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The Isle Royale Wolf–Moose Project (1958-present) and the Wonder of Long-Term Ecological Research

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Introduction

In the dead of a northwoods winter, sometime in the late 1940s, wolves crossed[1] the roughly 15 miles of iced-over waters separating Thunder Bay, Ontario from the shores of Isle Royale (ISRO), a federally designated wilderness island and US National Park of ~544 km^2 in Northwestern Lake Superior (Figure 1).[2] This was fortuitous. Just prior to this crossing, managers and wildlife ecologists had been discussing plans to use ISRO as a sanctuary for the heavily persecuted grey wolf population. The introduction of wolves was, moreover, seen as a possible way to control the booming and busting moose population that had swam to the island some 50 years previously.[3]

Immediately upon seeing convincing evidence that wolves had in fact colonized ISRO in 1952, wildlife ecologist Durward Allen (then working for the US Fish and Wildlife Service) recognized a rare opportunity to study the interactions of 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 (Figure 2). Allen 'tried for three years to get funding for a major predator–prey study on Isle Royale'[4] and was finally successful after joining the faculty at Purdue University.

These were some of the darkest days for wolves in North America. North Americans of European descent had been systematically hunting, trapping, and poisoning wolves for hundreds of years. The US government, through the US Biological Survey, had been actively engaged in a wolf eradication program that was redolent of genocide – or perhaps more accurately 'genuscide'. Wolf eradication went far beyond the presumed 'practical necessity' of removing a threat to livelihood. Wolves were, in fact, vilified and hated. This hatred manifest itself in sometimes gruesome fashion, where wolves would be trapped and systematically tortured to death.[5] For many people, 'wolves not only deserved death but deserved to be punished for living'.[6] Or, as Durward Allen himself put it, 'To them a carnivorous animal is not wildlife; he is the enemy of all honest wildlife. The wolf doesn't live in the forest; he *infests* it. You don't just kill a predator; you execute him. You don't hunt him for sport; you track him down in a crusade for moral reform'.[7] Arguably, our Western attitudes toward wolves were but the pinnacle of our larger dysfunctional relationship with nature. But in the early part of the 20th century that began to change. Voices of dissent from within the scientific community were beginning to offer a different vision of the human–nature relationship and the important role predators such as wolves might play in a larger, healthy ecosystem. Along with such luminaries as Aldo Leopold and Sigurd Olson, Durward Allen offered one such vision. Viewing wolves and other predators as a critical

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[1] Wayne et al. used mtDNA to suggest the ISRO wolf population had been founded by a single female wolf, see Robert Wayne, N. Lehman, D. Girman, P. J. P. Gogan, D. A. Gilbert, K. Hanson, R. O. Peterson, U. S. Seal, A. Eisenhawer, L. D. Mech, and R. J. Krumenaker. (1991) Conservation Genetics of the Endangered Isle Royale Gray Wolf, *Conservation Biology* 5, pp. 41–51. Adams et al. used microsatellite DNA to suggest the population had been founded by a single female and at least 2 males, see Jennifer Adams, Leah Vucetich, Phil Hedrick, Rolf Peterson, and John Vucetich. Genetic Rescue of the Wolves of Isle Royale, in review.

[2] The general details of the project are well documented in L. David Mech. (2002, originally published in 1966) *The Wolves of Isle Royale*. University Press of the Pacific, (Honolulu); Rolf O. Peterson. (1977) *Wolf Ecology and Prey Relationships on Isle Royale*. National Park Service scientific monograph; no. 11 (Washington, D.C.); Rolf O. Peterson. (2007, originally published in 1995) *The Wolves of Isle Royale: A Broken Balance*. University of Michigan Press (Ann Arbor); Durward L. Allen. (1994, originally published in 1979) *Wolves of Minong: Isle Royale's Wild Community*. University of Michigan Press (Ann Arbor); John A. Vucetich and Rolf O. Peterson. (2004) Long-Term Population and Predation Dynamics of Wolves on Isle Royale. *Biology and Conservation of Wild Canids*, edited by D. Macdonald and C. Sillero-Zubiri. Oxford University Press (Oxford), pp. 281–292; John A. Vucetich and Rolf O. Peterson. (2004) The Influence of Top-Down, Bottom-Up, and Abiotic Factors on the Moose (*Alces alces*) Population of Isle Royale. *Proceeding Royal Society of London, B* 271, pp. 183–189; and John A. Vucetich, Rolf O. Peterson, and Michael P. Nelson. (2010) Will the Future of Isle Royale Wolves and Moose Always Differ From Our Sense of Their Past? *The World of Wolves: New Perspectives on Ecology, Behaviour and Management*, edited by M. Musiani, L. Boitani, and P.C. Paquet. University of Calgary Press (Calgary), pp. 123–154. President Franklin D. Roosevelt established Isle Royale as a National Park on April 3, 1940. It was designated a Wilderness Area in 1976 and in 1980 was made an International Biosphere Reserve.

