Browsing Impact Report for the Pennsylvania State Forests

2006

Pennsylvania Department of Conservation and Natural Resources
Bureau of Forestry

J. Merlin Benner, Wildlife Specialist

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Executive Summary

The DCNR Bureau of Forestry conducted widespread habitat browsing surveys across the state forests in late winter 2006 to assess forest regeneration conditions and the current levels of overwinter deer browsing. The purpose of this monitoring was to assess the current status of deer browsing and regeneration, and to evaluate the ongoing need for the use of the Deer Management Assistance Program and other management options. Transects, spaced two miles apart, were sampled by visiting vegetative plots every 200 feet, recording woody species, and assigning a browsing category to that species at that plot. Also, presence or absence data was recorded for "desirable" and "undesirable" woody vegetation at every plot. Plot data from 41,657 individual plots along more than 1,600 miles of transects was entered into the database for analysis, with 88 % coverage of the state forest system. Field work was completed between snow melt and the spring greenup period. This initial survey represents a baseline snapshot against which future conditions can be compared to evaluate trends in forest habitat health and sustainability.

Major Findings and Accomplishments:

- At a system-wide level, a deer browsing preference index was developed for the woody species observed, which promises to be very useful for guiding future monitoring efforts and development of indicators of browsing intensity.
- The system-wide proportion of plots with desirable regeneration (only 24.45%) and the proportion of plots with no woody regeneration (44.45%) indicate that browsing has not been down long enough for a widespread regeneration response.
- On those plots with woody species present (55.5% of the plots), the majority of the woody stems (88.77%) observed were not browsed above the light category, although browsing intensity varied among and within forest districts.
- From all the various indices evaluated, an average ranking was calculated by forest district. Based on this, from lowest browsing impact to most severe, the districts ranked as follows: relatively lightly browsed with better regeneration – Districts 11, 2, 1, 12, 3, 6, 14; relatively moderately browsed with less regeneration – Districts 9, 15, 5, 4, 7, 16; relatively severely browsed with poor regeneration – Districts 18, 8, 20, 10, 19, and 13.
- The current plan is to keep monitoring to locate areas of continued excessive browsing to focus deer harvest on them, and keep the remainder of the areas at low browsing levels until the regeneration responds.
- These results will be used to adapt the development of the Rapid Habitat Assessment Tool through the contract with USGS through Penn State University. The new tool will hopefully replace this Habitat Browsing Survey for ongoing habitat monitoring for deer browsing impacts.
- Ongoing monitoring and management efforts will be linked via a deer management section in the State Forest Management Plan. This will include adaptive management mechanisms like thresholds for management activities from the monitoring indicators and timelines for evaluation of goals.

Introduction

The Pennsylvania Department of Conservation and Natural Resources' (DCNR) Bureau of Forestry manages the state forests of Pennsylvania to ensure long-term sustainability of the forest communities that occur on these lands. Deer overbrowsing has been identified as the primary factor in the failure of many of these areas to regenerate many forest plant species, both woody and herbaceous. This problem has been documented in various forms, including the Forest Certification review process. Beginning in 2003, efforts have been taken to reduce deer browsing in these problem areas by enrolling them in the Game Commission's Deer Management Assistance Program, or DMAP. To judge the progress and success of these efforts, monitoring must be focused on the goals of the management – to reduce deer browsing and allow natural regeneration. So, rather than monitoring deer numbers, as is often the case but does not account for food availability or long-term residual impacts (legacy effects of overbrowsing), DCNR decided to monitor the habitat impacts directly through ecological measures.

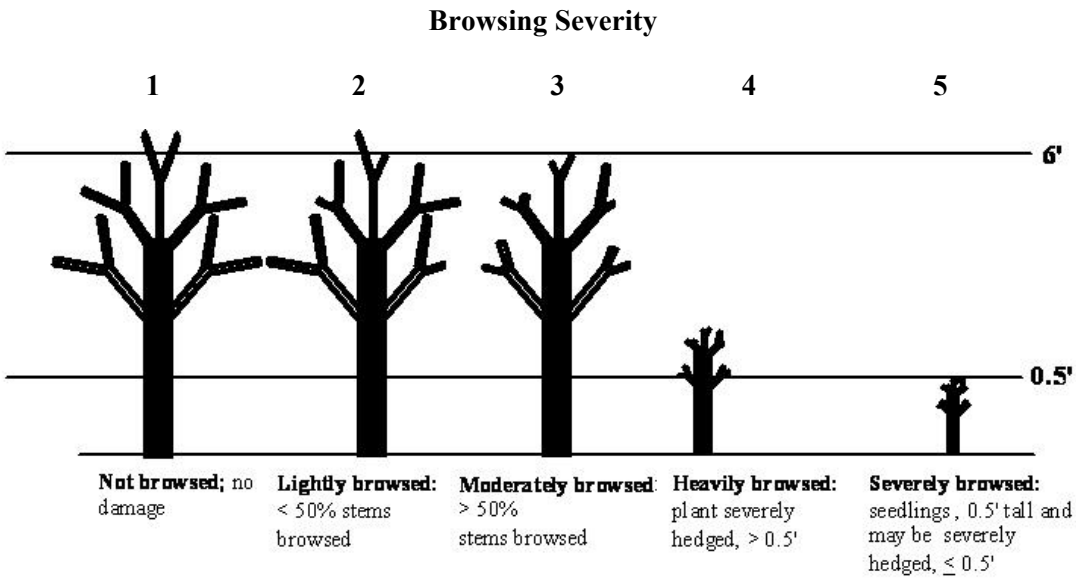
Habitat monitoring to assess deer browsing impacts is a developing science, with the state of the art adapting each year in response to ongoing analyses. The Kinzua Quality Deer Cooperative (www.kqdc.com) in northwestern Pennsylvania has been a leader on testing and refining such techniques, through their ongoing partnership with the USDA Forest Service and the Sand County Foundation (http://www.sandcounty.net/). The technique chosen by DCNR for our habitat monitoring was a modification of the most current protocol in use by the KQDC; modified to suit the larger landholdings of the Pennsylvania state forest system.

Basically, this technique assesses the browsing by deer overwinter on the woody forest plant species. Data on plant species and intensity of browsing was collected to account for the feeding preferences of white-tailed deer in a wild setting. Overwinter was selected because this period of time follows most of the hunting seasons and allows us to gauge the success of the management. Also, with no new growth occurring during this time, either in the deer population or the vegetative biomass, the cumulative effects of browsing are best observed with the fewest variables confounding analysis. Winter is also the time when food resources are most limiting for deer survival and when their impacts are most severe on the forest community.

Methods

This survey occurred in the time period following snow melt in the spring up to the point of the emergence of new plant growth (green up). The monitoring protocol consists of collecting data from a series of 6' radius plots spaced evenly along linear transects. The linear transects were evenly spaced every 2 miles across the areas surveyed. Along each transect, a browsing plot was located every 200'. Browsing was categorized into one of five levels of browsing intensity (see Figure 1) and recorded by species, although some species were grouped, like the white oaks. Also, presence or absence data was recorded for "desirable" and "undesirable" woody vegetation (not just trees, but including shrubs and vines) at every plot. The complete survey protocol is included in Appendix I.

Figure 1. Browsing Severity Categories.



Seedlings > 0.5' provide best evidence of browsing damage. Under severe deer browsing, seedlings may never exceed 0.5' tall and will be severely hedged*: deer browsing keeps them suppressed below 0.5'. Small, current year seedlings may never grow above 0.5' under severe deer browsing.

*** Severely hedged = seedling browsed repeatedly over years; all stems short, thick, with "bonsai" appearance.**

Each forest district was requested to conduct surveys across the entire forest system, and most, but not all districts reached that goal. Two districts, the Forbes and the Susquehannock State Forests, actually covered their entire forests with transects spaced at twice the suggested intensity (one transect every 1 mile). A few districts were able to complete surveys only on portions of their forests, including the DMAP areas and some additional areas of special interest. Table 1 quantifies the number of browsing plots surveyed in each forest district, and the total transect lengths. Collection of these data represented a substantial effort by the staff of the Bureau of Forestry. Field data from the survey was entered into a Microsoft Access database for compilation. A total of 41,657 browsing plots were surveyed and entered into the dataset, covering 88 % of the state forest system.

Table 1. Browsing Plots Surveyed by Forest District – 2006.

DISTRICT	# Browsing Plots	Transect Length (ft)	Transect Length (mi)	Unsampled Transect Length (mi)	% Transects Sampled
1	1,851	371,200	70.30	0	100.0%
2	1,094	230,900	43.73	0	100.0%
3	1,316	304,300	57.63	19.14	75.1%
4	2,227	447,600	84.77	0	100.0%
5	1,813	360,700	68.31	0	100.0%
6	449	142,700	27.03	0	100.0%
7	2,381	481,700	91.23	54.57	62.6%
8	470	97,000	18.37	0	100.0%
9	1,861	369,800	70.04	83.25	45.7%
10	5,962	1,200,700	227.41	29.26	88.6%
11	226	44,600	8.45	0	100.0%
12	3,024	608,500	115.25	0	100.0%
13	2,756	551,700	104.49	14.25	88.0%
14	72	14,700	2.78	0	100.0%
15	8,740	1,755,800	332.54	15.56	95.5%
16	3,066	616,200	116.70	0	100.0%
18	1,126	231,200	43.79	0	100.0%
19	1,257	249,200	47.20	1.69	96.5%
20	1,966	391,300	74.11	0	100.0%
Sum	41,657	8,469,800	1,604.13	217.72	88.0%

Results and Discussion

The results of this survey can be interpreted at 3 levels: 1) system-wide; 2) forest district-wide; and 3) on a specific area within a forest district, such as a DMAP area. This report will focus on the broader scale analyses. The finer-scale analyses were used in determination of whether or not individual areas would be included in the DMAP program (http://www.dcnr.state.pa.us/forestry/dmap/dmap_justification.aspx), and for decision-making on other management actions.

