



# FOREST EXCLOSURES

## AN EXPERIMENTAL APPROACH TO UNDERSTANDING BROWSING BY MOOSE AND DEER

Photo © Stephen DeStefano

by

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**The peculiar fences hikers may encounter in certain areas of Massachusetts are part of a long term experiment to study the impacts of moose and deer on the forest habitats of southern New England...**

If you have been out hiking in the past couple of years on parts of the Quabbin or Ware River watersheds, or perhaps in the Harvard Forest, you may have come upon some mysterious, relatively large fenced areas in small clearings located out in the woods. These fenced areas are square in shape, about 66 feet on a side (20 meters by 20 meters), and their 8-foot-tall fences are supported by 4x4 cedar or pressure-treated posts. You may also have noticed that each site has a pair of these fenced areas, exactly the same in size and design, except for one detail: the fencing on one has been held 2 feet off the ground (a “Partial Exclosure”) while the fencing on the other goes right down to the ground (a “Full Exclosure”). So, what’s up with these fenced areas, or “experimental exclosures” as we call them, out in the middle of the woods? Let us explain.

### **An Experimental Approach**

Experimentation has been called the foundation of science. In an experiment, the scientist strives to isolate or manipulate the variable or factor of interest while controlling, or holding constant, other variables. In this way, the researcher can see how that main factor affects the outcome of the experiment without interference from other variables. For example, an agricultural scientist can conduct an experiment to determine if a new formula of fertilizer will produce higher yields of corn. He or she will apply the old, the new, and maybe even no fertilizer to various patches or plots in a field. At the same time, all other variables, such as sunlight, soil type, and water, will be constant for all the patches. In this case, the question of interest is: “Does this new fertilizer improve corn yield?”

The plots getting the new fertilizer are the “treatment” plots, while the plots getting the old or no fertilizer are the “controls.” At harvest, the researcher compares treatment to controls, and if the patches with the new fertilizer produce significantly more bushels of corn, then it can be concluded that the new fertilizer had a positive effect on corn yield. What’s more, an estimate can be made of how much more corn – by the bushel or the pound – can be grown with this new fertilizer.

Experiments can quickly get complicated far beyond our simple corn-yield example. Disputable components of good study design include randomization, replication, interspersion of plots, sample size, statistical models, assumptions, and analysis. But experimentation, if it can be carried out successfully, can be very effective because it forces the researcher

to carefully define both the questions being asked and the design used to try to answer those questions. And the results can be more definitive, because comparing a treatment to a control can yield an unequivocal answer.

Despite the importance and strength of well-thought-out experiments in advancing scientific knowledge, experimentation is rare in wildlife studies. Most wildlife research is “observational” and “descriptive,” that is, biologists simply study animals and observe and describe their behavior, habitat use, movements, numbers, density, reproduction, or survival. Experimental manipulations and application of treatments and controls are uncommon, largely because of the logistics involved. Wild, free-ranging animals pose all sorts of challenges to researchers, and so, in most cases, observational studies are the best we can do.



Photo © Dave Small

*An aerial view, taken in winter, of two of the experimental exclosures constructed within the Quabbin Reservation. The results of this experiment will provide invaluable data on the effects of having the “ecological driving force” that is the Moose return to our forest ecosystems, and also allow its impacts to be compared with those that are associated with the White-tailed Deer.*



Despite their limitations, observational studies are extremely valuable and form the foundation of what is known about wildlife populations.

But if an experimental approach is at all possible, it can add a new dimension to our constant search for knowledge on wild animals and their interactions with their environment. In 2007, we had an opportunity to begin such an experiment thanks to the support of the Massachusetts Division of Fisheries & Wildlife (DFW) and the Department of Conservation and Recreation, and additional collaborations with the USGS Co-operative Research Unit; the U.S. Forest Service; the University of Massachusetts-

Amherst; Harvard Forest; the Highstead Foundation; and Great Mountain Forest (the latter two in Connecticut).

