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# Creating Wildlife:
# Synthesis of a Gaming Simulation

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A gaming simulation is a sequence of social interaction designed to present a body of theory. Instead of employing a mechanical analogy, such as is still sometimes used to follow action and reaction around bays and estuaries, or developing a computer program that generates reasonable approximation of outputs, a gaming simulation operates through guiding human behavior. The model is not mapped upon paper, plaster, or computer instructions, but upon intragroup transactions.

All simulations — gaming, computer, and otherwise — are devices intended to teach or learn. They indicate potential consequences of external effects, including human interventions. Some of the outcomes are likely to be surprising, a few downright disturbing. A player committed to a strategy for intervention often finds that he has miscalculated the responses to his actions. A planner, or an executive, will then be forced to think through far more carefully the chains of consequences that flow from his proposals.

An effective gaming simulation is far more difficult to construct than a computer simulation. The behavioral model of the real world must cope with irregularities of human behavior, whereas a computer simulation abstracts from the objective world of nature and traces it out in a consistent sequence. This difference was not understood when the creation of *Wildlife* was undertaken in 1960; at that time it was believed that they were interchangeable. At first graduate students were employed as if they were mini-computers, then when more extended sequences were to be explored, the program went to the computer to overcome fatigue, and finally back to people again so as to maximize the rate of learning about living systems.

Justification for designing a working model must be substantial. Quite a few man-years of research are involved; the risk of failure followed by dissolution of the effort is high. Therefore, the choice of the environment to be modeled and the principles to be emphasized should yield social benefits equal to many millions of dollars. Anything less than this return means that the project should be regarded primarily as education and training of the developer of the simulation, with the hope that he would have advanced his technique far enough to be more productive the next time. Only a few projects and issues reach this scale of potential benefits, and even fewer fit the time scales required for developing a working model.

The rule-of-thumb transmitted to administrators and resource managers in those days was, "Don't spend a

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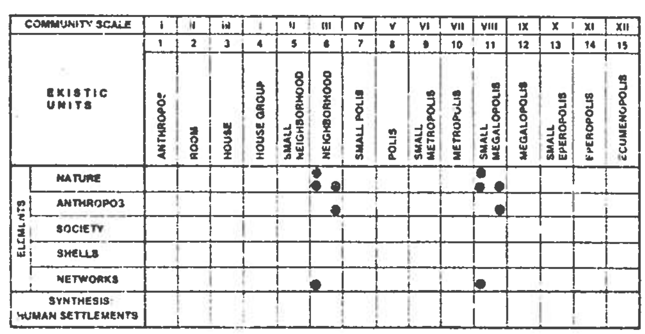