Browsing Preference by Deer

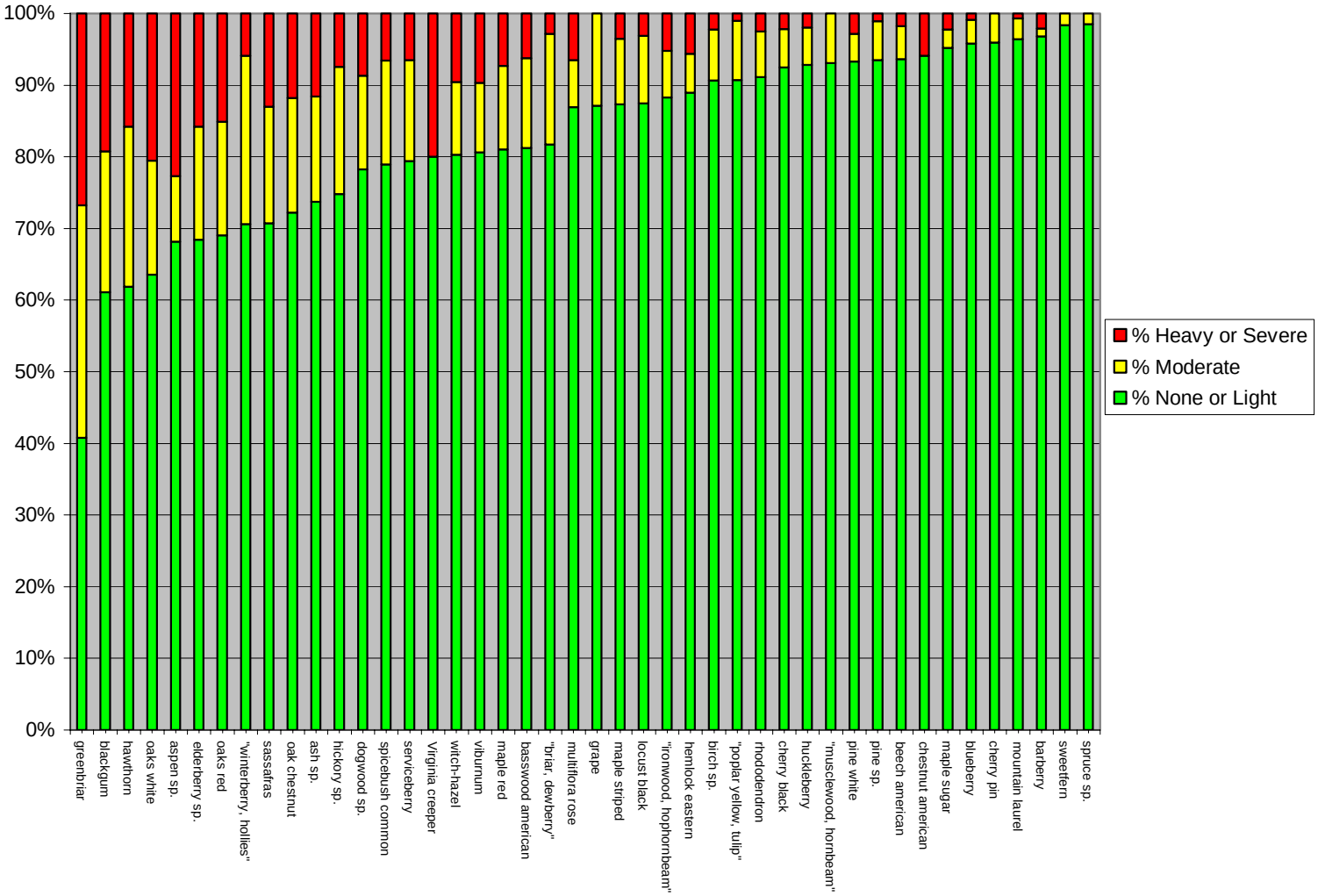
One system-wide use can be obtained when ranking each species of woody plants by the intensity of browsing that was observed to develop a circumstantial browsing preference index. The objective of this analysis was to obtain a ranking of browsing preference by deer, which is difficult to find in existing literature. Most preferred species lists are based on undocumented observations and anecdotal information. To some extent this data is biased by availability. If a preferred species is lightly browsed, but that is because it is only beginning to regenerate and is found in an area of very low deer density, then this type of analysis does not truly reflect preference by deer. As we continue to gather more data over time, however, and sample sizes grow, such biases will have less impact on the interpretation of these results. This preference index is certainly to be considered a work in progress - a monitoring indicator in an adaptive management process.

To analyze browsing preference, the intensity of browsing was truncated from five categories to 3 categories. Browsing classified as either heavy or severe was combined, moderate remained as one category, and classifications of light or none were combined. Species found on fewer than 10 browsing plots were excluded from the analysis. The species were sorted in ascending order by the percent of the plots where that species was categorized with no browsing or lightly browsed. Next they were sorted in descending order by the percent in the moderately browsed category, then the heavily or severely browsed categories (Table 2, Figure 2). It is important to note that these percentages are for the plots where the particular species were found, not the percentage of the total plots surveyed.

Table 2. Browsing Preference Ranking of Woody Species from Plots With the Woody Species Present.

Ranking	Species	% None or Light	% Moderate	% Heavy or Severe
1	greenbrier	40.78%	32.42%	26.79%
2	blackgum	61.14%	19.65%	19.21%
3	hawthorn	61.84%	22.37%	15.79%
4	oaks, white	63.55%	15.89%	20.56%
5	aspen sp.	68.18%	9.09%	22.73%
6	elderberry sp.	68.42%	15.79%	15.79%
7	oaks red	69.04%	15.86%	15.09%
8	winterberry, hollies	70.59%	23.53%	5.88%
9	sassafras	70.73%	16.24%	13.03%
10	oak, chestnut	72.19%	16.00%	11.80%
11	ash sp.	73.71%	14.74%	11.55%
12	hickory sp.	74.77%	17.76%	7.48%
13	dogwood sp.	78.26%	13.04%	8.70%
14	spicebush, common	78.95%	14.47%	6.58%
15	serviceberry	79.44%	14.08%	6.48%
16	Virginia creeper	80.00%	0.00%	20.00%
17	witch-hazel	80.29%	10.15%	9.56%
18	viburnum	80.65%	9.68%	9.68%
19	maple, red	81.06%	11.63%	7.31%
20	basswood, American	81.25%	12.50%	6.25%
21	briar, dewberry	81.69%	15.49%	2.82%
22	multiflora rose	86.96%	6.52%	6.52%
23	grape	87.10%	12.90%	0.00%
24	maple, striped	87.31%	9.19%	3.50%
25	locust, black	87.50%	9.38%	3.13%
26	ironwood, hop hornbeam	88.31%	6.49%	5.19%
27	hemlock, eastern	88.95%	5.41%	5.64%
28	birch sp.	90.68%	7.07%	2.25%
29	poplar, yellow, tulip	90.72%	8.25%	1.03%
30	rhododendron	91.14%	6.33%	2.53%
31	cherry, black	92.46%	5.40%	2.14%
32	huckleberry	92.81%	5.23%	1.95%
33	musclewood, hornbeam	93.10%	6.90%	0.00%
34	pine, white	93.27%	3.86%	2.87%
35	pine sp.	93.48%	5.43%	1.09%
36	beech, American	93.60%	4.62%	1.78%
37	chestnut, American	94.12%	0.00%	5.88%
38	maple, sugar	95.19%	2.60%	2.21%
39	blueberry	95.80%	3.29%	0.91%
40	cherry, pin	95.97%	4.03%	0.00%
41	mountain laurel	96.40%	2.92%	0.69%
42	barberry	96.84%	1.05%	2.11%
43	sweetfern	98.34%	1.66%	0.00%
44	spruce sp.	98.51%	1.49%	0.00%
45	teaberry	99.40%	0.40%	0.20%

Figure 2. Browsing Intensity by Woody Species of Trees and Shrubs Found on Browsing Survey Plots – Deer Browsing Preference (% of Plots Where that Species was Found).



Forest Regeneration Analysis

The system-wide proportion of plots with desirable regeneration (only 24.45%) and the proportion of plots with no woody regeneration (44.45%) indicate that browsing has not been down long enough for a widespread regeneration response (Table 3). In Table 3 and Figure 3, plots with desirable woody species and undesirable woody species can add up to greater than 100 percent, since some plots had both types of species occurring on them. Districts with the most desirable woody vegetation in descending order were Districts 14, 11, 8, 1, 2, 3, 5, 4, 15, 9, 12, 18, 6, 16, 19, 7, 20, 10, and 13. This analysis indicates very poor desirable regeneration on Forest Districts 13, 10, 20, 7, 19, 16, and 6 (under 20% of plots). Districts 10, 19, and 20 had the greatest proportion of plots with no woody regeneration occurring (see the red bars on Figure 3). As we look more closely at the browsing levels on the preferred and non-preferred species of woody vegetation, for the most part, indicator species reflect the District conditions regarding desirable vegetation and plots with no woody regeneration.

