Browsing and Regeneration Monitoring Report for Pennsylvania's State Forests

2007

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 and again in 2007 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, and plots were categorized as adequately stocked to regenerate or not. Pellet plot data was also collected along these transects at 100 feet intervals. Plot data from 74,615 plots over the two year period (40,892 & 33,723 in 2006 & 2007 respectively) was entered into the database for analysis. Field work was completed between snow melt and the spring vegetation greenup period. This ongoing survey represents a baseline snapshot against which future conditions can be compared, and a tool to evaluate trends in forest habitat health and sustainability.

Major Findings and Accomplishments:

- At a system-wide level, the deer browsing preference index was further refined for the woody species observed, which is very useful for assessing indicators of browsing intensity.
- The system-wide proportion of plots with desirable regeneration rose from 24% to 28% and the proportion of plots with no woody regeneration dropped from 44% to 26%, indicating that browsing has not been down long enough for a widespread regeneration response, but progress is underway.
- On those plots with woody species present (74% of the plots), the majority of the woody stems (85%) observed were not browsed above the light category, although browsing intensity varied among and within forest districts.
- From all the various indices evaluated, several Districts exhibited some apparent changes. Notably, conditions worsened in Districts 1, 2, and 3. The regeneration showed improvement in District 19. Districts 8, 11, and 14 continued to show the lowest browsing impact and healthiest regeneration.
- 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.
- The Bureau of Forestry's foresters recently ranked the importance of the indicators monitored through this survey to provide additional feedback into the decision-making processes.
- These results will be used to continue to adapt the development of the Rapid Habitat Assessment Tool as tested by USGS through Penn State University. The new tool will modified and further tested, hopefully to 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 the time when food resources are most limiting for deer survival and when their browsing impacts are most severe on the forest community. Overwinter monitoring also allows the collection of deer pellet and deer population data and follows most of the hunting seasons and allows us to gauge the success of the hunting as a management tool. 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.

Recently, the Bureau of Forestry conducted a workshop to begin development of a model for analysis of the Browsing and Regeneration Survey results and application to our DMAP decision-making process. Presentations were given on the statewide results for several indicators, as well as within- and among-District comparisons. One presentation focused on broad findings, another on using GIS to display findings and trend data spatially and visually, and a third presentation discussed the decision making variables and process using the above indicators. Finally, the foresters in attendance were asked to rank the indicators monitored in the survey for their value in DMAP decision-making based on their understanding. The discussion included issues and constraints, but focused on how to successfully implement a decision model using these monitoring indicators. Issues of lack of uniformity in coverage by the surveys and failure to follow the protocol were identified. The values of short term and long term indicators were discussed, too, with thought focused on potential thresholds of either progress towards goals or sustainability. Currently, policy decisions are being discussed to determine the level of effort that will be devoted to ensure uniformity in the application of this technique, which will determine whether or not a decision model can be applied effectively and should be developed.

The Department is in the process of evaluating other techniques and indicators for monitoring browsing impacts on the forest ecosystems, and has contracted out with USGS through the Penn State Cooperative Fish and Wildlife Unit to evaluate a "Rapid Habitat Assessment Technique." DCNR proposed this technique to monitor a broader spectrum of the forest vegetative community including more herbaceous plants as suggested by much of the current literature, so it is a summer survey. The technique was developed and evaluated for one

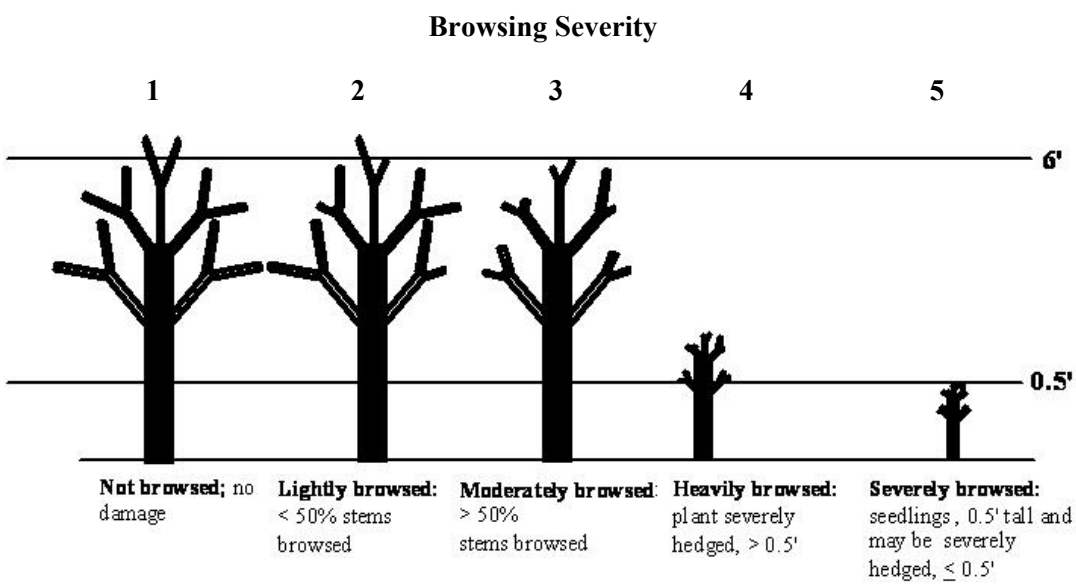
field season, and a preliminary analysis was completed (Appendix II). The Department now plans to continue testing of the protocol as modified per the recommendations of the analysis. This testing is to be done in the summer field season of 2008 in selected forest districts.

Another effort by the Department to further refine and adapt the monitoring of our forest habitats and the browsing issue is that DCNR is in the process of completing a "peer review" of our current monitoring protocol, the analysis and interpretations, and the subsequent management decision process for DMAP. This review is underway currently. Our hopes are to receive recommendations on changes that can be made to improve the efficiency and sensitivity of the monitoring and selection of DMAP Areas.

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. Transect lines are segmented at pre-determined points to allow for area analysis to correspond to current and proposed DMAP areas. Areas inside of deer deterrent fencing were not sampled. 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. In 2007 a new assessment was added to the protocol, where each vegetative plot was categorized by the forester as either "adequately stocked" to regenerate successfully (without a deer fence or other remediation) or "not adequately stocked." 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. Several districts actually covered their entire forests or large portions of them 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 33,723 browsing plots were surveyed and entered into the dataset, covering ?? % of the state forest system. This was a reduced effort from 2006, where 40,892 plots were surveyed over 88% of the state forest lands.

Table 1. Number of Browsing Plots Surveyed per Forest District in 2007.

