Riparian Forest Buffer Survival and Success in Maryland

Maryland Department of Natural Resources
Forest Service

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Parris N. Glendening, Governor
Kathleen Kennedy Townsend, Lt. Governor
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Stanley K. Arthur, Deputy Secretary

Steven W. Koehn, Acting Director, Forest Service

Maryland Department of Natural Resources
Forest Service
Tawes State Office Building
580 Taylor Avenue
Annapolis, MD 21401
Phone 410-260-8531
TTY for the Deaf: 1-410-974-3683
http://www.dnr.state.md.us/forests

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Cover Photo – One-Year Old Riparian Forest Buffer Planting in Carroll County, MD

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Authors

Philip D. Pannill, Regional Watershed Forester, Western Region.
Anne B. Hairston-Strang, Ph.D., Forest Hydrologist, Annapolis, Maryland.
Charles E. Bare, formerly Regional Forest Hydrologist, Western Region.
David E. Robbins, Natural Resources Technician, Western Region.

Abstract

In order to determine the survival and success of planted riparian forest buffers in Maryland 130 randomly selected sites, 1 to 3 yrs. of age, were measured. Data were collected using 1/100th acre plots with a random-start systematic line-plot cruise at an overall average 3.3% sample intensity. Average stocking was 488 trees per acre, and the median stocking level was 434 trees per acre. Acceptable stocking (≥200 trees/acre) was found on 82% of sites. Preferred stocking levels (≥400 trees/acre) were found on 52% of sites. Natural regeneration made a significant contribution to stocking, in many cases augmenting planted stock sufficiently to achieve acceptable or preferred stocking levels. Average percent survival of planted trees was estimated to be 60%, with a median survival of 67%. Seventy-nine species of trees and shrubs were found within sample plots, with an average site having 8.2 species counted. The most common individual species was loblolly pine, though deciduous trees and shrubs made up 72% of stocking. Of the total stocking, 41% were planted seedlings without tree shelters, 11% were planted seedlings with tree shelters, 11% were balled and burlapped or containerized saplings, 36% were natural regeneration, and 1% were pre-existing trees within the planted areas. State-listed noxious weeds - thistles and Johnson-grass - were common (found on 68% of sites), as were invasive exotic plants such as multiflora rose, Japanese honeysuckle, mile-a-minute, and ailanthus (found on 72% of sites). The overall average degree of vegetative competition provided by weeds, grasses, and brush was rated as moderate, and there was an inverse relationship between the degree of competition and the survival of planted trees, but correlations were not close ($r^2 < 0.1$). Problems that affected survival and growth were identified at almost all sites (95%), with the principal problem being weed competition. Drought, deer, vines, machinery, and insects were lesser but still significant problems.

Contents

Figures, Tables

Acknowledgements

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Introduction

Riparian forest buffers are being planted around Maryland with the intent of improving water quality and habitat for living resources, spurred by the State's commitment in 1996 to plant 600 miles of new buffers by 2010. An initial measure of success is the survival of the newly established trees. The MD DNR Forest Service began a 2-year study of tree survival to quantify mortality rates and collect information that could be used to improve buffer design, installation, or maintenance. The first year, 1999, was dedicated to a pilot study (Pannill, 2000) in the Monocacy River and the Little Gunpowder Falls watersheds. The pilot study results were used to fine-tune the sampling methodology for the statewide data collection carried out in the summer of 2000. This report summarizes the results of this second phase of the study.

The purpose of this study was to determine the survival and success of riparian forest buffers planted in Maryland. It is anticipated that this information will provide those agencies and organizations involved in the establishment of riparian forest buffers with information on the overall success of these programs. It is also hoped that this information will enable foresters and land managers to more effectively plan and manage riparian forest buffer plantings.

Background

The primary issue in evaluating the success of planted riparian forest buffers is whether or not an adequate number of trees have been established to create forest-like conditions on the site within a reasonable period of time. Important aspects of this are the survival and growth of planted trees, i.e., are the trees and shrubs being planted successful, or are the effort and expense devoted to this being wasted. Related issues are the role of natural regeneration in supplanting or augmenting planted stock, and the relative benefits of using tree shelters and balled and burlapped or containerized saplings.

It is also important to understand the species makeup of these afforestation areas. The species may have an impact on the economic and ecological value of the buffer, and the future management expectations. It is also valuable to know which species tend to be successful and which should no longer be planted in certain situations, if at all.

One issue of concern in afforestation areas is noxious weeds. Maryland law (Annotated Code of Maryland, 1999) declares certain biennial thistles, including musk thistle (*Carduus nutans)*, plumeless thistle (*Carduus acanthiodes),* bull thistle (*Cirsium vulgare)*; the perennial Canada thistle (*Cirsium arvense*); Johnson-grass (*Sorghum halapense)*; and shattercane (*Sorghum bicolor*) to be noxious weeds. In addition to certain other restrictions, this law requires the owner or manager of the land to eradicate or control these weeds to prevent their spread, and provides for penalties for non-compliance. Shattercane is almost never found in afforestation areas. The biennial thistles are primarily a concern due to the legal requirement for their control, though a heavy infestation can compete with small seedlings. Canada thistle and Johnson-grass, however, can form dense colonies with extensive root systems that severely compete with young trees, usually resulting in loss of seedling vigor and often causing mortality.

Aside from the legal requirement, there are concerns regarding the stigma of having these weeds present in the afforestation area, possible spread to other parts of the property or neighboring properties, cost of control, and negative impacts of control once the trees are planted, (i.e., damage to seedlings from mowing or spraying).

Invasive exotic plant species have been the focus of greater attention in recent years. Federal agencies are instructed to take measures to prevent and limit the spread of exotic invasive plants (Clinton, 1999). Exotic invasive plants have the potential to degrade ecological functions or economic, recreational, or aesthetic values, and exclude native species. They may also compete with desirable planted or natural tree and shrub regeneration. Certain species such as multiflora rose (*Rosa multiflora*), Japanese honeysuckle (*Lonicera japonica*) and mile-a-minute (*Polygonum perfoliatum*) have been identified as being both damaging and strongly invasive in Maryland (Cooley, 1993). Exotic herbaceous weeds, trees, shrubs and vines are of concern not only from the ecological aspect, but can also impair or out-compete desirable planted or natural regeneration.

Problems such as vegetative competition, deer, insects or disease can affect the success of afforestation efforts. Identifying and quantifying the problems associated with these efforts can help improve success through better planning and management.

Species choices and survival are affected by general climate, physiography, and land use, which vary among the regions used in this study. Maryland has a moderate climate with average annual temperature of 55°F. Precipitation averages 40.8 inches with 20.6 inches as snow, distributed throughout the year. Frost-free days average 185 per year, ranging from 130 days in the far western region to 230 days in the Southern and Eastern regions. The Western Region includes the Ridge and Valley, Blue Ridge, and Appalachian Plateau physiographic provinces, forested mountainous areas with shale, siltstone, and sandstone and some karst/limestone areas in valleys, where agricultural use is concentrated. Temperatures are colder (53°F annual average in Hagerstown) and snow is a greater portion of the precipitation than in other regions (29.7" of snow). The Central Region is predominately Piedmont province, with rolling hills, fine-textured soils, and substantial urbanization in the Baltimore-Washington corridor. The Southern Region includes the Piedmont and Coastal Plain provinces, with greater relief than Eastern Shore Coastal Plain sediments. The Eastern Region is in the Atlantic Coastal Plain province, with low relief, deep alluvial sediments, and agriculture and forestry as common land uses.