At the broad level, across all the State Forests, the picture looking at browsing levels alone looks pretty good. A majority of the woody stems (88.77%) observed were not browsed above the light category (Table 4), although browsing intensity varied among and within forest districts. When, however, this is taken in light of the proportion of plots with desirable regeneration (only 24.45%) and the proportion of plots with no woody regeneration (44.45%) (Table 3), this indicates that the browsing has not been down long enough for a widespread regeneration response.

Another finding is that undesirable woody regeneration was prevalent across the plots (43.70%, Table 3). Generally speaking, undesirable woody regeneration most often indicates species of plants that are not preferred by deer, and that indicate a legacy effect of overbrowsing. When deer browse the highly-preferred species, non-preferred species dominate the forest community over time, creating a legacy effect of overbrowsing. These species can then out compete other species for light and resources, given their freedom from browsing pressure.

Table 3. Desirable Regeneration on Browsing Plots by Forest District.

DISTRICT	# BROWSING PLOTS	# Plots w/ Desirable Spp.	# Plots w/ Undesirable Spp.	# BOTH	# NONE	% Desirable	% Undesirable	% None
1	1851	345	687	583	14	56.97%	77.96%	0.86%
2	1094	49	526	448	89	44.69%	87.59%	8.00%
3	1316	104	557	306	186	35.56%	74.85%	16.13%
4	2227	199	540	430	1055	28.28%	43.62%	47.44%
5	1813	292	258	218	966	29.41%	27.45%	55.71%
6	449	53	259	83	306	19.40%	48.79%	43.65%
7	2381	84	1613	322	281	17.65%	84.13%	12.22%
8	470	60	7	50	35	72.37%	37.50%	23.03%
9	1861	351	319	76	942	25.30%	23.40%	55.81%
10	5962	882	324	133	4619	17.04%	7.67%	77.53%
11	226	117	52	51	6	74.34%	45.58%	2.65%
12	3024	340	921	331	1429	22.21%	41.44%	47.30%
13	2756	174	1313	203	1080	13.61%	54.73%	38.99%
14	72	18	0	50	4	94.44%	69.44%	5.56%
15	8740	1073	3153	1186	3361	25.75%	49.46%	38.31%
16	3066	236	1426	349	1049	19.12%	58.01%	34.28%
18	1126	135	217	94	659	20.72%	28.14%	59.64%
19	1257	178	117	56	896	18.77%	13.87%	71.85%
20	1966	154	428	185	1200	17.23%	31.16%	61.01%
Total	41657	4844	12717	5154	18177	24.45%	43.70%	44.45%

Figure 3. Woody Regeneration by Forest District.

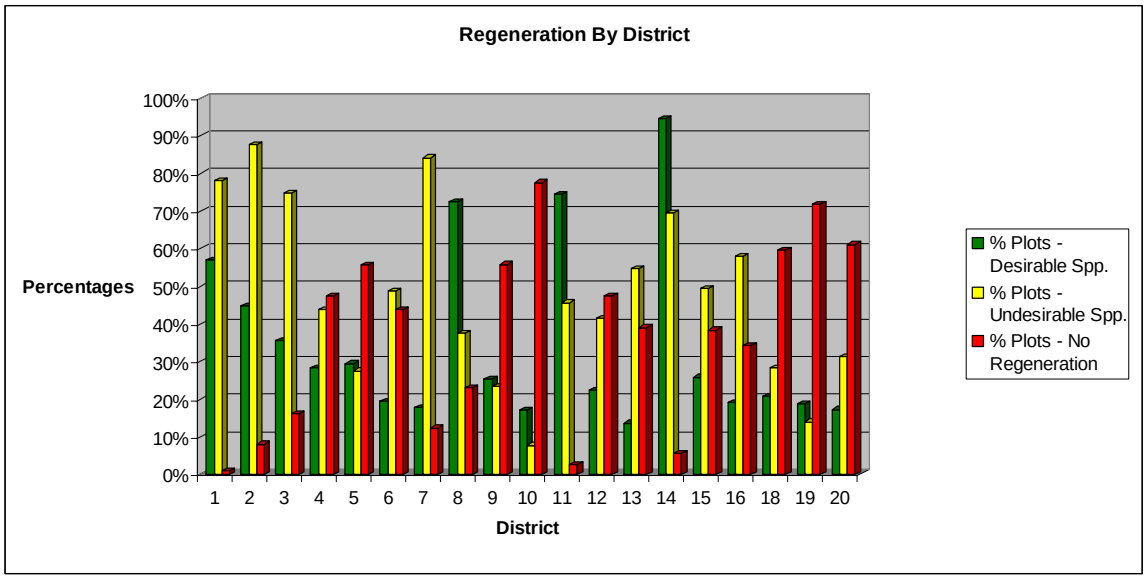


Table 4. Browsing Intensity by Species.

Species	Sum Of None – 1	Sum Of Light - 2	Sum Of Moderate - 3	Sum Of Heavy - 4	Sum Of Severe - 5	Total # Plots
greenbrier	97	142	190	148	9	586
blackgum	86	54	45	36	8	229
hawthorn	24	23	17	6	6	76
oaks, white	86	50	34	35	9	214
aspen sp.	17	13	4	8	2	44
elderberry sp.	8	5	3	1	2	19
oaks, red	674	401	247	196	39	1557
winterberry, hollies	17	7	8	2	0	34
sassafras	229	102	76	57	4	468
oak, chestnut	846	408	278	153	52	1737
ash sp.	136	49	37	22	7	251
hickory sp.	62	18	19	7	1	107
dogwood sp.	16	2	3	2	0	23
spicebush common	40	20	11	5	0	76
serviceberry	181	101	50	20	3	355
Virginia creeper	3	1	0	1	0	5
witch-hazel	620	203	104	71	27	1025
viburnum	32	18	6	6	0	62
maple, red	2433	1003	493	267	43	4239
basswood American	26	13	6	2	1	48
briar, dewberry	185	105	55	10	0	355
multiflora rose	32	8	3	3	0	46
grape	26	1	4	0	0	31
maple, striped	2575	893	365	120	19	3972
locust, black	24	4	3	1	0	32
ironwood, hop hornbeam	41	27	5	4	0	77
hemlock, eastern	674	131	49	40	11	905
birch sp.	1945	673	204	56	9	2887
poplar, yellow, tulip	64	24	8	1	0	97
rhododendron	66	6	5	1	1	79
cherry, black	1421	393	106	33	9	1962
huckleberry	4432	1508	335	104	21	6400
musclewood, hornbeam	16	11	2	0	0	29
pine, white	806	136	39	24	5	1010
pine sp.	77	9	5	1	0	92
beech, American	2391	767	156	50	10	3374
chestnut, American	24	8	0	2	0	34
maple, sugar	626	107	20	14	3	770
blueberry	3684	952	159	41	3	4839
cherry, pin	99	20	5	0	0	124
mountain laurel	6428	1303	234	42	13	8020
barberry	82	10	1	2	0	95
sweetfern	332	24	6	0	0	362
spruce sp.	64	2	1	0	0	67
teaberry	487	8	2	1	0	498
magnolia sp.	2	0	0	0	0	2
partridgeberry	1	0	0	0	0	1
poison ivy	2	0	0	0	0	2
redbud, eastern	10	0	0	0	0	10
SUM	32249	9763	3403	1595	317	47327
Percentage of Total	68.14%	20.63%	7.19%	3.37%	0.67%	

Analysis of Browsing Intensity by Species

Several species of trees were selected as indicator species to compare the regeneration and browsing conditions across the forest districts. Indicator species were selected in the highly-preferred, moderately-preferred, and non-preferred ranges. Species were selected that were relatively common and widespread, so that indicators could be found in each forest district from each of the three preference ranges.

Highly-Preferred Species Browsing

The presence of highly-preferred species is a good indication of low deer browsing pressure for a long enough time period to allow establishment of the species in the regeneration. Generally, deer browsing must be lower to allow the establishment of these species than for less-preferred species, as these are more highly sought after by deer and receive more browsing-related stress. Areas with high percentages of these species occurring on the plots, regardless of the browsing intensity on them, indicate the most sustainable regeneration condition.

Species considered highly-preferred for our analysis were those species where browsing on 20-40% of the plots was categorized as moderate, heavy, or severe. The three species selected to represent the varying forest ecotypes across the State Forests were oaks (all oaks combined), greenbrier, and white ash. Oaks were the best indicator species in this category, being found in all of our forest districts (Figure 4) on 8.46% of the plots statewide. Greenbrier is also widely distributed, but was only found on 1.40% of the plots (Figure 5). Ash, while highly-preferred and widely distributed (Figure 6), may be so highly-preferred that it has not regenerated on a widespread basis across the state forests yet (0.6% of the plots), except within fenced deer-deterrent areas.

Oak regeneration was observed on greater than 50% of the plots in Forest Districts 11 and 14, clearly our least impacted districts over the long term (Figure 4), although District 14 indicates more current browsing and may require more ongoing attention and close monitoring to ensure that the deer herd does not begin to suppress the regeneration. Districts 1, 2, and 3 followed with 20-30% of the plots sampled containing oak regeneration. District 12 was also notable in that where oaks did occur on approximately 18% of the plots, the browsing was low, indicating low deer populations. Greenbrier was most abundant (occurring on > 2.5% of plots) in Districts 2 and 4, while ash was only found on greater than 2.5% of the plots in one district, District 11.