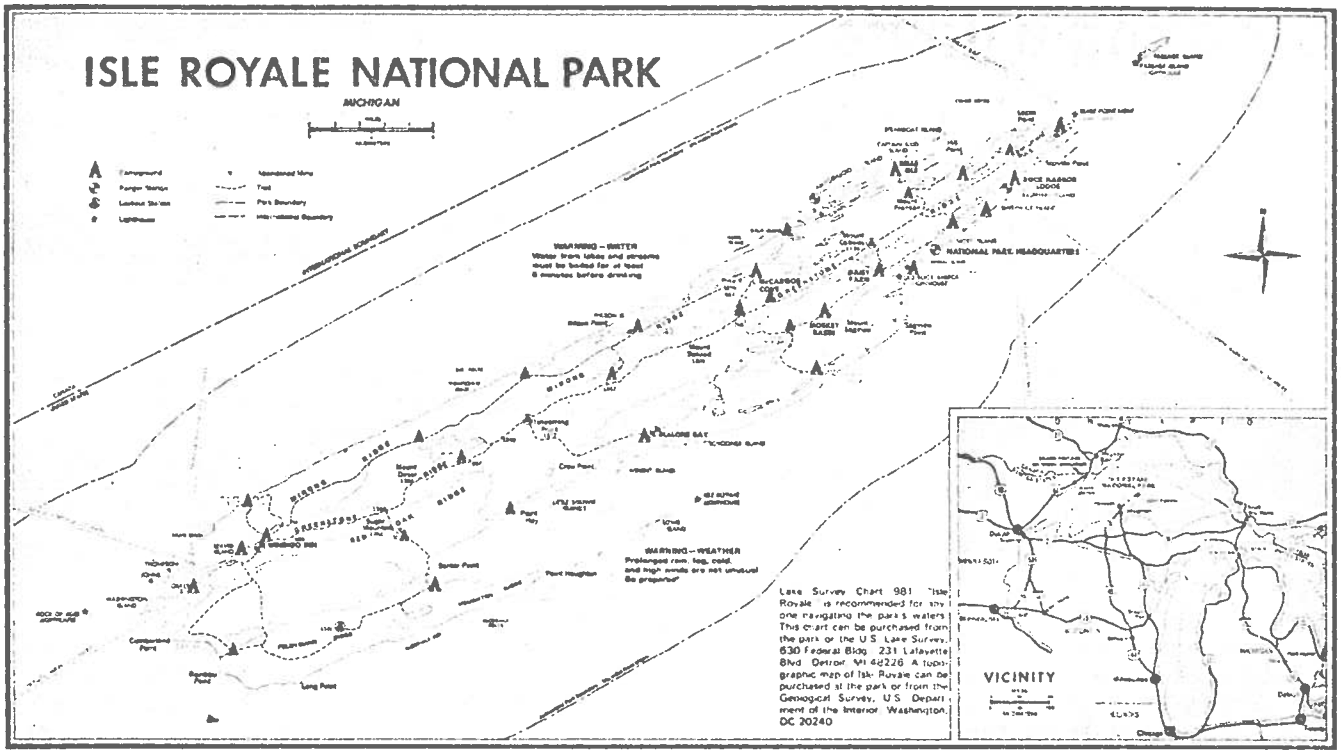


**Fig. 1:** Isle Royale National Park

planner on a program that will produce less than the equivalent of a megabuck ($1,000,000) of public benefits." Now, after a decade of inflation, it should be several millions — unless the returns were almost certain and relatively short run.

The teaching of ecology was chosen as a suitable target. Quite a large amount of doctrinaire mythology is bound up in the transmission of ideas to teachers, and some of the folk beliefs are harmful. Observations made in the School of Natural Resources of the University of Michigan indicated that concepts concerning community in the ecosystem were difficult to transmit, using texts, lectures, and films.

Recognizing that errors in learning while training for the profession were likely to be reproduced a thousand fold in the next generation, an adequate justification appeared to be present for launching the project. As it has turned out, the actual uses found in the latter stages of development of the simulation have been much broader than that, since the model illuminates fundamental principles in living systems that need to be acquired by many other professionals.

## An island setting

Ecologists interested in population dynamics and community relationships had already found a convenient site for coordinated empirical studies. Isle Royale, a US national park in Lake Superior, is the largest island in the largest body of fresh water in the world (fig. 1).

The natural history of Isle Royale had been reported upon over a period of three centuries; a series of doctoral dissertations, masters theses, wildlife censuses, and technical reports had been accumulated. Moreover, after the territory had been cut over for timber and its native copper had been mined, it had been abandoned by settlers, and had begun to return to its original state. At this point, it was accepted by the US Government as a national park. The park managers have zealously guarded the island's condition by preventing any disturbance other than on the periphery. Access by tourists has been limited to passage provided on park service vessels. Anyone playing out an alternative future for the natural history of Isle Royale could check its validity by considering its 30,000 or so visitors per year.

## Building the model

All nonessential information needed to be stripped away. (This stage of theory building is usually very painful for naturalists and they are tempted to collude with the model builders — particularly computer programmers — to incorporate those features upon which a large amount of investigative work had been expended.) Lack of ruthlessness in pruning away the largely unneeded content leads to a model that collapses from its own weight — too much effort is required to push it through successive cycles along alternate paths. In this case, the fish, the insects, and the botanizing were all well recorded, but on Isle Royale they are loosely coupled with the dominant fauna and their supports — moose, beaver, wolf, and forage vegetation — so they have been excised. Even the males can be taken for granted and are excused from the model. A minimal community can be articulated from three trophic levels.