Methods

During the summer of 2000, one hundred and thirty riparian forest buffer sites were identified and inspected for survival and success. These sites were randomly selected from a statewide database of riparian forest buffers planted in Maryland from 1997 – 1999. These sites were well distributed across the state, with 23 sites in Western Region, 39 sites in Central Region, 31 sites in Southern Region, and 37 sites in Eastern Region (Figure 1). The sites surveyed ranged in size from 0.3 acres to 21.35 acres, with the total area of all sites being 633.6 acres and the average size being 4.87 acres. Information from records and maps were used to determine acreages, stand age, initial planting density (number of trees planted), and species planted.

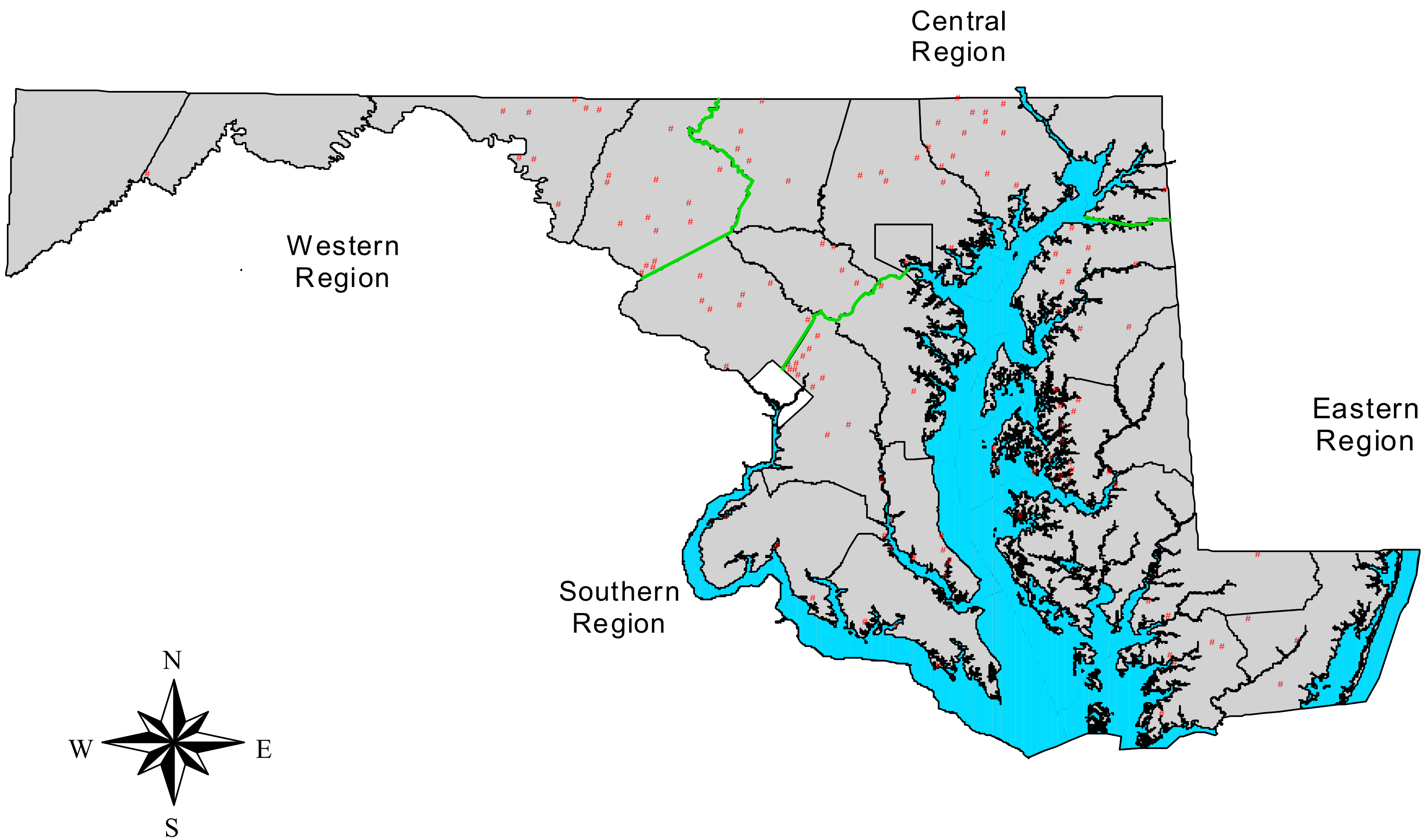
Sampling was done using 1/100th acre plots, having a radius of 11.78 feet. This was deemed large enough to capture planted trees at the widest spacing used, yet small enough to be quickly measured in difficult conditions. A systematic line-plot cruise was used to select plot locations, with a randomly located starting point for the first plot in order to avoid bias in plot selection. This method was tested during the 1999 pilot phase and was deemed to be the most manageable sampling technique, and statistically appropriate since an estimate of the mean is the primary inventory objective (Wenger, 1984). It has the advantage of familiarity to foresters, as well as being simple to convey in training new people. Statistical validity was established using 1999 data, with paired two-sample T-tests used to test a 95% probability that the sample estimates were different than the 100% tally density. None of the sample estimates (ranging from 2.5 to 20% sample) of tree density could be statistically distinguished from a 100% tally count (Pannill, 1999). The sampling method yielding estimates closest to the 100% tally density (and highest p-value, 0.26, for rejecting the hypothesis of different densities) was lines 4 chains apart (264 ft) and plots ½ chain apart (33 ft) along the lines. This method, which gives an average 5% sampling intensity, was selected as a target to collect information on average sized sites, 1-10 acres. On smaller sites (<1 acre), the plot and line distribution was adjusted to achieve a targeted 10% sampling intensity, while on larger sites (>10 acres) a 2.5% sampling intensity was planned. Prior recommendations (MD Dept. of Forests and Parks, 1965) indicated that a sampling intensity of 10% was appropriate for areas less than 1 acre, with a lesser percentage sampled for larger areas. Sampling intensity, weighted by acres, for the measured sites averaged 3.3%.

A total of 2,289 plots were measured on the 130 sites. At each plot information was collected on the number of trees and shrubs, species, type of planting stock, natural regeneration, noxious weeds, invasive exotic weeds, vegetative competition, and any problems that were impairing the survival and growth of the planted trees. Only the ten tallest trees in each plot were counted, since this would represent a stocking of 1000 trees per acre, more than enough to meet stocking needs.

It was determined that 400 trees per acre would be considered the preferred stocking level and 200 trees per acre would be considered a minimum acceptable stocking. This determination was based on past policies (Maryland Dept. of Forests and Parks, 1965), current spacing practices, review of other reforestation studies (Schweitzer, 1998), and criteria for funding programs such as the Conservation Reserve Enhancement Program

Figure 1.