[3] In 1929, famed wildlife ecologist Adolph Murie was commissioned by the State of Michigan, through the University of Michigan's Museum of Zoology to study the mammals of Isle Royale, with a special focus on the island's moose population. "The moose," Murie writes in his follow up report, "present something of a problem on the island." "There is little opportunity for the animals to leave, and as there is apparently little check on their increase, it becomes obvious that sooner or later many plant species will be over-browsed to the extent that it will require years for a return to normal, and some extinction is possible". In addition to considering hunting, professional culling, and relocation, Murie makes a suggestion to "introduce an effective predator" to the island. Interestingly, he suggests "bear, cougar, or timber wolf" but admits a limiting factor is our lack of knowledge "if and to what extent our larger predators…prey on moose". From Adolph Murie. (1934) *The Moose of Isle Royale*. University of Michigan Press (Ann Arbor), pp. 7 and 42.

[4] Durward L. Allen. (1994, originally published in 1979) *Wolves of Minong: Isle Royale's Wild Community*. p. xix.

[5] Sources relaying our history with wolves include Rick McIntyre, ed. (1995) *War Against the Wolf: America's Campaign to Exterminate the Wolf*. Voyageur Press (Stillwater), and Jon T. Coleman. (2004) *Vicious: Wolves and Men in America*. Yale University Press (New Haven).

[6] Ibid, Coleman, p. 2.

[7] Durward L. Allen. (1954) *Our Wildlife Legacy*. Funk and Wagnalls Co. (New York), p. 232.

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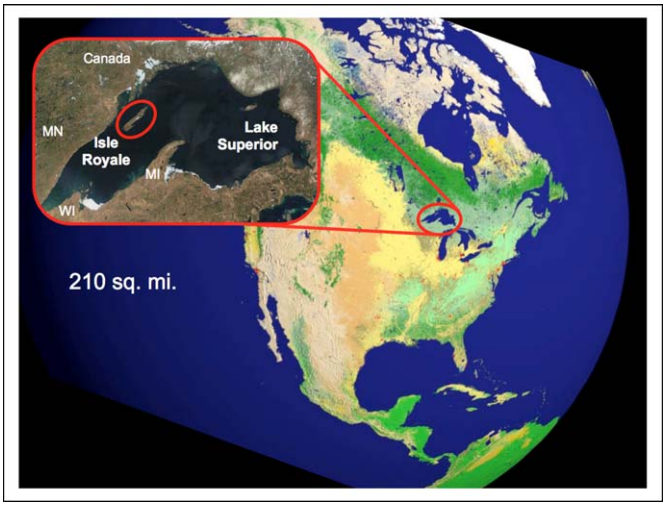

Figure 1. Isle Royale sits in the northwest corner of Lake Superior (the world's largest freshwater lake), North America and is the site of the Isle Royale Wolf-Moose Project.

Figure 2. The prospect of killing a ~1000 pound moose with your teeth should not be taken lightly. Though Chippewa Harbor Pack has managed to stop this moose, when one wolf attempts to latch on to the moose's rear it instead receives a blow to the abdomen.

part of a larger, healthy ecological system, Allen considered our ability to learn to live with wolves something of a critical moral test:

> I suspect that this curious, impartial sympathy toward *all* creatures, regardless of their diet, is an attitude of the cultivated mind. It is a measure of a man's civilization. If ever we are to achieve a reasonable concord with the earth on which we live, it will be by our willingness to recognize, tolerate, and employ the biological forces and relationships both in our own numbers and in the living things about us.[8]

Allen knew many of these attitudes were premised upon certain assumed facts about the nature of wolves, facts that, given the poverty of genuine scientific studies on wolves and other predators, we had no real reason to believe (or not believe): 'We will fail completely to develop a realistic view of predation and predator control unless, first of all, we face the fact that we are hopelessly preconditioned on the subject'.[9] The study of wolves on ISRO provided an opportunity to test, and possibly undo, our many biases toward wolves.

Running continuously since 1958, the ISRO wolf–moose project is, by some distance, the longest continuous study of a predator–prey system in the world. By various measures the project has been successful. Many of the US's most recognized contemporary wolf ecologists cut their teeth on the project; including L. David Mech, Doug Smith, and Mike Phillips. For the past 40 years budding ecologists and wildlife managers repeatedly encounter the project as a case study in their textbooks. Descriptions of the project in dozens of newspaper and magazine articles on the project are sprinkled with adjectives like 'iconic' and 'classic'. In a 2008 issue of *Audubon* magazine, journalist Les Line dubbed ISRO's wolves 'the most famous *Canis lupus* population in the world'.[10] The project has served as fodder for important scientific understanding, popular articles and books, and even artistic expressions.[11]

Though it is easy to take this all for granted, to assume such a project happens simply because researchers decide to do it would be a mistake. The productivity and longevity of the ISRO wolf–moose project is quite literally a phenomenal accomplishment: something that exists outside of the realm of normal happenings, 'an extraordinary occurrence'. While wonderful and inspiring in the case of this project, such success is as fickle and tragically rare as it is critically important.