Figure 4.

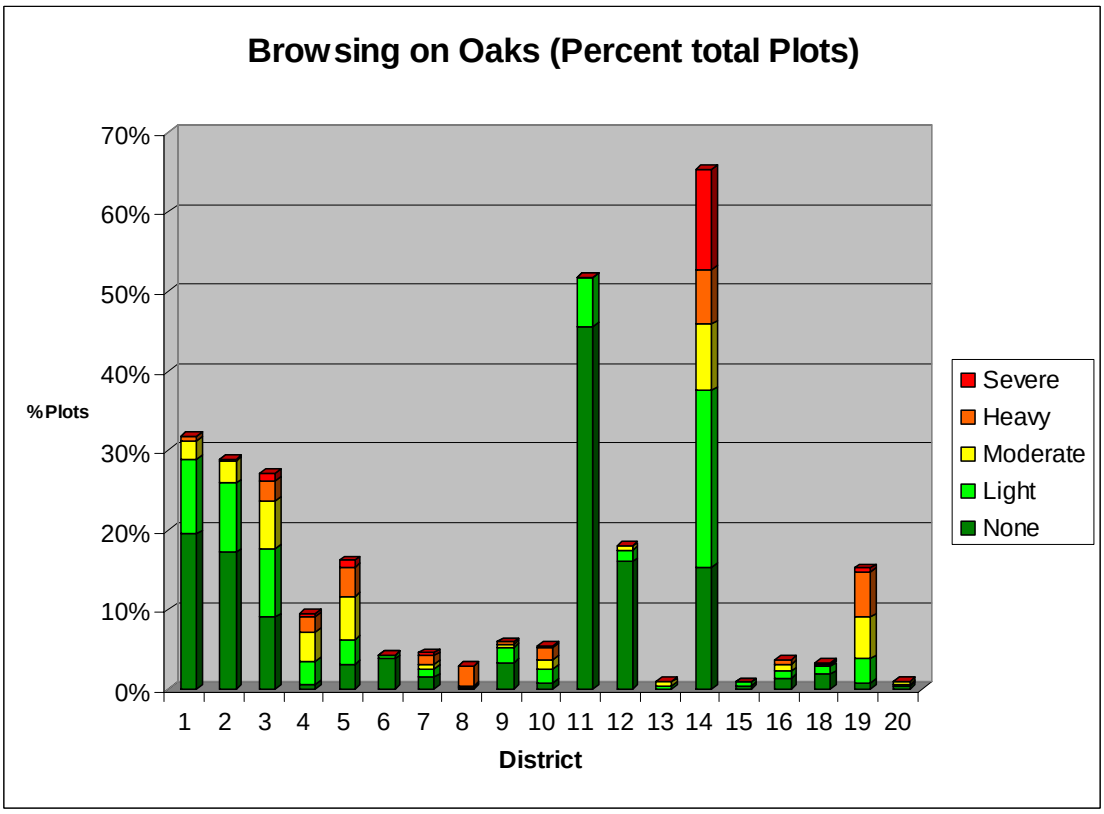


Figure 5.

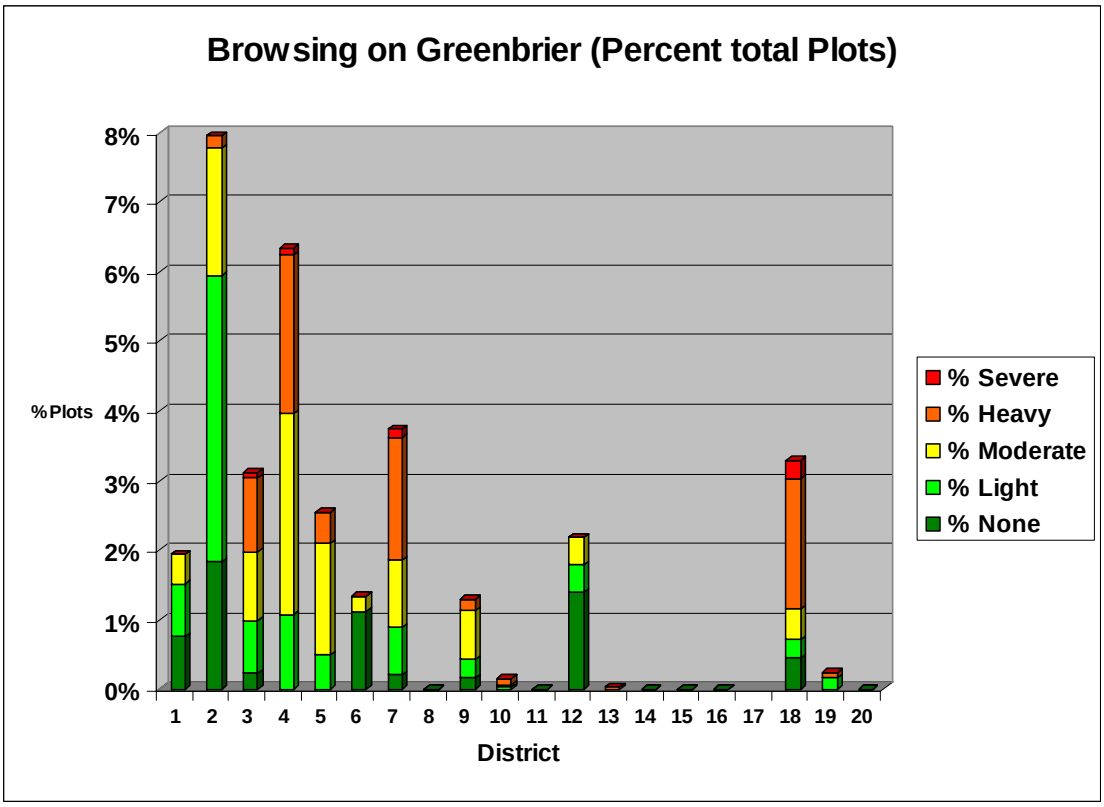
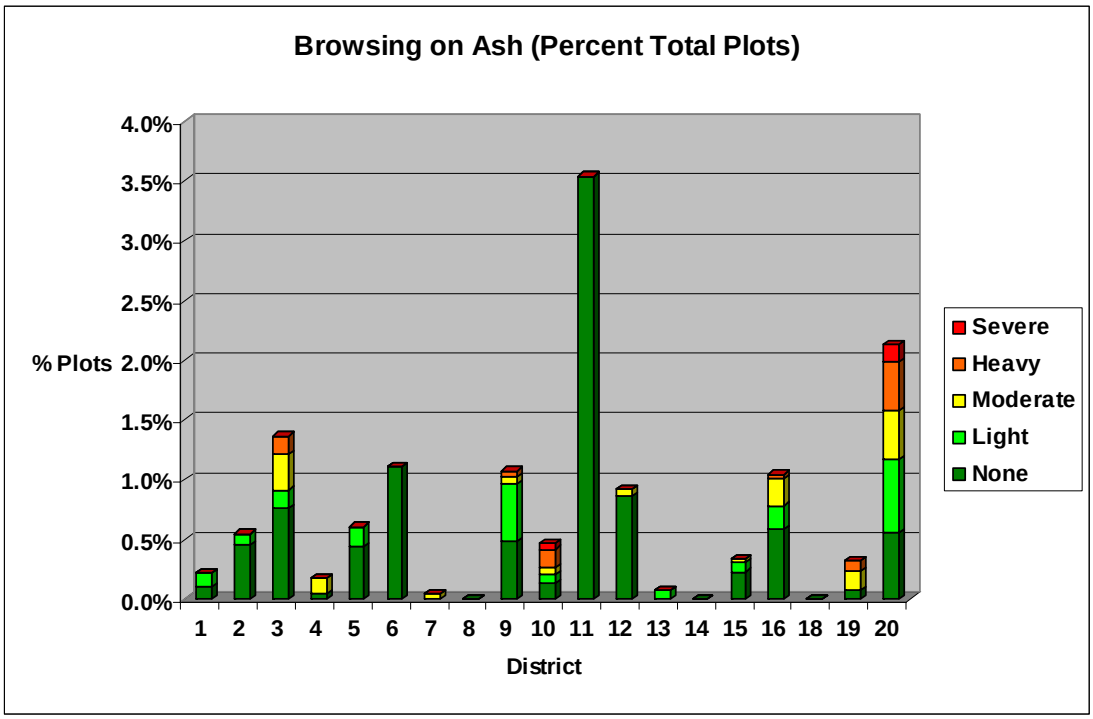


Figure 6.