Locations of Riparian Forest Buffer Sites Sampled



Map by: Ranger K. Moore

(USDA-NRCS, 2000) and the Buffer Incentives Program (MD DNR 1991). As part of the 1999 pilot study, evaluation of the height growth of trees (1.84 ft/yr annual average) found on riparian forest buffer sites indicated that sites with a stocking of 200 trees per acre should achieve crown closure in about 10 years. Similarly, the preferred survival rate was set at ≥ 65% of the original planting density, based on past and current policies and funding program guidelines.

Results

Data for the 130 sites measured were segregated and analyzed on the basis of individual sites, counties, regions (Western Region = Garrett, Allegany, Washington, and Frederick Counties; Central Region = Carroll, Baltimore, Howard, Montgomery, Harford, and Cecil Counties; Southern Region = Prince George's, Anne Arundel, Calvert, Charles, and St. Mary's Counties; Eastern Region = Kent, Queen Anne's, Talbot, Caroline, Dorchester, Wicomico, Somerset, and Worchester Counties). Data were also segregated between rural and urban/community sites, due to the differences in site conditions, planting stock types, spacing, and maintenance practices sometimes found on urban/community sites such as parks, schools, roadsides, and community common areas. Reference to "trees" includes shrubs unless otherwise indicated. Reference to "weighted" figures indicates averages weighted proportionally on a per acre basis.

Planting Density

The number of trees per acre initially planted varied from 67 to 1250 per acre, with an average planting density statewide of 511 trees/acre (502 trees/acre weighted). One site had no trees planted, relying totally on natural regeneration. Eastern and Southern Regions had higher average planting densities (580 & 491 trees/acre un-weighted, and 548 & 638 trees/acre weighted, respectively). Western and Central Regions had planting densities in the range of 414 - 485 trees/acre.

In some cases there was great difficulty in accurately establishing the number of trees per acre actually planted on each site. Often the planting plans, seedling order forms, RFB reporting forms, and landowners or foresters recollections gave different information. In some cases volunteers, contractors or landowners planted more or less trees than expected. The acreages reported for some sites varied from those observed in the field, affecting density where a given number of trees were planted on the site regardless of spacing. On some sites random planting (not in rows) and tall weeds made it impossible to use estimation of spacing for determining an intended planting density. Also, replanting in subsequent years did not always replace only dead trees on a one-for-one basis, thus increasing stocking above the initial planting density. These circumstances make accurate determination of survival rates problematic.

Stocking

Stocking, the total number of trees per acre, was a count of all planted trees, natural regeneration, and pre-existing trees within the planted area. Pre-existing riparian forest between the planting site and the waterway was not included in measurements. Stocking of individual sites ranged from 0 to over 1,000 trees per acre, with a weighted average of 488 trees per acre and a median of 434 trees per acre (Figures 2a-2e). This does not include "extra" trees where there were more than 10 trees per $1/100^{th}$ acre plot, so the maximum measurable stocking would be in the range of 1000 trees per acre. Both the statewide average and median stocking were above the preferred stocking level of 400 trees per acre. On a regional basis, every region had weighted stocking levels above 400 trees per acre, though Central and Southern Regions had median and un-weighted averages below 400, due to lower average stocking on the smaller (mostly urban) sites. Eighteen percent of sites had stocking levels below 200 trees per acre, and fifty-two percent of sites had stocking above 400 trees per acre.

Most sites (82.3%) had over 200 trees/acre stocking, and the inclusion of natural regeneration was needed to reach this minimum level on 21% of these. Sixty-eight sites, or 52%, had stocking above 400 trees per acre, and natural regeneration was needed to reach this desirable stocking level on 65% of those. Without the contribution of natural regeneration the average stocking levels for all regions would be below the preferred stocking. Urban/Community sites generally had lower stocking rates than rural sites (Table 1). This is partially due to the lower planting density on some sites where B&B and containerized saplings were planted at a wider spacing, partly due to site conditions and maintenance practices that discourage natural regeneration, and may also reflect the special problems associated with these urban sites. Seven of the urban/community sites (20%) had stocking below 100 trees per acre.

Table 1. Relative Stocking of Urban/Community and Rural Sites Statewide. Number of sites and % by site type.

Stocking (trees/acre)	**Urban/Com. Sites**	**Rural Sites**	**All Sites**
< 100	7 (20%)	2 (2%)	9 (7%)
100 - 200	8 (24%)	6 (6%)	14 (11%)
200 - 400 (*acceptable stocking)*	9 (26%)	30 (31%)	39 (30%)
> 400 (*preferred stocking)*	10 (29%)	58 (60%)	68 (52%)
Total	34 sites	96 sites	130 sites

