The Isle Royale Wolf–Moose Project: Fifty Years of Challenge and Insight

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> To hear even a few notes of [the song of ecology] you must first live here for a long time, and you must know the speech of hills and rivers. Then on a still night, when the campfire is low and the Pleiades have climbed over rimrocks, sit quietly and listen for a wolf to howl, and think hard of everything you have seen and tried to understand. Then you may hear it—a vast pulsing harmony—its score inscribed on a thousand hills, its notes the lives and deaths of plants and animals, its rhythms spanning the seconds and the centuries.
>
> — *Aldo Leopold*

Introduction

THE ISLE ROYALE WOLF–MOOSE PROJECT IS THE LONGEST CONTINUOUS STUDY of a predator–prey relationship in the world. Though it is easy to take this for granted, to assume that such a project happens simply because the researchers do it would be a mistake. This is quite literally a phenomenal accomplishment: something that exists outside of the realm of normal happenings, "an extraordinary occurrence."

The general details of the project are well documented (Mech 1966; Peterson 1977, 1995; Allen 1979; Vucetich and Peterson 2004a, 2004b, 2004c). The project is located on Isle Royale, a wilderness island and national park located in northwest Lake Superior, North America. Moose found their way to the 210-square-mile island in Lake Superior, fifteen miles from the Canadian coast near Thunder Bay, at the turn of the 20th century. For fifty years, moose abundance fluctuated with weather conditions and food abundance.

Wolves first arrived to Isle Royale in 1949—coincidentally just as humans were working to introduce them to the park—by crossing an ice bridge that connected the island to Canada. The lives of Isle Royale moose would never be the same. Within a decade Purdue University wildlife ecologist Durward Allen (Figure 1) recognized a rare opportunity to study the interactions between a newly established predator–prey relationship in a setting as close to a laboratory as ecologists get: an island ecosystem with a seemingly isolated population of a single predator and a single prey, a simple system where population dynamics are the result of moose and the wolves who eat them.

By a variety of measures the project has been successful. Several of the United States' most recognized contemporary wolf biologists and ecologists cut their teeth on the project, including L. David Mech (Figure 2), Doug Smith, and Mike Phillips.

Descriptions of the project are sometimes sprinkled with adjectives like "iconic" and "classic." In a recent issue of *Audubon* magazine, journalist Les Line (2008) dubbed Isle Royale's wolves "the most famous *Canis lupus* population in the world." The project has served as fodder for important scientific understanding, popular articles and books, and even artistic expressions (exhibited at www.isleroyalewolf.org).

While wonderful and inspiring in the case of the Isle Royale wolf– moose project, such success is fickle and tragically rare—yet critically important. In this essay, we review the administrative history of the Isle Royale wolf–moose project. From that historical narrative we infer what obstacles might represent a general challenge to long-term ecological research. Finally, while many take for granted that data collected from long-term research is especially valuable, the reasons why have not been explored in great depth. We conclude this essay by considering the importance of long-term research.

Figure 1. The originator of the wolf–moose study, Durward Allen. Photo provided by George Desort.

An administrative history

A 1986 study by the Institute of Ecosystem Studies (Strayer et al.) analyzed several long-term ecological studies. The supporting agency, the National Science Foundation (NSF), hoped to establish the foundation for a program supporting long-term ecological research by identifying factors common to successful programs. But it turned out there was no consistent theme, research characteristic, or subject of study that seemed to matter. The only point worth mentioning was that frequently there was one person whose commitment and interest provided the long-term foundation: "Every successful long-term study that we studied has had associated with it one (or a few) good, dedicated scientist who has devoted much time and energy to the long-term study" (Strayer et al. 1986:5).

For wolf–moose research at Isle Royale, one of these people was the late Robert M. (Bob) Linn (1926–2004), whose thoughtful support of research in national parks began with a career with U.S. National Park Service (NPS), but expanded thereafter to include all parks and equivalent reserves in the world. Durward Allen frequently spoke of Linn and the critical role he had played in helping to maintain the Isle Royale wolf–moose project. As the first naturalist for Isle Royale National Park (Figure 3), Linn had participated in an early winter study on the island, in 1956, when he and NPS biologist Jim Cole spent several weeks on the island in February, snowshoeing extensively, trying to estimate how many wolves were present and what their activities might mean for the isolated moose population.