People in southern New England have long been interested in white-tailed deer and their role in forest ecosystems, but now a larger species of deer is among us: the North American moose. The moose has returned to southern New England after a long absence, and is now widespread and fairly common in the woodlands of central and western Massachusetts, extending south into Connecticut. There is much that we would like to know, and are learning, about moose in our state (see the No. 4, 2009, issue of *Massachusetts Wildlife*). Among the questions we



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*The Moose diet is roughly 90% woody browse; a single adult may consume as much as 40-60 pounds of buds and twigs each day. Compare that to the diet of the White-tailed Deer, which is composed of 60% woody browse. While white-tails are more numerous than Moose, both species are capable of altering forest ecology. The exclosure experiment will provide data on how the feeding activities of these two species compare, and allow us to make predictions about how our forests are likely to change under their combined influence.*



*At each of eight sites there is a full enclosure that excludes all ungulates; a partial enclosure that excludes Moose, but not deer; and one or two “controls” that do not have any fencing at all. Here, a White-tailed Deer, its image captured by a remote, infra-red camera, is shown within a partial enclosure.*

have is how are moose interacting with their forest habitat now that they have returned to southern New England?

## Moose and Browsing

Historically, New England was occupied by a host of “ungulates” – hoofed animals that feed on a variety of vegetation, some of which were “browsers” because they feed primarily on the buds, twigs, and leaves of woody shrubs and trees, others considered “grazers” because they feed on grasses and other herbaceous growth, and still others adopting a mix of both strategies. Elk, woodland caribou, moose, and white-tailed deer at one time lived in the region we now call New England. The interactions of these herbivores with their environment evolved over the millennia, the animals developing strategies that improved their foraging efficiency and the plants developing defenses (such as certain chemical compounds) to help cope with being eaten.

As we well know, however, the diversity of large animals and the character of the landscape changed quickly with

the onset of European settlement in North America. During the early phases of European settlement, some of these ungulate species may have at first benefited by the changes wrought by the early settlers. Creating openings in the forest and setting back plant succession, as well as eliminating major predators such as wolves and cougars, would at first create boom times for some of these species. However, European settlers also used large numbers of these animals for food, and land clearing became so extensive that all of these species, with the exception of the white-tailed deer, were entirely extirpated from southern New England. At one point, even the white-tail was reduced to remnant populations numbering only in the hundreds. During the time of market hunting (which has long since been banned in the United States) they fell to what was probably their lowest numbers in many centuries.

But the moose has made a comeback in southern New England. Moose are also among the most voracious of browsers,

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with about 90% of their diet being comprised of woody browse (compare that to 60% for white-tailed deer). It takes a lot of vegetative material to feed that large body (most adult moose weigh between 600-1,200 pounds), with an individual eating as much as 40-60 pounds of buds a day. There is no question that moose affect the structure and composition of forests and are what ecologists call an “ecological driving force.” Most people who care about Massachusetts’ wildlife welcome the moose back to its place among the native fauna of our state. A question at this point, however, is how might we expect forests to change now that this ecological force is back in the driver’s seat.

### Exclosures to Experimentally Manipulate Browsing

One way to begin to answer this question is to create exclosures to keep browsers like moose and deer out. Then you just wait and see how the protected vegetation inside the fence grows in the absence of browsing by ungulates. Of course, we would also want some kind of control plot. That is easily accomplished by marking out a patch of the same size and in the same area as the exclosure and simply not fencing it. Moose and deer are then free to browse in the control, while we are “manipulating” (that is, eliminat-

ing) browsing in the exclosure, which is the treatment.

We have done something else to add to the value of this experiment, however. We have essentially created a second treatment by creating a second fenced plot. The only difference between the two fenced plots is that we have held the fencing 2 feet off the ground in the second plot to allow deer, but not moose, access to the food within. Deer are able to crawl under fences and brush that are a lot closer to the ground than this, but we wanted to give them as free access to these partial exclosures as possible, while at the same time keeping moose out. Our observations and remote camera photographs have confirmed that this design, with a 2-foot opening running all along the bottom, is working: Because of their size and body configuration, moose (including calves) are not able to get into the partial exclosures, but deer (including adult bucks with large antlers) have been observed inside them.

