Exclosure Sampling Methodology in Morristown National Historical Park

For Exclosures Established Between 1987 and 1995, Adapted from Previous Standard Operating Procedures, and Updated for Current Conditions

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This report received informal peer review, which was provided by a subject-matter expert was not directly involved in the developing this document. The level and extent of peer review was based on the importance of report content or its potentially controversial or precedent-setting nature.

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Please cite this publication as:

May 2020

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Summary

The purpose of this document is to provide clear sampling methodology for the three sets of deer exclosures installed between 1987 and 1995 throughout Morristown National Historical Park (MORR). It provides specific directions for navigation to each exclosure location and specific sampling methodology. This will allow each exclosure area to be assessed in the same manner as previous years, which is necessary for successful long-term data collection and precise analyses. These methods may also be useful for similar sampling studies in other regional NPS properties, so that the fate of different landscapes can be better compared.

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Introduction

Numerous deer exclosures have been erected throughout Morristown National Historical Park (MORR) to observe the differences in vegetative growth and structure when exposed to or protected from deer herbivory over time. This document reviews the detailed sampling protocol for deer exclosures established between 1987 and 1995. Each original experiment had differing research purposes (Table 1), but have since adapted similar sampling and census protocols so information across experiments can be compared and analyzed together. The following methodologies provide streamlined navigational and sampling directions for each exclosure area.

Original Five Deer Exclosures

In 1987, the resource management specialist of Morristown National Historical Park began monitoring the impact that white-tailed deer were having on the park's vegetation. To do this, two deer exclosures were established in 1987 and three more in 1988 (Figure 1). These five exclosures were 6.1m x 6.1m in size, numbered #1 through #5, and were placed in different forest types to monitor vegetation in absence of deer herbivory. Exclosure #1 was established in a mature broadleaf forest of mixed oak (*Quercus* spp.) and tuliptree (*Liriodendron tulipifera*), #2 in a successional broadleaf forest of ash (*Fraxinus* sp.) and tuliptree, #3 on the edge of an open field, #4 in a successional broadleaf area of black locust (*Robinia pseudoacacia*) and ash, and #5 a mature forest of chestnut oak (*Quercus montana*) and black birch (*Betula lenta*). A control area, open to deer access, was established adjacent to the each exclosure. Methods for monitoring changed and adapted over the years. The final and most thorough methodologies included in this document are now the accepted methods for sampling.

Biotic Exclosures

In 1995, two 10m x 10m exclosures were built (#6 & #7) in specific locations that contained high floral biodiversity. Each location has an exclosure an adjacent control area. The purpose of this study was to observe the success of protected native seed reservoirs and protected flora over time. Methods for sampling were adapted from the original five deer exclosure methods.

Exotic Exclosures

In 1995, four 10m x 10m exclosures were established in areas just outside of locations invaded by Japanese barberry (*Berberis thunbergii*) and Japanese stiltgrass (*Microstegium vimineum*) to observe if the invasive plants spread in areas protected from deer access and herbivory. It was also to test if native plants would reestablish without deer presence and if native plants could outcompete invasive plant infiltration when protected from deer. Methods for sampling were adapted from the original five deer exclosure methods.

Table 1. Exclosure studies established between 1987 and 1995, attributes, and original research purposes.

| Name of Study	Year of Inception	Size	Total # of Exclosures	Individual Exclosure Identification	Original Research Purpose
Deer Exclosures	1987 & 1988	6.1 x 6.1m	5	1, 2, 3, 4, 5	Observe differences in vegetation in exclosures protected from deer to adjacent areas open to deer herbivory under a range of forest cover types.
Biotic Exclosures	1995	10 x 10m	2	6, 7	Preserve native seed reservoirs in specific areas of significant native plant biodiversity and measuring the success of preservation in an exclosure
Exotic Exclosures	1995 (monitoring began in 1998)	10 x 10m	4	SHT, GLT, CR, NJB (CR no longer exists)	Assess whether nearby Japanese barberry and Japanese stiltgrass would spread into the exclosure if protected from deer, if native could reestablish if protected by deer, and if native plants reestablishment could reduce invasive plant infiltration.

2
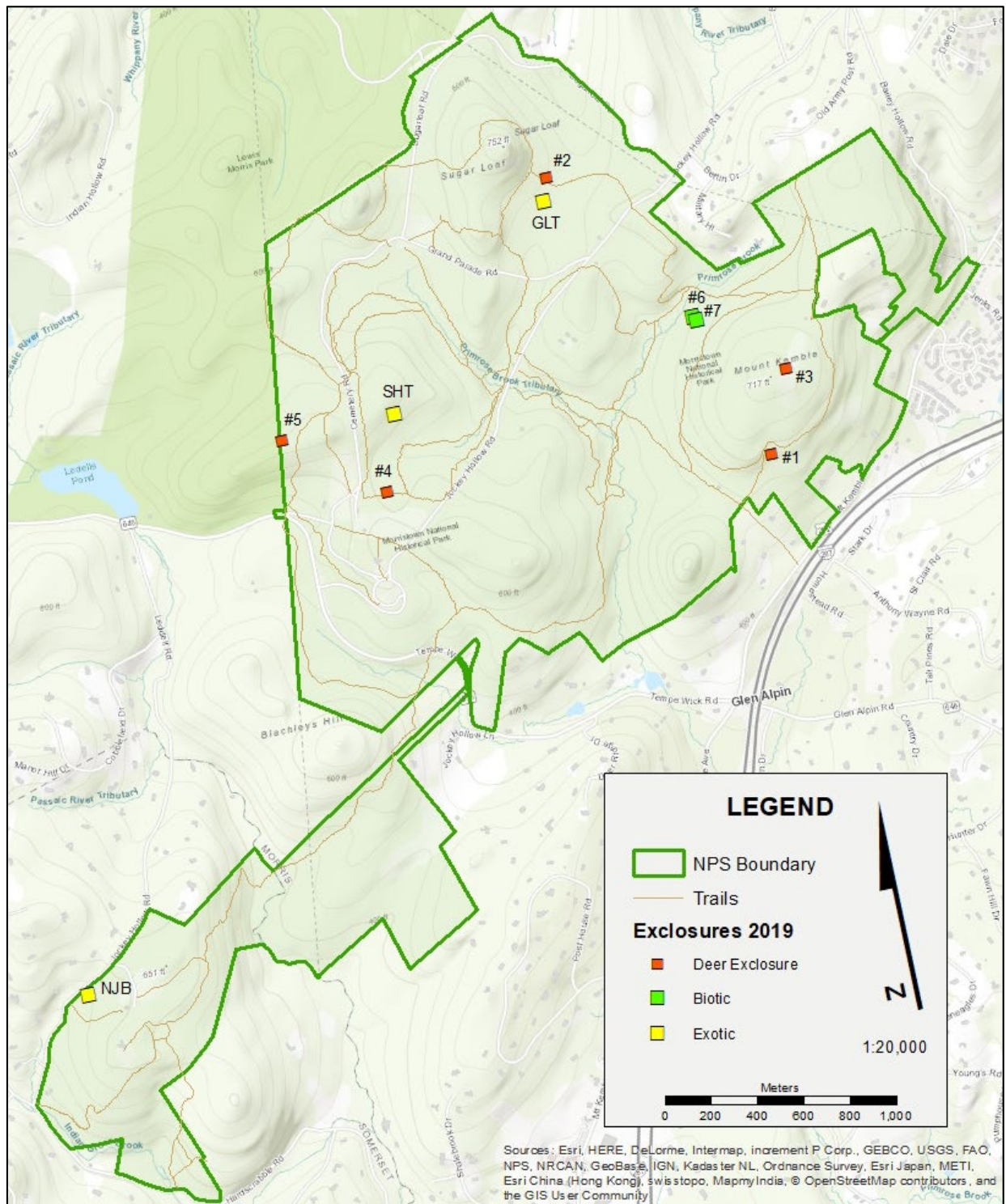
Figure 1. 2019 map of deer exclosures established between 1987 and 1995 in Morristown National Historical Park. Exclosures are labeled by their identification codes. Exclosures are symbolized by original exclosure study. The digital location of the site where Exclosure CR once stood could not be found in 2019 during field searches and is not included in this map of existing exclosures.