Linn was also the person who had to deal with the aftermath, in 1952, of a private effort to introduce wolves to Isle Royale. Zoo-raised wolves were used, after a search in Michigan for wild wolf pups failed. After the four semi-tame wolves became uncooperative pests, Linn led efforts to remove them, knowing that there was evidence that wild wolves had recently made it to the island on their own.

In the mid-1950s there was substantial concern that the newly arrived wolves would increase and get out of hand, threatening the moose population and posing a danger to people (including some longtime residents of Isle Royale, whose efforts had helped establish the national park). Suddenly, sharing the island with an unregulated wolf population seemed a worrisome proposition. Anticipating a need to somehow rein in the wolf population, in 1956 Gordon Fredine, Linn's successor as chief biologist for the NPS, wrote to his close colleague Jim Kimball, commissioner of conservation for the state of Minnesota, and asked if Minnesota would accept some live wolves from Isle Royale. Kimball declined the invitation to participate, citing public opposition to wolves generally and the fact that Minnesota was spending (wasting, in Kimball's view) some $300,000 per year in bounty payments for dead wolves.[1] Linn wrote the reports and letters necessary to establish that the wolves were not a threat to people, and helped establish a policy whereby the NPS supported the existence of an unmanaged wolf population on Isle Royale.

Figure 2 (top). Researcher L. David Mech with a collection of moose jaws. Photo provided by George Desort. Figure 3 (bottom). Bob Linn at Isle Royale, 1956. Photo courtesy of Milt Stenlund.

Meanwhile, in a harbinger of wolf reintroduction to Yellowstone forty years later (Smith et al. 2003), with the arrival of wolves the controversy over an overabundance of moose quickly evaporated.

Aristotle's famous quip that all inquiry begins in wonder rings true for the origin of the Isle Royale wolf–moose project. The uncertainty surrounding the presence of wolves served as a catalyst for those interested in initiating serious research on the wolf and moose population. In 1958, Linn was

on hand when Allen and his graduate student Dave Mech first visited Isle Royale to begin an ambitious ten-year study to evaluate the role of wolf predation in the dynamics of the moose population.[2] Most immediately there was a need for a field base for Mech, who bounced around from one spot to another in 1958 and 1959. In 1960, Linn arranged for Mech to use the cabin at the Bangsund Fishery as a base for his summer fieldwork, following the death of fisherman Jack Bangsund in 1959. The Bangsund cabin has served a valuable research role ever since, long exceeding its tenure as a commercial fishery. Mech also needed a boat, and Linn donated his own wooden boat to the project (it did not last as long as the fishery cabin).

Allen had launched the wolf–moose project with funds from the National Geographic Society and the NSF, but as these funding sources cycled through to completion, additional sponsors were needed. By the late 1960s, Linn was in Washington, D.C., leading the science program of the NPS, and he began to provide a modest grant each year to support continuing research on wolves and moose at Isle Royale.

But the original ten-year duration of the study was over by 1968, and the one-time minister-turned-attorney and now powerful long-time director of the National Park Service, George Hartzog, instructed Linn to oversee its conclusion—in other words, to terminate it. As Allen recalled it in the early 1970s, Linn quietly ignored the directive, and in fact continued to provide annual grants from his science budget.[3]