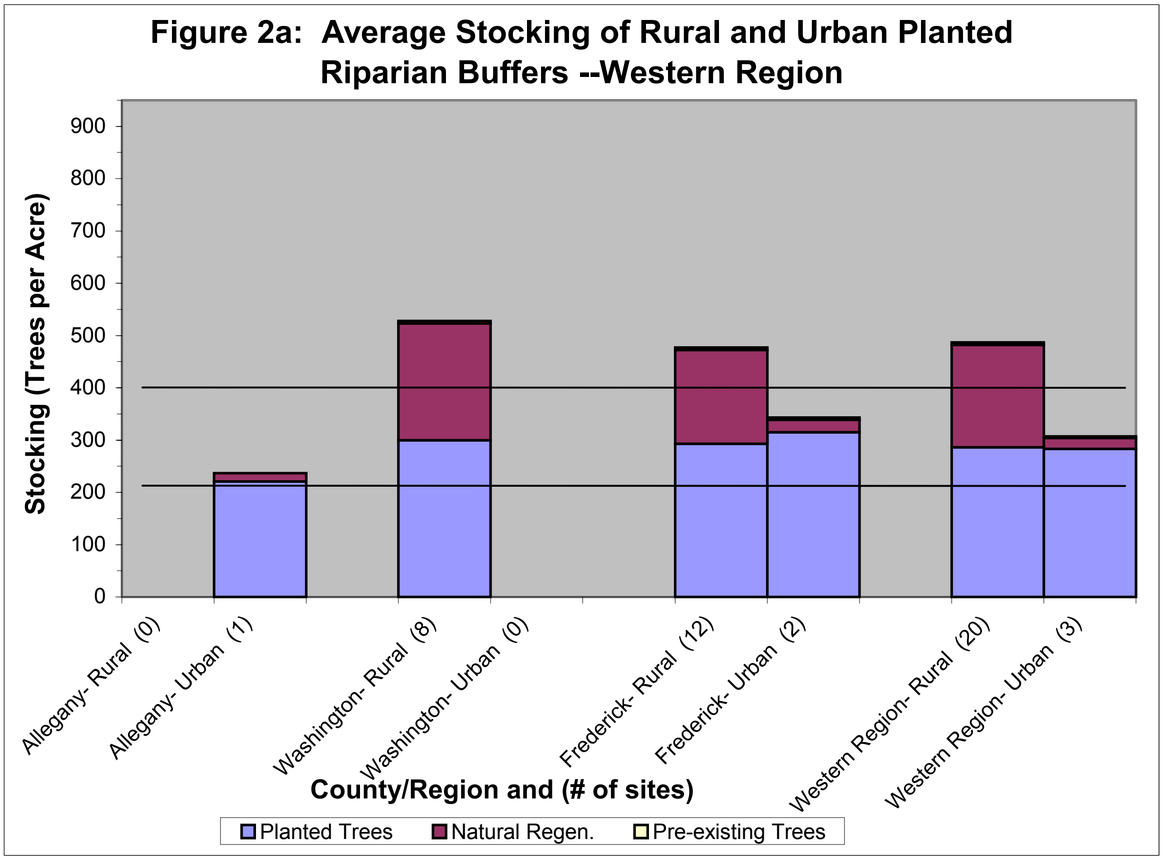


Figure 2a: Average Stocking of Rural and Urban Planted Riparian Buffers --Western Region
Stocking (Trees per Acre)
900
800
700
600
500
400
300
200
100
0
Allegany- Rural (0)
Allegany- Urban (1)
Washington- Rural (8)
Washington- Urban (0)
Frederick- Rural (12)
Frederick- Urban (2)
Western Region- Rural (20)
Western Region- Urban (3)
County/Region and (# of sites)
Planted Trees
Natural Regen.
Pre-existing Trees

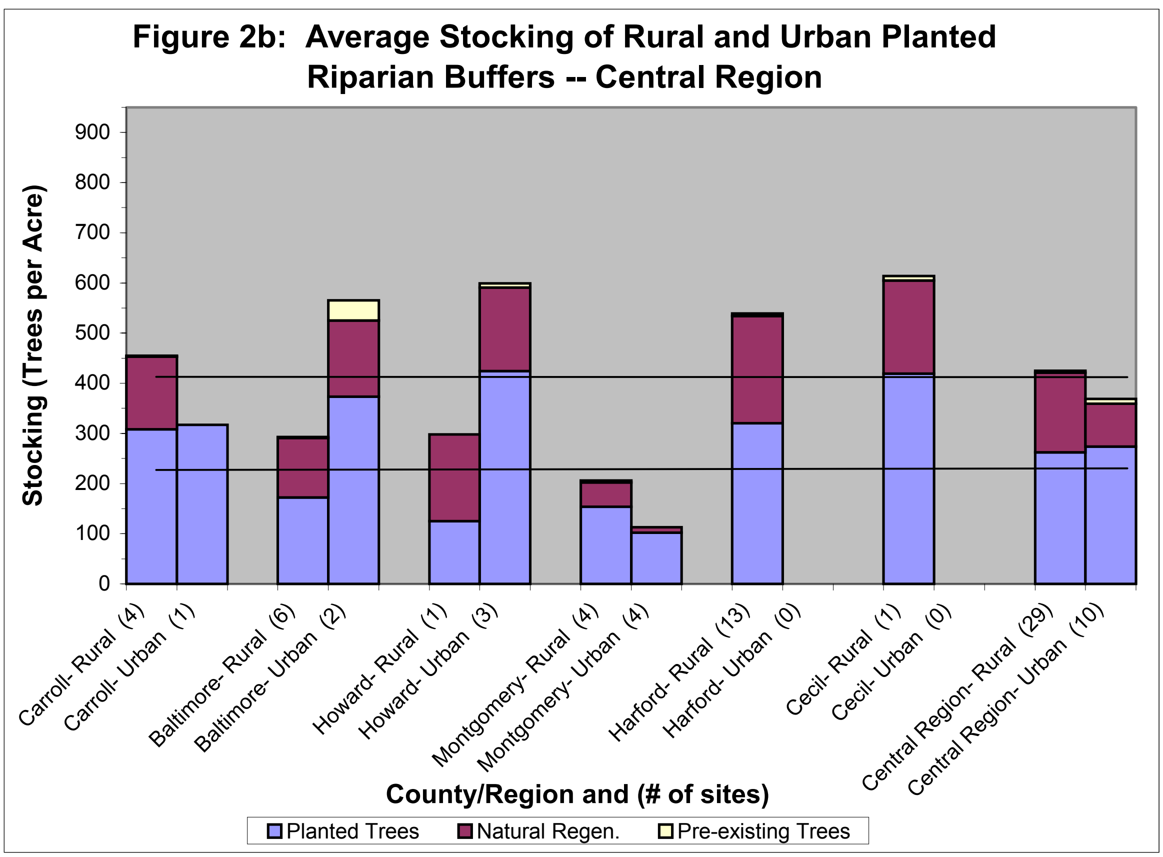


Figure 2b: Average Stocking of Rural and Urban Planted Riparian Buffers -- Central Region
Stocking (Trees per Acre)
900
800
700
600
500
400
300
200
100
0
Carroll- Rural (4)
Carroll- Urban (1)
Baltimore- Rural (6)
Baltimore- Urban (2)
Howard- Rural (1)
Howard- Urban (3)
Montgomery- Rural (4)
Montgomery- Urban (4)
Harford- Rural (13)
Harford- Urban (0)
Cecil- Rural (1)
Cecil- Urban (0)
Central Region- Rural (29)
Central Region- Urban (10)
County/Region and (# of sites)
Planted Trees
Natural Regen.
Pre-existing Trees