Browsing on Ash (Percent Total Plots)
% Plots
4.0%
3.5%
3.0%
2.5%
2.0%
1.5%
1.0%
0.5%
0.0%
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 18 19 20
District
Severe
Heavy
Moderate
Light
None

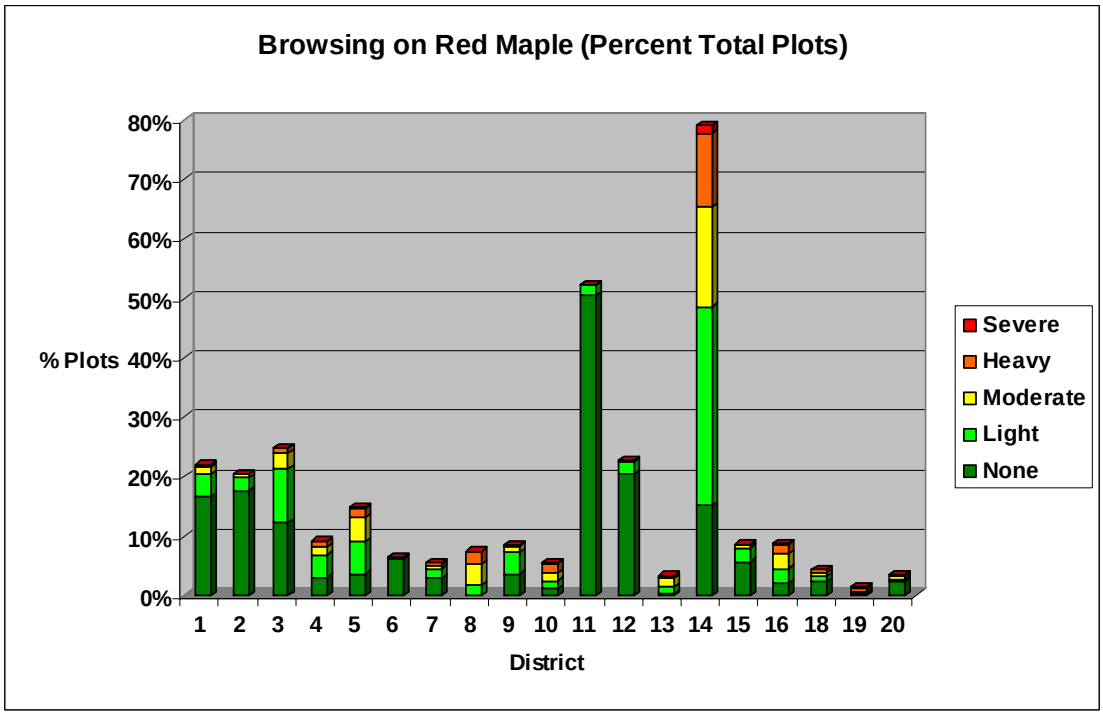
Moderately-Preferred Species Browsing

Moderately-preferred species generally are more widespread, regardless of browsing history than the highly-preferred species, and may be better overall indicators because of that. They establish at relatively higher deer browsing pressures than the highly-preferred species. In areas with a long history of severe browsing, these species will be the first to respond to reductions in the deer herd.

Species considered moderately-preferred for our analysis were those species where browsing on 10-20% of the plots was categorized as moderate, heavy, or severe. We chose red maple as our indicator in this category because of its widespread distribution (10.19 % of the plots statewide) and quick growth characteristics.

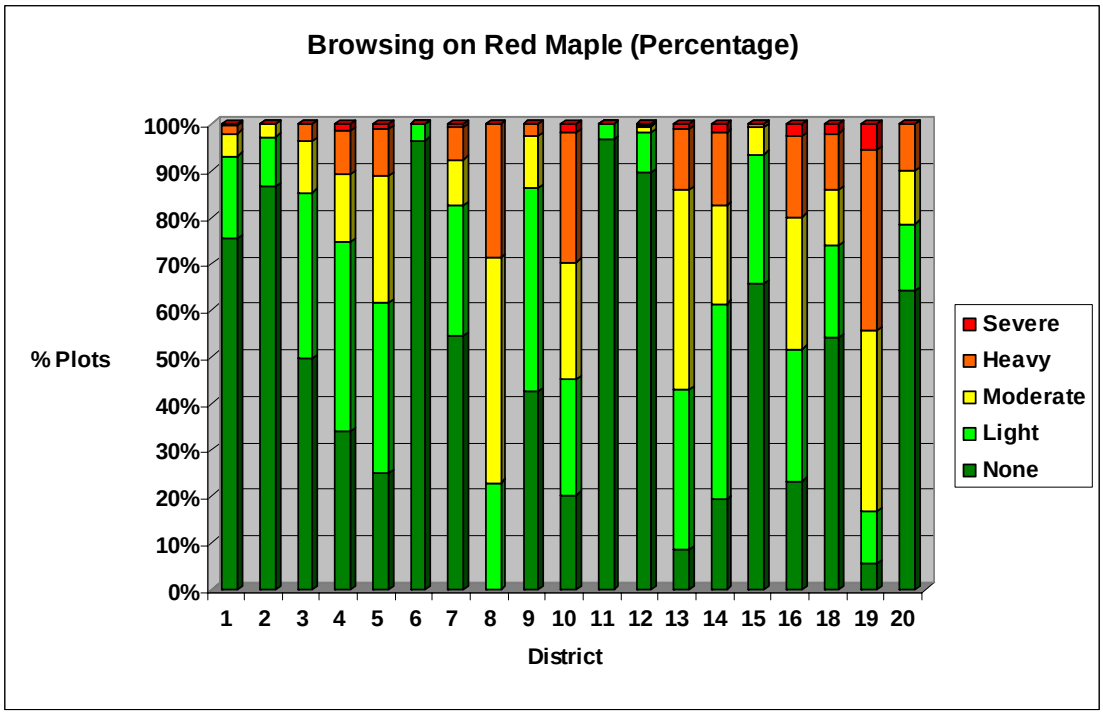
As with the oaks, Districts 11 and 14 once again came ahead on regeneration, with red maple occurring on greater than 50% of the plots (Figure 7). Again, District 14 exhibited more browsing, however, indicating a higher current deer herd. Districts 1, 2, 3, and 12 all followed, with about 20% of the plots containing red maple. When ranked by percentage of plots with red maple, and the intensity of browsing, in descending order, the Districts ranked as follows: 11, 14, 12, 3, 1, 2, 5, 15, 9, 4, 6, 7, 16, 18, 20, 10, 8, and 13.

Figure 7.



Other districts can be assessed using red maple based on the severity of browsing. Districts like 8, 10, 13, and 19 show high browsing pressure, with more than 50% of the plots with red maple being browsed moderately, heavily, or severely (Figure 8). Districts 4, 5, 9, 15, 16, and 18 fell within an intermediate range.

Figure 8.



System-wide, a total of 4263 plots were observed with red maple occurring on them (10.19% of the total plots), of them 57% were not browsed, 24% lightly browsed, 12% moderately browsed, 6% heavily browsed, and 1% severely browsed. Dr. David DeCalesta reported similar statistics from the spring 2006 monitoring of the KQDC, where red maple occurred on 5.7% of the total plots (Dr. David DeCalesta, personal communication, 2006). Most of the red maple on the KQDC plots was characterized by light browsing, with fewer plots in the moderate or heavy impact categories. Very few plots were reported in the severe impact category. From the initiation of their monitoring in 2002, the proportion of the plots in the lower impact categories has increased, and those in the higher categories of impact has decreased.

Non-preferred Species Browsing

When non-preferred species are heavily browsed, this indicates extreme deer browsing pressure. These species are less palatable and digestible to deer, and deer condition is very low when they are forced to eat these species of plants. In desperate situations, regeneration of these species can even be reduced. In such cases the ground is often devoid of any understory and a distinct browse line is evident across the area. If these species are widespread and not heavily browsed, but few more highly-preferred species are observable, it indicates an area with relatively recent reductions in the deer herd.

Species considered non-preferred for our analyses were those species where browsing on less than 10 % of the plots was categorized as moderate, heavy, or severe. We chose American beech, birch, and black cherry, which occurred on 15.12%, 6.83%, and 4.66% of the plots statewide respectively. These species occurred in varying abundance in the different ecoregions, with the three taken together ensuring good coverage.

Several forest districts exhibited high percentages of beech regeneration on the plots (greater than 20%), including Districts 6, 11, 15, 16, and 20 (Figure 9). Districts 8, 10, and 14 showed high levels of browsing on beech (Figure 10).

Figure 9.