By 1974 Allen had made no secret of his intention to retire the next year, and one of Linn's own science administrators in the NPS (who shall remain nameless) embarked on a secret bid to take over the project. He visited Purdue and had a pleasant chat with Allen, who came away mystified about the reason for the visit. Before the visitor left, Rolf Peterson showed him a recently tanned hide of a wolf that had been killed by other wolves on Isle Royale the previous winter. A few days later, Allen got a phone call from Linn, at that time still the chief scientist of the Park Service in Washington, who had discovered the scope of the takeover bid and alerted an incredulous Allen. The wolf skin that had been shared was being used as part of an attempt to discredit Peterson, Allen's obvious successor to the project, the claim being that Peterson possessed an endangered species without authorization. After some discussion Linn told Allen not to worry, he (Linn) would take care of the matter. The visiting NPS scientist and would-be wolf researcher was not heard from again. In 1975, as Allen retired, he turned the project over to Peterson who had by then secured an academic post and a new home for the wolf–moose project at Michigan Technological University (MTU) in Houghton, also the mainland headquarters of the park. Linn was already at MTU, having established a Cooperative Park Studies Unit there with himself as unit leader. Linn would soon retire from his NPS position, but not from his involvement with the Isle Royale wolf–moose project.

In 1981, newly inaugurated President Ronald Reagan appointed James Watt as secretary of the interior. Given Watt's record and beliefs, the environmental community was both outraged and horrified. In the face of a perceived threat, however, the appointment of Watt also served to coalesce the environmental community in powerful ways. For the post of assistant secretary for

fish, wildlife, and parks, Watt appointed G. Ray Arnett, a geologist from the petroleum industry who gained distinction in 1956 for the initial discovery of oil in Alaska (on a national wildlife refuge, no less—the Kenai National Moose Range) and who had previously been the director of the California Department of Fish and Game under Reagan when he was the state's governor.[4] It was not long before Arnett, an avowed wolf-hater, crossed paths with the wolf–moose research at Isle Royale. His signature was required on the annual contract between NPS and MTU that by then provided $30,000 to carry out the winter counts of wolves and moose. Such paperwork typically dragged on for weeks or months. As normal, the 1983 winter study began in January without the signed contract: Peterson, an NPS staffer, pilot Don Glaser, and student assistant Doug Smith all working on the island (Figure 4). Isle Royale Chief Ranger Stu Croll called one evening by radiophone with some "unpleasant news." Not only did Arnett refuse to authorize NPS funding, he demanded the wolf–moose project be immediately terminated. Croll explained that all personnel would have to leave the island, and he arranged to have the Forest Service supply airplane, a ski-equipped Beaver, pick everyone up at the first opportunity. Croll expressed sincere regret at seeing everything end in this manner. The Beaver soon arrived. The only person who left the island, however, was the NPS staffer. Croll agreed to look the other way as Peterson explained that he would be staying to complete the surveys, as intended, and Glaser and Smith would be staying as well.

So far, so good; but this committed the project to spending money it did not have. Enter Linn one more time. In a wonderfully roundabout manner, he saved the day. Linn contacted (probably through Durward Allen) Nathaniel Reed, one of Arnett's predecessors in the Nixon–Ford years, and Reed in turn contacted Amos Eno, vice-president of the National Audubon Society, who knew Arnett well enough to give him a call. Meanwhile, the Washington-based Defenders of Wildlife began to prepare testimony on yet another example of political interference, to be used in the congressional budget hearings for the Interior department. That proved unnecessary, as Eno persuaded Arnett that the wolf–moose project was not an appropriate vehicle for his agenda. A period of bureaucratic track covering followed, and Isle Royale National Park Superintendent Don Brown flew to Washington for a personal audience with Arnett. Brown reported that Arnett's office sported

Figure 4. Winter study pilot Don Glaser and researcher Doug Smith. Photo provided by George Desort.

walls lined with trophy mounts of animal heads and a wolf skin on the floor. After enduring the requisite chitchat with Arnett, Brown emerged with the original $30,000.

For Bob Linn, Isle Royale was quite simply the finest place on Earth. The final twenty-five years of professional activity found him establishing the George Wright Society, dedicated to research and education in parks and preserves around the world. But Linn always tried to be as close as possible to Isle Royale (which explains why the office of the George Wright Society is in Hancock, Michigan, a few city blocks from the mainland headquarters of Isle Royale National Park). The island was never far from his thoughts.

