The appropriate response to the video was taken: a coordinated and extensive search effort was initiated. However, after more than a year of intensive searches by a large cadre of observers (Fitzpatrick et al. 2005, Wilcove 2005), no conclusive evidence was found. Consequently, the announcement that the ivory-billed woodpecker persisted in North America relied on anecdotal visual observations as confirmatory evidence. Fitzpatrick and colleagues stated:

> T. Gallagher and B. Harrison were struck by the apparent authenticity of this [Sparling's] sighting and arranged to be guided through the region by Sparling. At 13:15 CST on 27 February 2004, within 0.5 km of the original sighting, an ivory-billed woodpecker (sex unknown) flew directly in front of their canoe with the apparent intention of landing on a tree near the canoe, thereby fully revealing its dorsal wing pattern. (Fitzpatrick et al. 2005, p. 1460)

In the view of Fitzpatrick and colleagues (2005), there is no uncertainty about whether an ivory-billed woodpecker was seen. Doubts about the match between evidence and conclusions were raised (Jackson 2006) but largely ignored in the general furor and ebullience associated with the "discovery" that a charismatic and iconic species was not extinct after all. In addition to purportedly confirming its escape from extinction, Fitzpatrick and colleagues (2005) made claims about the ivory-bill's population size and reproduction. Others echoed these speculations (Wilcove 2005), and the reported finding was seen as the validation of numerous conservation efforts (Dickinson 2005). In part because of the prestige of the journal *Science*, which published the account, the persistence of a population of ivory-billed woodpeckers has been widely accepted by the general public, and new conservation strategies have been initiated (USFWS 2005). In Arkansas, more than 7400 hectares of swampland have been given protected

status to provide habitat for the ivory-bill (White 2006). Funds for habitat acquisition and land stewardship consumed approximately $4,200,000 of federal funds and an additional $2,000,000 in grants (USFWS 2006).

A year later, Hill and colleagues (2006) used similar evidence to report the possible presence of ivory-billed woodpeckers in Florida. Although Hill and colleagues are much more circumspect than Fitzpatrick and colleagues (2005) in their conclusions, they also propose that the ivory-billed woodpecker is present in Florida, without providing any conclusive evidence. Their data consist of sightings (14), many putative vocalizations, and cavities that appeared larger than those created by pileated woodpeckers (Hill et al. 2006).

It is now more than four years since the blurry video was taken in Arkansas, and it remains the only physical data supporting the claim that an ivory-billed woodpecker was found, despite intensive surveys in swampy areas that included annual searches coordinated by the Cornell Laboratory of Ornithology, and ad hoc searches by countless amateurs. Diagnostic DNA markers have recently been developed from museum specimens (Fleischer et al. 2006), so now even a feather or guano could provide proof of the presence of ivory-bills. However, none of these survey efforts has produced any indisputable physical evidence of the persistence of ivory-bills in North America. Although it is always possible to invent rationales to explain the lack of conclusive evidence (e.g., Bivings 2006), available evidence indicates that the ivory-billed woodpecker probably became extinct in the southeastern United States by the middle of the 20th century.

Conclusions

Anecdotal data are considered notoriously unreliable by most scientists, and many disciplines have endeavored to limit or eliminate their influence. However, anecdotal information continues to influence our political and legal systems as well as the public's understanding of the natural world. In a court of law, jurors generally consider eyewitness accounts to be particularly reliable—much more so than they actually are (Heller 2006). Juries can often be convinced to give little weight to forensic evidence (Thompson and Schumann 1987), but, as Supreme Court Justice William Brennan noted, "[T]here is almost nothing more convincing than a live human being who takes the stand, points a finger at the defendant, and says 'That's the one!'" (Handberg 1995, p. 1014).

Thus, it is important to carefully consider why, for example, we are willing to convict an alleged perpetrator on the basis of a single eyewitness's testimony, but are unwilling to believe hundreds of often compelling sighting reports of the Loch Ness monster or other creatures unknown to science. It seems clear that our weighting of anecdotal data is not related to its intrinsic reliability, but rather to our preconceptions about the described phenomena. We overestimate the reliability of eyewitness accounts in courts of law as much as fivefold (Brigham and Bothwell 1983), but no amount of anecdotal data will convince most people that the Loch Ness monster or Bigfoot exists. The degree to which we accept or reject anecdotal data is therefore largely a matter of belief, not reason. Some have cast the dispute over the presence of the ivory-billed woodpecker in terms of believers versus nonbelievers (Jackson 2006, White 2006), but if the debate is thus reduced, it will never be resolved.

In all three of the case histories presented here, reliance on anecdotal occurrence data led to significant errors regarding the presence, population dynamics, and range of the species in question. For the California wolverine and the ivory-billed woodpecker, the use of anecdotal data led to the resurrection of extinct organisms. In California, not only were wolverines assumed to be present, but the case was made that they were expanding their range and recolonizing their putative former habitat, much of which probably did not support wolverines historically (Aubry et al. 2007). In the case of the fisher, extreme overestimation of its current range led the USFWS to conclude that populations of fishers were large and well connected, when in fact they were small and highly fragmented. In all three cases, the use of anecdotal occurrence data resulted in vast overestimations of range and abundance (figure 1). As the fisher case history illustrates, anecdotal occurrence records are particularly insidious in a conservation context because they are often numerous and well distributed in time and space; consequently, they can preclude biologists from documenting range losses in time for appropriate conservation actions to be taken. Had conservation decisions been based solely on verifiable records, accurate understandings would have been derived and more appropriate management decisions would probably have been made.