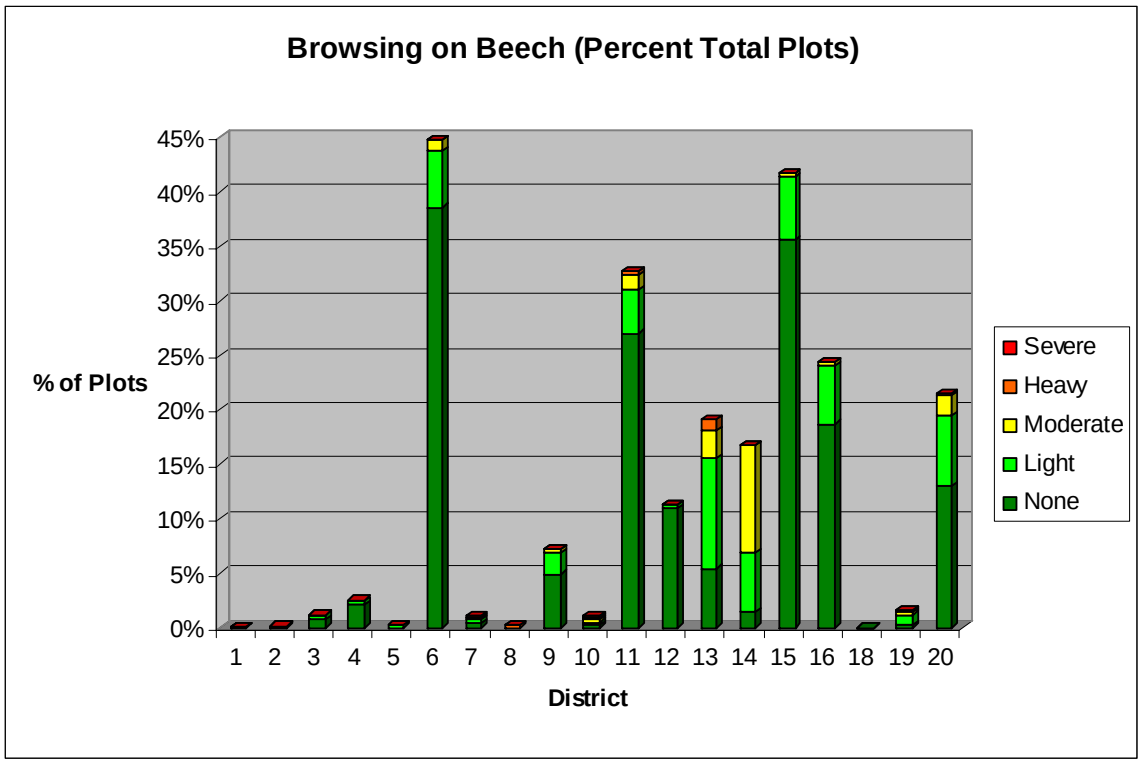
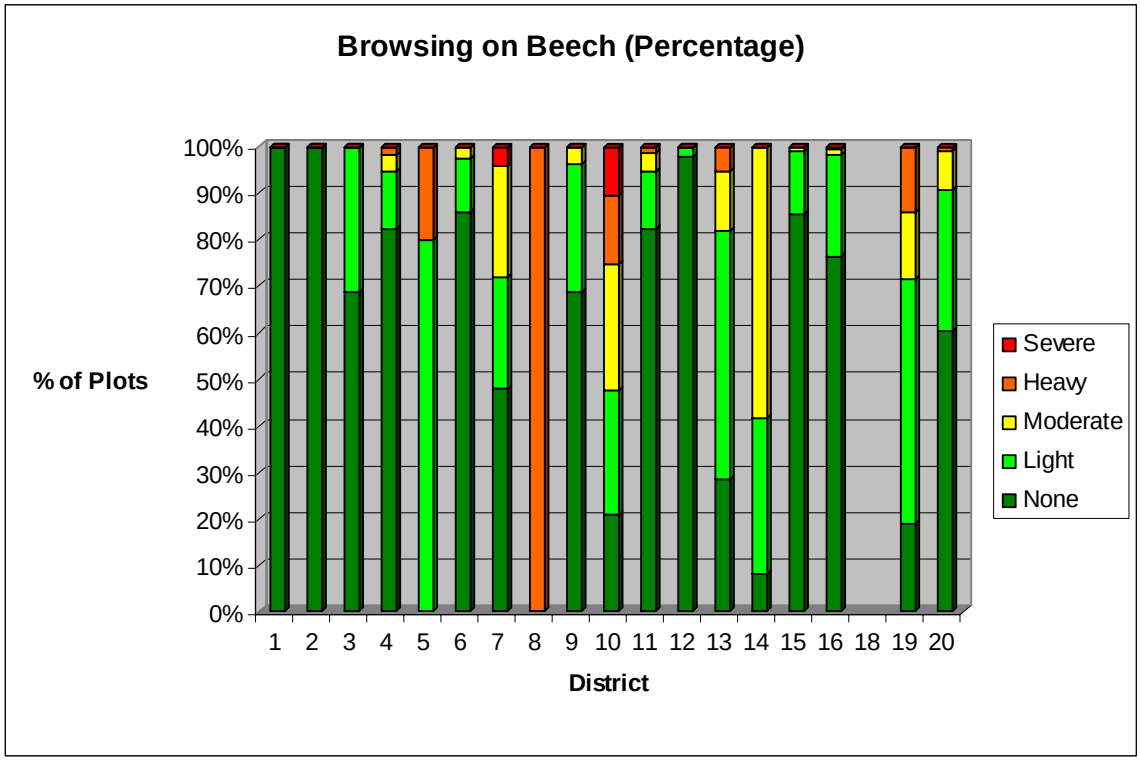
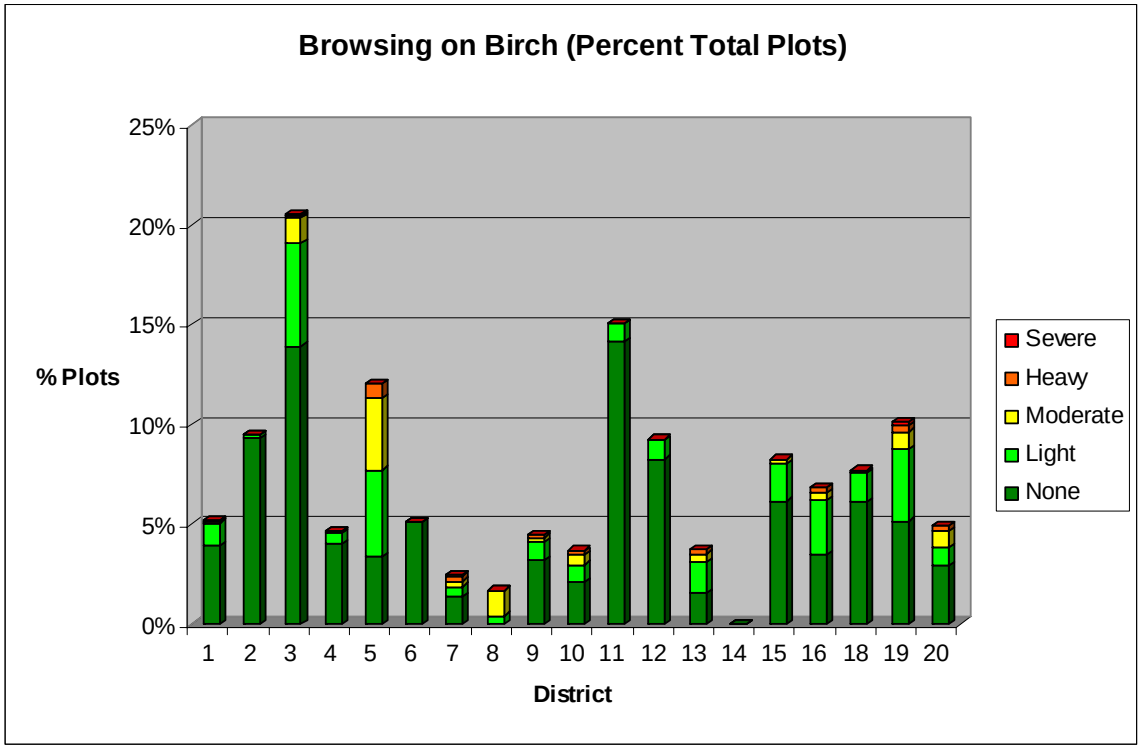


Figure 10.


Browsing on Beech (Percentage)
% of Plots
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 18 19 20
District
Severe
Heavy
Moderate
Light
None

Birch is more evenly widespread but somewhat less abundant than American beech. An interesting finding was the high level of browsing on birch in District 5, which did not appear to have a severe browsing problem based on all other indicators (Figure 11).

Figure 11.



Black cherry was most abundant in the more northern hardwood forest districts (Figure 12). Districts 8, 13, 14, and 19 showed the heaviest browsing on black cherry, with greater than 50% of the plots browsed moderately or above (Figure 13). Based on this, and the results of the previous indicator species, these are our most severely impacted districts for deer browsing, although District 14 has some of the best regeneration across all indicators. This may be a good example of an area that has high deer pressure, but high food availability, based on the small size of the forest and the context of the surrounding habitats.

Figure 12.

