Cedar
Evaluation
Development
informAtion and
Research

ACTION GROUP

CEDAR NOTE #1

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G U I D E L I N E S F O R E S T A B L I S H I N G A N I M A L E X C L O S U R E S F O R R E S E A R C H I N C E D A R S T A N D S

Raymond O. Miller

Wildlife exclosures have been built in the past and have been excellent areas for demonstrating wildlife effects on various stages of cedar development. These exclosures have not proved as valuable for quantitative research, however, because they were not designed for that purpose. As the need for accurate and quantifiable information about the cedar resources and it's regeneration has increased, the need for more exclosure research has become evident. The *CEDAR Action Group* has assembled the following guidelines for use by researchers and others who are considering building small wildlife exclosures for testing or demonstration purposes in cedar stands. We hope that this will improve the quality of information provided by these exclosures.

This document is arranged in three parts: 1) A description of the steps we think are important to consider when planning work with wildlife exclosures, 2) tables and explanations to be used when deciding how large to build your exclosures, and 3) suggested fence designs and materials cost estimates.

KEY POINTS

- **Plan to answer a specific question.**
- **Limit the number of variables in the test.**
- **Establish adjacent control plots.**
- **Replicate, replicate, replicate.**
- **Set up a written measurement schedule.**
- **Build exclosures large enough to accommodate an adequate sample AND border area.**

PART ONE: PLANNING AN EXCLOSURE PROJECT

DEVELOP AN HYPOTHESIS

This is the first and most critical step in designing a successful, long-term exclosure study. Many times fences are erected with no thought about what information will be collected or how this information will be used. Often the result is an expensive demonstration with no research value. The hypothesis will govern all other aspects of the project: How big will the fence be, how many fences are needed, how long will the fence stand, etc. The hypothesis is tested by comparing fenced treatments with each other and with adjacent, unfenced control plots.

Hold as many things constant as possible; avoid a shotgun trial. The number of plots must be very high when testing more than one factor at a time. For example, if *Factor A* represents the type of animal being excluded (4 levels: deer, hare, both, or none), *Factor B* represents the type of site preparation (3 levels: none, scarification, or burning), and there are to be four replications of the test, then the test design might be as follows:

To test only the effects of different animals you would need 16 plots: one for each level of *Factor A* replicated four times (A[4] x R[4] = 16).

To test only the effects of site preparation you would need 12 plots: B[3] x R[4] = 12.

To test both factors simultaneously you would need 48 plots: A[4] x B[3] x R[4] = 48.

You can see that testing one factor at a time reduces the number of plots needed from 48 to only 28. Testing both factors simultaneously has the advantage of providing information about the interaction between the factors (i.e. is animal damage the same for all types of site preparation methods, or does it vary?). In this case there would be little reason to suspect an interaction and testing both factors simultaneously would be a waste of 20 plots.

Example hypothesis may include:

- *Hare are more damaging to small cedar seedlings than deer.*

  This question could be answered with a few small fences that excluded both deer and hare. They might be located in areas where both species were abundant and need only be used for a short time (5 years). The plots could be small and fences could be short. Deer proof areas could have tops over them to prevent the deer from reaching in to browse.

- *Deer do not effect the establishment of cedar but rather prevent it's development.*

  This question implies a longer-term study in areas of high deer populations. No hare fencing is implied, so the fence mesh size could be fairly large. Trees would be tall by the end of this study, so plot size would have to be larger than for the first hypothesis mentioned above. Larger plots would necessitate taller fences.

- *Deer damage to cedar limits regeneration success at population densities above 15 deer per square mile.*

  This study would be long term and extend over a wide range of sites in order to place exclosures in areas with varying deer densities. Because of the large number of exclosures, it may be desirable to use smaller individual fences at a large number of sites (that is, sacrifice information about individual trees in exchange for better data about the region).

DESIGN THE EXCLOSURE

When the objectives of the study are known, the design and location of the fences can begin. The primary questions to answer are:

1) What type of wire should be used?
2) How high should the fence be?
3) What size area should be fenced?
4) How many exclosures are needed?
5) Where should these exclosures be located?
6) How long will the fences be needed?