Large numbers of anecdotal occurrence records can accumulate over time, and they frequently contain convincing details and occur in plausible locations or habitats. Observers are typically well-meaning and conscientious individuals, and sometimes are experienced, well-trained biologists (e.g., Fitzpatrick et al. 2005). Consequently, it is not surprising that anecdotal data are difficult for many people to dismiss as lacking in scientific value. However, even a very small misidentification rate associated with hundreds of observations made over many decades (60 and 80 years, respectively, in the cases of the ivory-billed woodpecker and California wolverine) will produce a large number of very convincing but misleading occurrence records.

We propose that the reliability of an occurrence data set depends not only on the intrinsic reliability of each record but also on the rarity of the species. As a species becomes rarer, the proportion of false positives will increase. For example, in the contiguous United States, bobcats (*Lynx rufus*) are common and Canada lynx (*Lynx canadensis*) are rare; occasionally bobcat observations are misidentified as lynx. Even if such misidentifications happen only 1 percent of the time, for every 1000 bobcat sightings, 10 will be identified as lynx, and false lynx observations can easily outnumber actual ones. Even if lynx were extirpated from the area, lynx would continue to be reported each year and, over many years, hundreds of spurious lynx records would accumulate.

Records obtained with this misidentification rate would be useful and reliable for bobcats, but extremely misleading for lynx.

Species rarity not only decreases the average reliability of occurrence data but simultaneously increases the social and economic consequences associated with decisions based on such data. Thus, an accepted evidentiary standard for documenting the occurrence of the common American robin (*Turdus migratorius*) would not be appropriate for the potentially extinct ivory-billed woodpecker. We therefore propose the use of a gradient of evidentiary standards for occurrence records that increases in rigor with species' rarity (figure 2). For example, a set of standards might permit the use of anecdotal data when an organism is common and easily recognized, but require indisputable physical evidence before the announcement of the rediscovery of a species thought to be extinct. The best approach to deriving specific standards may be for professional societies associated with particular taxa (e.g., American Society of Mammalogists, American Ornithological Union) to independently develop evidentiary standards for the use of occurrence data by their membership and in their publications. For example, guidelines for the appropriate use of anecdotal data could be included in instructions for authors and reviewers. Once rules were adopted, they could be used to standardize reliability ratings for existing databases, greatly enhancing their value. Such standards should consider a species' rarity, prior evidence of its existence, and the goals of the study or survey (figure 2). We recognize the value of coordinated, long-term survey efforts, such as the Breeding Bird Survey and the Christmas Bird Count, and we do not intend that the establishment of evidentiary standards interfere with the collection of useful data for common species. However, for rare or elusive species, such standards are essential for accurately determining their distribution and status.

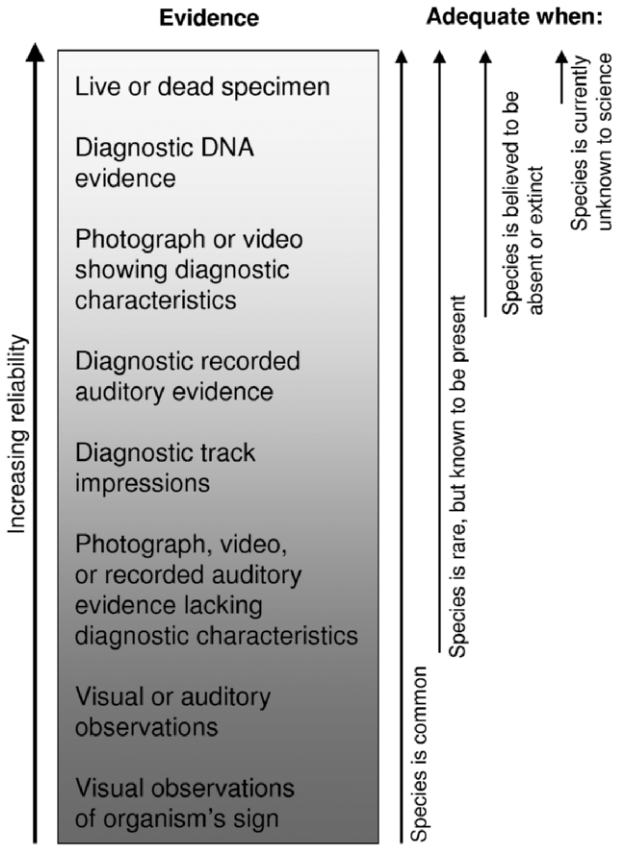

Figure 2. A sample set of evidentiary standards based on a gradient of increasing species rarity. The relative reliability of data types is expected to vary among taxa.

Some have argued that making decisions on the basis of the possibility that a species of concern is present is a prudent approach to conservation (i.e., the precautionary principle). Indeed, the Endangered Species Act and many other conservation agreements and accords specifically apply this principle to conservation (Applegate 2000). We agree with the application of the precautionary principle in conservation, but its application is a matter of policy, not science. Consequently, we believe the best way to ensure that policy decisions are based on reliable data and sound understanding is for scientists to establish evidentiary standards for the use of occurrence data. Just as evidentiary standards for the rejection of experimental hypotheses should be arrived at a priori, the existence and distribution of rare organisms should be debated within the context of established evidentiary standards.

Acknowledgments

Leonard F. Ruggiero and Daniel H. Pletscher provided helpful comments on previous drafts of this manuscript. Three anonymous reviewers offered additional helpful comments. This study was funded by the US Forest Service, Rocky Mountain and Pacific Northwest Research Stations.

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doi:10.1641/B580611
Include this information when citing this material.