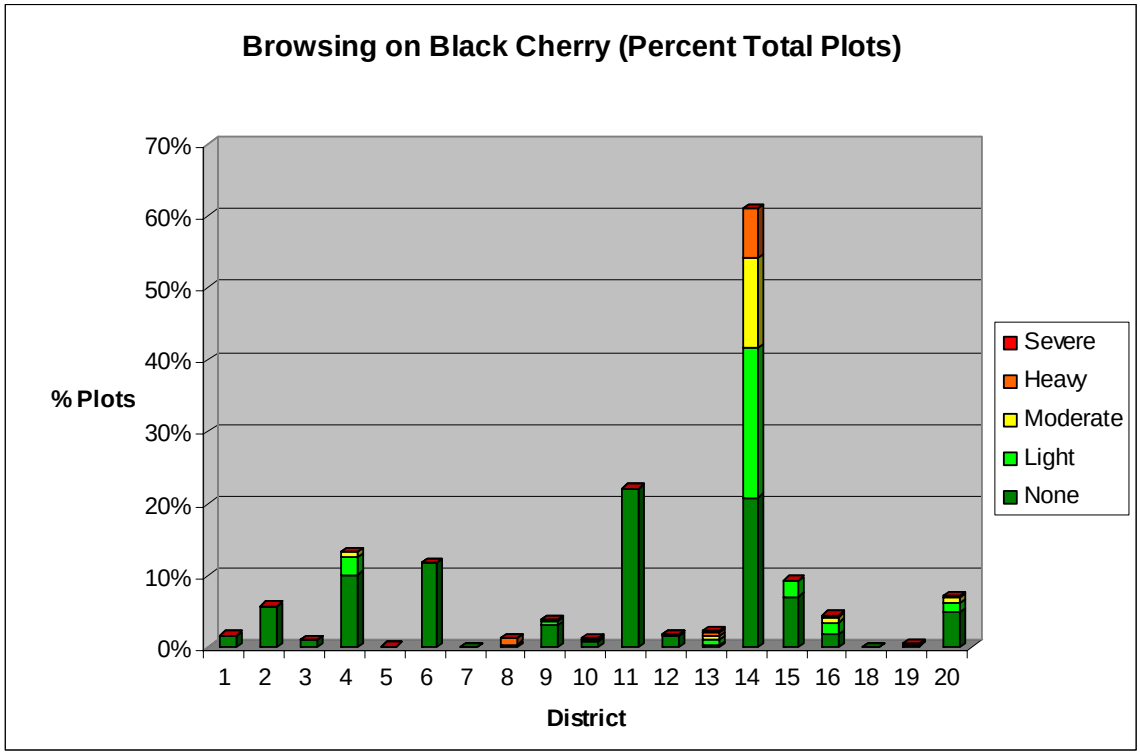
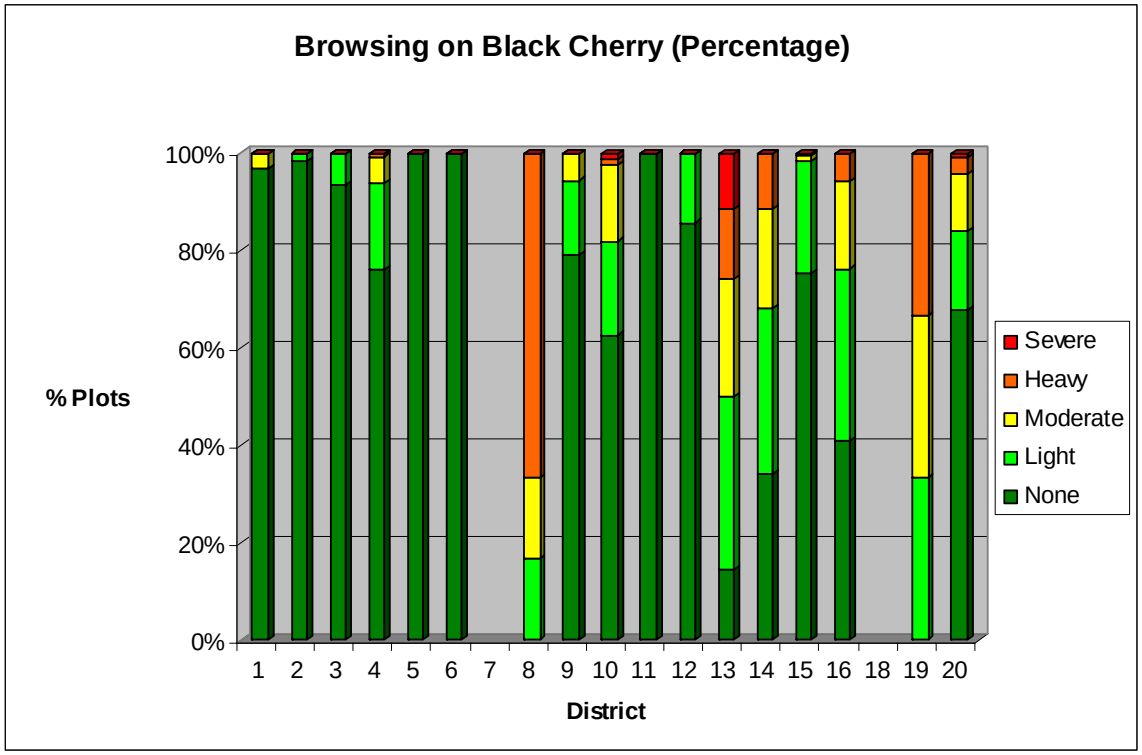


Figure 13.


Browsing on Black Cherry (Percentage)
100%
80%
60%
40%
20%
0%
% Plots
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 18 19 20
District
Severe
Heavy
Moderate
Light
None

Management Implications

At the broad level, across all the State Forests, the picture looking at browsing levels alone looks pretty good. A majority of the woody stems (88.77%) observed were not browsed above the light category (Table 4). When, however, this is taken in light of the proportion of plots with desirable regeneration (only 24.45%) and the proportion of plots with no woody regeneration (44.45%) (Table 3), this indicates that the browsing has not been down long enough for a widespread regeneration response. This initial survey will serve as a baseline snapshot in time, against which to compare future habitat conditions. So, the current plan is to keep monitoring to locate areas of continued excessive browsing to focus deer harvest on them, and keep the remainder of the areas at low browsing levels until the regeneration responds. As localized areas respond with regeneration and are approaching the sustainable condition, deer herd levels may be allowed to rise slightly, cautiously, with close monitoring to ensure the herd does not rise too rapidly causing the habitat to regress into an overbrowsing situation.

Using the regeneration analysis of plots with desirable woody species, the forest districts ranked as follows in descending order: 14, 11, 8, 1, 2, 3, 5, 4, 15, 9, 12, 18, 6, 16, 19, 7, 20, 10, and 13. When ranked based on percentage of plots with red maple and the intensity of browsing on that species, in descending order, the Districts ranked as follows: 11, 14, 12, 3, 1, 2, 5, 15, 9, 4, 6, 7, 16, 18, 20, 10, 8, and 13. Comparing all indicators, the rankings of the forest districts are quite comparable with a few exceptions (Table 5). The biggest differences become evident when a particular indicator species is much more characteristic of the ecoregions of a particular forest district. Also, Forest District 14 was highly unusual because of the high level of regeneration of several species, but also being characterized by a high intensity of browsing.

Table 5. Forest District Ranking of Regeneration and Browsing Pressure by Various Indicators.

Ranking	Desirable Regen	No Woody Regen	Red Maple Regen & Browsing	Oak Regen & Browsing	Green-brier Regen & Browsing	Ash Regen & Browsing	Beech Regen & Browsing	Birch Regen & Browsing	Black Cherry Regen & Browsing
1	14	1	11	11	2	11	6	11	11
2	11	11	14	14	4	20	12	2	6
3	8	14	12	1	7	6	14	12	2
4	1	2	3	2	18	9	9	6	9
5	2	7	1	3	3	3	3	4	12
6	3	3	2	12	5	12	2	8	1
7	5	8	5	5	12	16	1	14	3
8	4	16	15	9	1	5	18	15	5
9	15	15	9	6	6	2	15	1	7
10	9	13	4	19	9	15	7	18	18
11	12	6	6	4	19	1	4	9	10
12	18	12	7	18	10	10	5	3	15
13	6	4	16	7	13	19	16	10	4
14	16	5	18	10	8	13	20	16	19
15	19	9	20	16	11	4	8	13	16
16	7	18	10	15	14	7	19	20	20
17	20	20	8	20	15	8	10	7	13
18	10	19	13	13	16	14	11	19	8
19	13	10	19	8	20	18	13	5	14

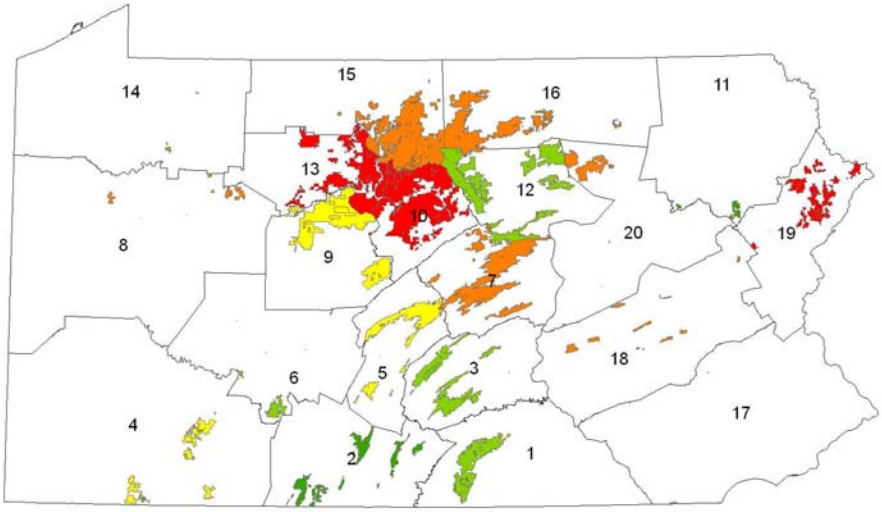
From all these various indices, an average ranking was calculated by forest district (Table 6, Figure 14). Based on this, in ascending order, the districts ranked as follows: 2, 11, 1, 3, 12, 6, 14, 9, 4, 5, 15, 7, 18, 16, 8, 20, 10, 19, and 13.

Table 6. Woody Regeneration and Browsing Intensity Ranking by District using various Indicators.

