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Letters

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Natural range expansion of Barred Owls? A critique of Monahan and Hijmans (2007).—Monahan and Hijmans (2007:61) concluded that the range expansion of Barred Owls (*Strix varia*) to western North America is "best characterized as 'natural.'" Here, we explain why their conclusion is entirely unfounded and warn of a possible, critically negative consequence of accepting it.

The epistemological structure of their argument seems to follow that of abductive inference, which is a form of inference used frequently in everyday life that resembles the following pattern (modified from Josephson and Josephson 2003:5, 15): there is information (e.g., data, facts, or observations); a hypothesis (if supported) explains the information; the hypothesis explains the information better than all other available hypotheses; therefore, the hypothesis is highly likely to be correct.

The information Monahan and Hijmans (2007) presented comprises nine observations: (1) Barred Owls expanded their range; (2) Barred Owls "started expanding west from the midwestern United States through southern Canada in the early 1900s (Houston and McGowan 1999)" (p. 63); (3) Barred Owls first contacted the range of the Northern Spotted Owl (*S. occidentalis caurina*) in southwestern British Columbia "around 1973" (p. 56); (4) from 1901–1910 to 1961–1970, an increase in mean summer temperature in the Barred Owl's expansion corridor (1.1°C) was significantly more than that in the source area (0.5°C); (5) the most energetically demanding season for Barred Owls is when they are feeding their young; (6) metabolic-energy requirements increase with decreasing temperature; (7) "the two portions of the Barred Owl range became energetically more similar as the [20th] century progressed" (p. 61); (8) anthropogenically mediated climate warming began "about 1970" (p. 61); and (9) distributions of coniferous forests in the species' range-expansion corridor in 2000 were similar to those in the source area. We find problems with their fourth, seventh, eighth, and ninth observations, as described below. Monahan and Hijmans's (2007) implied hypothesis appears to be that the temperature increase in the higher-latitude corridor lessened the metabolic-energy demand for breeding Barred Owls sufficiently to allow them to expand their range westward beginning in the early 1900s.

The strength of an abductive conclusion depends on several factors: the adequacy of the proposed hypothesis by itself, independent of alternatives; the exhaustive investigation of possible alternative hypotheses or explanations; and the decisiveness with which the hypothesis surpasses the alternatives (Josephson and Josephson 2003). Willingness to accept a conclusion often depends not only on the strength of the conclusion, but on pragmatic considerations such as costs of being wrong and benefits of being right (Josephson and Josephson 2003).

Adequacy of the hypothesis.—Monahan and Hijmans (2007) did not support the stand-alone adequacy of their hypothesis in three main ways. First, they did not test their hypothesis. They did not provide information concerning temperature limitations at the edge of the Barred Owl's range or those of any other birds, and they did not present data concerning whether their reported increase in temperature was consistently high enough to alleviate the temperature barrier for Barred Owls. They stated that "the two portions of the Barred Owl range became energetically more similar as the century progressed" (p. 61), but they provided no information for determining whether the two portions of the range were similar *enough* given the energy demands of Barred Owls. To support their hypothesis, temperatures in source and expansion areas must be shown to equilibrate, which in turn assumes equilibration of the metabolic-energy requirements of individual Barred Owls in the expansion area compared with those in the source area. (This latter assumption needs to be tested, because other factors, such as prey availability, may restrict energetic demands.) Without this information, their hypothesis cannot be supported. Johnson (1994) observed a spatiotemporal correlation between increased temperatures and the range expansion of Barred Owls and stated that the level of analysis needed to test a hypothesis concerning this correlation would be similar to those of Salt (1952) and Hayworth and Weathers (1984). We agree with Johnson's recommendation and suggest that Root (1988) and Meehan et al. (2004) also provide good examples of such analysis.

Second, the temperature comparisons made by Monahan and Hijmans (2007) are placed incorrectly in time. Comparisons pertinent to their hypothesis would be temperatures at the population's source area and in the expansion corridor well before the range expansion (e.g., early to mid-1800s) versus those during the years immediately leading up to and including the beginning of the expansion (e.g., late 1800s to early 1900s), coupled with evidence that the temperature increase at least maintained itself through 1970. Monahan and Hijmans (2007) implied that they examined whether climate change occurred in the early 1900s: "We. . .assess whether the Barred Owl's range expansion was spatiotemporally concomitant with early 20th-century climate change. . ." (p. 58). However, they excluded the pre-expansion, baseline temperatures in their analysis. They compared temperatures at the source area and in

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the corridor in 1901–1910, during the beginning of the range expansion, with those in 1961–1970, when Barred Owls had arrived on the west coast (1969) and entered the range of the Northern Spotted Owl (1970; Taylor and Forsman 1976). Thus, they tested whether there was a temperature change during the first 70 years of the range expansion, not whether there was a change during the early 20th century that may have initiated the range expansion.