Choice of these interacting populations was reinforced by public attention: romanticized reports in print and on film picked out animals as leading actors in this biodrama, particularly moose, beaver, and wolves. These public conceptions are incomplete, but they enable the park personnel to develop a corresponding strategy for preservation.

Too much abstraction from the real world leads to child's play. Many boxed games dealing with phenomena in nature have been reduced to the recognition and naming of patterns and relationships, sometimes with the aid of mnemonics. What is the appropriate level for a serious student? Noting that the games of Chess and Go are readily learned by virtually all students, but not mastered completely even by the best, the level of complexity in the field presented (that is, the playing board) should generate a minimum of confusion, yet almost universal respect. Therefore, I chose a simple, symmetric grid (fig. 2), dispensing with realism in the form of maps and photographs, or even any imagery with strong associations. This is a compromise that accedes to the purely positivist approach to understanding the environment; the contemplative approach is likely to result in an interpretation that appears as a painting, a dance, or a videotape. (As emphasized earlier, preferred teaching methods would draw upon all these approaches to understanding community in the ecosystem, but the population dynamics posed the greatest conceptual difficulty.)

The scale of representation chosen allows a maximum of sixty-four units of vegetation of varying utility to the animal populations and a smaller number of animal chips that migrate in search of better conditions within the restricted field of this "island." The number of animal "actors" whose presence on the board can be picked up at a glance (up to forty) does not permit proportionate sampling, since less than one wolf would be allowed when the board contained a

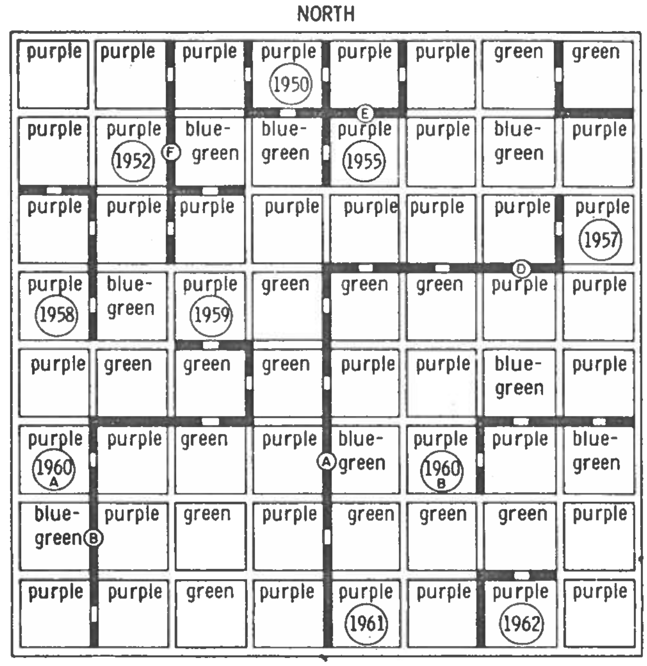


**Fig. 2:** Playing field representing "Utopian" environment used to launch natural histories in succeeding examples. (Purple represents best forage, blue-green the next best, green a level below, white circles containing a year represent female moose of that birth date, while smaller circles containing letters are beaver lodges labeled in order of formation, but wolves are not shown as yet.)

maximum quota of moose. Therefore, a mathematical model of the relationships between the populations had to be prepared and parameters chosen so that a higher proportion of wolves (about 20 percent) and beaver could be maintained on the playing board without causing unbalanced development. Both the dimensions of the field and the form of mathematics were selected so as to allow one to resort to a computer if that became advisable at any stage.