District	Desirable Regen	No Woody Regen	Red Maple Regen & Browsing	Oak Regen & Browsing	Green-brier Regen & Browsing	Ash Regen & Browsing	Beech Regen & Browsing	Birch Regen & Browsing	Black Cherry Regen & Browsing	Average Ranking
1	4	1	5	3	8	11	7	9	6	6.00
2	5	4	6	4	1	9	6	2	3	4.44
3	6	6	4	5	5	5	5	12	7	6.11
4	8	13	10	11	2	15	11	5	13	9.78
5	7	14	7	7	6	8	12	19	8	9.78
6	13	11	11	9	9	3	1	4	2	7.00
7	16	5	12	13	3	16	10	17	9	11.22
8	3	7	17	19	14	16	15	6	18	12.78
9	10	15	9	8	10	4	4	11	4	8.33
10	18	19	16	14	12	12	17	13	11	14.67
11	2	2	1	1	14	1	18	1	1	4.56
12	11	12	3	6	7	6	2	3	5	6.11
13	19	10	18	18	13	14	19	15	17	15.89
14	1	3	2	2	14	16	3	7	19	7.44
15	9	9	8	16	14	10	9	8	12	10.56
16	14	8	13	15	14	7	13	14	15	12.56
18	12	16	14	12	4	16	8	10	10	11.33
19	15	18	19	10	11	13	16	18	14	14.89
20	17	17	15	17	14	2	14	16	16	14.22

Figure 14. Average Ranking Scores for State Forest Lands by District (note: this does not indicate District-wide conditions, only those occurring on State Forest lands within that area).

District	Average Ranking
2	4.44
11	4.56
1	6
3	6.11
12	6.11
6	7
14	7.44
9	8.33
4	9.78
5	9.78
15	10.56
7	11.22
18	11.33
16	12.56
8	12.78
20	14.22
10	14.67
19	14.89
13	15.89



Major Findings and Accomplishments:

- At a system-wide level, a deer browsing preference index was developed for the woody species observed, which promises to be very useful for guiding future monitoring efforts and development of indicators of browsing intensity.
- The system-wide proportion of plots with desirable regeneration (only 24.45%) and the proportion of plots with no woody regeneration (44.45%) indicate that browsing has not been down long enough for a widespread regeneration response.
- On those plots with woody species present (55.5% of the plots), the majority of the woody stems (88.77%) observed were not browsed above the light category, although browsing intensity varied among and within forest districts.
- From all the various indices evaluated, an average ranking was calculated by forest district. Based on this, from lowest browsing impact to most severe, the districts ranked as follows: relatively lightly browsed with better regeneration – Districts 2, 11, 1, 3, 12, 6, 14; relatively moderately browsed with less regeneration – Districts 9, 4, 5, 15, 7, 18, 16; relatively severely browsed with poor regeneration – Districts 8, 20, 10, 19, and 13.
- The current plan is to keep monitoring to locate areas of continued excessive browsing to focus deer harvest on them, and keep the remainder of the areas at low browsing levels until the regeneration responds.
- These results will be used to adapt the development of the Rapid Habitat Assessment Tool through the contract with USGS through Penn State University. The new tool will hopefully replace this Habitat Browsing Survey for ongoing habitat monitoring for deer browsing impacts.
- Ongoing monitoring and management efforts will be linked via a deer management section in the State Forest Management Plan. This will include adaptive management mechanisms like thresholds for management activities from the monitoring indicators and timelines for evaluation of goals.

Appendices

Appendix I. Browsing Impact Survey Field Data Form

DCNR Deer Density and Impact Data Sheet

District # _____ Transect Line_____ Observer_____ Date _____

Date of Leaf-drop previous fall? _____	**Pellet Count Data**		**Total**	**Acorns present from previous fall?**	
Number of Plots				Very heavy	
Number of Pellet Groups				heavy	
				normal	
Number of Dead Deer				light	
				none	
Winter Severity: snow conditions previous winter	Heavy (>18" for 3+ months)		Light (0-6" with periods of no snow cover		
	Normal (6-18" up to 3 months)				

Browsing Impact Data

Note - Record impact data at every other pellet group plot. First impact plot taken at first pellet plot.						**TOTAL**
Number of Plots						
Plots With Regeneration	Desirable		Undesirable		Both	
Plots With No Regeneration	Competing Vegetation	Herbicide Treatment	Conifer Cover	High BA Stand	Deer Browsing	Other Reason? _____

Note - If regeneration present continue below, if none present move to next plot.

Woody Species	None	Light	Moderate	Heavy	Severe	Notes
American Beech						
Striped Maple						
Red Maple						
Rubus spp.						
Mountain Laurel						

Appendix I (continued).

Woody Species (continued)	None	Light	Moderate	Heavy	Severe	Notes

Appendix II. Browsing Impact Survey Data Collection Protocol.

Instructions: Pellet Groups

1. Fill out the header on the other side. (Note – Only one transect line per page.)

2. Record the total number of plots and pellet groups for the transect line.

3. Pellet groups are counted within 6 ft. radius plots located at 100 ft. intervals along transect lines. The first plot should be taken 100 ft. from beginning of the transect line and the last plot ~ 100 ft from the end of the transect line. Distances should be measured by pacing or hip chain.

4. There must be a minimum of 10 pellets in a group before it is counted; at least ½ of the pellets must be within the plot radius. Pellets must be on top of the leaves or vegetation. Record pellet groups with a dot tally (see instructions below).

5. If fenced enclosures or waterways are encountered along the transect line, either climb through the fence or waterway and continue along the transect line or take a sighting on the other side, walk around, and resume the line. **Do not** count pellet groups inside the fence or water. Deduct the number of plots that would have fallen within the fence or water from the total possible plots on that line.

6. Record dead deer sighted by dot tally. Do not differentiate between age class or sex.

Instructions: Browsing Impact Data

1. Browsing impact plots will be taken at every other pellet group plot, each plot will be dot tallied. Record deer browsing impact on seedlings within the 6 ft. radius plot. Record data on seedlings over 2 inches.

2. Plots with no desirable regeneration will be dot tallied under the column best describing why the desirable regeneration is absent. (Competing vegetation – fern, striped maple, beech brush, grasses..)

3. Plots with desirable or undesirable regeneration only will be dot tallied under the columns desirable and undesirable. Plots with both desirable and undesirable regeneration under the column labeled both. Undesirable regeneration consists of striped maple, beech, birch and pin cherry. All other commercial species are classified as desirable.

4. When regeneration is present on the plot, the browsing intensity will be recorded for each species group as follows (use blank rows for additional species encountered) (see figure below):

    1. **Not Browsed** – no visible browsing damage;
    2. **Light** – 0 to 50% of seedling stems are browsed;
    3. **Moderate** - more than 50% of stems are browsed but plant is not hedged;
    4. **Heavy** - more than 50% of stems are browsed and the plant is severely hedged (plant is browsed to a small ball of twigs), but it is taller than ½ foot.
    5. **Severely browsed** – no seedlings of the species within the plot are > ½ foot tall. Seedlings are severely hedged.

5. There may be more than 1 seedling for any species within the plot (including groups of seedlings as stump sprouts). Use your best judgment to characterize the browsing across seedlings for each species within a plot, i. e. if most are heavily browsed, record damage as heavy for the species for that plot.

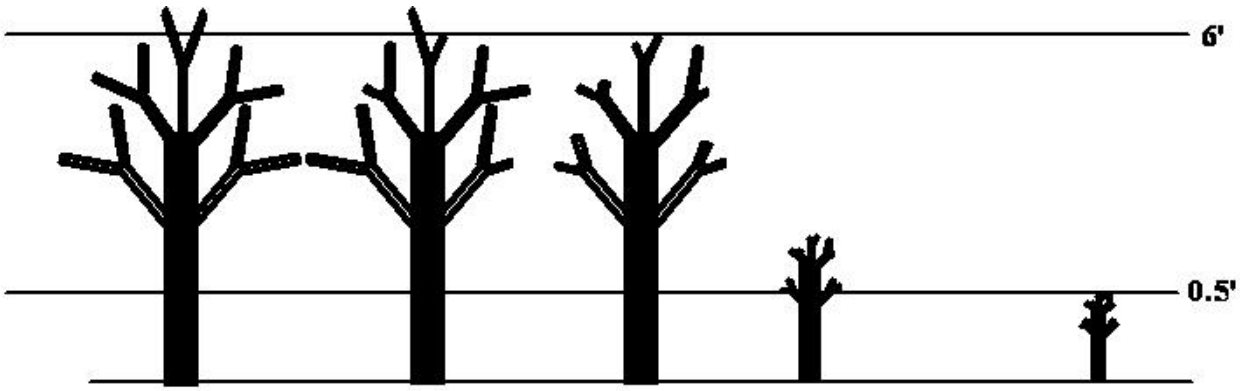
Appendix II (continued).

Recording dot tally:

1 = .
2 = . .
3 = .:
4 = ::
5 = |:
6 = | |
8 = □
10 = ⊠

Browsing Severity

1 **2** **3** **4** **5**



Not browsed; no damage

Lightly browsed: < 50% stems browsed

Moderately browsed: > 50% stems browsed

Heavily browsed: plant severely hedged, > 0.5'

Severely browsed: seedlings, 0.5' tall and may be severely hedged, ≤ 0.5'

Seedlings > 0.5' provide best evidence of browsing damage. Under severe deer browsing, seedlings may never exceed 0.5' tall and will be severely hedged*: deer browsing keeps them suppressed below 0.5'. Small, current year seedlings may never grow above 0.5' under severe deer browsing.

*** Severely hedged = seedling browsed repeatedly over years; all stems short, thick, with "bonsai" appearance.**