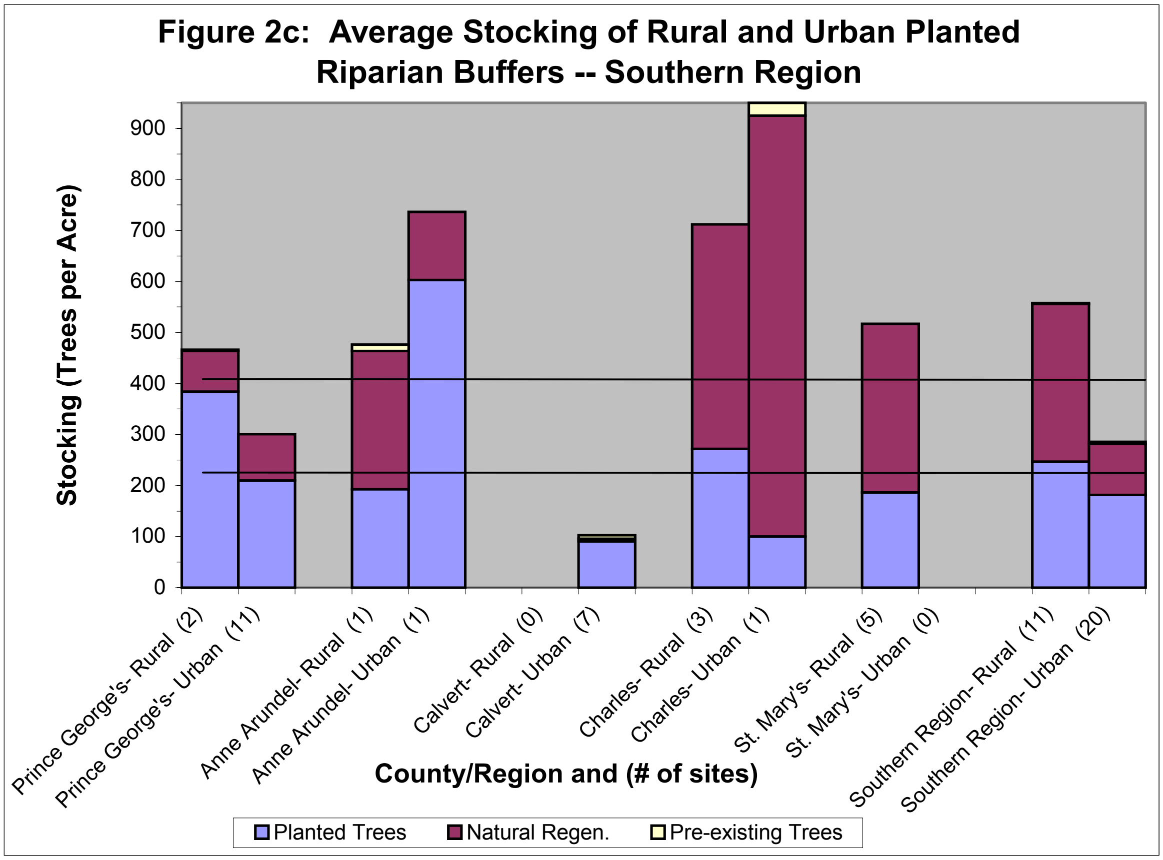


Figure 2c: Average Stocking of Rural and Urban Planted Riparian Buffers -- Southern Region
Stocking (Trees per Acre)
0
100
200
300
400
500
600
700
800
900
Prince George's- Rural (2)
Prince George's- Urban (11)
Anne Arundel- Rural (1)
Anne Arundel- Urban (1)
Calvert- Rural (0)
Calvert- Urban (7)
Charles- Rural (3)
Charles- Urban (1)
St. Mary's- Rural (5)
St. Mary's- Urban (0)
Southern Region- Rural (11)
Southern Region- Urban (20)
County/Region and (# of sites)
Planted Trees
Natural Regen.
Pre-existing Trees

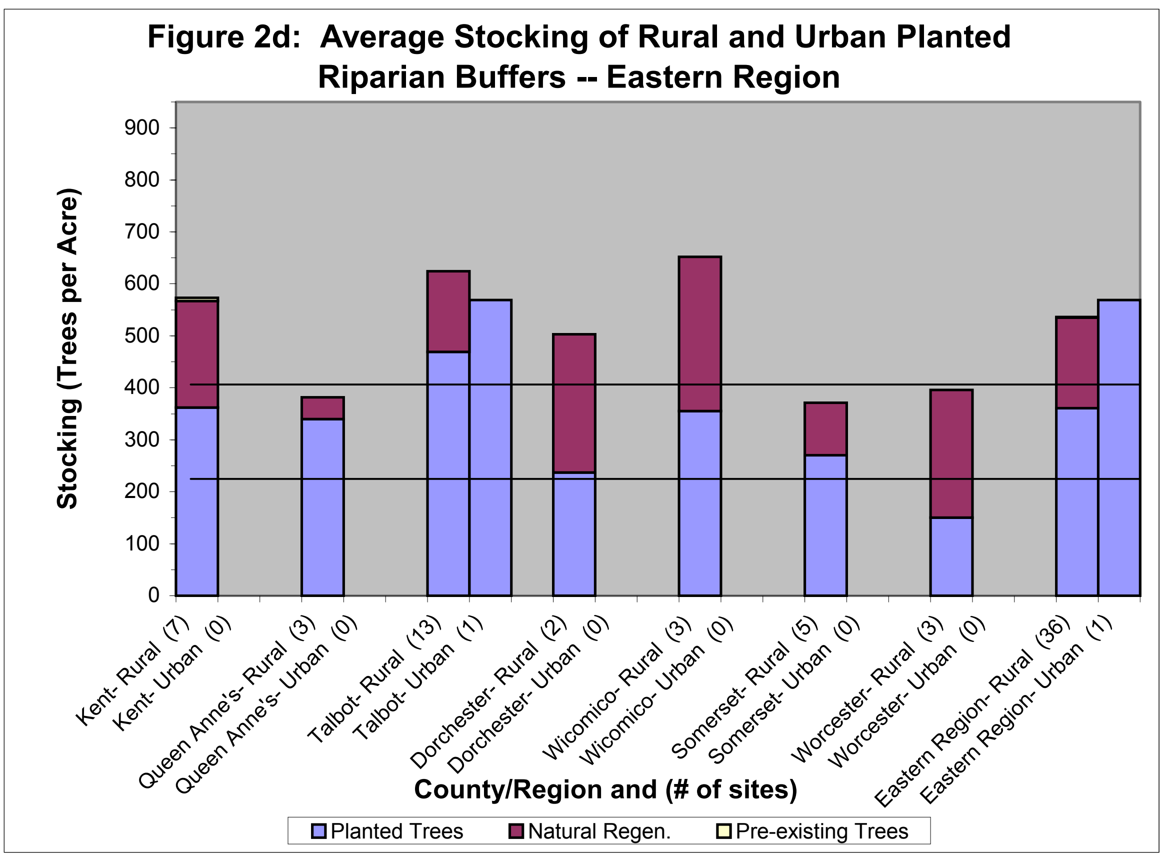


Figure 2d: Average Stocking of Rural and Urban Planted Riparian Buffers -- Eastern Region
Stocking (Trees per Acre)
0
100
200
300
400
500
600
700
800
900
Kent- Rural (7)
Kent- Urban (0)
Queen Anne's- Rural (3)
Queen Anne's- Urban (0)
Talbot- Rural (13)
Talbot- Urban (1)
Dorchester- Rural (2)
Dorchester- Urban (0)
Wicomico- Rural (3)
Wicomico- Urban (0)
Somerset- Rural (5)
Somerset- Urban (0)
Worcester- Rural (3)
Worcester- Urban (0)
Eastern Region- Rural (36)
Eastern Region- Urban (1)
County/Region and (# of sites)
Planted Trees
Natural Regen.
Pre-existing Trees