Sampling Methods

Each exclosure should be sampled once a year in the growing season using a square 1m x 1m frame. Sampling in May can reveal presence of native spring ephemerals, while sampling in the summer increases the cover percentage of all other species.

All species should be recorded by scientific name (genus and species). If a specimen cannot be identified to species take multiple clear photos of all plant parts and save the photos by the subplot number, exclosure or control site, and date. In addition, take a sample of the species, if possible from outside of the sampling area, and place it in a sealed plastic bag (add air to it and quickly seal the bag to preserve the specimen until it is pressed). Samples can be later identified, and records updated. If photos and samples cannot be identified to species, record the plant by genus or as an unknown. Consult a botanist before final determinations or discarding specimens.

Deer Exclosures #1 to #5

Subplot Sampling

Originally the sampling was performed in randomly placed plots between 1987 and 1990. In 1991, the sampling used a 5m x 5m grid for subplot placement. However, this design included potential edge effects of the exclosure. In the 1990s, the methods changed to use a 3m x 3m grid of subplot sampling areas, which is now the accepted protocol. All nine 1m x 1m subplots are to be sampled in the exclosure and nine in the control. Percent cover of each vegetative species per 1m x 1m subplot are to be recorded in categories in Table 2.

Table 2. Percent cover categories, recorded value/symbol, and median value of category for data analysis.

Recorded value or symbol to represent percent cover category	Field percent cover range per category	Median value of category used for data analysis
r	solitary with small cover	0.25
t	few with small cover or solitary with <5% cover	0.5
1	numerous with <5% cover	1
2	5 to 25% cover	15
3	26 to 50% cover	38
4	51 to 75% cover	63
5	76 to 95% cover	85.5
6	96 to 100% cover	98

Multiple layers of vegetation can overlap, and subplot totals can exceed 100% when multiple species are totaled. For each percent cover record, record the height of the vegetation in the following categories: 0 to 1m; 1 to 3m; >3m. Vegetation by species can include more than one height classification. Additional notes per species are helpful such as: germinant (<15cm in height); seedling (15cm to over 150cm but <1cm dbh); many seedlings; one sapling (1cm–10cm dbh). Trees

that are over 10cm dbh are considered canopy trees and any canopy tree data should be collected separately from understory vegetation. In each subplot the following attributes can be collected in the same percent cover categories: bare soil, rock, leaf litter, moss, etc.

Census of Exclosure and Control Areas

In addition to sampling, a census should be performed. The census areas are the entire exclosure and the entire control area. The census information includes the same species and attributes of percent cover and height categories as listed in the sampling methods but are estimated for the entire plot area for the exclosure and separately for the control area. This provides a record of the overall condition, which is helpful in years when the vegetation is too thick to accurately estimate in samples or if the area is hazardous and cannot be entered to sample.

A survey of the deer exclosure fence is also necessary. Examine the fence structure for any openings or breakages and note them in detail. Note any obvious signs of deer herbivory. This can be observed as twigs and leaves of plants that look to be haphazardly cut. Also note any deer rub damage to stems. Report any new fence openings and deer damage to the park biologist for immediate response to make needed repairs.

Biotic Exclosures #6 & #7

Subplot Sampling

These large exclosures contain 64 subplots. Use a random number generator (available online) to determine the three subplots that will be sampled both in the exclosure and in the control area. No repeats are allowed; if a repeat number is generated, generate another number. Record the subplot numbers. The subplot percent cover and sampling methods per subplot are the same as for the deer exclosure #1 to #5 (see previous section).

Census of Exclosure and Control Areas

Methods for biotic exclosure and control censuses are same as above for the deer exclosures #1 to #5 (see previous section).

Exotic Exclosures SHT, GLT, & NJB

Subplot Sampling

These large exclosures each contain 64 subplots. Use a random number generator (available online) to determine the three subplots that will be sampled in the exclosure area only. The newly assigned control area was not sampled in the past and is not necessary to sample. No repeats of subplots are allowed; if a repeat number is generated, generate another number. Record the subplot numbers. The subplot percent cover and sampling methods per subplot are the same as for the deer exclosure #1 to #5 (see previous section).

In previous years, specific data collection procedures for the Exotic Exclosures were unique to these sites and include the following: Count the number of Japanese barberry plants inside the exclosure; estimate the height of the barberry in the exclosure; using a 1m x 1m square frame estimate the number of squares covered by Japanese stilt grass; qualitatively describe the area surrounding the

exclosure. These methods can be replicated to compare past years to present. However, the newly added census data helps to determine the coverage of each species within the entire area as well.