DISTRICT	Total Plots	Lineal Feet	Miles
1	1609	321800	60.95
2	866	173200	32.80
3	1419	283800	53.75
4	994	198800	37.65
5	1792	358400	67.88
6	838	167600	31.74
7	2336	467200	88.48
8	275	55000	10.42
9	2955	591000	111.93
10	2181	436200	82.61
11	396	79200	15.00
12	1540	308000	58.33
13	1871	374200	70.87
14	101	20200	3.83
15	7961	1592200	301.55
16	4891	978200	185.27
17	0	0	0.00
18	438	87600	16.59
19	697	139400	26.40
20	563	112600	21.33
Totals	33723	6744600	1277.39

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, 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 (this condition may be characteristic of some of the species with very low sample sizes). 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. The preference ranking in this report was compiled from the cumulative monitoring efforts of 2006 and 2007.

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 (Figure 2, Table 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. The “Total” bar in Figure 2 represents the average browsing intensity for all species found on the plots. Also, the “Species Total” column in Figure 2 reflects the total number of plots where that species was observed.

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).

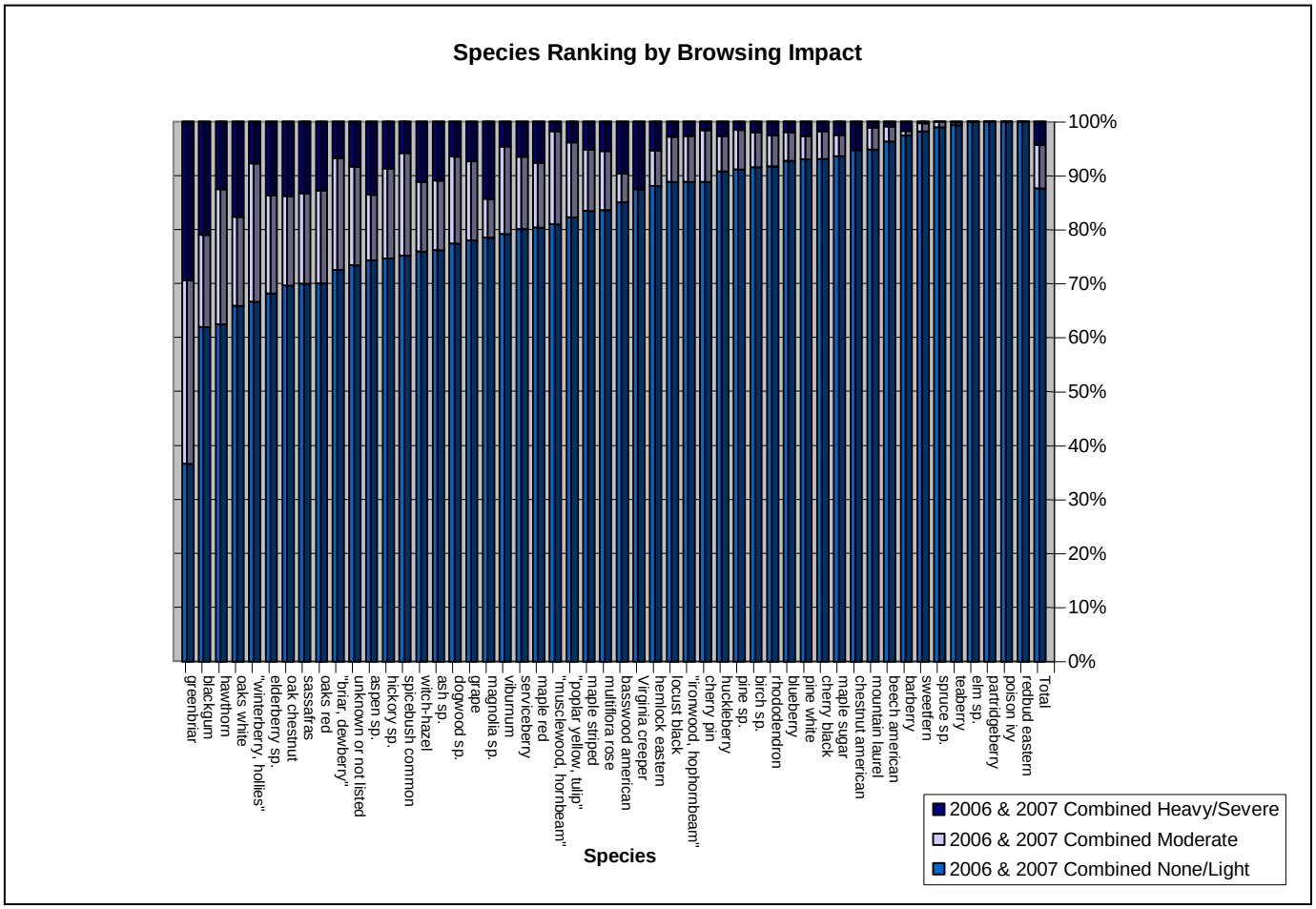


Table 2. Browsing Preference Ranking of Woody Species from Plots With the Woody Species Present – 2006 & 2007 Data Combined.

	2006 & 2007 Combined				
Ranking	**Species**	**None/Light**	**Moderate**	**Heavy/Severe**	**Species Total**
1	greenbriar	37%	34%	29%	1185
2	blackgum	62%	17%	21%	358
3	hawthorn	63%	25%	13%	104
4	oaks white	66%	16%	18%	358
5	"winterberry, hollies"	67%	26%	8%	39
6	elderberry sp.	68%	18%	14%	22
7	oak chestnut	70%	17%	14%	2397
8	sassafras	70%	17%	13%	710
9	oaks red	70%	17%	13%	3210
10	"briar, dewberry"	73%	21%	7%	1201
11	unknown or not listed	73%	18%	8%	1373
12	aspen sp.	74%	12%	14%	74
13	hickory sp.	75%	17%	9%	150
14	spicebush common	75%	19%	6%	121
15	witch-hazel	76%	13%	11%	1678
16	ash sp.	76%	13%	11%	450
17	dogwood sp.	77%	16%	6%	31
18	grape	78%	15%	7%	41
19	magnolia sp.	79%	7%	14%	14
20	viburnum	79%	16%	5%	260
21	serviceberry	80%	13%	6%	448
22	maple red	80%	12%	8%	7758
23	"musclewood, hornbeam"	81%	17%	2%	58
24	"poplar yellow, tulip"	82%	14%	4%	130
25	maple striped	84%	11%	5%	7631
26	multiflora rose	84%	11%	5%	55
27	basswood american	85%	5%	10%	114
28	Virginia creeper	88%	0%	13%	8
29	hemlock eastern	88%	7%	5%	1729
30	locust black	89%	8%	3%	36
31	"ironwood, hophornbeam"	89%	8%	3%	153
32	cherry pin	89%	10%	2%	252
33	huckleberry	91%	7%	3%	13370
34	pine sp.	91%	7%	1%	136
35	birch sp.	92%	6%	2%	5570
36	rhododendron	92%	6%	3%	157
37	blueberry	93%	5%	2%	5781
38	pine white	93%	4%	3%	1789
39	cherry black	93%	5%	2%	3754
40	maple sugar	94%	4%	2%	1458
41	chestnut american	95%	0%	5%	38
42	mountain laurel	95%	4%	1%	13145
43	beech american	96%	3%	1%	12877
44	barberry	97%	1%	2%	117
45	sweetfern	98%	1%	0%	681
46	spruce sp.	99%	1%	0%	99
47	teaberry	99%	0%	0%	654
48	elm sp.	100%	0%	0%	2
49	partridgeberry	100%	0%	0%	9
50	poison ivy	100%	0%	0%	2
51	redbud eastern	100%	0%	0%	10
	Total	**88%**	**8%**	**4%**	**91797**