Wire. Studies have been done on the effectiveness of different wires but for purposes of these guidelines we will say that chicken wire is sufficient for excluding hare and a woven wire fence is acceptable for deer. The woven wire should be a grid of not more than 6" x 6". Wire should be galvanized sufficiently to meet the life expectancy of the fence.

Fence Height. Fencing designed to exclude hare should extend at least two feet higher than the maximum snow depth expected during the winters of the study. This fence should also extend at least one foot horizontally out from the bottom of the fence to prevent animals from digging underneath. Deer fence should be at least seven feet high, unless the exclosures have wire covering the top. It is possible to leave a one foot gap in deer fencing at the bottom.

Fenced Size. The area to be fenced will depend largely on statistical considerations and operational limitations; is there enough room for researchers to move around inside a small fence and are large fences affordable. Section two provides more details about the statistical considerations effecting fence size. Costs of fencing may be reduced if several treatment plots are included within the same fence; cost per linear foot decreases as the perimeter of the fence increases.

How Many? The number of fences needed will be determined by the questions you hope to answer. It is essential that treatments be replicated so that statistical confidence can be established. It is advisable to seek advice from a statistician, as there are no general rules of thumb to follow here.

Where? The location of fences will again depend on the hypothesis you have chosen to test. It will be important to have a good working knowledge of the wildlife use patterns and site types in your area. It is also important that control areas (unfenced plots) be located adjacent to each fenced plot so test sites should be chosen that are large enough to accommodate these controls. The control plots should not touch a fenced plot because animals frequently travel the perimeter of fences.

Lifetime. The time a fence needs to stand and exclude animals will be determined by the hypothesis. Fences that need to stand for a long time will necessarily cost more than short lived fences (you get what you pay for). The fence designs in part three of this brochure are of two types: a fence designed with a 5-year life span and another with a 30-year life expectancy. The longer a fence stays on a site, the more maintenance it will require, but this can usually be done during measurement trips.

REPLICATE THE PLOTS

In order to test even the most rudimentary hypothesis, exclosures and their associated control plots MUST BE REPLICATED at least three and preferably more times. For example, if deer density effects on cedar regeneration are to be examined, several exclosure and control plot combinations must be located in each deer density class. This assumes that discrete classes will be used but even if density were measured on a continuous scale for regression analysis, many plots would be needed.

Plot replication increases the cost of any exclosure study but is the only way to draw meaningful, quantitative conclusions from the work. Isolated fences serve as excellent demonstrations but do nothing to advance the state of scientific knowledge. Fences cost money but so do mistakes made from a lack of sound information.

MEASURE THE PLOTS

Many exclosures have been erected in the past and left to molder in the woods. A measurement plan, designed at the outset of the research, is essential to the success of any study. This is particularly true when the project extends for many years and involves several generations of personnel. Plan a schedule that includes the dates measurements should be taken and the nature of the measurements to be made. Put the plan in writing and distribute copies.

Remember that walking around inside the exclosure can damage vegetation and bias the next set of measurements. Small exclosures are particularly susceptible to this problem. Determine vegetative distribution (both horizontal and vertical) first before allowing much traffic through the plots.

PART TWO: EXCLOSURE SIZE COMPUTATION

Exclosure size will be determined by financial and statistical factors. This section deals with the statistical factors governing exclosure size: plot size and border width. The last section reviews cost factors.

A sample plot should be surrounded by a border, or buffer area to limit "edge effects". If there is more than one plot, each should be surrounded by its own border. The fence should be placed so both the plots and borders are enclosed.

The width of the border is a matter of considerable uncertainty, but conservatively the border should be as wide as the height of the tallest tree in the plot at the end of the study (Table 1).

Table 1. Tree size over time on various sites.

Age (yrs)	Site Index (at age 50-years) 10	20	30	40
	height in feet			
3	<1	<1	1	2
5	1	2	3	4
10	2	4	6	8
20	4	8	12	16
30	6	12	18	24

The size of the measurement plot is a function of the number of trees to be sampled and the density of these trees in the sample area. We

Table 2. Exclosure size example calculations.