In 2007 and 2008, we began looking for small cleared patches in the forest, one to a few acres in size, that were already cut or that were planned for cutting, so that we could construct the exclosures as soon after timber harvest as possible. We also tried to select the same kind of forest type: mixed hardwoods and conifers with a component of oaks and pines. In this way, our different sites (two on Quabbin, four on Harvard Forest, and one each on Ware River and Great Mountain) could



Photo © Mass. Coop. Unit

*A cow Moose and calf in one of the control areas. The control areas, used for comparison purposes, are only marked with a green fence post at each corner.*





*Construction of the exclosures in remote areas required portable power equipment and lots of hand labor. The fencing must be capable of withstanding New England weather for the decade or more necessary to run the experiment.*



serve as replicates, another important feature of good experimental design. We also manipulated the amount of slash and woody debris left on the ground at each plot, so that variable was consistent among all plots.

At each of these eight sites, then, there is a full enclosure (fencing to the ground to keep out moose and deer), a partial enclosure (fencing 2 feet off the ground to keep out moose but allow deer in), and one or two control plots (no fencing). The wire is a high-strength woven livestock fencing used by livestock growers and game keepers. A roll weighs at least a few hundred pounds, but with the aid of a front-end loader and lots of helping hands, we were able to stand it up against the posts and hammer it in place with large fencing staples.

The other component to this experiment is time. We are not talking about corn with a single growing season of a few months to see results. Here we are talking about trees, and a growing period measured in decades. In fact, we plan on monitoring the enclosure sites for at least 10 years. However, even after a season or two of sampling the vegetation, we are already seeing results: the vegetation in the enclosures is noticeably taller and bushier than in the controls.

## Sampling the Enclosures

Within each of the enclosures and control plots, we have set up a matrix of circular subplots, 2 meters (about 6 feet) across. Each spring a crew of field assistants will spend days identifying and measuring the vegetation growing in these plots, and quantifying the amount of browse by counting and measuring twigs that have been nipped by moose or deer.

Contrary to some opinions, it is nearly impossible to tell whether it was a moose or a deer that nipped a bud off a twig. Moose will browse as low to the ground as deer, and they do not select larger twigs than deer as is commonly thought. The smaller buds are often the ones with the highest concentration of nutrients, and both moose and deer instinctively know to eat these small buds. The partial enclosures, where only deer will be browsing, are our best opportunity to see how deer and not moose may impact woody vegetation.



*Wildlife readily adjusts to the presence of the enclosures, and in addition to Moose (below) and white-tails, diverse species such as (clockwise from the top) Black Bear, Bobcat, Wild Turkey, and Eastern Coyote have been photographed in and around them.*








*Should you encounter an enclosure while hiking or hunting, please do not enter it or disturb the fencing. Trampling vegetation in these or the control areas (which are more difficult to discern because they consist of only four corner posts with no fencing) could affect the collection and analysis of vegetation growth data.*

As we sample the woody vegetation in our plots, we will also take note of herbaceous growth. Over time, we may be able to say something about how browsing--or a lack of browsing – affects plants such as non-native invasives or woodland wildflowers (see the No. 1, 2010, issue).

## Exclosure Etiquette

If you happen upon any of these exclosures while out in the woods, please stay clear of them, because trampling in the subplots could affect our vegetation measurements. It is especially important that you do not enter the exclosures or compromise the fences in any way. It is harder to recognize the controls, because all that distinguishes them from the surrounding terrain is a green metal fence post in each of the four corners, but please look for those markers and steer clear. If you do see a problem with the fencing, such as any damage or a

breach, please contact the Mass. Cooperative Research Unit at the University of Massachusetts-Amherst right away. As we monitor these experimental plots over the years, we will report our findings, and what they might mean to moose, deer, and the structure and composition of their forest habitat, to the readers of *Massachusetts Wildlife*. 

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