Herein we explain some of the major findings of the ISRO wolf–moose project as a long-term ecological study. We then develop a historical narrative of the project by reviewing the early administrative history of the ISRO wolf–moose project. From that early historical narrative we illustrate a series of obstacles presenting a general challenge to long-term ecological research. Finally, we briefly consider the importance of this kind of sustained ecological inquiry.

A history of ecological insight

> '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[12]

The importance of long-term research is echoed repeatedly in the scientific literature.[13] 'Liv(ing) here for a long

[8] Ibid, Allen, p. 256–57.
[9] Ibid, p. 231.
[10] Les Line. (2008) The Long View. Audubon, March–April, on line at http://audubonmagazine.org/features0803/wildlife.html.
[11] These are on display at the project's website www.isleroyalewolf.org.
[12] Aldo Leopold. (1949) *A Sand County Almanac: And Sketches Here and There.* Oxford University Press (New York), p. 149.
[13] See, most recently, Justin S. Brashares. (2010) Filtering Wildlife, *Science* 259329, pp. 402–03, who argues that in regard to the protection of endangered species, "A critical first step is a renewed commitment to wildlife monitoring in protected areas.…*Intensive, long-term monitoring* is essential to gaining empirical knowledge of synergies among threats, the role of indirect effects, and other questions critical to minimizing species loss in protected areas" (emphasis added).

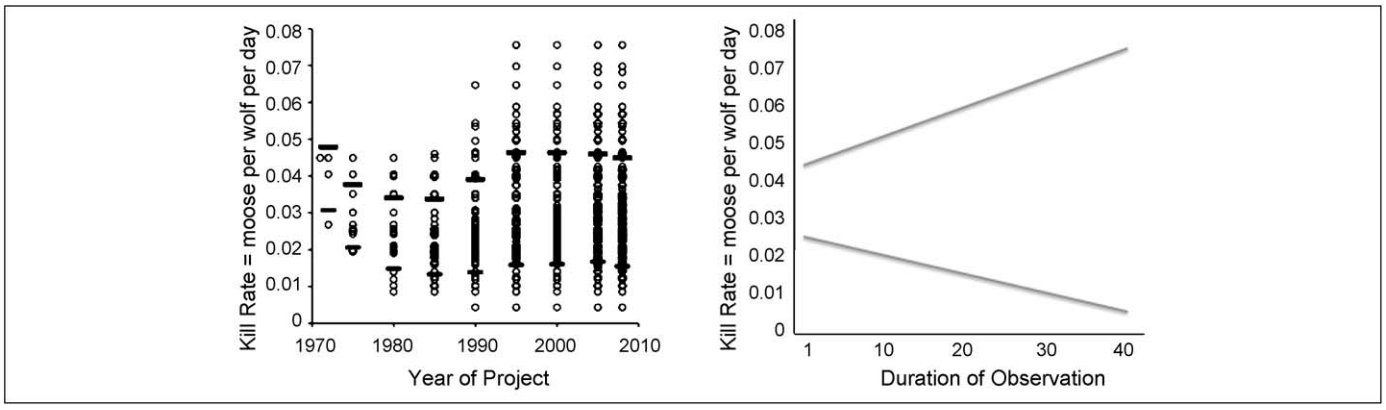

Figure 3. Two graphical representations of the same kill rate data. The graph on the left represents the rate at which wolves kill moose (moose per wolf per day) over a 40-year period, with increasing number of data points from 1970 to 2010. Note that the full range of kill rates took ~25 years to observe. The graph on the right represents the increasing range of kill rates over the 40-year period of observation. In both graphs the range of confidence decreases significantly over time, meaning that observations made over shorter periods of time might be more precise though less accurate than those made over a longer period of time which may be more accurate though less precise.

time', however, is not east to achieve in ecology. But, if Leopold is right, if we do in fact have to study things over time in order to understand them, and if we are not doing that, then we are not in fact learning even a few notes of the song of nature. There is a disconnect, then, between the questions we want ecology to answer and the manner in which we pursue those questions.

Two contemporary 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 (Figure 3)?' This kind of knowledge is valuable for managers aiming to promote wolf population viability and maintain human-caused mortality at appropriately low levels. Ironically, such knowledge is also valuable for the efficient reduction or even overexploitation of wolf populations. Though humans do not exploit wolves or moose on ISRO (making the ISRO wolf population arguably the last remaining unexploited wolf population in the world, an honor shared with Yellowstone National Park until 2009 when hunters killed key members of the Cottonwood Pack thereby eliminating a park pack) the wolf–moose project of ISRO has provided important insight on both questions.

One of the primary reasons humans despotize wolf populations is because humans sometimes believe that wolves threaten their ability to enjoy the highest possible rates of ungulate hunting (especially 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. In the early years of the project, it was discovered that wolves are selective predators, tending to focus their predation on moose that are young, old, or sick.[14] Subsequently, it was learned that wolves tend to kill more when winters are severe and when moose are abundant.[15] These discoveries suggest that wolves are the proximate, but not ultimate, cause of most moose deaths.[16] That is, wolves seemed to have relatively little impact on moose abundance (Figure 4).