A breadboard version was prepared with a chessboard containing depressed squares. Rectangles of colored paper (color coded to a sense of environmental quality so that purple was the lushest possible forage, and grey represented bare, eroded clay) could be placed in these squares to represent changes in the level of support provided to moose and beaver. Poker chips represented moose, adhesive paper dots the beaver lodges, and paper clips with springs (inverted) could be used to locate wolf dens. The moose operated upon a field of sixty-four squares of variable and exhaustible quality, the beaver in a number of streams of different forms placed upon the lines between the squares with a maximum of thirty-two lodges, and the wolves were assigned the interstitial corners — an

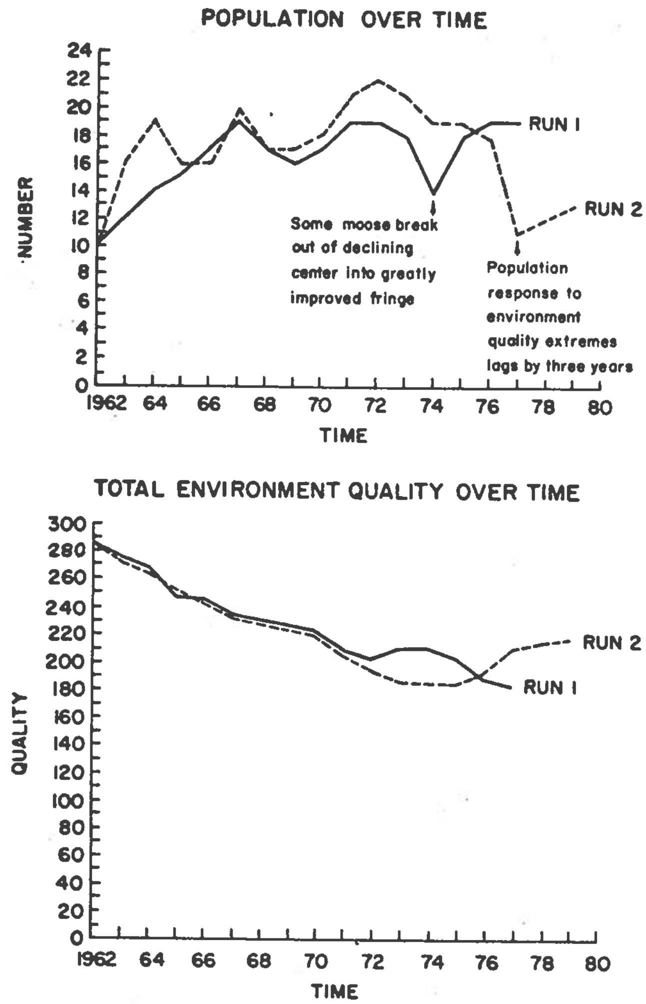


**Fig. 3:** Population and environment quality trends for simulated moose starting from "Utopian" initial conditions

array of seven by seven possible locations. Random numbers were used to determine which representative animals gave birth successfully and which succumbed to environmental stresses. Thereafter, volunteers were playing out natural history and keeping records for us, so that we could then discover whether any evolving combination appeared "unnatural." The parameters selected yielded no absurdities over the course of several hundred hours (representing roughly twice as many years) of manipulating the simulation. (Figures 3 to 5 describe two simulations starting from conditions as nearly ideal as possible in the absence of wolves whose presence would not have affected these results significantly.)

Unexpectedly, a major hurdle to be overcome in the design of a teachable workable model was the formulation of an adequate accounting system for births and deaths, migration, and environmental changes. Initially, we believed all obtainable data should be retained, so that the best possible explanation for trends in populations was obtainable. The ecologists, and the users of the natural communit have many different ways for viewing biosystems, and one prefers not to discard information before he is sure that it is not relevant to the questions that may be asked. However, comprehensiveness in data collection soon compounds the computations, and tabulations per cycle increase, so the operation of the simulation slows down. One of the principal sources of delay is the occurrence of mistakes in simple arithmetic or in the recording of items of information. Mistakes that are discovered must be removed; any that remain are assumed to be comparable in size and number to the field observations that provided the original data. Therefore, forms needed to be prepare which minimized error and enhanced the rate at which the data could be scanned.