Census of Exclosure and Control Areas
Methods for exotic exclosure and control censuses are the same as above for the deer exclosures #1 to #5 and biotic exclosures (see previous sections). The control areas in this exotic exclosure experiment were established in 2019 to provide information that can be compared with the other exclosure experiment control sites.

Data Entry
Every data record needs to be entered in Excel for long term preservation. Submit hard copies and Excel data records to the park biologist. Save the Excel data records on more than one location and online on a drive, for redundancy as an additional data source. All data records should be entered by site, subplot, and species. For further analysis, the median of the percent cover category can be used (Table 2).

Navigation and Orientation
The following sheets contain specific GPS coordinates, navigational directions, and experimental plot design and orientation for each exclosure and control area. Contact the NPS biologist to obtain the shapefile of the exclosure locations for GPS navigation. If a GPS unit is not utilized follow the directions on each sheet for navigation. Utilize each figure to properly orient the subplot locations and control areas that are no longer marked in the field.

Deer Exclosure #1 – Mt. Kemble Woods – Established 1987
Coordinates
40°45'48.479"N   74°31'18.202"W

Directions
1. From the Visitor Center, approach the intersection of Tempe Wicke Rd. and Rt. 202 (Mt. Kemble Ave.) turn left to proceed north on 202.
2. Go approximately ½ mile on rt. 202 and take left on Old Camp Rd. that leads to Quarter 65 (the Hartshorne House).
3. At the authorized park official parking area proceed to the entrance of the Mt. Kemble Loop Trail and head north ¼ mile.
4. The exclosure is approximately 30ft off trail to the right.

Exclosure, Control, and Subplot Orientation
Use the location of the exclosure sign at the exclosure site to orient to the experiment design diagram (Figure 2).

Figure 2. Deer Exclosure #1 experimental design and orientation. Exclosure size is 6.1m x6.1m; subplot size is 1m x 1m; the exclosure fence is 1.55m from the subplot grid area shaded in blue, which is 3m x 3m in total area. There are nine numbered subplots. The exclosure sign denotes the orientation of the deer exclosure and control plots. The arrow denotes which direction is the nearest trail.

Deer Exclosure #2 – Western Avenue – Established 1987

Coordinates
40°46'33.279"N   74°31'46.992"W

Directions
1. From the comfort station, turn right on to Western Ave.
2. Turn left on the Grand Loop Trail.
3. Walk on the Grand Loop Trail 460 ft.
4. The exclosure is approximately 20ft off trail to the right.

Exclosure, Control, and Subplot Orientation
Use the location of the exclosure sign at the exclosure site to orient to the experiment design diagram (Figure 3).
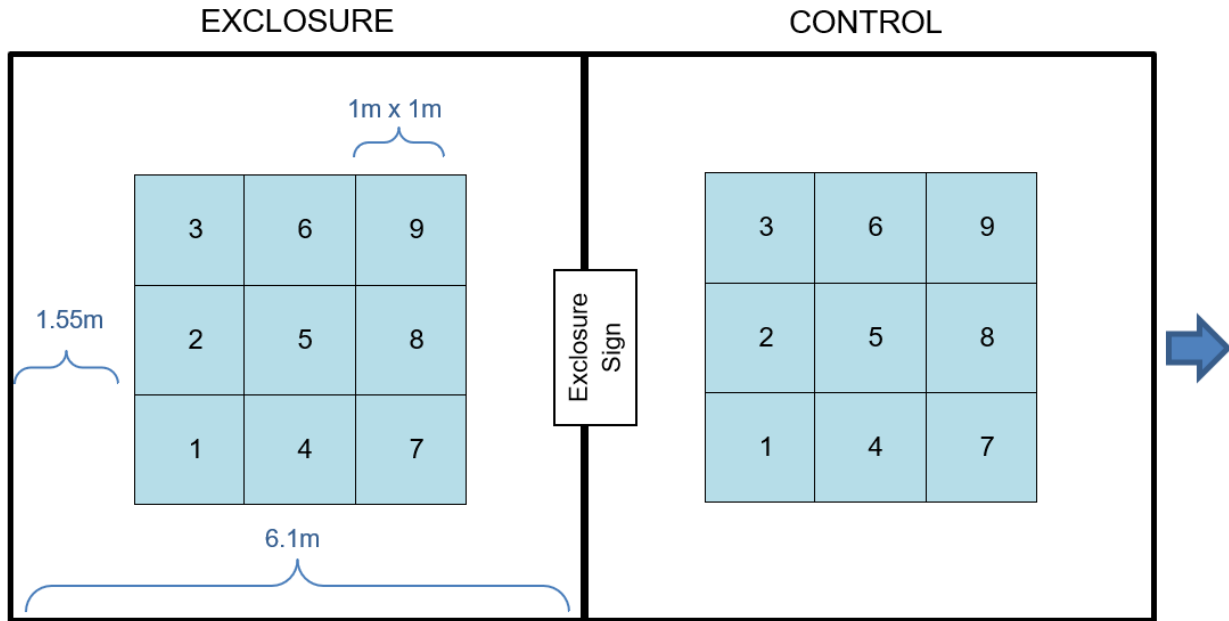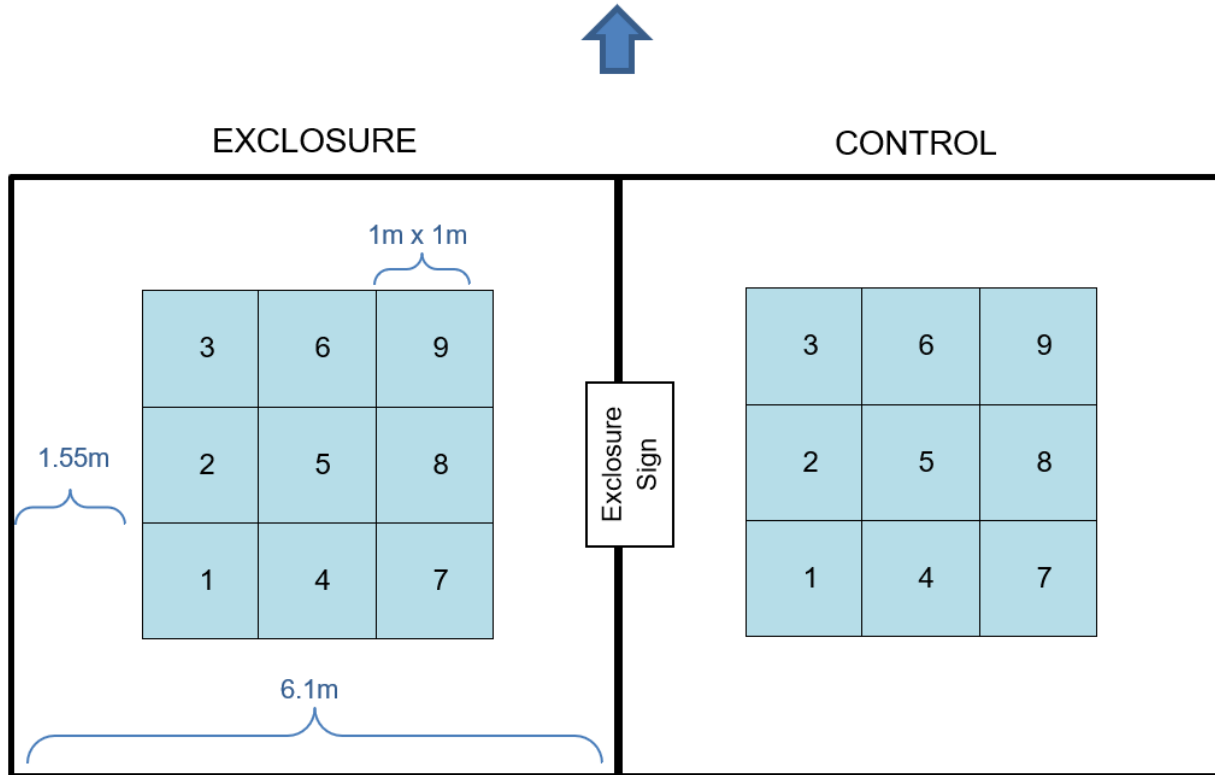
Figure 3. Deer Exclosure #2 experimental design and orientation. Exclosure size is 6.1m x 6.1m; subplot size is 1m x 1m; the exclosure fence is 1.55m from the subplot grid area shaded in blue, which is 3m x 3m in total area. There are nine numbered subplots. The exclosure sign denotes the orientation of the deer exclosure and control plots. The arrow denotes which direction is the nearest trail.