Third, Monahan and Hijmans (2007) placed the start of anthropogenically influenced climate warming at "about 1970" (p. 61) and, consequently, incorrectly dismissed the possibility that the temperature increase they documented could have been anthropogenically influenced. The precise time of the onset of anthropogenically mediated climate warming is uncertain. However, the Intergovernmental Panel on Climate Change (IPCC) (2007a) reported that the increase in global average surface temperature has escalated since at least 1855 (increase per decade [mean ± SE], 1855–2005: 0.05 ± 0.01°C; 1905–2005: 0.07 ± 0.02°C; 1955–2005: 0.13 ± 0.03°C; 1980–2005: 0.18 ± 0.5°C). Several studies have shown that humans contributed significantly to the escalating temperature increases (e.g., Reichert et al. 2002, Gillett et al. 2004, IPCC 2007b). Indeed, certain species have been used to show that changes in plants and animals associated with regional temperature trends indicate that humans are a measurable force behind these trends (Root et al. 2005). So it is highly likely that a measurable portion of the increasing temperatures presented by Monahan and Hijmans (2007) was caused by human emission of greenhouse gasses into the atmosphere.

Investigation of alternative hypotheses.—Monahan and Hijmans (2007) did not analyze several alternative explanations found in the literature concerning ecological changes in the Great Plains that may have facilitated the range expansion of this forest-dwelling owl. These include increased availability of trees owing to planting (Dark et al. 1998) or fire suppression (Mazur and James 2000), and denser forests owing to fire suppression that created cover in which Barred Owls could better avoid Great Horned Owls (*Bubo virginianus*) and large accipiters (Wright and Hayward 1998).

Superiority of their hypothesis.—Monahan and Hijmans (2007) did not adequately analyze whether their hypothesis surpasses the three alternative processes they mentioned. They referred to two processes proposed by others (changes in forest-management practices that benefited Barred Owls, and adaptations of Barred Owls to coniferous forests) but did not analyze them, and their analysis of a third process (distribution of forests) misinterpreted its timing and incorrectly limited its area. They indicated that a lack of forests in the Great Plains may have been a barrier to the range expansion: "Areas south of the corridor were warmer and would have afforded a more direct route to western North America. However, southern areas lacked the forested habitats. . ." (p. 59). They also stated that "the Barred Owl expansion may have been influenced by anthropogenic factors, including. . .the establishment of wooded riparian areas in the Great Plains (Dark et al. 1988)" (p. 56). A relevant analysis would examine whether the distribution of coniferous forests, deciduous forests, or riparian woodlands throughout the northern and central Great Plains increased between the pre-expansion period and the early 1900s and, if so, whether the increase was sufficient to facilitate the range expansion. This analysis would show, in part, that the Great Plains were virtually treeless for many millennia until the arrival of Europeans in the 18th century, after which time the distribution of coniferous forests, deciduous forests, and riparian woodlands greatly increased throughout the Great Plains of Canada and northern United States as a result of anthropogenic influences (e.g., Houghton et al. 2000). However, Monahan and Hijmans (2007) mapped the distribution of coniferous forests in south-central Canada in 2000; they "mapped the owl localities on top of layers of. . .vegetation (Latifovic et al. 2002) to assess support for the Barred Owl range expansion being constrained by the presence of coniferous forests" (p. 58). Their mapping effort, therefore, excluded both pertinent time-periods and the distributions of deciduous forests and riparian woodlands in the northern and central Great Plains.

Pragmatic considerations.—Monahan and Hijmans (2007) neither mentioned nor, apparently, considered the risks involved in being wrong. Many studies strongly indicate that Barred Owls are negatively affecting site occupancy (Kelly et al. 2003, Pearson and Livezey 2003, Gremel 2005, Olson et al. 2005), fecundity (Olson et al. 2004), and survival (Anthony et al. 2006) of Northern Spotted Owls. The 2007 Draft Recovery Plan for the Northern Spotted Owl (U.S. Fish and Wildlife Service [USFWS] 2007) identified the Barred Owl as a major threat, and USFWS (2007) and Buchanan et al. (2007) described various methods under consideration to manage this threat. Barred Owls also are negatively affecting other species in their expanded range, including Western Screech-Owls (*Otus kennicottii*; Elliott 2006). The unsubstantiated conclusion in Monahan and Hijmans (2007) could create serious consequences for Northern Spotted Owls and other species if land managers use it to justify doing little or nothing to alleviate the negative effects of Barred Owls.

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[*Editor's Note.*—W. B. Monahan and R. J. Hijmans declined to respond to this letter.]

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Mass or weight: What is measured and what should be reported?—Many years ago, ornithologists weighed a bird by placing it on a balance and reading the bird's weight from the scale in grams. Chardine (1986:832), however, suggested that "the term mass be used in preference to weight" because "although balances

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