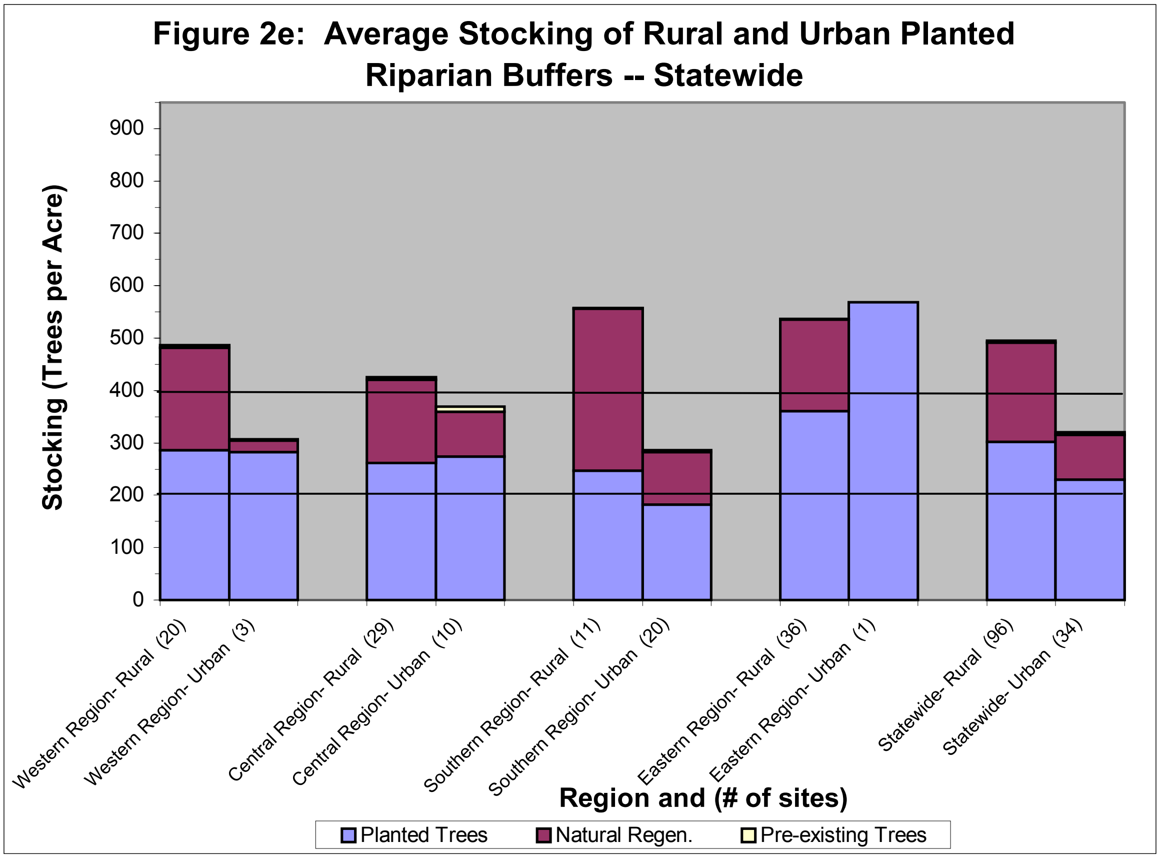


Figure 2e: Average Stocking of Rural and Urban Planted Riparian Buffers -- Statewide
Stocking (Trees per Acre)
900
800
700
600
500
400
300
200
100
0
Western Region- Rural (20)
Western Region- Urban (3)
Central Region- Rural (29)
Central Region- Urban (10)
Southern Region- Rural (11)
Southern Region- Urban (20)
Eastern Region- Rural (36)
Eastern Region- Urban (1)
Statewide- Rural (96)
Statewide- Urban (34)
Region and (# of sites)
Planted Trees
Natural Regen.
Pre-existing Trees

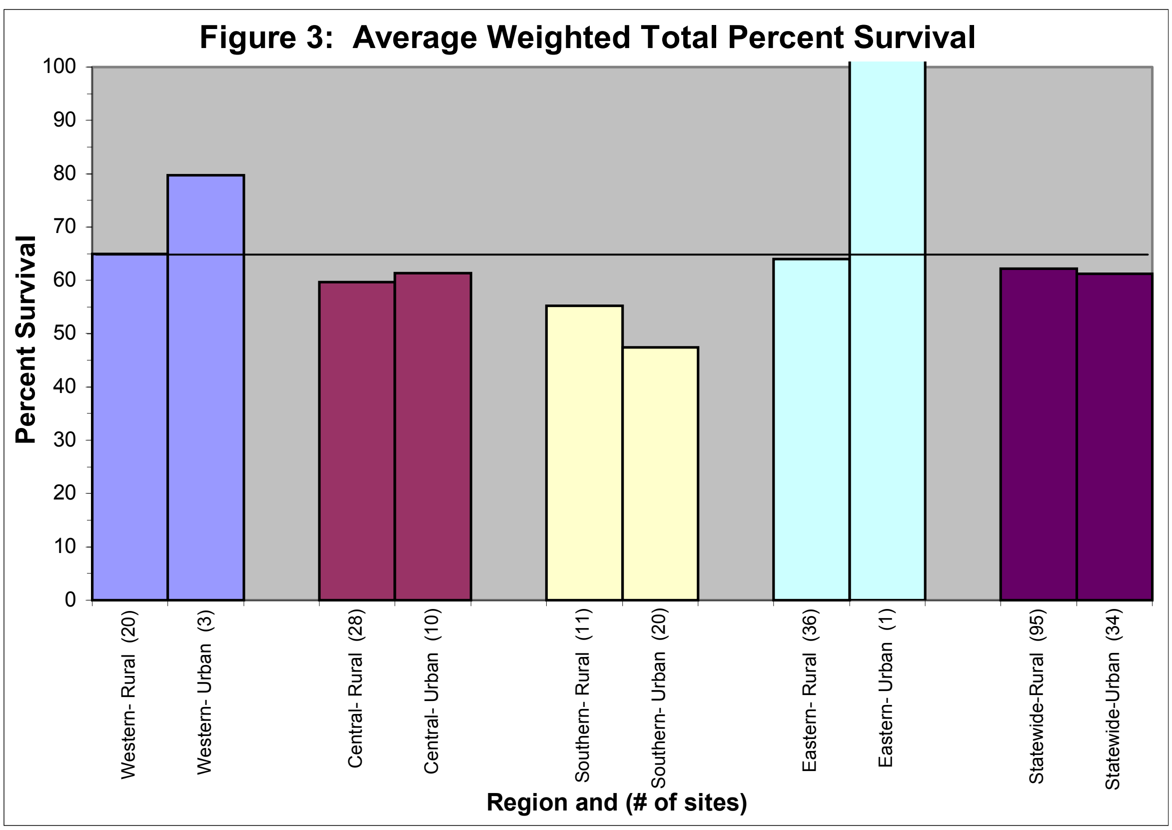


Figure 3: Average Weighted Total Percent Survival
Percent Survival
100
90
80
70
60
50
40
30
20
10
0
Western- Rural (20)
Western- Urban (3)
Central- Rural (28)
Central- Urban (10)
Southern- Rural (11)
Southern- Urban (20)
Eastern- Rural (36)
Eastern- Urban (1)
Statewide-Rural (95)
Statewide-Urban (34)
Region and (# of sites)

Survival
The survival rate was more difficult to determine than stocking. In many cases it was difficult to determine the exact number of trees per acre originally planted, as discussed in Planting Density, above. Due to these factors survival may sometimes be overestimated, but would not as likely be underestimated, especially since the action of replanting, sometimes repeatedly, tends to mask the mortality. The percent survival determined for planted trees ranged from 0% to over 100%, with sites over 100% being within the range of sampling error, mistakenly counting natural regeneration for planted trees, and/or incorrect information on planting density. The weighted average survival rate was 60% and the median was 67% (Figure 3). Survival rates were fairly consistent between regions, ranging from 54% in Southern Region to 66% in Western Region. There was little difference in the overall survival rates between Urban/Community and Rural planting sites, but individually Urban/Community sites were more likely to have very poor survival (Table 2).

Table 2. Relative Survival of Urban/Community and Rural Sites Statewide. Number of sites and percent by site type.

Survival of Planted Trees	Urban/Com. Sites	Rural Sites	All Sites
Less than 20% survival	7 (20%)	9 (9%)	16 (12%)
20 - 65% survival	10 (29%)	38 (40%)	47 (36%)
≥ 65% survival – *(preferred level)*	17 (50%)	48 (50%)	66 (51%)
Total	34 sites	95 sites	129* sites

* One site had no trees planted, natural regeneration only.