Deer Exclosure #3 – Mt. Kemble Field – Established 1988

Coordinates
40°45'59.822"N   74°31'13.28"W

Directions
1. From the Rt. 202, turn left on Bailey Hollow Rd. and in 20ft make a quick left to ascend Jenks Hill Rd.
2. Travel to the second park gate on the left.
3. Enter the gate unto the field and walk along the fire road 0.2mi to the exclosure
4. The exclosure is approximately 30ft off trail to the right under two large, prominent conifers.

Exclosure, Control, and Subplot Orientation
Use the location of the exclosure sign at the exclosure site to orient to the experiment design diagram (Figure 4).

9

TWO LARGE CONIFERS &
FIRE ROAD ON THIS SIDE ⬆

EXCLOSURE

CONTROL

1m x 1m

3	6	9
2	5	8
1	4	7

1.55m

6.1m

Exclosure Sign

3	6	9
2	5	8
1	4	7

Figure 4. Deer Exclosure #3 experimental design and orientation. Exclosure size is 6.1m x 6.1m; subplot size is 1m x 1m; the exclosure fence is 1.55m from the subplot grid area shaded in blue, which is 3m x 3m in total area. There are nine numbered subplots. The exclosure sign and location of conifers denote the orientation of the deer exclosure and control plots. The arrow denotes which direction is the nearest trail.

Deer Exclosure #4 – Wick Woods – Established 1988

Coordinates
40°45'54.606"N   74°32'28.74"W

Directions
1. From the Wick House Parking lot take a right on trail that parallels the Wick Orchard.
2. The exclosure is approximately 30ft off trail to the left through a maze of downed trees, brambles, and other vegetation

Exclosure, Control, and Subplot Orientation
Use the location of the exclosure sign at the exclosure site to orient to the experiment design diagram (Figure 5).
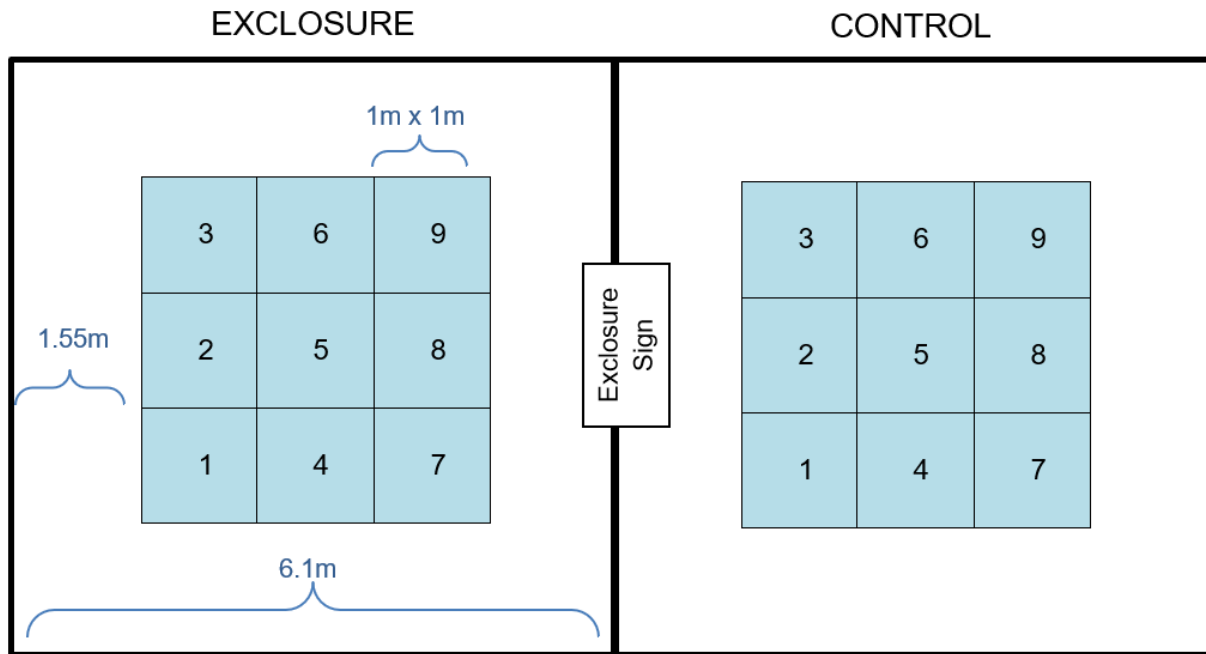
Figure 5. Deer Exclosure #4 experimental design and orientation. Exclosure size is 6.1m x 6.1m; subplot size is 1m x 1m; the exclosure fence is 1.55m from the subplot grid area shaded in blue, which is 3m x 3m in total area. There are nine numbered subplots. The exclosure sign denotes the orientation of the deer exclosure and control plots. The arrow denotes which direction is the nearest trail.