Tree Size (ft)	Trees Per acre (times 1000)	Plot Size (acre)	Stems In Plot	Border Width (ft)	Life Of Fence (yrs)	Fence Size Square (ft)	Round (ft)
<2'	10 - 40	1/1000	10-40	1'	5	9	10
2-4'	2 - 4	1/100	20-40	4'	15	29	32
6-16'	1 - 2	1/50	20-40	16'	25	62	65
>16'	.25 - .5	1/10	25-40	24	>30	114	122

assume that a sample size of 20 or 30 trees will be required for most investigations and so have computed plot sizes as shown in Table 2.

Using these plot sizes and border widths, as described above, exclosure sizes can be calculated as in Table 2.

PART THREE: SUGGESTED FENCE DESIGNS

Small woven wire animal exclosure.

DESIGN I: SMALL WOVEN WIRE FENCE

A small fence, enclosing a milacre plot and buffer strip, can be used to study early stand regeneration. It would be useful for looking at seedlings during the first few years of stand development. The proposed design uses 6' high woven wire and 7' tall metal "T" posts (Figure 1). This fence can be erected by one person in about an hour. The gate is formed by overlapping the ends of the wire at one of the posts.

MATERIALS FOR SMALL WOVEN WIRE FENCE

- 6 ea. 7' metal "T" posts @ $3.50 each
- 33' of 2" x 4" x 6' woven fence wire @ $1.10 per foot
- TOTAL APPROXIMATE MATERIALS COST: $57.00

Eight-foot high woven wire animal exclosure.

DESIGN II: MID-SIZE 8' WOVEN WIRE FENCE

This mid-sized fence encloses a 1/50 acre plot and buffer area. It would have a life of about 25 years and be useful for protecting saplings up to about 16' high. The fence stands 8' tall on 12' posts that are driven 4' into the ground. Two widths of 4' woven wire are placed on the posts and fastened with large staples. The gate is formed at one corner by leaving one segment of the lower wire loose. A fence like this can be erected on a cleared site by three people in about a day and a half (12 hrs).

MATERIALS FOR MID-SIZE WOVEN WIRE FENCE

- 5 ea. 4" x 12' cedar corner posts @ $5.00 each
- 27 ea. 3" x 12' cedar line posts (and braces) @ $3.00 each
- 550 ft of 4' woven wire @ $0.30 per ft.
- Asst. hardware @ $50.00
- TOTAL APPROXIMATE MATERIALS COST: $325.00


10-wire electric deer exclosure.

DESIGN III: LARGE, MULTI-STRAND ELECTRIC FENCE

Fencing large areas can be enormously expensive but there are fences that have been shown to exclude most deer at moderate cost. These fences are psychological rather that physical barriers and use electrified, high-tensile strength wire in various configurations. Deer, just like livestock, learn that the fence is bad and consequently stay away from it. If the fenced area is small enough (40 acres maximum) the deer will travel around it.

Many different fence designs have been tried, but most people are now using a 5 or 6 strand vertical fence, 5 to 6 feet tall. Substantial corners are built and wire is strung between them on line posts spaced at 40 to 50 foot intervals. Natural trees can be used for line posts, but it is not recommended that trees be used as corners in swamps (their shallow root system will not sufficiently anchor them and they will be pulled over).

Books and handouts are available that describe how to build this type of fence, so details will not be included here. It has been the experience of this author that this fencing system is the least expensive and most durable available for large areas. Costs actually go down as the size of the fence increases due to economies of scale. Materials will cost between &75.00 to $200 per acre for fences of 40 to 5 acres. A crew of three people can erect a 40 acre fence in about one week with the proper tools and equipment.

The *CEDAR Action Group* is a group of managers, researchers, and land owners that are interested in the northern white-cedar resource of Michigan. They meet regularly, schedule educational events, support information gathering activities, and periodically publish reports like this one. CEDAR NOTE #2 is titled: "Site Preparation for Northern White-Cedar". For more information contact the Chair: Raymond O. Miller, Michigan State University Department of Forestry, 6005 J Road, Escanaba, MI 49829.