Then, quite by accident, researchers made an observation giving a very different impression. In the early 1980s wolves declined dramatically (~80% decline) due to an outbreak of canine parvovirus. Shortly after this decline, moose increased to an incredibly high abundance,[17] only to themselves crash (also ~80% decline) due to the combined effects of a severe winter, a tick outbreak, and a catastrophic food shortage. Most recently, it was learned that of all the factors affecting short-term fluctuations in moose abundance, wolves are the least important[18]; whereas climatic factors, such as summer heat and winter severity, are far more significant. Most importantly, most of the fluctuations in moose abundance are attributable to factors researchers have yet to identify. These observations highlight limitations of our knowledge about how wolves affect moose on ISRO, despite their being well studied. To some, this limitation suggests our ability to control many wildlife populations is less precise and reliable than commonly thought. This suggestion is not unjustified pessimism, but a reasonable conclusion to draw from 50 years of research.[19] (Figure 5)

More recently, researchers discovered a special relationship between wolves and ravens.[20] Specifically, a critical advantage of group living is that wolves lose substantially less food to scavengers such as ravens. Ravens may be an

[14] This bit of contemporary "common wisdom" was the product of Rolf Peterson's Ph.D. work, subsequently published as Peterson (1977) *Wolf Ecology and Prey Relationships on Isle Royale*.

[15] Rolf O. Peterson and Durward L. Allen. (1974) Snow Conditions as a Parameter in Moose-Wolf Relationships, *Naturaliste canadienne* 101, pp. 481–492; E. Post, R. O. Peterson, N. C. Stenseth, and B. E. McLaren. (1999) Ecosystem Consequences of Wolf Behavioral Response to Climate, *Nature* 401, pp. 905–907; E. Post, N. C. Stenseth, R. O. Peterson, J. A. Vucetich, and A. M. Ellis. (2002) Phase Dependence and Population Cycles in a Large-Mammal Predator–Prey System, *Ecology* 83, pp. 2997–3002; John A. Vucetich, Rolf O. Peterson, and C. L. Schaefer. (2002) The Effect of Prey and Predator Densities on Wolf Predation, *Ecology* 83, pp. 3003–3013.

[16] John A. Vucetich and Rolf O. Peterson. (2004) The Influence of Prey Consumption and Demographic Stochasticity on Population Growth Rate of Isle Royale Wolves (*Canis lupus*), *Oikos* 107, pp. 309–320.

[17] Brian McLaren and Rolf O. Peterson. (1994) Wolves, Moose, and Tree Rings on Isle Royale, *Science* 266, pp. 1555–1558.

[18] Vucetich and Peterson. (2004) The Influence of Prey Consumption and Demographic Stochasticity on Population Growth Rate of Isle Royale Wolves (*Canis lupus*).

[19] John A. Vucetich and Rolf O. Peterson. (2009) Wolf and Moose Dynamics on Isle Royale, *Recovery of Gray Wolves in the Great Lakes Region of the United States: an Endangered Species Success Story,* edited by A. P. Wydeven, T.R. Van Deelen, and E.J. Heske. Springer-Verlag (New York), pp. 35–48.

[20] John A. Vucetich, Rolf O. Peterson, and Thomas A. Waite. (2004) Raven Scavenging Favours Group Foraging in Wolves, *Animal Behaviour* 67, pp. 1117–1126.

Figure 4. Wolves may revisit a kill site for weeks. In this image, captured by a motion activated camera, a wolf from Chippewa Harbor Pack picks over a moose carcass.

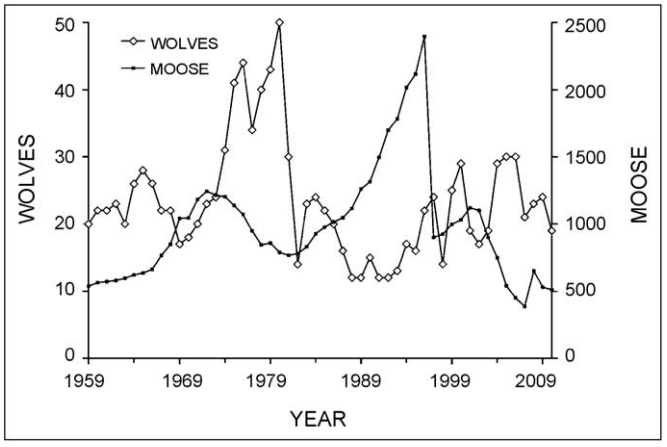

Figure 5. Fifty-two years (1959–2010) of wolf and moose fluctuations on Isle Royale National Park, Lake Superior, USA.

important reason why wolves live in packs – a trait otherwise uncommon among carnivores. This discovery grabbed much press attention (Figure 6). But why? It was certainly not valuable for controlling anything in nature. Rather, the work is appreciated, because it highlights a beautifully unexpected and intricate ecological connection. Likewise, ISRO wolf–moose research grabbed press attention when researchers described how wolves and moose are affected by moose ticks, which in turn are influenced by climate. Connections like these seem important for conservation more generally because of their ability to generate wonder, awe, and respect for nature.