Deer Exclosure #5 – Holcomb Woods – Established 1988

Coordinates
40°46'4.918"N   74°32'45.107"W

Directions
1. From the Wick House parking lot take Cemetery Rd. northward.
2. Take left on the Aqueduct Trail where it quickly comes to an end and bear left onto the Grand Loop Trail.
3. After 180ft on the Grand Loop Trail take a right into the woods walking towards the western NPS park boundary.
4. The exclosure is near to NPS boundary posting.

Exclosure, Control, and Subplot Orientation
Use the location of the exclosure sign at the exclosure site to orient to the experiment design diagram (Figure 6).
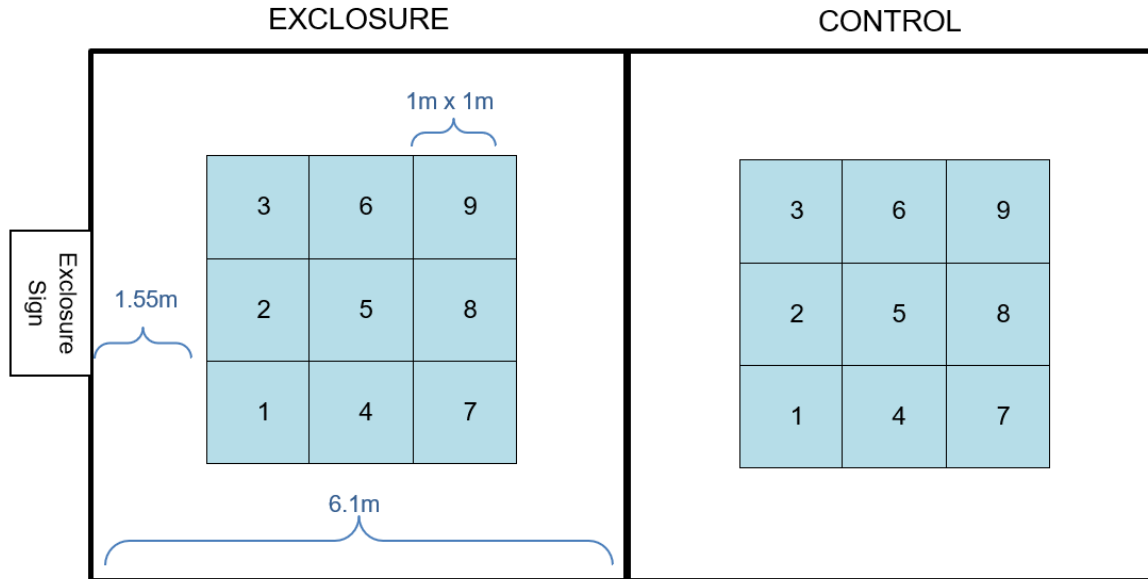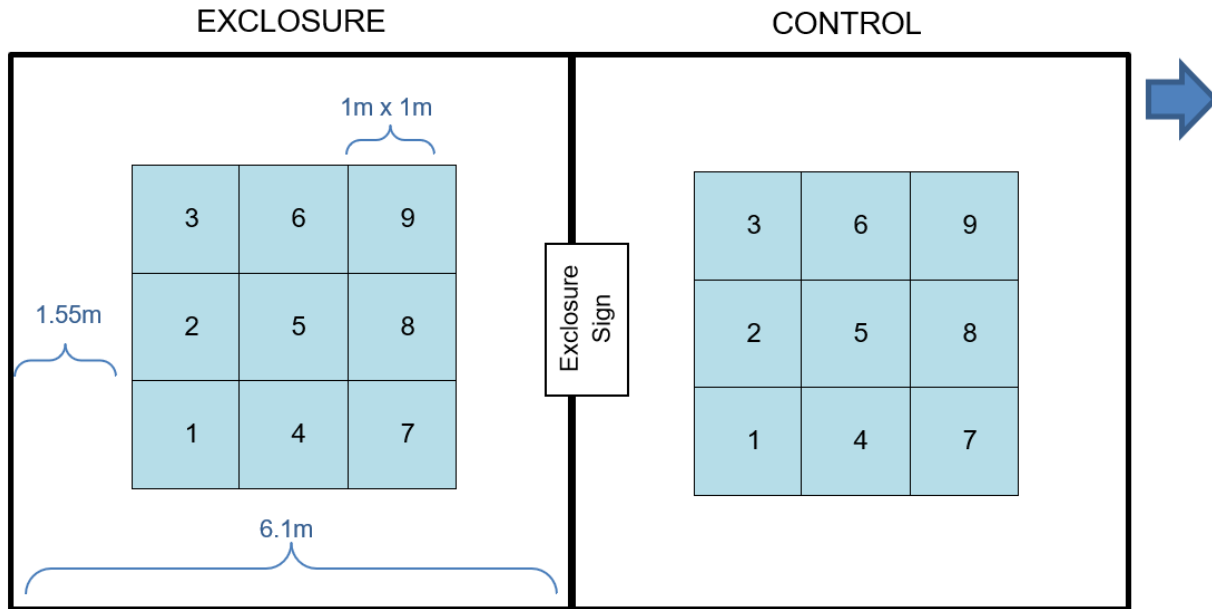
Figure 6. Deer Exclosure #5 experimental design and orientation. Exclosure size is 6.1m x 6.1m; subplot size is 1m x 1m; the exclosure fence is 1.55m from the subplot grid area shaded in blue, which is 3m x 3m in total area. There are nine numbered subplots. The exclosure sign denotes the orientation of the deer exclosure and control plots. The arrow denotes which direction is the nearest trail.