Forest Regeneration Analysis

This year for the first time, the foresters conducting the monitoring made an assessment of the regenerative capacity of each vegetative plot, categorizing them into either "adequately stocked" or "not adequately stocked." They were directed to use their professional judgement and determine if the plot, in the absence of deer-deterrent fencing or other remediation, would regenerate successfully if the overstory was removed. Initial findings (Table 3) indicate that this may be a particularly useful indicator of "long-term" sustainability in the forest, particularly since this assesses the "established" seedlings on each plot. The agency's professional staff was questioned about this indicator, and the consensus is that a threshold of between 30 % and 40 % of the plots being ranked as adequately stocked would be a good initial goal for assessing local forest sustainability. Much consideration in the discussion of this threshold acknowledged that this assessment is being conducted on all plots regardless of stocking and shading and the presence of competing vegetation. The three forest districts that appeared to be most sustainably regenerating in the 2006 assessment ranked the highest for this indicator, Districts 8, 11, and 14. Forest District 5 was also entering the sustainable range. On the other end of the spectrum, Districts 13, 18, and 20 all reported less than 5 % of the plots as adequately stocked. The system-wide average for this indicator was only 10.80 % of the plots categorized as adequately stocked, indicating that the state forests are not yet at a long-term sustainability threshold for woody regeneration. Over time, the initial intuitive thresholds for various indicators will likely be adjusted based on the accumulation of information through an adaptive resource management process.

The other indicators being monitored, like browsing intensity by species and presence of desirable woody species on the plots, were recommended as more "short-term" indicators of regenerative sustainability. These can be heavily influenced by annual changes related to seed source, mast availability, winter severity, or rapid changes in browsing intensity.

In discussing the results of the 2006 survey, we found that there was some confusion among our field staff on what constituted "woody regeneration," where some species like mountain laurel were not classified as such. This was clarified and data collection became more standardized in 2007. This resulted in increases in the number of plots categorized as containing "undesirable" woody regeneration, and decreases in the number categorized as containing "none" where no real change in the habitat may have occurred. Continued standardization and training will be an important part of the ongoing effort for this type of monitoring.

The system-wide proportion of plots with desirable regeneration in 2007 (only 27.57%) indicates that browsing still has not been down long enough for a widespread regeneration response (Table 3). Many areas of the state forest have been affected by long term deer overbrowsing and now have an established layer of competing vegetation that will restrict development of desirable regeneration even under favorable deer population levels. Compared to 2006 (24.45%), however, this is a slight improvement at the system-wide level. The percentages for this indicator should range higher than for the assessment of adequate stocking since this is looking at the presence or absence of a single stem of desirable regeneration existing on the plot, regardless of size or level of stocking. Again, Districts 8, 11, and 14 ranked the highest, with greater than 50% of the plots containing desirable regeneration. Districts 1, 5, 9, and 19 all reported over 30% of the plots with desirable regeneration. The system-wide average for this indicator was 27.57%. No district reported less than 15% plots with desirable regeneration, but Districts 3, 13, and 18 were below 20%. This, too, is an improvement from 2006, where 7 districts reported under 20% of the plots containing desirable regeneration. District 3 is the one district that moved from above 20% to below.

Table 3. Desirable Regeneration and Regenerative Stocking Capacity on Browsing Plots by Forest District – 2007.

DISTRICT	Adequately Stocked	Not Adequately Stocked	% Adequately Stocked	# Desirable	# Undesirable	# BOTH	# NONE	% Desirable
1	278	1299	17.63%	136	806	417	250	34.37%
2	130	739	14.96%	54	536	205	71	29.91%
3	115	1274	8.28%	65	870	202	282	18.82%
4	59	937	5.92%	111	347	118	418	23.04%
5	568	1241	31.40%	150	897	419	326	31.75%
6	58	790	6.84%	93	400	81	264	20.76%
7	174	2215	7.28%	86	1444	449	357	22.90%
8	128	162	44.14%	103	73	53	46	56.73%
9	421	2534	14.25%	442	1333	467	713	30.76%
10	157	2305	6.38%	246	1270	329	336	26.36%
11	160	236	40.40%	162	66	137	31	75.51%
12	121	1400	7.96%	130	825	255	330	25.00%
13	83	1818	4.37%	178	764	153	776	17.69%
14	49	52	48.51%	23	18	48	12	70.30%
15	651	7482	8.00%	791	3195	1407	2568	27.61%
16	462	4485	9.34%	533	1792	818	1748	27.62%
17	0	0		0	0	0	0	
18	17	420	3.89%	9	282	77	70	19.63%
19	67	638	9.50%	10	384	224	79	33.57%
20	6	555	1.07%	34	288	84	157	20.96%
Totals	3704	30582	10.80%	3356	15590	5943	8834	27.57%

Table 4 compares plots with desirable woody species, undesirable woody species, and plots with no woody species between the two years of monitoring. As mentioned previously, changes in data collection in some districts have caused increases in the recorded number of plots with undesirable regeneration and decreases in the number of plots with no woody regeneration. In light of this, the significant changes include any change in the plots with desirable woody regeneration, decreases in the plots with undesirable regeneration, or increases in the plots with no woody regeneration. Also note that totals for these variables can add up to greater than 100 percent, since some plots had both types of woody species occurring on them.

Districts with the most desirable woody vegetation ranked in descending order were Districts 11, 14, 8, 1, 19, 5, 9, 2, 16, 15, 10, 12, 4, 7, 20, 6, 18, 3, and 13. Some significant changes occurred from 2006 to 2007. Most encouraging is District 19, which moved from among the worst to near the best, and exhibited nearly a 15% increase in plots with desirable regeneration. Districts 10 and 16 also trended strongly in a positive direction. On the other hand, Districts 1, 2, 3, 8, and 14 showed dramatic reductions in the % of plots with desirable regeneration. Additionally, District 1 showed almost a 15% increase in the proportion of plots with no woody regeneration. Districts 4 and 13 are also troubling, with the greatest proportion of plots with no woody regeneration, and this is increasing in District 13.