When used as a device for teaching undergraduate classes this simulation encountered an unanticipated reaction that faces most other working models of nature — there is no interesting strategy that is also realistic. Animal populations do not behave in a foresighted or ingenious manner. No real thinking is involved when the pieces are moved, since migration should occur by tropism or some built-in rules (superstitions). Death occurs as a matter of chance encounter with disease or predator. The model is more readily comprehended than reports of observations from the field and the technical generalizations but it would rarely be played "for fun." The only kind of improved performance the student visualizes is the reduction in the amount of time that it takes to complete a series of cycles with flawless records! Skill of this sort is rarely regarded as rewarding. It is a game of solitaire, played out by a team, with no means of "beating the system," and no real finale, since in a typical ecosystem life merely goes on and on.

The "goodness" of a game depends upon the degree to which intellectual ability enables players to win or noticeably to improve their performance. Goodness is a characteristic that allows new facets to be learned which affect success or failure. As formulated by I.J. Good,[1] a suitable index would be obtained from the number of handicapping levels, or distinguishable grades of competence, that are obtainable in a population of players. Thus, games of pure chance permit no distinctions, the best parlor games may provide three to five levels after ten hours of play, while for Chess the goodness lies between ten and twenty and Go is said to allow even more distinctions. How is the concept of "contest" incorporated into the environment? Those possibilities are essential to any long-term utility of the working model, but they require a rare ingenuity, and have been explored only to a small degree.

**Enter the manager and the hunter:** One means of attaching interest to the operation of the model is to assign a meaningful role to the player. He could be appointed to the position of consultant to the park manager to advise him on the vulnerabilities of this central community to outside threat. If the question of epidemic is raised, for example, the consultant could look into the greater threats to moose or beaver that are recorded in the scientific literature and could construct a simple model for the propagation of the disease that is superimposed upon the model of the ecosystem.

The impact of a perturbation of this sort is often as surprising for the manager as for the layman. Thus, a disease that weakens or kills the main body of the moose population causes first an upsurge in the population of the wolves, followed by their almost certain extinction on the island, and a dozen years later or so, after isolated moose invade the main ranges, the moose population is exploding. Thus, it would appear for quite a while that the moose population had more than completely recovered from the catastrophic epidemic, yet the loss of the predator population would leave it unregulated and more vulnerable, especially after the population had crashed downward following a population explosion. A disastrous forest fire poses similar threats to the wolves, although the sequence is greatly changed.

Managers may introduce substitutes for predators. One of them could be man himself. For example, during the 1960s one of the Canadian approaches was to treat the American Indians as if they were Canadian farmers — the government would guarantee a high enough price for their product to keep them active in food production. The tribal population could be given the right of harvesting the game and exporting it to the premium markets in the cities. If that were the case, the managers would need to encourage an efficient technology for hunting and export of game that would allow a sustained yield. What would be the sustained yield in beaver and moose from a preserve like Isle Royale? It quickly becomes evident that much depends upon the amount of detailed knowledge the manager has and the cost of being selective when identifying animals for slaughter. High levels of information result in a situation very similar to the rancher maintaining herds on the open range, where the number marked to go to the slaughterhouse depends upon news about market prices.

Wildlife managers have other options. They can, depending upon the money, equipment, and time available to them, enhance the yield of biomass in the environment. In order to reduce winter kill they could put down drift fences to guide migration into areas with better forage, or they could harvest large trees in time to produce more browse. They might even