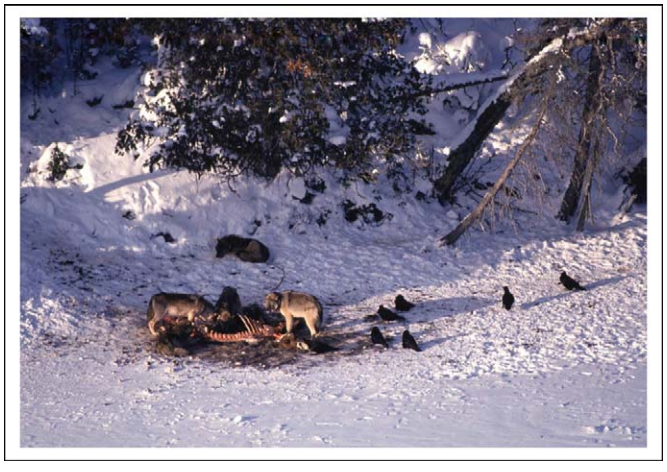

Figure 6. Wolves and ravens exhibit a special relationship. Since a single raven can eat or cash up to 4 pound of meat per day, wolves live in packs (a trait otherwise rare among carnivores) so as to more efficiently consume a carcass. The intensely social lives of wolves is attributed, at least in part, to the presence of ravens.

Over the years, researcher's sense and awareness of ISRO's complexity and unpredictable nature has continued to grow and deepen. They have learned that the most important events in the history of ISRO wolves and moose are severe winters, disease, and tick outbreaks – events that are essentially unpredictable. Moreover, every 5-year period in the wolf–moose chronology seems to differ from every other 5-year period – and this seems true even after more than 50 years of observation. Going further, the first 25-year period of the project was profoundly different from the second, and researchers have every reason to expect the next 50 years will differ substantially from the first, but, strangely, they are in no position to say how.[21] These and related observations suggest the futility of trying to reliably predict nature's responses to our intense exploitation; a sense of futility following an extraordinarily long and careful period of observation.

A history of help, a history of hindrance

A 1986 study by the Institute of Ecosystem Studies (IES)[22] 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. It turned out, however, 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'.[23]

For wolf–moose research at ISRO, one of these people was Robert (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. As the first naturalist for Isle Royale National Park, Linn had participated in an early winter study on ISRO in February of 1956 where he and NPS biologist Jim Cole spent several weeks 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 ISRO. Detroit newspaperman Lee Smits successfully

[21] Vucetich, Peterson, and Nelson. (2010) Will the Future of Isle Royale Wolves and Moose Always Differ From Our Sense of Their Past?

[22] D. Strayer, J. S. Glitzenstein, C. G. Jones, J. Kolasa, G. E. Likens, M. J. McDonnell, G. G. Parker, and S. T. A. Pickett. (1986) Long-Term Ecological Studies: an Illustrated Account of Their Design, Operation, and Importance to Ecology, *Occasional Publication of the Institute of Ecosystem Studies, Number 2* (Millbrook, NY), 38 pp.

[23] Ibid, p. 5.

petitioned to have four zoo-raised wolves introduced to the island (strangely, this introduction occurred even after there was solid evidence that wild wolves had made it to the island on their own). After the four semi-tame wolves became uncooperative pests, Linn led efforts to remove them (two were shot, one was removed, and one eluded capture).

In the mid-1950s there was substantial concern that the newly arrived wild wolves would increase and get out of hand, threatening the moose population and posing a danger to people (including some long-time residents of ISRO, whose efforts had helped establish the national park). Suddenly, sharing the island with an unregulated wolf population seemed a worrisome proposition. Anticipating a future 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 ISRO. 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 annually in bounty payments for dead wolves. It was Linn who wrote the reports and letters necessary to establish that the wolves were not a threat to people, and to help establish a policy whereby the NPS supported the existence of an unmanaged wolf population on ISRO. Meanwhile, in a harbinger of wolf reintroduction to Yellowstone 40 years later,[24] 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 ISRO 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 ISRO to begin an ambitious 10-year study to evaluate the role of wolf predation in the dynamics of the moose population. 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 continues to serve as a valuable research and educational outreach center for the project, long exceeding its tenure as a commercial fishery. Mech also needed a boat, and Linn donated his own wooden boat to the project (though the boat did not last as long as the 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 ISRO.

But the original 10-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 – that is, to terminate it. As Allen recalled the situation in the early 1970s, Linn quietly ignored the directive, and in fact continued to provide annual grants from his science budget.

By 1974 Allen had made no secret of his intention to retire the next year and to hand the project over to Rolf Peterson, one of Allen's last Ph.D. students. During that transition, however, one of Linn's own science administrators in the NPS (we wish to not reveal his name but will instead use the initials M.H.) embarked on a secret bid to take over the project. M.H. visited Purdue and had a pleasant chat with Allen, who came away mystified about the reason for the visit. Before the visitor left, Peterson showed M.H. a recently tanned hide of a wolf that had been killed by other wolves on ISRO the previous winter. A few days later, Allen received a phone call from Linn, 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 shown to M.H. was being used as part of an attempt to discredit Allen's obvious successor Peterson, 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, M.H., was not heard from again. This was but one of a number of overt or covert attempts to wrest the study away from the ISRO research team.