Table 4. Change in the percentage of plots containing desirable, undesirable or no woody regeneration from 2006 to 2007.

	2006			2007			% Change 2006 to 2007		
DISTRICT	% Desirable	% Undesirable	% None	% Desirable	% Undesirable	% None	% Change Total Desirable	% Change Total Undesirable	% Change None
1	56.97%	77.96%	0.86%	34.37%	76.01%	15.54%	-22.60%	-1.95%	14.68%
2	44.69%	87.59%	8.00%	29.91%	85.57%	8.20%	-14.78%	-2.02%	0.20%
3	35.56%	74.85%	16.13%	18.82%	75.55%	19.87%	-16.74%	0.70%	3.74%
4	28.28%	43.62%	47.44%	23.04%	46.78%	42.05%	-5.24%	3.16%	-5.39%
5	29.41%	27.45%	55.71%	31.75%	73.44%	18.19%	2.34%	45.99%	-37.52%
6	19.40%	48.79%	43.65%	20.76%	57.40%	31.50%	1.36%	8.61%	-12.15%
7	17.65%	84.13%	12.22%	22.90%	81.04%	15.28%	5.25%	-3.09%	3.06%
8	72.37%	37.50%	23.03%	56.73%	45.82%	16.73%	-15.64%	8.32%	-6.30%
9	25.30%	23.40%	55.81%	30.76%	60.91%	24.13%	5.46%	37.51%	-31.68%
10	17.04%	7.67%	77.53%	26.36%	73.31%	15.41%	9.32%	65.64%	-62.12%
11	74.34%	45.58%	2.65%	75.51%	51.26%	7.83%	1.17%	5.68%	5.18%
12	22.21%	41.44%	47.30%	25.00%	70.13%	21.43%	2.79%	28.69%	-25.87%
13	13.61%	54.73%	38.99%	17.69%	49.01%	41.48%	4.08%	-5.72%	2.49%
14	94.44%	69.44%	5.56%	70.30%	65.35%	11.88%	-24.14%	-4.09%	6.32%
15	25.75%	49.46%	38.31%	27.61%	57.81%	32.26%	1.86%	8.35%	-6.05%
16	19.12%	58.01%	34.28%	27.62%	53.36%	35.74%	8.50%	-4.65%	1.46%
17	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
18	20.72%	28.14%	59.64%	19.63%	81.96%	15.98%	-1.09%	53.82%	-43.66%
19	18.77%	13.87%	71.85%	33.57%	87.23%	11.33%	14.80%	73.36%	-60.52%
20	17.23%	31.16%	61.01%	20.96%	66.07%	27.89%	3.73%	34.91%	-33.12%
Totals	24.45%	43.70%	44.45%	27.57%	63.85%	26.20%	3.12%	20.15%	-18.25%

Browsing Intensity Analysis

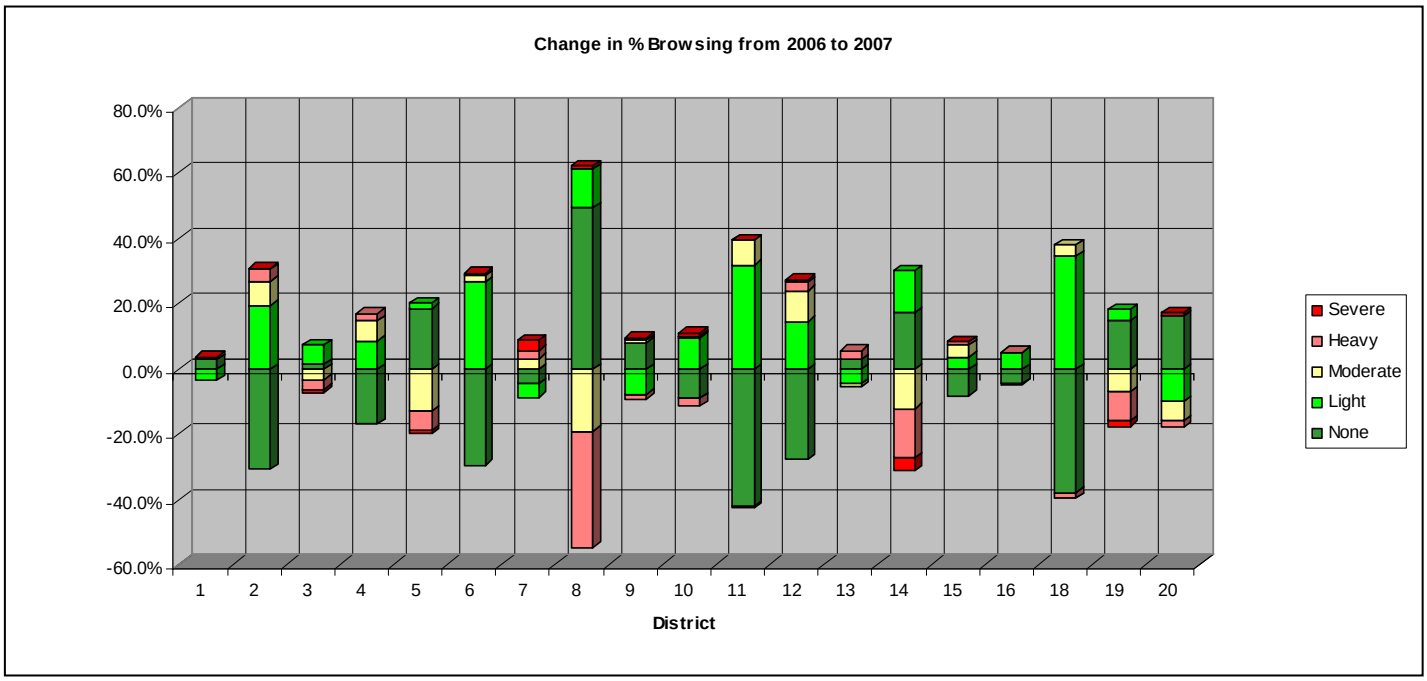
Looking across all the State Forests, the picture looking at browsing levels alone is indicating an increase in browsing intensity (Table 5). This may be caused, however, by increases in the proportions of desirable woody species growing in the forests shown above (Table 4). There was a shift from the category of no browsing to the categories of light and, to a lesser extent, moderate. The plots where browsing was described as heavy or severe remained relatively unchanged or slightly increasing in proportion.

Table 5. Change in browsing intensity from 2006 to 2007 across all species and forest districts.