Biotic Exclosures #6 & #7 – NY Brigade Area – Established 1995

Coordinates
40°46'9.415"N   74°31'26.893"W
40°46'9.866"N   74°31'27.226"W

Directions
1. From the NY Brigade comfort station take the NY Brigade trail southeastward into the forest.
2. Continue down this trail until it joins the Grand Loop Trail. When they split stay right on the NY Brigade trail.
3. Cross the Primrose Brook, continue about 150ft and turn right into the woods.
4. Off the trail headed south, walk about 400ft and the two exclosures will be in sight.

Exclosure, Control, and Subplot Orientation
Use the location of the brook west of the exclosure site to orient to the experiment design diagram (Figure 7). The two exclosure areas #6 and #7 neighbor each other; #6 is further south, #7 is further north and slightly closer to the brook.
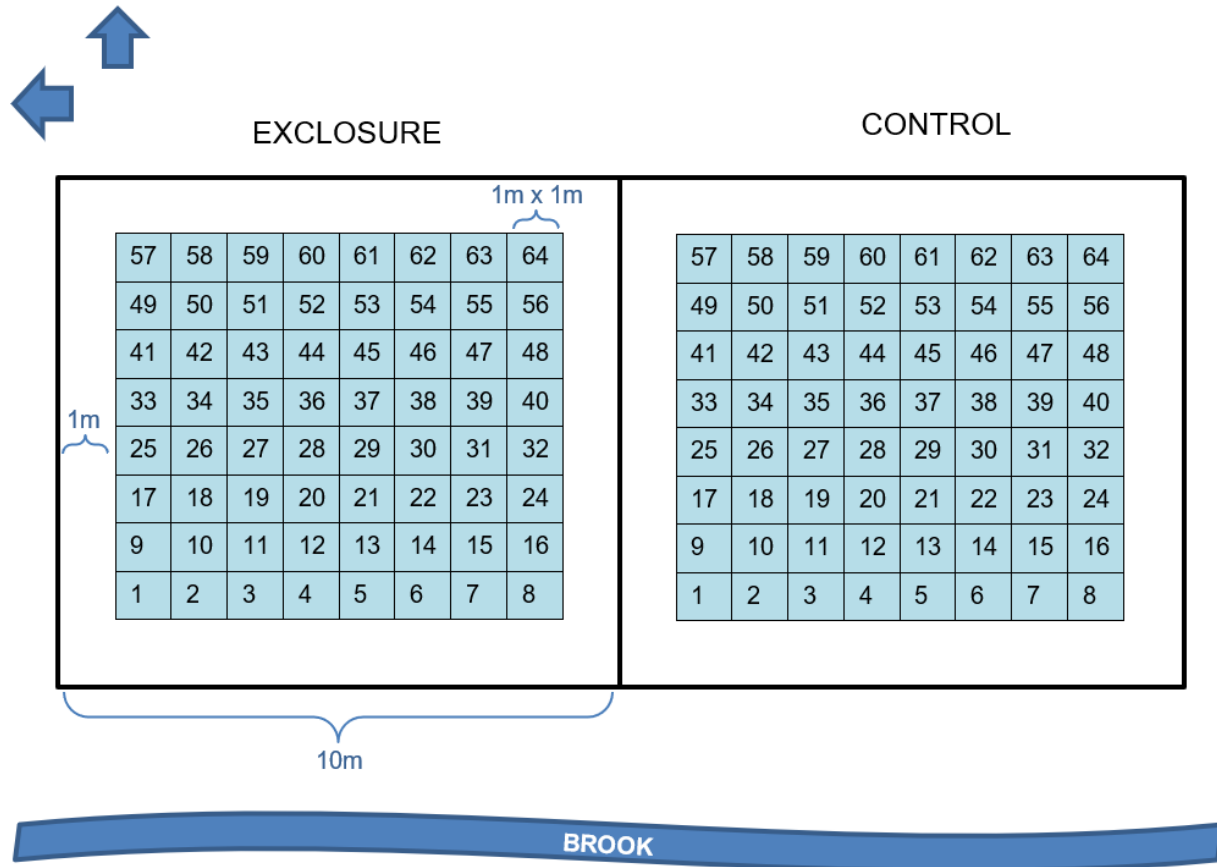
Figure 7. Biotic exclosures #6 & #7 experimental design and orientation. Exclosure size is 10m x 10m; subplot size is 1m x 1m; the exclosure fence is 1m from the subplot grid area shaded in blue, which is 8m x 8m in area. There are 64 numbered subplots. The location of the brook denotes the orientation of the deer exclosure and control plots. The arrows point to the nearest trails; here there are two directional options.