In 1975, as Allen retired, he turned the project over to Peterson who had by then secured 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 ISRO wolf–moose project.

In 1981, newly inaugurated US 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 (in fact on the Kenai National Moose Range, a national wildlife refuge) and who had previously been the director of the California Department of Fish and Game under (then Governor) Ronald Reagan.[25] Since his signature was required on the annual contract between the NPS and MTU that by then provided $30,000 to help carry out the winter

[24] Doug W. Smith, Rolf O. Peterson, and D. B. Houston. (2003) Yellowstone After Wolves, *BioScience* 53, pp. 330–340.

[25] 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".). For an interesting glimpse of Arnett as Assistant Secretary see F. Golden. (1984) A Sharpshooter at Interior, Time magazine, Monday, April 16. On line at http://www.time.com/time/magazine/article/0,9171,954259-1,00.html.

counts of wolves and moose on ISRO, it was not long before Arnett, an avowed wolf-hater, crossed paths with the wolf–moose project. 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 E. Glaser, and student field assistant Doug Smith all working on the island. ISRO Chief Ranger Stu Croll called one evening by radiophone with some 'unpleasant news.' Not only did Arnett refuse to authorize NPS funding but he ordered the wolf–moose project immediately terminated. Croll explained that all personnel would have to leave the island, and he arranged to have the Forest Service supply plane, a ski-equipped Beaver, pick up the team 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, Glaser, and Smith would be staying to complete the surveys as intended.

This act of disobedience, however, committed the project to spending money it did not have. Enter again Bob Linn, who, in a strikingly roundabout manner, saved the day. Linn contacted (most likely 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 alleged 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 ISRO National Park Superintendent Don Brown flew to Washington for a personal audience with Arnett. Brown reported that Arnett's office sported walls lined with trophy mounts of animal heads and a wolf skin on the floor. After the requisite chitchat with Arnett, Brown emerged with the original $30,000. While certainly dramatic, similar attacks and 'cancellations' happen repeatedly and continue to this day. In a June 17th, 1974 diary entry, Peterson's wife Candy noted, '[D.P] stopped by at 6:30 for a long chat. . .. Heard new rumor – NPS is not going to fund winter study this year since nothing new is coming from it!!!!!!' As recently as Spring 2010, an upper-level park administrator announced that NPS financial support for the project would be terminated, a decision that was then rescinded.

The final 25 years of Bob Linn's professional life 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 ISRO, which explains why the office of the George Wright Society is in Hancock, Michigan, a few city blocks from the mainland headquarters of ISRO National Park. The island was never far from his thoughts.

The challenge of long-term ecological research

While long-term research such as the ISRO wolf–moose project happens, it does not 'just happen.' In fact, as noted above, it rarely happens at all. The 1986 IES study cited above indicates that, other than the enthusiasm of some individual, there really are no clear and specific conditions describing or predicting success. We suggest, however, there are four critical and underappreciated, but necessary, conditions. Moreover, the precariousness of these conditions when they are satisfied is such that long-term studies are exceptionally rare.

Figure 7. Since the lives of the wolves and moose of ISRO are recorded in their bones, bone collection is a centerpiece of the project, collecting the bones of more than 4000 moose and a few dozen wolves. In this image, Rolf Peterson is preparing the bones of a wolf.

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 ISRO wolf–moose project requires a lineage of interest, and the ISRO project has just that. From Bob Linn to Durward Allen to Rolf Peterson to John Vucetich, individual scientists have taken a personal interest in this particular project; have made it the focus of their life's work (Figure 7).[26] But this sort of interest is very 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 often reward or encourage scientists whose sense of place is so strong (in fact, quite the opposite).

Ultimately, the interest of the researchers must also transfer to, and spark, the interest of the public – a tough audience, especially when the project is largely about an animal with which we have a troubled past and present relationship. Fortunately, the ISRO project has been 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, to the surprising role parasites such as winter ticks might play in the

[26] Strayer et al. point out how critical the focus of the scientist (and ultimately 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" D. Strayer, et al. (1986) Long-Term Ecological Studies: an Illustrated Account of Their Design, Operation, and Importance to Ecology, p. 5. According to Earl Werner, current Director of the George Reserve (the site of the old-field), "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." Earl Werner. (2008) Personal communication with M. P. N., 18 May 2008. Evans' fifty-year study lasted from 1948–1997, Evans died in 2002.

dynamics of the system – to intentional and extensive public outreach, 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 IES 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 difficulties and retirement of the PI, but never for lack of important research questions'.[27]

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 ISRO wolf–moose project, however, is interesting because its annual budget is only a fraction of that of many other ecological studies, while the contributions of the ISRO project are comparable to those of other significant research projects. Despite its relatively high return, however, the ISRO project remains financially limited.