Comparisons were made between sites with planted by different categories of persons, different types of site preparation, and different types of maintenance. Information was sometimes limited, and other variables affecting survival could not be discounted. While actual recommendations need to be made on a site-specific basis, some general trends can be observed.

- For those 125 sites where the planter was known, average survival for the 80 contractor-planted sites was 61%, for the 33 volunteer-planted sites was 58%, and for the 12 landowner-planted sites was 79%.

- For those 87 sites where the site prep (or lack thereof) was known, average survival for the 2 chemically prepared sites was 54%, for the 68 mowed-only sites was 62%, for the 2 sites with both mowing and chemical preparation survival was 75%, and for the 15 sites with no site-prep survival averaged 67%. The absence of active site preparation may have been due to a determination that existing site conditions would allow successful planting.

- For those 105 sites where the maintenance (or lack thereof) was known, average survival for the 15 chemically treated sites was 69%, for the 43 mowed-only sites was 64%, for the 11 sites with both mowing and chemically maintenance survival was 77%, for the 6 mulched-only sites was 47%, and for the 30 sites with no significant vegetative competition maintenance survival averaged 47%.

Figure 4a: Percent of Total Stocking by Species -- Western Region

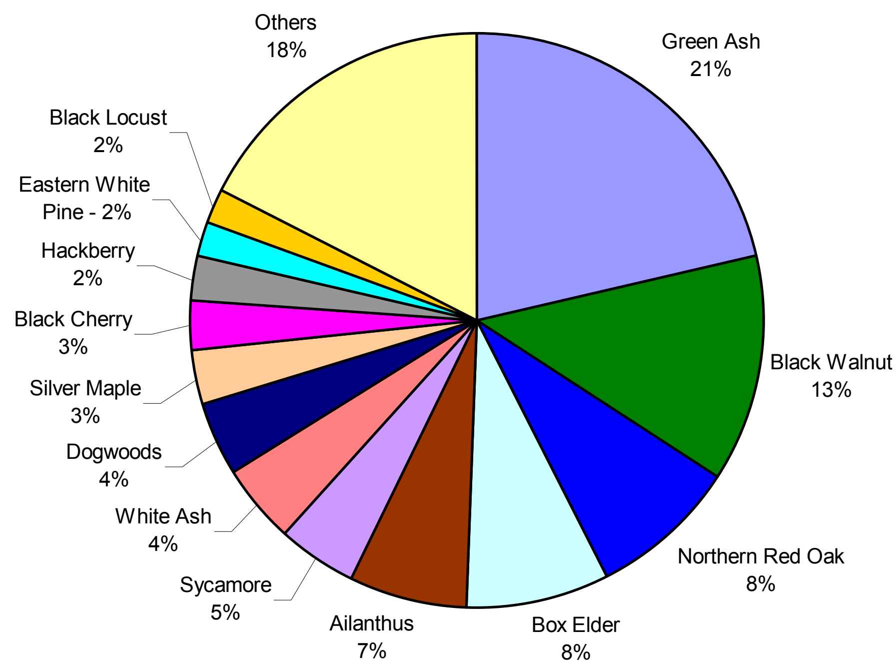


Figure 4b: Percent of Total Stocking by Species -- Central Region

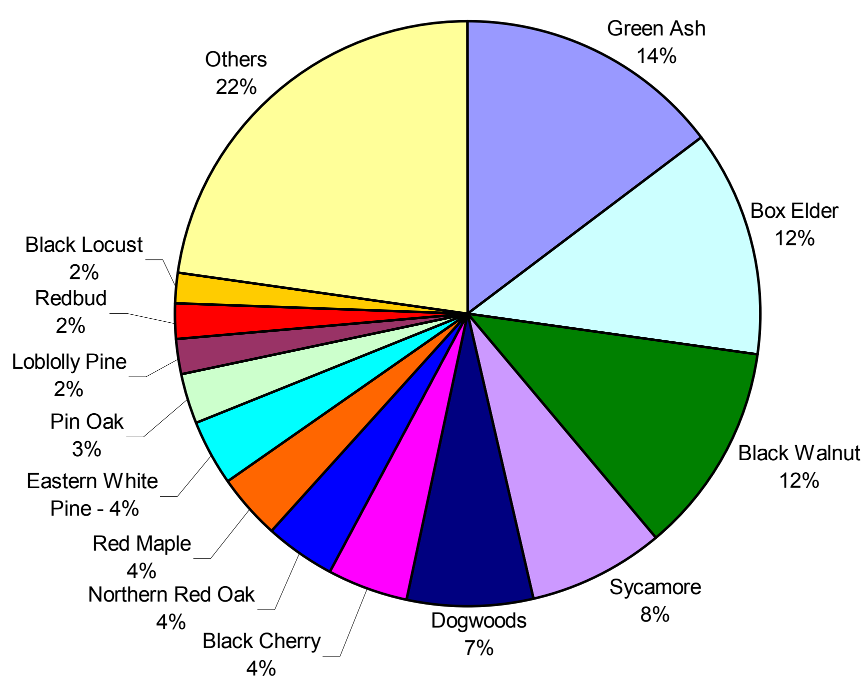


Figure 4c: Percent of Total Stocking by Species -- Southern Region

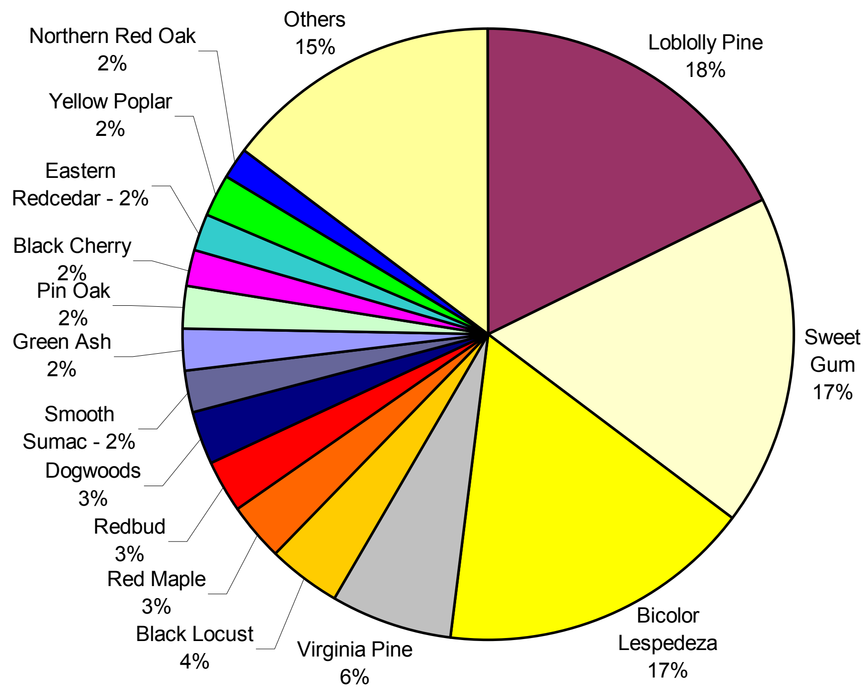
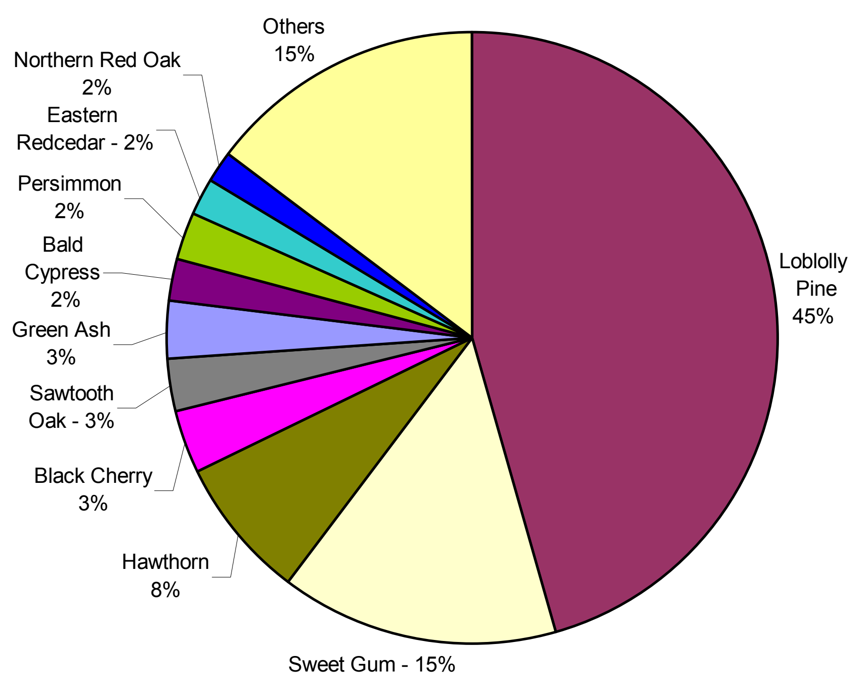
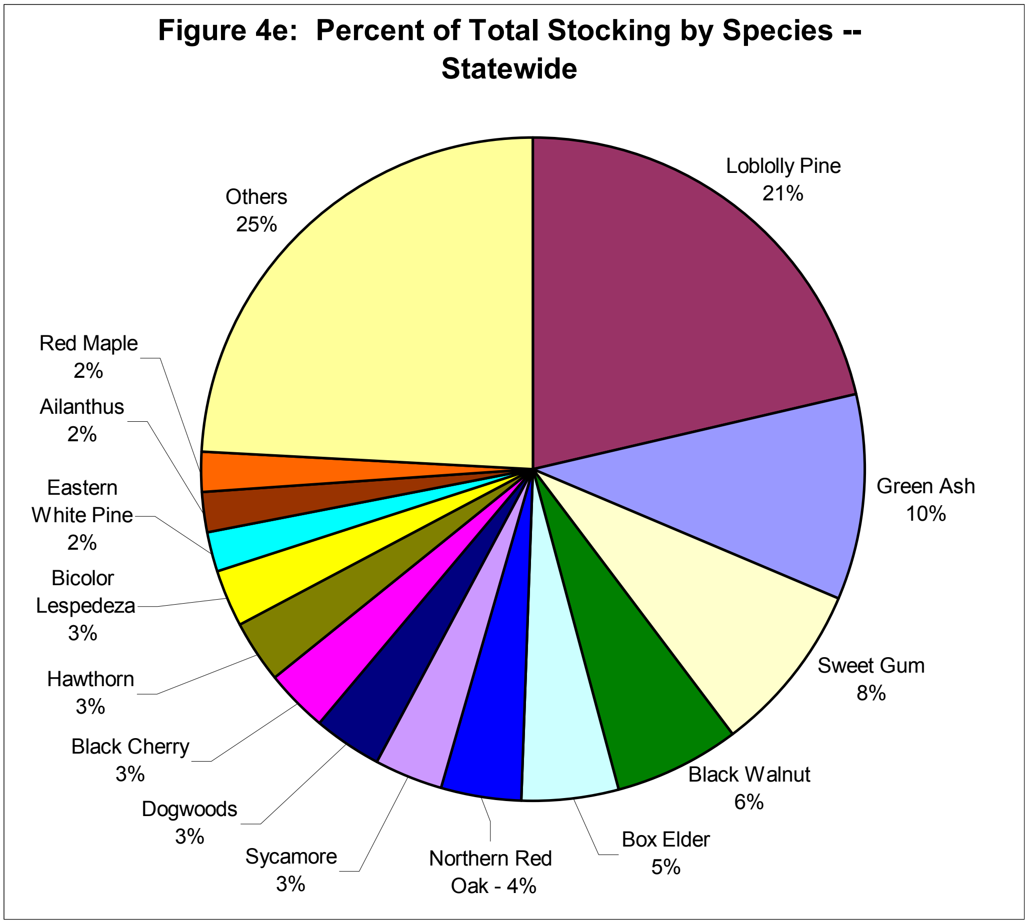


Figure 4d: Percent of Total Stocking by Species -- Eastern Region





Tree and Shrub Species