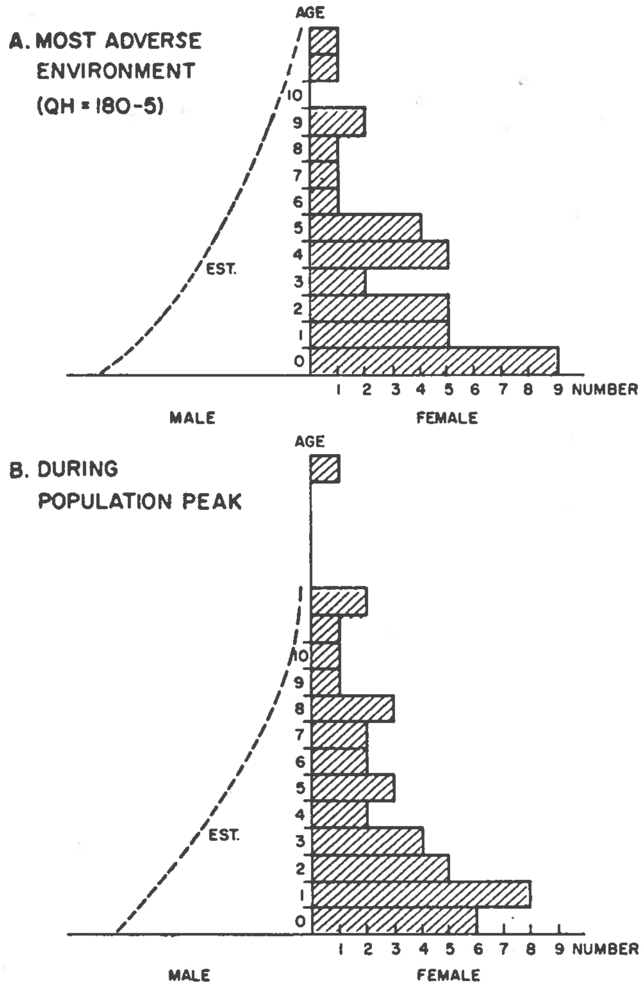


**Fig. 4:** Age distribution of moose in absence of predator

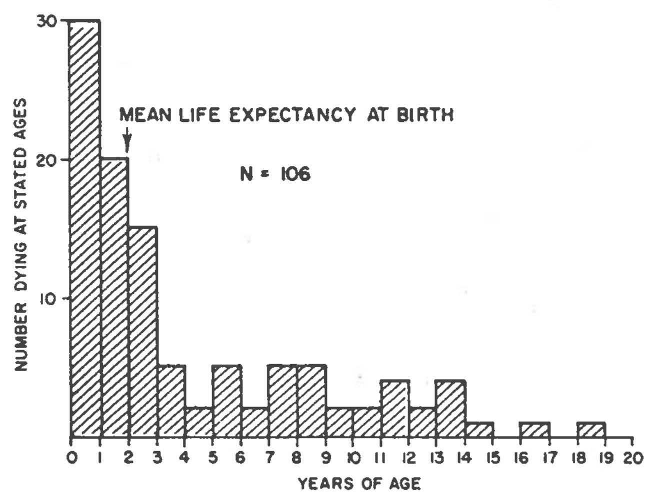


**Fig. 5:** Mortality by age for simulated female moose in absence of predation (thirty yearly cycles starting twice from "Utopian" initial conditions)