But funding is fickle. The $30,000 that the National Park Service originally committed to the project in 1976 has remained essentially unchanged (it now stands at $36,600) – though inflation calculators indicate that its worth in 2010 was roughly $7,832. Adjusted for inflation, funding the project at $30,000 in 1976 would require funding the project at $114,920 in 2010. That is, current funding for the project is ~32% or less than one-third, of the original funding. 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 ISRO project can pursue answers to only a small handful of the fascinating and important questions that bubble up year after year. The real tragedy of underfunded long-term science, however, 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 exact science we need most. In short, because of the financial strains on long-term projects, we should never assume that because a project has lasted for more than 50 years that it will last 50 more – or even for one more!

Third, successful long-term study requires the ability to weather the periodic threat of rival ideologies and the administrators who sometimes evoke them. As we saw above, there have been at least two close calls for the ISRO project on these grounds. In addition to the attempted post-Allen NPS 'takeover' of the project, others have expressed a willingness to quash serious scientific research in the name of an ideology suggesting wolves are some sort of evil incarnate (making the work of wolf research somehow devilish). However, a different set of ideologies – suggesting either that predators such as wolves have an important effect on ecosystems[28] or assuming that predators are critical components of healthy ecosystems,[29] coupled with the recent 'greening' of a variety of the world's religions,[30] for instance – might mean that work focused on predation is perceived by some groups as a way of caring for what they see as God's Creation.

More recently, certain ideologies about the nature of wilderness can and have interfered with environmental research in this project and elsewhere.[31] 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 ISRO's wolves and moose. The final chapter of Peterson's 1995 book chronicles how a difference in wilderness ideology between researchers and the NPS might have allowed the wolves of ISRO to die out, and the project to end, during the 1990s. The ISRO project is not alone in this way. Other long-term research projects have failed, or their continuation has been threatened, by administrations and ideologies opposed to certain kinds of knowledge about the environment.[32]

ISRO researchers have all learned that ideological righteousness coupled with power knows few limits and is seldom subject to negotiation. Of course, ideology when combined 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.

Fourth, and finally, successful long-term research requires institutional support. Though it may sound somewhat surprising, especially in this case, we should not assume that contemporary research universities are necessarily equipped to support, or interested in, such research. ISRO wolf–moose researchers have been criticized (and, in fact, have had their academic positions threatened) by university colleagues for 'continu[ing] work initiated by others;' which is, of course, an inevitable part of long-term research.[33] Moreover, within the academy it is increasingly expected that fieldwork will be conducted by graduate students, leaving faculty members to write grants and publish results. It is, therefore, notable that the PIs of the ISRO wolf–moose project continue to conduct the field research. One might suggest that many of the findings from the study would not have been otherwise

[27] D. Strayer et al. (1986), p. 13.

[28] See, for example, William J. Ripple and Robert L. Beschta. (2005) Linking Wolves and Plants: Aldo Leopold on Trophic Cascades, *BioScience* 55, pp. 613–621; Mark Hebblewhite, C. A. White, C. Nietvelt, J. M. McKenzie, T. E. Hurd, J. M. Fryxell, S. Bayley, P. C. Paquet. (2005) Human Activity Mediates a Trophic Cascade Caused by Wolves, *Ecology* 86, pp. 2135–2144; and Christina Eisenberg. (2010) *The Wolf's Tooth: Keystone Predators, Trophic Cascades, and Biodiversity*. Island Press (Washington, DC).

[29] See, for example, Aldo Leopold (1949), pp. 129–133.

[30] See, for example, Bron R. Taylor, ed. (2005) *The Encyclopedia of Religion and Nature*, two volumes. Thoemmes Continuum (London).

[31] See, for example, J. Baird Callicott and Michael P. Nelson, eds. (1998) *The Great New Wilderness Debate*. The University of Georgia Press (Athens); Michael P. Nelson and J. Baird Callicott, eds. (2008) *The Wilderness Debate Rages On: Continuing the Great New Wilderness Debate*. The University of Georgia Press (Athens).

[32] For good examples of such accounts see Michael E. Fraidenburg. (2007) *Intelligent Courage: Natural Resource Careers that Make a Difference*. Krieger Publishing Company (Malabar).

[33] Information from the personal personnel files of J. A. V.

possible, that they were the result of prolonged study by the researchers themselves, researchers familiarizing themselves with a place over a long period of time. Commenting on the value of the intensive fieldwork of pioneering animal ecologist Niko Tinbergen, scientist Thomas Seeley points out 'you discover something when you are looking over here, but then unexpectedly you see something interesting going on over there.' Good data comes after a long period of 'watching and wondering,' Seeley points out, watching and wondering done by the scientists themselves.[34] In fact, the 1986 Institute of Ecosystem Studies study also affirms this, 'There is a widespread perception among scientists involved in long-term studies that long-term studies often produce important serendipitous findings'.[35]

Conclusion

It may be difficult to understand precisely how the North American relationship with nature changed from a culture of wolf eradicators to a culture of wolf restorers, but change it did. A bounty for wolves was still in place in both Michigan and Minnesota in 1958 at the dawn of the wolf–moose project.[36] By 1973, however, the US had enacted the Endangered Species Act, listing the Gray Wolf as endangered in 1974.