The challenge of long-term ecological research

While long-term research such as the Isle Royale wolf–moose project happens, it does not "just happen." In fact, it rarely happens at all. When it does, what are the conditions that allow for long-term research? The 1986 Institute of Ecosystem Studies study cited above indicates that, other than the enthusiasm of some individual, there really are no clear and specific conditions that describe or predict success (Strayer et al. 1986). We would suggest, however, there are three critical and underappreciated, but necessary, conditions: conditions so precarious that they explain why long-term research is so rare.

The first requirement of a successful long-term study is *interest*. Without the enduring interest of some researcher—a researcher with vision, a researcher willing to take a chance—no long-term study would happen. But this kind of interest is required for any study, long- or short-term. A successful long-term study such as the Isle Royale wolf–moose project requires a *lineage of interest.* The Isle Royale project has that. From Bob Linn to Durward Allen to Rolf Peterson to John Vucetich (Figure 5), individual scientists have taken a personal interest in this particular project; have made it the focus of their life's work.[5] But this sort of interest is exceptionally rare in science. Scientists do not typically spend their careers unpacking the mysteries of a single place or a single relationship, and academia does not typically reward or encourage scientists whose sense of place is so strong.

Ultimately, the interest of the researchers must also transfer to, and spark, the interest of the public—another tough audience, especially when the project is largely about an animal with which we have a troubled past (and present). Fortunately, the Isle Royale project has been quite successful in impressing both the scientific community and the public. From unusual findings—such as the impact scavengers like ravens have on wolf pack size (Vucetich et al. 2004), to the surprising role parasites such as winter ticks might play in the dynamics of the system (Vucetich and Peterson 2007)—to intentional and extensive public outreach,[6] the story of the wolf–moose project has captured a broad interest.

But interest, no matter how rich and nurtured, is not enough. Long-term studies end, and, according to the 1986 Institute of Ecosystem Studies paper, they end regardless of interest by scientists, regardless of interest by the public, and regardless of important scientific findings. They end because of other factors: "It is perhaps significant that none of the long-term studies that we studied were terminated voluntarily because the PI [principal investigator] felt that the study no longer justified the cost. Studies were stopped by funding difficul-

Figure 5. Researchers Rolf O. Peterson and John A. Vucetich. Photo courtesy of George Desort.

ties and retirement of the PI, but never for lack of important research questions" (Strayer et al. 1986:13).

The second necessary condition for a successful long-term study is *money*. Scientific research is an expensive endeavor. Long-term research is "expensive *multiplied by* long-term." The case of the Isle Royale wolf–moose project, however, is interesting because its annual budget is only a fraction of that of many other ecological studies. And yet the contributions of the Isle Royale project are comparable to those of other significant research projects. Despite its relatively high return, however, the Isle Royale project remains financially limited. If funded at a higher level, the Isle Royale project would undoubtedly produce even more valuable knowledge and interest.

But money is fickle. The $30,000 that the National Park Service originally committed to the project in 1976 has remained essentially unchanged—though inflation calculators indicate that its worth in 2007 was roughly $8,085, or less than one-third its original value. Federal sources of funding can change (that is, "shrink") given the fancy of an administration not interested in scientific research generally, or more interested in funding other projects. Because of limited funding, the Isle Royale project can pursue answers to but a small handful of the fascinating and important questions that bubble up year after year. Of course, the real tragedy of underfunded long-term science is for society. Given that critical knowledge and insight about living sustainably (a long-term proposition) comes at least in part from long-term studies, and given the current necessity of understanding what sustainable living might look like, we might well be underfunding the very science that

we need most in today's world. In short, because of the financial strains on long-term projects, we should never assume that because a project has lasted for fifty years that it will last fifty more—or even for one more!