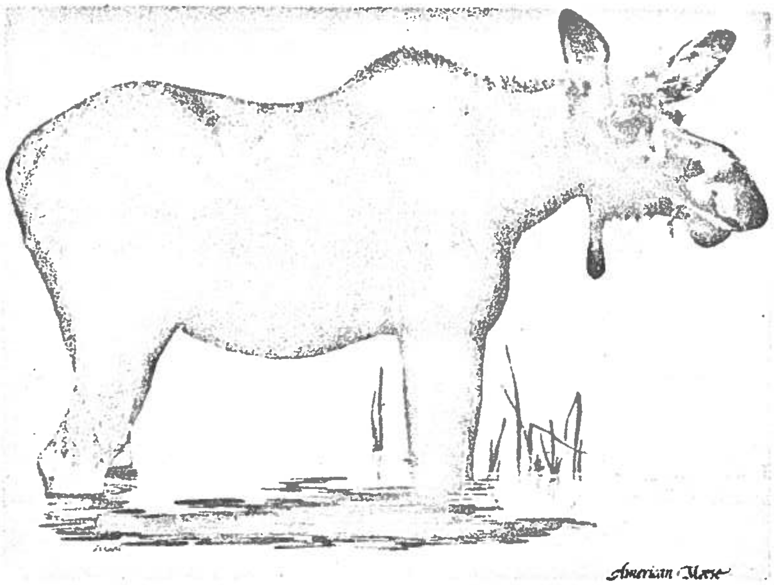


**Fig. 6:** American moose (from Sierra Club Wildlife Calendar)

plant catch crops in crucial areas that would sustain valuable populations in the event of a hard winter.

All of these games that preserve managers play are essentially games against nature. Being a slow and ponderous adversary, nature exposed as living system does not present many exciting challenges. The strategies are worked out slowly; their unfolding is even more gradual than that of a game of chess played by mail. The simulation can speed up the consideration of alternatives, but if I were such a consultant I would resort to a computer, which would allow me to play out the fifty-year consequences of a hundred different moves or policies on the part of the manager.

## Species introduction

**The tourist:** The real game any manager of wildlife plays today is that of gaining the attention of the top levels of a bureaucracy in order to obtain more freedom for action in preventing catastrophe. It is a many-person game that changes in structure with each new state of the world. Over the past twenty years the park manager has become increasingly aware of the expectation from above that he is involved not so much in a sustained yield situation but one of maximizing recreation benefits. Therefore, he must think carefully about the introduction of a new spécies into his wilderness — the tourist. How does the tourist interact with these other species? What threats does he pose? How is the tourist best managed? A team of students asked themselves these questions.

Tourists were interviewed aboard ship on the way to and from Isle Royale. From that information a simplified model began to emerge. The bulk of the tourists — the kind that were likely to respond to plugs for the park in the mass media — came for the "park experience," which means participation in the sights, sounds, smells, and feels associated with the park. Their booty took the form of pictures. A most envied picture was that of a cow moose standing in the middle of a beaver pond with a calf, lazily munching on pond weed. Another was that of a beaver, displaying his full body rather than an inquisitive nose or a disappearing tail. It became apparent that mainstream tourists were validating the image that had been presented by the media. They would report to their friends and acquaintances. People planning vacations would sample the reports, many of them third and fourth hand, and then decide whether or not they should spend a part of their precious weeks on this attraction. Tourists, these students inferred, are produced season after season, according to the quality of the rumors that originate from previous seasons. A model was prepared based upon the likelihood of seeing moose and beaver in their habitat (not even the rangers had seen the wolves, except from the air in the winter), and the quality of the vegetation around the landing place. In one instance, parameters were chosen which set off a population explosion in tourists — the greatest single fear of the park manager.

The consequences for the natural community of a sevenfold multiplication of tourists was most unexpected. They significantly improved the quality of the environment to which they were exposed and stabilized the moose, beaver, and wolf populations. This is certainly not what park managers had anticipated, based upon what they had been taught. The working of the model says that tourists in that situation could function over the long run (a period involving several decades) in much the same manner as might an extra predator.

This outcome is so surprising it deserves at least partial explanation. It starts with the observation that park managers were so concerned about the preservation of the natural areas they kept the overnight and picnicking facilities close to the two landing areas and at the periphery of the wilderness. It was more obvious that these settlements would not be allowed to penetrate the island very far, but expanded overnight services would be tightly clustered in lodges. Then, walks into the interior in search of the prize sights and photos would cause some retreat of wildlife from human population pressure, but exceedingly few tourists are willing to cross a beaver pond or a marshy valley bottom during summer and autumn. The beaver would then cut selectively on the other side of the valley, use up the trees somewhat earlier, and be forced to migrate somewhat sooner. They would destroy only a few trees on the tourist side, thus leaving the area more parklike. Earlier migration should cause the beaver cycle to moderate, thus maintaining ponds, and therefore pond weed for the moose, more consistently. Moose are, therefore, attracted to places on the edge of tourist penetration and are available for picture-taking — even on many shorter expeditions by tourists.