Some have suggested that, given North America's predominantly Judeo-Christian culture, our changing relationship with nature is the result of our decision to interpret that relationship in a stewardship rather than a despotic fashion.[37] Others suggest the cause of our changing relationship lies in human demographic changes: citing our shift from a largely rural to a largely urban population and a subsequent alienation from nature. But it is difficult to know what to make of this. While some have asserted that this alienation from nature is the cause of our willingness to harm nature,[38] others seem to suggest such alienation results in our desire to preserve nature.[39] And even if urbanization is the root cause of our shifting values allowing wolves to return to the landscape, it is unclear why. While some suggest moving away from the land creates within us a desire to preserve and cherish that from which we have come,[40] it is not uncommon in contemporary wolf debates to hear urban dwellers who support wolf restoration ridiculed as naïve with regard to the real workings, and appropriate valuation, of nature. It seems, in fact, something of a cottage industry these days to blame nearly all of our environmental woes on our presumed alienation from nature, though at the same time this period of so-called alienation seems to be the source of the environmental movement over the past 50 years.

Whatever it was that prompted this sea change in attitudes, the ISRO wolf–moose project clearly benefited from, and perhaps even contributed to, the trend.

When considering the challenges to long-term research, both with wolves and moose on ISRO and elsewhere, there are two sorts of problems persist: 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 frequently devalued.[41] As Rolf Peterson noted back in 1981: 'As land use intensifies and research funding dries up, we face a regression in ecological inquiry at the very time we need it most'.[42] Thirty years later this is truer than ever.

Second, the paucity of long-term ecological research has potentially serious ethical implications. Aldo Leopold suggests that 'all ethics so far evolved rest upon a single premise: that the individual is a member of a community of interdependent parts'.[43] 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 50-year image of wolf–moose relationships is wildly different than that which we would have assumed if the project had been halted after only 5 years (see Figure 5), the longevity of the project informs environmental ethics in important ways. The ISRO wolf–moose project, then, takes on an unanticipated, yet important, moral significance.

The ISRO wolf–moose project began 52 years ago, during the darkest hour for wolves in North America. The 'genuscide' perpetrated against wolves required our vilifying them. The subsequent and quite phenomenal improvement in conditions for wolves required an antidote to this vilification. That antidote was knowledge. In the early

[34] D. O. Brown and M. S. Dantzker (producers). (2009) *Signals of Survival: animal communication through the lives of Great Black-backed Gulls and Herring Gulls*. Film from The Cornell Lab of Ornithology and Shoals Marine Laboratory.

[35] D. Strayer et al. (1986), p. 21. It is interesting to compare ISRO research with findings and benefits from other long-term ecological studies, see for example Anne E. Pusey, Lilian Pintea, Michael L. Wilson, Shadrack Kamenya, and Jane Goodall (2007) The Contribution of Long-Term Research at Gombe National Park to Chimpanzee Conservation, *Conservation Biology* 21, pp. 623–634; Richard Wrangham and Elizabeth Ross (editors). (2008) *Science and Conservation in African Forests: the Benefits of Long-Term Research*. Cambridge University Press (New York); and essays in Felix Müller, Cornelia Baessler, Hendrik Schubert, and Stefan Klotz. (2010) *Long-Term Ecological Research: Between Theory and Application*. Springer (New York).

[36] Upper Great Lakes states and provinces eliminated their wolf bounty programs in 1957 (Wisconsin), 1960 (Michigan), 1965 (Minnesota), and 1972 (Ontario).

[37] See Lynn White, Jr. (1967) The Historical Roots of Our Ecologic Crisis, *Science* 155, pp. 1203–07.

[38] See the growing literature on the No Child Left Inside movement, first articulated in Richard Louv. (2005) *Last Child in The Woods: Saving Our Children From Nature-Deficit Disorder*. Workman Publishing (New York).

[39] See Keith Thomas. (1984) *Man and the Natural World: Changing Attitudes in England, 1500–1800*. Penguin Books (London), who speaks of protected areas as "fantasies which enshrine the values by which society as a whole cannot afford to live."

[40] This seems a reasonable extrapolation from Frederick Jackson Turner. (1920) *The Frontier in American History*. Henry Holt and Company (New York).

[41] On this point see R. F. Keeling. (2008) Recording Earth's Vital Signs, *Science* 319, pp. 1771–1772.

[42] Rolf O. Peterson. (1981) Long-Term Research: an Answer to "When are You Going to Quit?", *The George Wright Forum* 1, pp. 35–38.

[43] Aldo Leopold. (1949), p. 203.

years, the ISRO wolf–moose project helped to give 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 ISRO wolf–moose project encouraged people to see that wolves are not gluttonous, wasteful killers. Instead, most wolves die young, and they die of starvation or by fighting for food. What wolves do not eat, scavenger species – foxes, ravens, and other resident bird species – depend on for their survival. Ultimately, the ISRO wolf–moose project created an awareness that has contributed to a sea change in attitudes, allowing for wolves to begin their recovery in the US.

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