Third, successful long-term study requires the ability to weather the periodic threat of zealous ideologies and the tyrannical administrators who sometimes evoke them. As we saw above, there have been at least two close calls for the Isle Royale project on these grounds. In addition to the attempted post-Allen NPS "takeover" of the project that was, by all appearances, simply a raw abuse of power, G. Ray Arnett expressed a willingness to quash serious scientific research in the name of a ideology suggesting wolves are some sort of evil incarnate (making the work of wolf research somehow devilish). However, a different set of ideologies—one suggesting either that predators such as wolves have an effect on ecosystems (Ripple and Beschta 2005; Hebblewhite et al. 2005) or one that assumes that predators are critical components of healthy ecosystems (Leopold 1949:129–133), coupled with the recent "greening" of a variety of the world's religions (Taylor 2005), for instance—might mean that work focused on predation is also work serving to care for the creation.

More recently, unsophisticated ideologies about the nature of wilderness can and have interfered with environmental research in this project and elsewhere (Callicott and Nelson 1998; Nelson and Callicott 2008). But is this really a threat to the project? It is not uncommon to meet an NPS employee who projects his or her personal interpretation of "wilderness" onto research projects, or who feels that the public is *too* interested in research on Isle Royale's wolves and moose. The final chapter of Peterson 1995 chronicles how a difference in wilderness ideology between researchers and the NPS might have allowed the wolves of Isle Royale to die out, and the project to end, during the 1990s. The Isle Royale project is not alone in this way. Other long-term research projects have failed, or their continuation has been threatened, by tyrannical administrations and ideologies that are opposed to certain kinds of knowledge about the environment (Fraidenburg 2007).

We have all learned that ideological righteousness coupled with power knows no limits and is seldom subject to negotiation. Of course, ideology coupled with intellectual honesty allows for reconciliation. Reconciliation here might be found in an understanding of what ideologies are, how they determine our thoughts and actions, and a recognition that other ideologies can also be motivated by, and result in, the care and protection of nature.

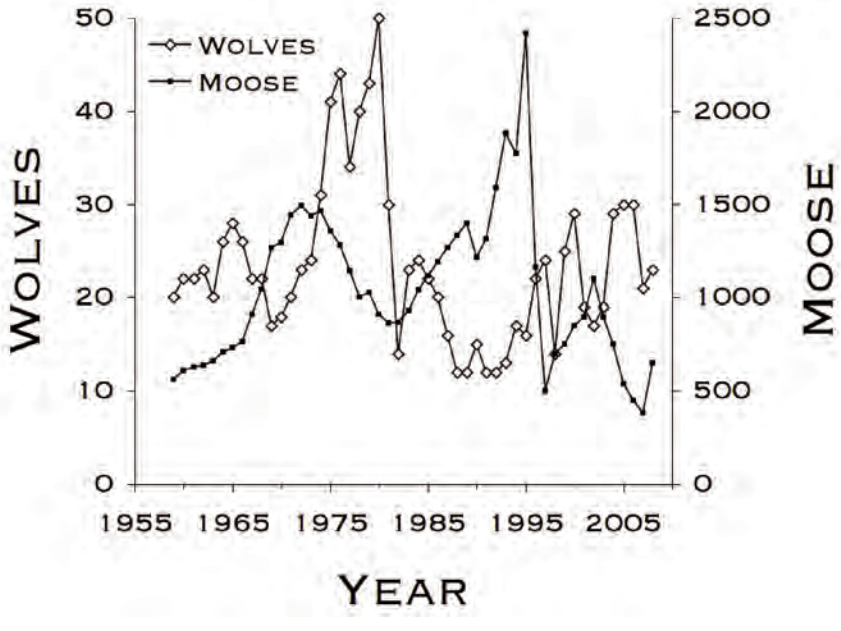
When considering the challenges to long-term research, both with wolves and moose on Isle Royale and elsewhere, there are two sorts of tragedies lurking: one pragmatic and one ethical. First, the value of long-term research is simply not duplicable elsewhere with shorter-term projects. Additionally, long-term ecological research seems an absolutely vital component of understanding those long-term processes that might help secure our continued long-term existence and the well-being of the planet. However, because of the reasons suggested above, and perhaps many others, long-term research is under great pressure, subject to diminishing support, and inappropriately devalued (Keeling 2008). As was noted back in 1981 on the pages of this very journal: "As land use intensifies and

research funding dries up, we face a regression in ecological inquiry at the very time we need it most" (Peterson 1981). Nearly thirty years later this is truer than ever.