	None	Light	Moderate	Heavy	Severe
2006	68.56%	20.40%	7.09%	3.28%	0.66%
2007	58.59%	27.48%	9.20%	3.70%	1.02%
Change	**-9.97%**	**7.08%**	**2.12%**	**0.42%**	**0.36%**

Among the forest districts, there was great variability in the trends in browsing intensity. Figure 3 shows the percentage of change from 2006 to 2007 among the browsing categories by district. An increasing trend in the category "none" is positive, as shown in Districts 5, 8, 14, 19, and 20. On the other hand, decreasing trends in "none" with shifts to the other categories indicates an increase in browsing within the district. This occurred in Districts 2, 6, 10, 11, 12, and 18.

Figure 3.



Analysis of Browsing Intensity by Species

In 2006, 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. For 2007, at least within this report, we will concentrate on browsing only on one indicator species, red maple (*Acer rubrum*). This species is widespread and abundant across Pennsylvania, and is preferred by deer above average (Figure 2). It also seeds consistently, and grows rapidly, so it is appropriate for use as a very short-term indicator.

Figure 4 shows the relative proportion of red maple among the occurrences of species on plots within each forest district. It also shows the proportion of those red maple occurrences in each browsing category. This illustrates both the relative abundance and the browsing. Figure 5 shows only the proportion of red maple in each browsing category by district. If we look at the districts where red maple was browsed moderately or above at least 30% of the time, this includes Districts 5, 7, 10, 13, and 20. Districts where this species was browsed lightly (less than 20% browsed above light) include Districts 6, 8, 9, 11, 12, 14, 15, and 18. Of those, however, red maple only occurred on less than 5% of the plots on Districts 6, 12, and 18.

Figure 4. The relative abundance of red maple (Acer rubrum) on the vegetative plots by browsing category and forest district in 2007.

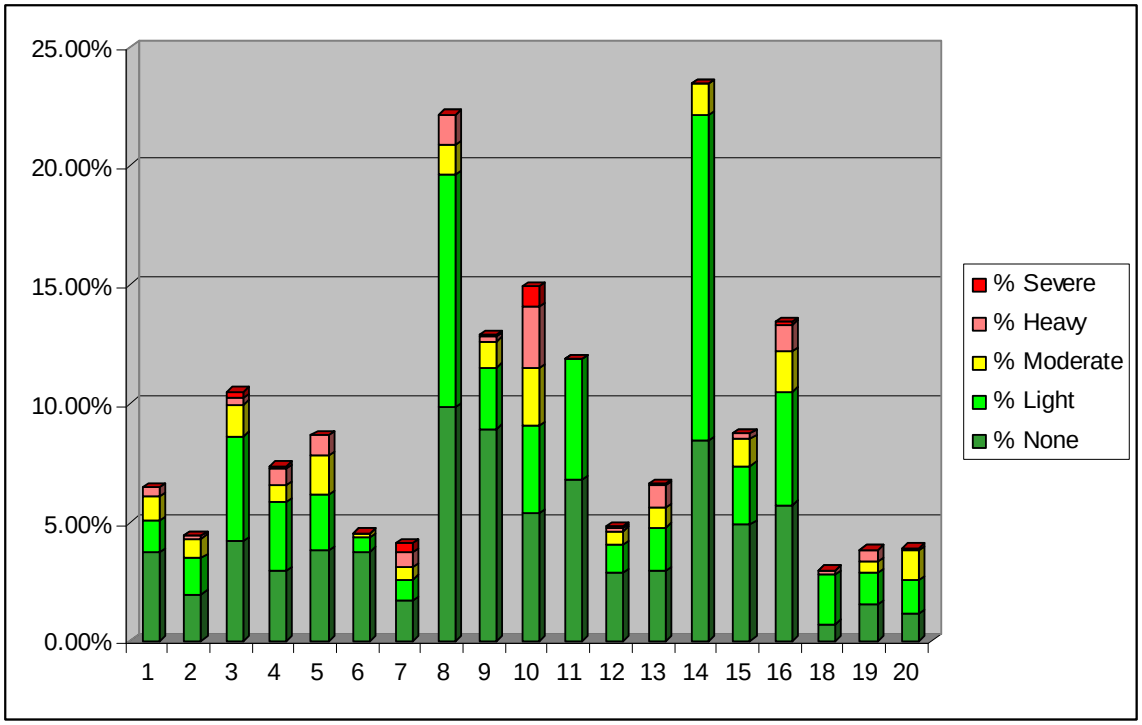
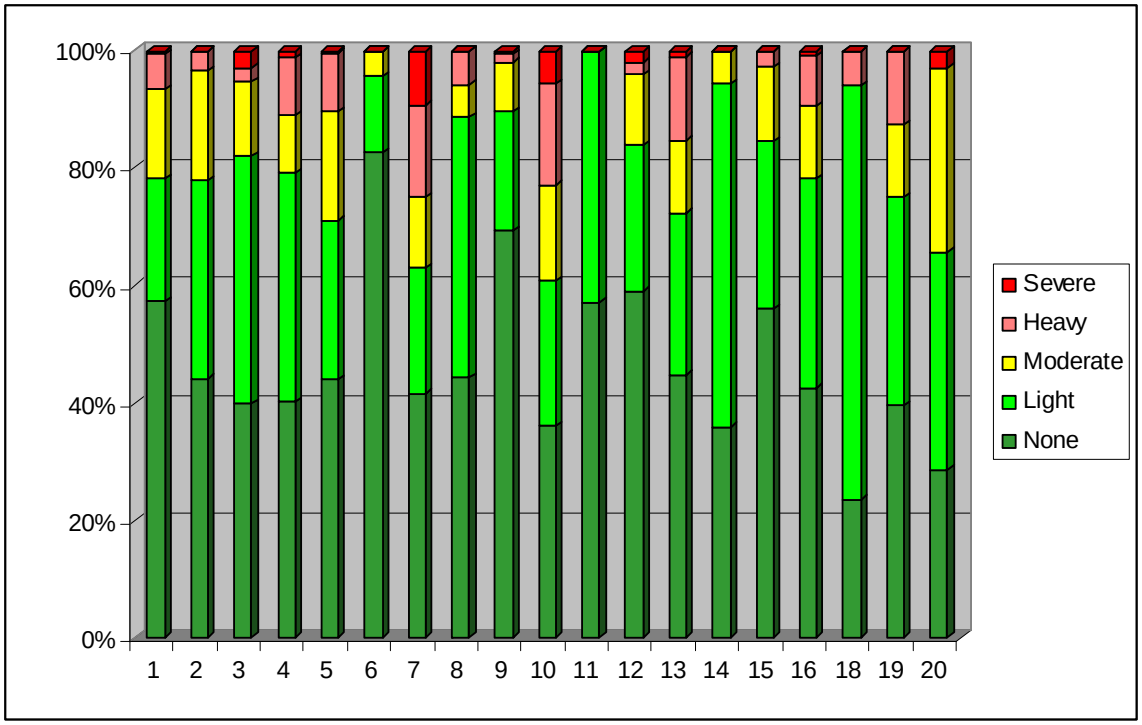
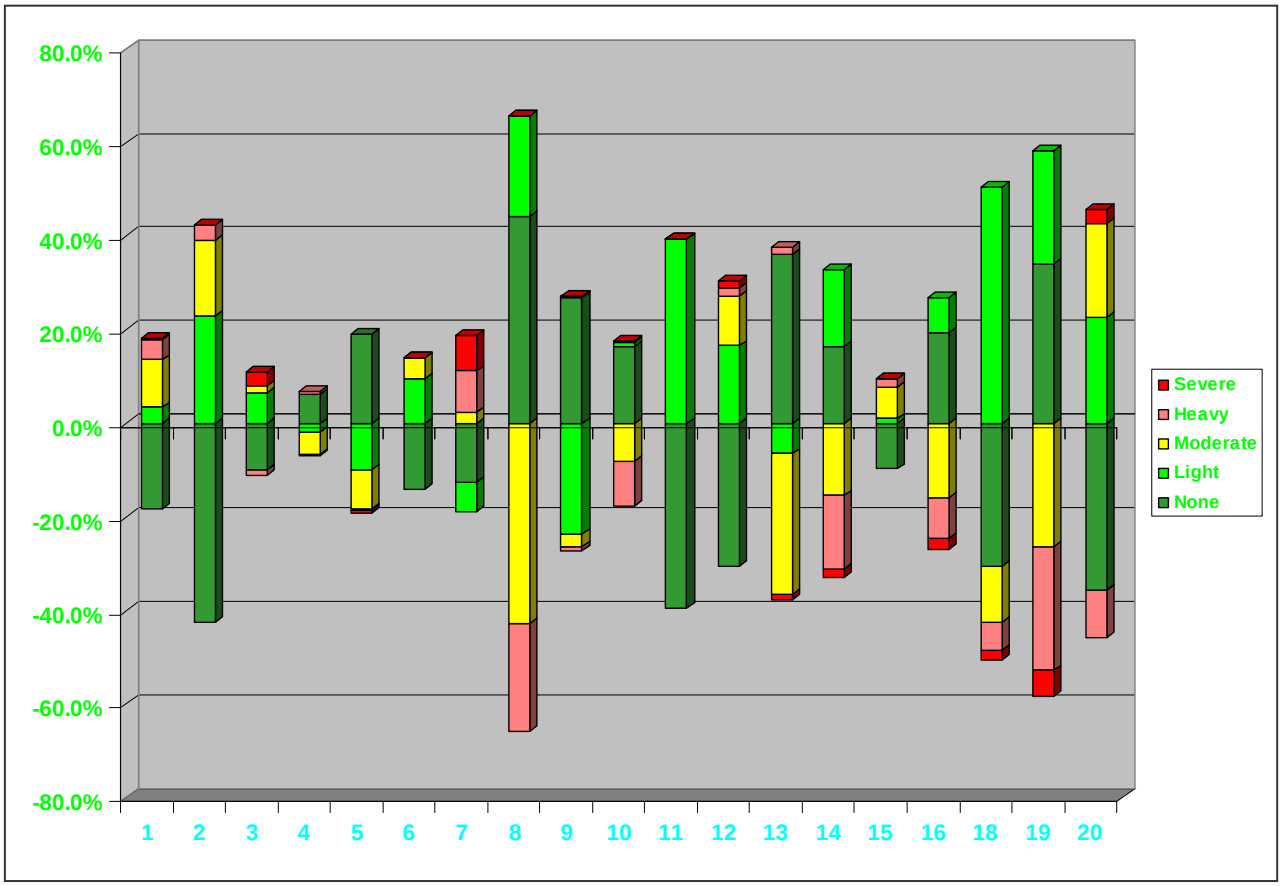