Exotic Exclosure – Soldier Hut Trail (SHT) – Established 1995

Coordinates

40°46'5.734"N   74°32'24.95"W

Directions

1. From the Wick House parking lot proceed north on the yellow trail.

2. Continue on the yellow trail for 1000 feet and turn right (East) into the forest.

3. Proceed 450 feet and the soldier hut trail exclosure is on a gentle Southeast-facing slope.

Exclosure, Control, and Subplot Orientation

Use the location of the yellow trail to the exclosure site to orient to the experiment design diagram (Figure 8).
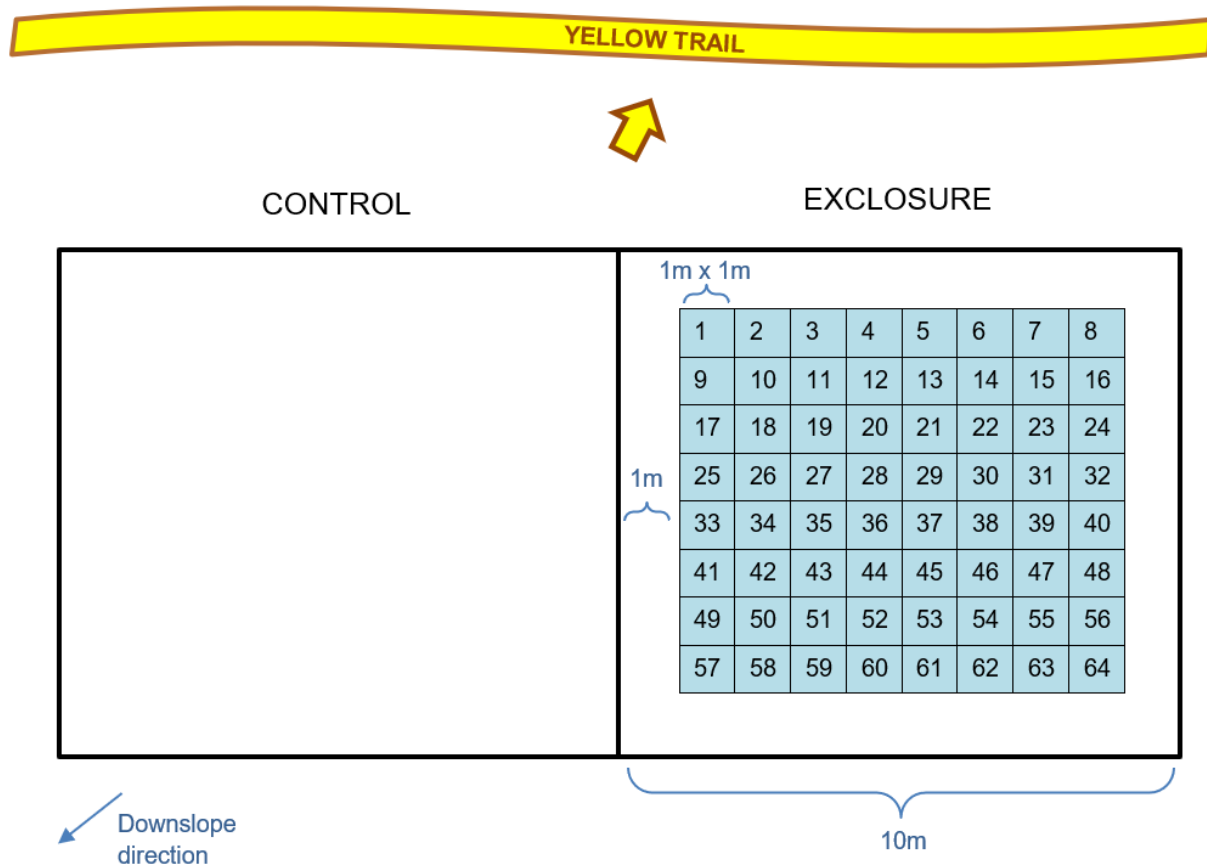

Figure 8. Exotic exclosure SHT experimental design and orientation. Exclosure size is 10m x 10m; subplot size is 1m x 1m; the exclosure fence is 1m from the subplot grid area shaded in blue, which is 8m x 8m in area. There are 64 numbered subplots in the exclosure. The location of the trail denotes the orientation of the deer exclosure and control areas. The control area does not contain subplots. The yellow arrow points to the nearest trail.

Exotic Exclosure – Grand Loop Trail (GLT) – Established 1995

Coordinates

40°46'30.177"N   74°31'49.636"W

Directions

1. From the Grand Parade Trail interpretive plaque and parking pull-off proceed north on the yellow trail.

2. After approximately 700ft bear right at the first fork in the trail and proceed northward.

3. After approximately 1000ft bear right at the second fork in the trail and proceed eastward on the Grand Loop Trail.

4. Walk 350 feet (pass the deer exclosure #2 on the left at 230 ft.). At 350ft., turn right 90° into the forest off the trail.

5. Proceed 270 ft. southward to the GLT exotic exclosure.

Exclosure, Control, and Subplot Orientation

Use the location of the Grand Loop Trail to the exclosure site to orient to the experiment design diagram (Figure 9).
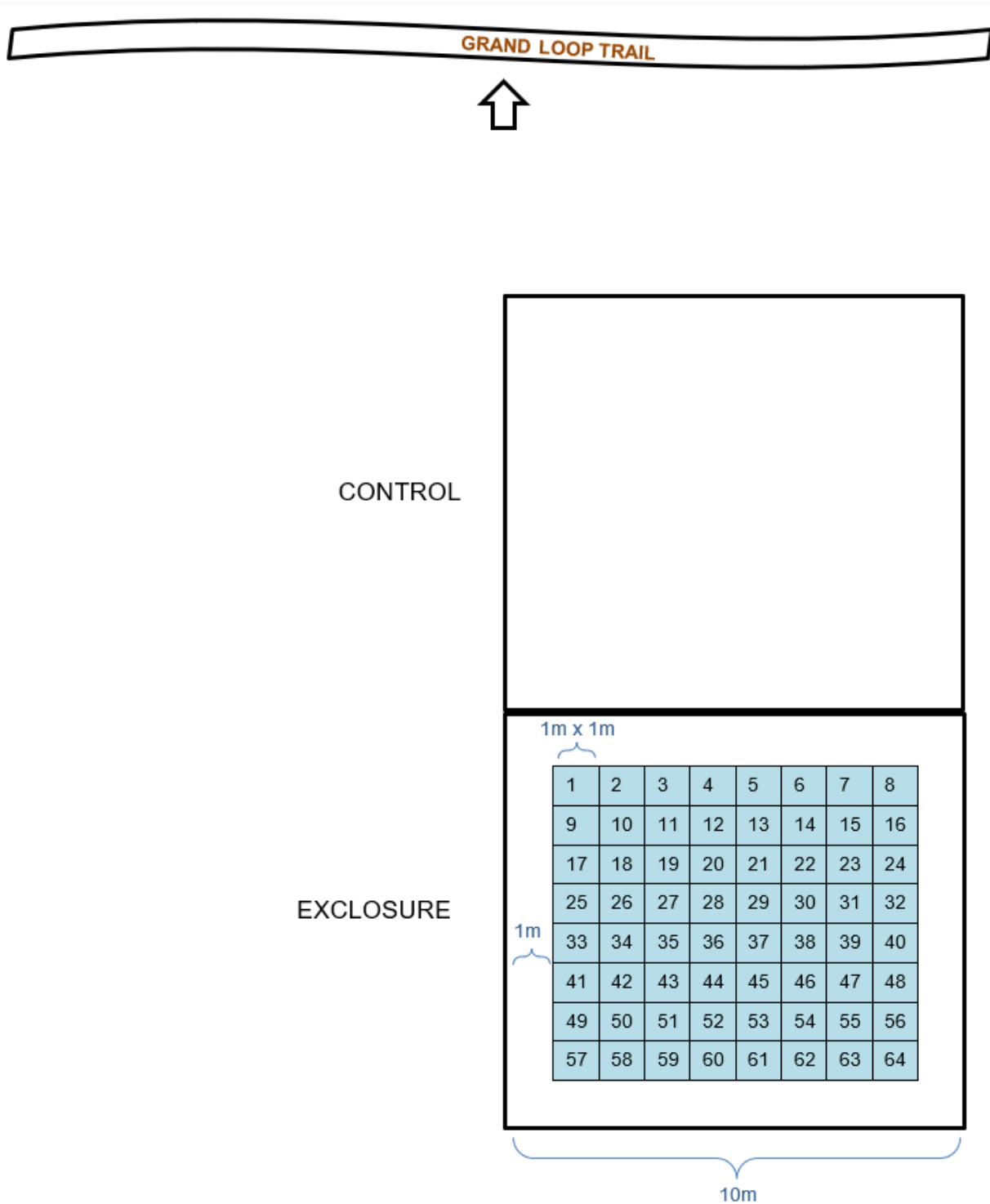
GRAND LOOP TRAIL