Second, there is an ethical tragedy prompted by a paucity of long-term ecological research. Aldo Leopold (1949:203) suggests that "all ethics so far evolved rest upon a single premise: that the individual is a member of a community of interdependent parts." If Leopold is correct, if we extend moral consideration only to those within our perceived community and the community as such—that is, if the development of a "sense of place" is a critical part of the development of a rich environmental ethic—then, although environmental scientists are important for the defense of natural places, many or most of the best scientists do not manifest this strong sense of place; the kind of sense that holds one's interest for an entire lifetime. Moreover, given the desire of contemporary environmental ethics to be consistent with, and informed by, the images of nature represented by ecology, and given that a fifty-year image of wolf–moose relationships is wildly different from that which we would have assumed if the project had been halted after only five years (see Figure 6), the longevity of the project informs environmental ethics in important ways. The Isle Royale wolf–moose project, then, takes on an unanticipated, yet important, moral significance.

Regionally, Isle Royale is known for fishing and boating. Nationally, Isle Royale is a wilderness-backpacking destination. However, on the international scene, Isle Royale is known for essentially one thing (which is one more than many places): its long-term study of the wolf–moose predator–prey system. But such a project is at the

Figure 6. Fifty years (1959–2008) of wolf and moose fluctuations on Isle Royale National Park, Lake Superior, USA.



mercy of many burdens: creative, financial, ideological, to name only a few. Hence, in addition to being precious (from the Latin *pretiosus*, meaning "costly, valuable") it is also precarious (from the Latin *precarius*, meaning "obtained by asking or praying"). And anything possessing these qualities should not be taken for granted.

The findings and applications: What knowledge have we gained?

> There is a widespread perception among scientists involved in long-term studies that long-term studies often produce important serendipitous findings.
>
> — *Strayer et al. 1986:21*

Two great concerns for wolf managers are "How much human-caused mortality can a viable wolf population sustain?" and "How do wolves affect the prey populations that humans also want to hunt?" Though humans do not exploit wolves or moose on Isle Royale, the wolf–moose project of Isle Royale has provided important insight on both questions.

Isle Royale is the only place where humans have monitored, for any serious length of time, the mortality rates of a wolf population not exposed to human causes of death (Figure 7). This kind of knowledge is valuable for managers aiming to promote wolf viability and maintain human-caused mortality at appropriately low levels. Ironically, knowledge about natural rates of wolf mortality is also valuable for the efficient reduction or even overexploitation of wolf populations.

One of the primary reasons humans despotize wolf populations is because too many humans perceive that wolves threaten our ability to enjoy the highest possible rates of hunting—hunting for deer, elk, moose, and caribou, the species upon which wolves' survival depend. Consequently, "How do wolves affect prey?" is considered by many a critical management question. Over the years, the Isle Royale wolf–moose project has continued to contribute important understanding on this topic. In the early years of the project, we

Figure 7. A lone wolf traverses a shoreline at Isle Royale National Park. Photo courtesy of George Desort, Rolf O. Peterson, and John A. Vucetich. Source: www.isleroyalewolf.org.

discovered that wolves are selective predators, tending to focus their predation on moose that are young, old, or sick (Peterson 1977). Subsequently, we learned that wolves tend to kill more when winters are severe and when moose are abundant (Post et al. 1999; Post et al. 2002; Vucetich et al. 2002). These discoveries suggested wolves are the proximate, but not ultimate, cause of most moose deaths (Vucetich and Peterson 2004b). That is, wolves seemed to have relatively little impact on moose abundance.