Figure 5. Proportion of red maple (*Acer rubrum*) within each browsing category by forest district – 2007.



As with the changes in browsing for all species above, Figure 6 compares the changes in browsing intensity on red maple by district. This only represents the change in percentages of plots distributed among the five browsing categories, not the abundance of red maple on the plots. To get a more complete picture of the status of browsing and regeneration on red maple, this figure should be used in conjunction with Figure 4. On Districts 14 and 8, for example, red maple occurred on > 20% of the vegetative sampling plots, and >50% of the browsing on it had also shifted from more severely browsed categories to either "light" or "none," indicating a reduction in browsing pressure. On District 7, in contrast, red maple occurred on <5% of the plots, but 20% of the plots where it did occur showed a switch from the two lighter browsing categories to the more severe. Districts showing reductions in browsing on red maple were Districts 4, 5, 8, 9, 10, 13, 14, 16, and 19. Districts 1, 2, 3, 6, 7, 11, 12, 15, and 20. Districts 18 showed more overall increase in browsing, but the major change was in more plots being classified as "light" with reductions in "none" and all the heavier categories. Red maple occurred on <3% of the plots in District 18, so this indicator probably has little significance at this point in District 18.

Figure 6. Change in browsing of red maple (*Acer rubrum*) by forest district – 2007.



Management Implications

As we continue to monitor the deer browsing and regeneration on the state forests in Pennsylvania, our knowledge of deer browsing preferences grows. Also, over time, we should gain a better understanding of the changes in species composition in the forest understory as these forests recover from a legacy of long-term overbrowsing by deer. Species less abundant on the plots, but highly preferred by deer, should begin to show in greater abundance and become the focus of browsing over time, when food is readily available and deer can select the most palatable and nutritious food sources. Species like common elderberry (*Sambucus canadensis*) and American yew (*Taxus canadensis*) fall into this category.

Next to the highly preferred species that have been greatly reduced in abundance by white-tailed deer browsing, the best long-term indicator of forest sustainability related to deer browsing is the percentage of plots adequately stocked. This indicator is particularly useful for professional foresters who are very involved in monitoring stocking related to timber harvest on a regular basis, and this indicator has direct relevance to their management decision-making processes.

Changes in the proportions of plots containing desirable, undesirable, or no woody regeneration are good short-term indicators in an ecosystem beginning recovery from long-term overbrowsing, where the species composition in the forest understory is reduced in diversity, especially of the preferred plant species. Starting from a baseline of a totally denuded understory, one would expect to see increases in the number of plots with undesirable species and reductions in the plots with no woody regeneration first. Unless, of course, deer were totally removed from the system like within a deer deterrent fence, in which case the desirable species would begin to appear at the same time. Next, typically, as more deer food became available on the landscape, the desirable species would begin to appear, as undesirables continued to increase and plots with no woody regeneration continued to decrease. At some point in sustainability, a balance point might be reached where the relative proportions of desirable and undesirable woody species would stabilize. At this point, the monitoring indicators should be focused on certain preferred species to track trends in deer browsing and ensure that a balance is maintained.