CONTROL

1m x 1m

EXCLOSURE

1	2	3	4	5	6	7	8
9	10	11	12	13	14	15	16
17	18	19	20	21	22	23	24
25	26	27	28	29	30	31	32
33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48
49	50	51	52	53	54	55	56
57	58	59	60	61	62	63	64

1m

10m

Figure 9. Exotic exclosure GLT experimental design and orientation. Exclosure size is 10m x 10m; subplot size is 1m x 1m; the exclosure fence is 1m from the subplot grid area shaded in blue, which is 8m x 8m in area. There are 64 numbered subplots. The location of the trail denotes the orientation of the deer exclosure and control areas. The control area does not contain subplots. The arrow points to the nearest trail.

Exotic Exclosure – New Jersey Brigade (NJB) – Established 1995

Coordinates

40°44'54.943"N   74°33'42.809"W

Directions

1. From the New Jersey Brigade designated parking lot proceed towards the Cross Estate Mansion, but quickly turn right to the driveway of the white garage at the bottom (an NPS office).

2. From the back of the driveway enter the fire road and proceed in a westerly direction.

3. Walk the fire road all the way to end at Old Jockey Hollow Road and turn right.

4. Just along the side of the road walk northeast uphill approximately 250 ft. and turn right, the exclosure can be seen from the road, it is only 80ft from the road.

Exclosure, Control, and Subplot Orientation

Use the location of Old Jockey Hollow Road to the exclosure site to orient to the experiment design diagram (Figure 10).
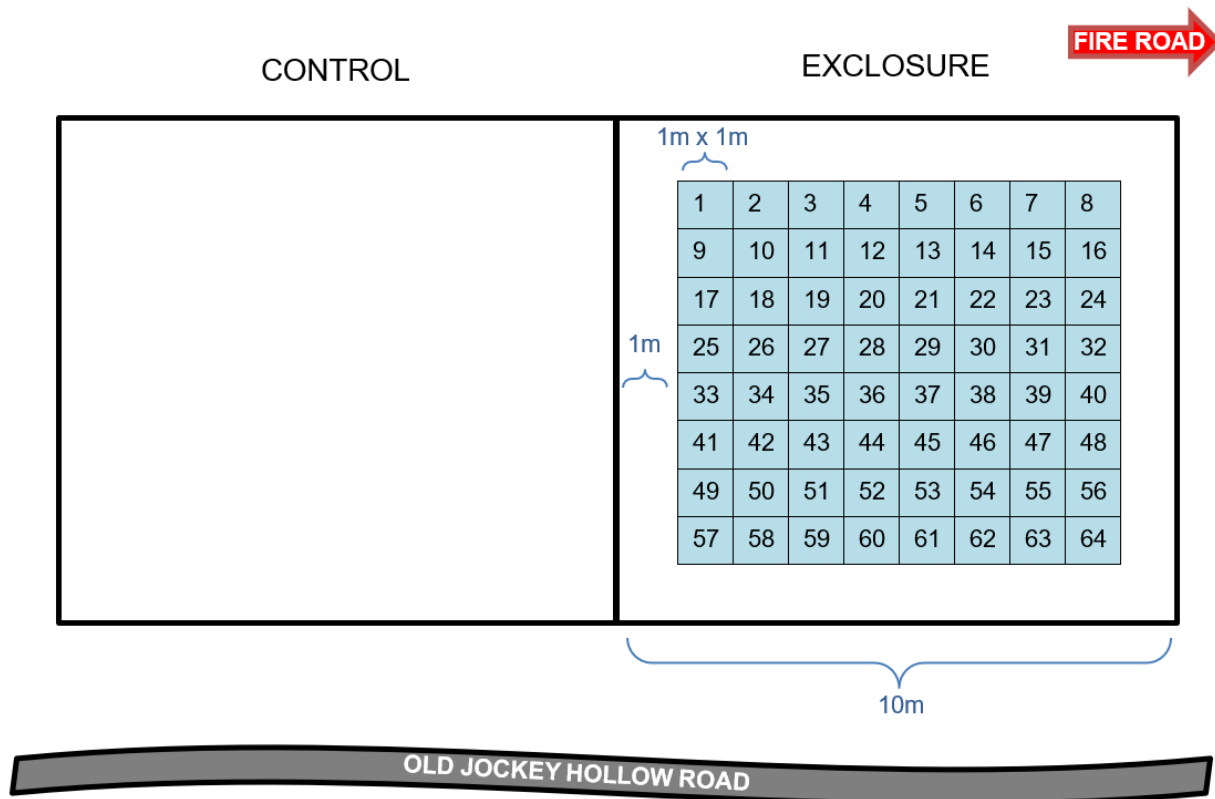

Figure 10. Exotic exclosure NJB experimental design and orientation. Exclosure size is 10m x 10m; subplot size is 1m x 1m; the exclosure fence is 1m from the subplot grid area shaded in blue, which is 8m x 8m in area. There are 64 numbered subplots in the exclosure. The location of the trail denotes the orientation of the deer exclosure and control areas. The control area does not contain subplots. The arrow points to the nearest trail.

May 2020

National Park Service
U.S. Department of the Interior