Then, quite by accident, we made an observation giving a very different impression. In the early 1980s, wolves declined catastrophically due to a disease. Shortly afterward, moose increased to an incredibly high abundance (McLaren and Peterson 1994), only to crash shortly thereafter due to the combined effects of a severe winter, a tick outbreak, and a catastrophic food shortage. Most recently, we learned that of all the factors affecting short-term fluctuations in moose abundance, wolves are the least important (Vucetich and Peterson 2004b). Climatic factors (such as summer heat and winter severity) are much more important. Most importantly, most of the fluctuations in moose abundance are attributable to factors that we have yet to identify (Figure 8). These observations highlight limitations of our knowledge about how wolves affect moose on Isle Royale, despite their being well studied. To some, this limitation suggests that our ability to control many wildlife populations is less precise and reliable than commonly thought. To these people, the suggestion is not unjustified pessimism, but a reasonable conclusion to draw from fifty years of research (Vucetich and Peterson, in press).

Though we are grateful for the opportunity to have made these contributions to science, there are two ironies about better

Figure 8. A moose feeds on moss at Isle Royale National Park. Photo courtesy of George Desort.

understanding of "how wolves affect prey." First, expecting an ecologist to study "how predators affect prey" for the purpose of knowing more about how to control them may be like expecting an astronomer to study how the stars move for the purpose of better controlling their movement. Learning to better live with and appreciate how nature is unpredictable and uncontrollable may deserve more attention than being fixated with controlling nature. The second irony is that "how wolves affect prey abundance" is important for justifying two management interests that are, to say the least, oddly juxtaposed. The justification of wolf control—killing wolves to maximize hunting of ungulates such as deer, moose, or elk—requires demonstrating that wolves have a profound effect on prey. However, the justification that wolf predation is a critical component of healthy ecosystems also seems to require demonstrating that wolves have a profound effect on prey. Adding to the confusion, many argue that wolf populations should be recovered or left unexploited because wolves have little impact on prey abundance. Again, the Isle Royale project contributed significantly to these scientific discoveries, but how they influence management remains an open question. The influence remains undetermined because we have yet to decide whether, where, how, or why wolves should (or should not) be hunted in the continental United States, and the question of how wolves affect ungulate prey abundance is seen as hugely important in decisions about this ethical debate.

The Isle Royale wolf–moose project seems also to have contributed knowledge of quite a different kind. To understand what we mean by "different kinds of knowledge," first ask yourself what is the *purpose* of science. Is it primarily to control nature for the "easing of man's estate," as the famous philosopher Francis Bacon suggested more than 400 years ago? Or, is it primarily to generate wonderment about the natural world—the kind of wonderment that can transform and enlighten our understanding about how we ought to relate to the natural world (a view roughly held by the famous 20th-century philosopher of science Karl Popper)?[7] If the latter is the greater purpose of science, the Isle Royale wolf–moose project has, we hope, contributed valuable knowledge. Moreover, given a variety of surprising and unexplained results that have been observed from this relatively simple set of relationships, the Isle Royale project represents a warning about the futility and arrogance of placing too much value on science for the purpose of predicting and controlling ecosystems.

The Isle Royale wolf–moose project began fifty years ago, during the darkest hour for wolves in North America. The mass slaughter perpetrated against wolves required our vilifying them. The subsequent and quite phenomenal improvement in conditions for wolves required an antidote for our vilification. That antidote was knowledge. In the early years, the project gave people reason to replace destructive myths with real knowledge that portrayed wolves as they are: predators, a natural part of ecosystems, not villains. For example, the Isle Royale wolf–moose project helped people see that wolves are not gluttonous, wasteful killers. Instead, most wolves die young, and they die of starvation or by fighting for food. And, what wolves do not eat, scavenger species—foxes, ravens, and other resident bird species—depend on for their survival. Ultimately, the Isle Royale

wolf–moose project created an awareness that has contributed to a sea change in attitudes, allowing for wolves to begin their recovery.

More recently, as mentioned above, we discovered a special relationship between wolves and ravens (Vucetich et al. 2004). Specifically, a critical advantage of group living is that wolves lose substantially less food to scavengers such as ravens. Ravens may be an important reason why wolves live in packs—a trait otherwise uncommon among carnivores. This discovery grabbed much press attention. But why? This knowledge is certainly not valuable for controlling anything in nature. Rather, the work is appreciated, we believe, because it highlights a beautifully unexpected and intricate ecological connection. Our work also grabbed press attention when we described how wolves and moose are affected by moose ticks, which in turn are influenced by climate. Connections like these are important because they can generate wonderment, awe, and respect.