The indicator tracking overall change in browsing intensity across all species is most useful for monitoring short-term change at broad spatial scales. In the long-term, species shifts could confound the interpretation of these changes in browsing intensity. This is a good indicator, however, to assess the impacts of annual changes in management at a broad scale, like the effects of a bad weather event during the rifle hunting season, or a reduction in hunting opportunity through shortened seasons or license allocations.

The change in browsing of red maple is most useful short-term indicator in monitoring progress or negative change in annual browsing pressure from deer, and can be useful in adaptive management through the use of tools like the Deer Management Assistance Program. Increases in browsing may suggest increasing deer harvest, whereas reductions in browsing, if coupled with increases in regeneration and that the area being monitored is approaching overall sustainability goals, would suggest the latitude to reduce deer harvest and allow the herd to increase.

Overall, the trend is an improving one in most from 2006, although some districts are trending towards increased browsing pressure. Based upon the findings of all the indicators assessed, the districts which appeared to be sustainably regenerating were Districts 8, 11, and 14, with District 5 approaching that threshold. Districts with the most desirable woody vegetation ranked in descending order were Districts 11, 14, 8, 1, 19, 5, 9, 2, 16, 15, 10, 12, 4, 7, 20, 6, 18, 3, and 13. Districts 11 and 14 should be cautious, because the good current stocking there, when coupled with the reduction in plots (D14) with desirable regeneration or increases in browsing (D11) indicates a possible deer herd increase in response to the good habitat conditions. Districts

1, 5, 9, and 19 are high in desirable regeneration on the plots, although District 1 appears to be trending towards reductions in regeneration, if browsing trends towards less browsing. District 19 is showing the greatest positive change towards increased regeneration and reduced browsing. Districts 10 and 16 also trended strongly in a positive direction. District 15 seems to be stable, but in need of improvement. Districts 2, 6, 7, 8, and 12 appear to be increasing in browsing, while District 20 is improving in regeneration. Districts 3, 4, 13, and 18 appeared to have the greatest impact currently. Districts 4 and 13 are also troubling, with the greatest proportion of plots with no woody regeneration, and this is increasing in District 13.

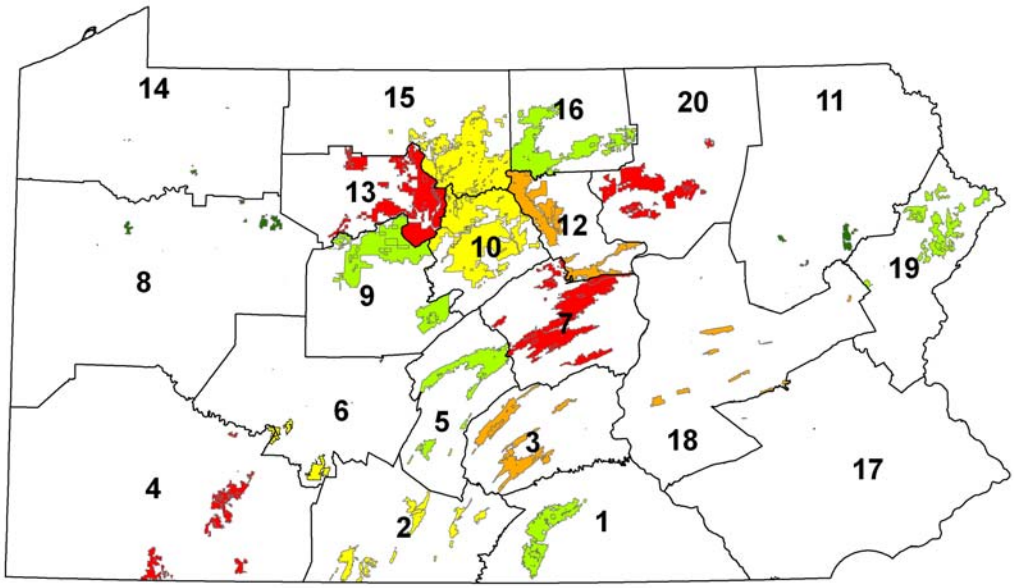
All forest districts were ranked for each of the indicators in order from least severe browsing and most sustainable to most severe browsing and least sustainable. These scores were tallied to compare the regenerative conditions among the districts (Table 6, Figure 7). A score of 1 indicated the most favorable conditions, a score of 19 the least. The browsing intensity categories were sorted first by the % "none" plus % "light" in descending order, then by the % "moderate" in descending order, then by the % "heavy" plus % "severe" in ascending order.

Table 6. Forest district ranking by indicators of browsing and regeneration – 2007.

District	% Adequately Stocked	% Desirable Regeneration	Change in % Desirable Regeneration	% None	Browsing Intensity - All Species	Browsing Intensity - Red Maple	Change in Browsing Intensity - Red Maple	Sum	Average
14	1	2	19	4	2	1	3	32	**4.571429**
11	3	1	12	1	8	3	11	39	**5.571429**
8	2	3	16	9	15	2	1	48	**6.857143**
9	7	7	4	13	5	4	10	50	**7.142857**
19	8	5	1	3	16	16	2	51	**7.285714**
16	9	9	3	17	9	5	5	57	**8.142857**
5	4	6	9	10	12	9	8	58	**8.285714**
1	5	4	18	7	3	11	17	65	**9.285714**
10	15	11	2	6	18	6	7	65	**9.285714**
15	11	10	10	16	4	8	14	73	**10.42857**
2	6	8	15	2	10	15	19	75	**10.71429**
6	14	16	11	15	1	13	13	83	**11.85714**
12	12	12	8	12	11	14	16	85	**12.14286**
18	18	17	13	8	7	17	6	86	**12.28571**
3	10	18	17	11	13	7	12	88	**12.57143**
13	17	19	6	18	14	12	4	90	**12.85714**
7	13	14	5	5	17	18	18	90	**12.85714**
20	19	15	7	14	6	19	15	95	**13.57143**
4	16	13	14	19	19	10	9	100	**14.28571**

Figure 7. 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
14	4.57
11	5.57
8	6.86
9	7.14
19	7.29
16	8.14
5	8.29
1	9.29
10	9.29
15	10.43
2	10.71
6	11.86
12	12.14
18	12.29
3	12.57
13	12.86
7	12.86
20	13.57
4	14.29



Major Findings and Accomplishments:

- At a system-wide level, the deer browsing preference index was further refined for the woody species observed, which is very useful for assessing indicators of browsing intensity.
- The system-wide proportion of plots with desirable regeneration rose from 24% to 28% and the proportion of plots with no woody regeneration dropped from 44% to 26%, indicating that browsing has not been down long enough for a widespread regeneration response, but progress is underway.
- On those plots with woody species present (74% of the plots), the majority of the woody stems (85%) observed were not browsed above the light category, although browsing intensity varied among and within forest districts.
- From all the various indices evaluated, several Districts exhibited some apparent changes. Notably, conditions worsened in Districts 1, 2, and 3. The regeneration showed improvement in District 19. Districts 8, 11, and 14 continued to show the lowest browsing impact and healthiest regeneration.
- 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.
- The Bureau of Forestry's foresters recently ranked the importance of the indicators monitored through this survey to provide additional feedback into the decision-making processes.
- These results will be used to continue to adapt the development of the Rapid Habitat Assessment Tool as tested by USGS through Penn State University. The new tool will modified and further tested, hopefully to 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.