Managers recognize that they need to cope with many special situations not in the model, so the simulation of this tourist-management-natural community game, seeking (but sometimes rejecting) recreation benefits, should only be considered as a stimulus for introducing unfashionable or "unthinkable" alternatives into the planning. The final choices of policy will usually depend upon considerations outside of the model. A simple simulation like this offers a cheap means of testing, sometimes overturning, received doctrine in the administrative agency. Every manager will be worrying, for example, about the changing technology of tourism (in this case, suitcase-size inflatable boats, lighter movie cameras, scuba gear, and so on) and must build new models based upon changed behavior, and then formulate new regulations.

**The unicorn (like the tourist):** The basic *Wildlife* simulation was used to introduce architects and landscape architects to the problems of modeling living systems in two spatial dimensions and time. A computer program was prepared so that questions of long-range stability could be answered, and the designers could be introduced to a new realm of modeling. Yet, although it was more appropriate than the alternatives, I detected that this mode of abstraction was not fully satisfying to the students recruited to these professions. Repeated questioning revealed that the potential for fantasy, a capacity that is treasured by those who seem born to design, had been ruled out by this purely objective, science-based approach. Therefore, it occurred to me that something more could be added; it could even be framed as another kind of management question. Why not synthesize a new species for introduction into the environment. Or provide a haven for some threatened species? When and how does common sense fail due to the feedback circuits in the system? Whatever the consequences, the tourists would be interested. Designing a species for a living system is a different kind of challenge, and therefore, intrinsically interesting.

Our colleagues, the classicists and archeologists, pointed out that civilizations have always been creating fantastic mythical beasts. There is a huge literature based upon sculptures and etchings. Of these, it appeared that the unicorn was most suited for introduction into the Isle Royale fauna. Its range was primarily central Europe during an era of romanticism. Students were instructed to find the equivalent of *Wildlife Abstracts* and track down its habits, migratory properties, preferred forage, reproduction requirements, aging, predation, and so forth. These would then need to be modeled as a new population.

This exercise had unexpected consequences. Although unicorns browsed normally, not much different from deer, their predators were (besides man) harpies, gryphons, dragons, and other mythical beasts. Most difficult of all was the need of the gentle unicorn for the lap of a virgin in order to breed! It appeared that some kind of mythical metaworld operating on a different plane was required for simulating these fantasies. Rules needed to be worked out which linked it to the standard ecosystem. Considering the current huge interest in fantasy and created myth, as typified by the numerous admirers of Tolkien's Hobbits, much room exists for the synthesis of reasoned ecological fantasies — or bioscience fiction. That remains for the future.

## The production process

All the foregoing experiments were carried out with heavy breadboard versions, 0.50 m on a side, constructed in a workshop, using materials from stationery shops. The semipublication stage requires going through a printing, production, and shipping operation that transforms the physical model.

Instructions needed to be refined, so that the eye could scan directions conveniently. The spectrum of colors representing environmental quality needed to be fitted to those available in printing grade papers. The playing board dimensions had to be reduced in order to prevent breakage in the mail. Pins replaced adhesive-backed dots for the beaver, and other pins registered the location of beaver dens. A population register was constructed. A suitably abstract logo was selected. An ordering and distribution system had to be arranged.[2] The publication of games and simulations at a serious level requires quite a different approach from the routine publication of reports, monographs, and reprints; so nothing can be taken for granted. Very likely something will still go wrong when the simulation is reproduced in other teaching environments, and further adaptations will have to be made before a satisfactory alternative to a textbook has been completely developed.

Fortunately, Isle Royale itself, the reference community, remains virtually unchanged.

## References

1. I.J. Good, "Theory of optimal games," *Nature*, vol. 186 (1960), p. 964.
2. R.L. Meier and Jane Doyle, *Wildlife*, Institute of Urban and Regional Development, University of California, Berkeley, California (December 1973).