Over the years, our sense and awareness of Isle Royale's complexity and unpredictable nature has continued to grow and deepen. We know the most important events in the history of Isle Royale wolves and moose are severe winters, disease, and tick outbreaks. These events are essentially unpredictable. Moreover, every five-year period in the wolf–moose chronology seems to differ from every other five-year period—and this seems true even after fifty years of observation (see Figure 6). Going further, the first twenty-five-year period of the project was profoundly different from the second. We have every reason to expect the next fifty years will differ substantially from the first, but, strangely, we are in no position to say how (Vucetich et al., in press). These and related observations suggest the futility of trying to reliably predict nature's responses to our intense exploitation.

The Isle Royale wolf–moose project has generated many scientific facts about wolves and moose. In doing so, the project has also developed and shared with others a deep sense of place about Isle Royale's ecology. From this, we believe, comes a knowledge that generates wonderment—the exact kind of knowledge we may most need at this moment in time.

Ed. note: An earlier version of sections of this essay appears under three separate titles by these authors in the summer 2008 edition of *International Wolf*.

Endnotes

1. "[W]e pay close to $300,000.00 each biennium in bounty payments, a large portion of which is for timber wolves. The fact that this money is wasted as a game management measure does not alter the fact that it is hard cash" (Kimball letter to Fredine, July 27, 1956, copy in R.O.P. files).
2. The organizing meeting included Fredine, Linn, Allen, Mech, Douglas Pimlott (University of Toronto), Milt Stenlund (Minnesota Department of Conservation), Laurits Krefting (U.S. Fish and Wildlife Service), and John Lewis (superintendent, Isle Royale National Park).
3. Years later, when asked about this matter, Linn denied it had ever happened. But that

was his manner of defusing controversy, which he had no stomach for—at least that is our interpretation. NPS historian Richard West Sellars agrees, and told R.O.P. by phone in 2006 that Allen's report on the actions of Hartzog and Linn was probably accurate.

4. Arnett would resign from this post on November 23, 1984 citing "a strong desire to pursue business and conservation initiatives that have opened to me in this area [presumably in Washington DC] and in California." Arnett would then go on to become the Executive Vice President of the National Rifle Association in 1985 (though in 1986 he would be dismissed for, among other things, "personnel decisions on the basis of his personal interest rather than the interests of the Association.") See Golden (1984) for an interesting glimpse of Arnett as Assistant Secretary.
5. Strayer et al. point out how critical the focus of the scientist (and, ultimately, of a string of scientists) is: "S.C. Kendeigh's 27-year-long studies of bird populations … ended when he retired in 1976, and Francis Evans believes that no one will take over studies of the Evans old-field when his work ends" (1986:5). According to Earl Werner (Werner 2008), current director of the George Reserve where the old-field site was located, "Indeed, Francis' fear did come true. While others have worked on the old-field site nobody has followed up with the sort of data collection that Francis was doing." Evans' fifty-year study lasted from 1948 to 1997. Evans died in 2002.
6. Isle Royale researchers maintain an interactive website that gets over 17,000 hits per year, descriptions of the work and findings appear in hundreds of media outlets annually, and researchers personally present the work to more than 5,000 scientists and members of the public annually.
7. This later purpose of scientific inquiry is also consistent with the concept of traditional ecological knowledge. Pierotti and Wildcat (2000), for example, commenting on the purpose of ecological science from an American Indian perspective, when asked "What good is the work that you do?", write: "This question contains the hidden assumption that if what we do does not directly benefit human beings in some way it is without value. We often answer that our work teaches us more about the other members of our community and how to live with them, but most people of Western heritage appear confused by this answer, and do not understand this point. In contrast, if we give this answer to Native American elders, they are completely satisfied, for they understand implicitly what we are trying to accomplish, and its significance to humans."

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