Appendix I.

Instructions: Pellet Groups

1. Fill out the header on the data form. (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 , hip chain, or GPS.

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 (every 200' along the transect), each plot will be dot tallied in "Number of Plots" category. Record deer browsing impact on seedlings within the 6 ft. radius plot. Record data on seedlings over 2 inches in height.

2. A subjective assessment of each browsing plot will be made to determine if the plot is adequately stocked to regenerate successfully with desirable species of trees if the overstory were removed. Place the dot tally in the appropriate box.

3. Plots with desirable or undesirable woody vegetation only will be dot tallied under the columns "desirable" and "undesirable." Plots with both desirable and undesirable woody vegetation tally under the column labeled "both." Desirable Woody Vegetation – Any species of woody tree or shrub that *IS NOT* considered "competing vegetation" (it does not inhibit regeneration of other woody species in that area). Undesirable Woody Vegetation – Any species of woody tree or shrub that *IS* considered "competing vegetation" that inhibits regeneration of other woody species in that area (typically, this includes mountain laurel, beech brush, striped maple, but other species may be deemed "competing vegetation" locally

4. Plots with no desirable woody vegetation will be dot tallied under the column(s) best describing why the desirable regeneration is absent. (Competing vegetation – fern, striped maple, beech brush, grasses, mountain laurel,...) Multiple entries per plot are acceptable, if more than one factor is apparent.

5. When woody vegetation 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.

6. 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.

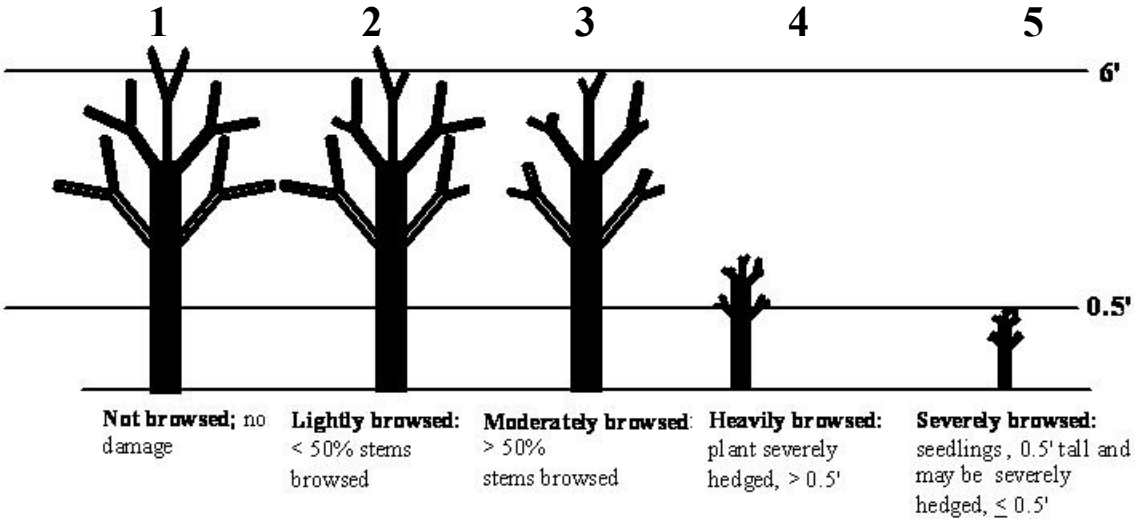
7. On a 1/20th acre plot (26.3' radius) tally all competing vegetation or factors where "light" = 0-25% ground cover, "moderate"= 26-50%, "heavy"=51-75%, and "severe"=76-100%. Also, count the number of competing factors on the plot in the last row of the datasheet.

Appendix I (continued).

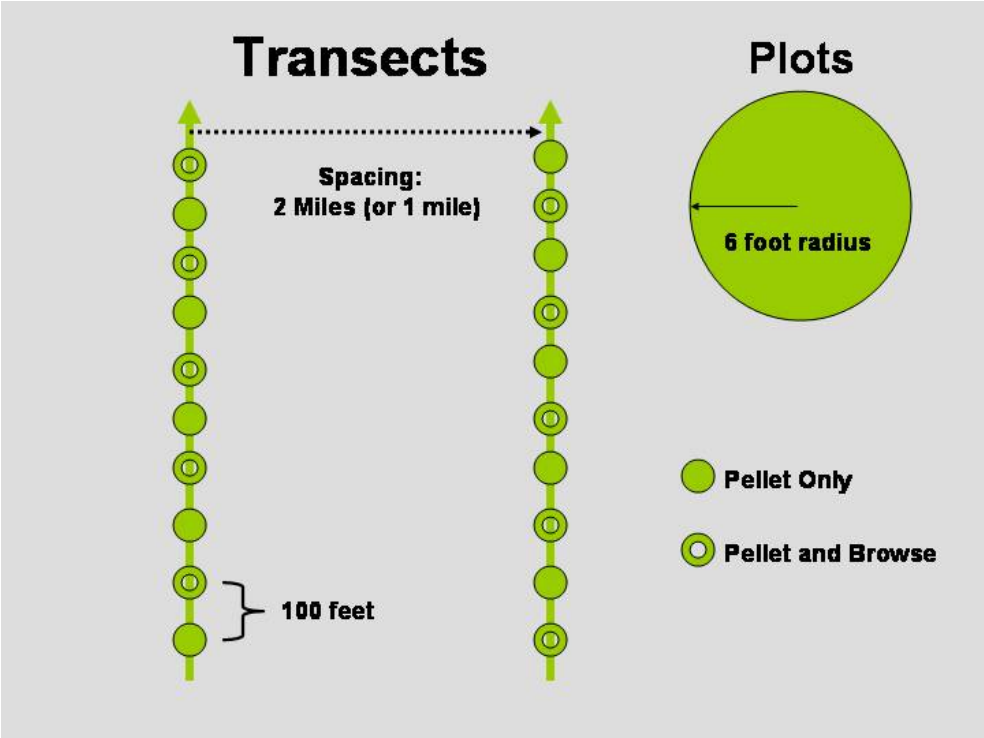
Recording dot tally:

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

Browsing Severity



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.**

Appendix I (continued).