There were many different species found, reflecting the variety of tree species planted, as well as natural regeneration (Table 3). As with stocking, the species counted were only for the ten largest trees per 1/100th acre plot, and there were undoubtedly other species present on the sites that were never counted because they were either outside the sample plots or they were within the plots but were relatively small. The number of species counted per site ranged from 0 to 20, with an average of 8.2 species counted per site. Western Region had the highest average number of species per site, 11.4, and Southern Region had the lowest, 5.7. There were a total of 79 different species counted on the 130 sites. The top 10 species were (in order of numerical predominance): loblolly pine, green ash, sweetgum, black walnut, boxelder, northern red oak, sycamore, dogwoods (silky, gray, red-osier, flowering), black cherry, and hawthorn (Figure 3e). The species composition of Western and Central Regions were very similar, as were those of Southern and Eastern Regions (Figures 3a-3d). Of the trees and shrubs that had been planted (not including natural regeneration) the top ten species found were: loblolly pine, green ash, black walnut, northern red oak, sycamore, dogwoods, bicolor lespedeza, white pine, pin oak, and sawtooth oak. Their frequency indicates that these are both commonly planted and good survivors.

Of the trees and shrubs found as natural regeneration, the top ten species found were: sweetgum, boxelder, hawthorn, black cherry, green ash, ailanthus, red maple, black walnut, black locust, and loblolly pine. When divided into several species groups, 28% were conifers (10 species), 21% were shrubs and small trees (24 species), 12% were ash (2 species), 8% were oaks (9 species), and 31% were other deciduous trees (34 species) (Figure 6).

There were 36 sites (mostly rural) where at least 50% of the planted stocking was conifers, mostly loblolly pine. The average percent survival for these sites was 69%. The average percent survival for the 92 sites which were primarily hardwoods and shrubs was 58%, with no significant difference between rural and urban/community sites.

For each site an assessment was made of the planted species that did well and those that did poorly. While there were many species that did well on some plantings and poorly on others for reasons which may not have anything to do with species suitability, certain species were found to be much more successful than not. These frequently successful species include (alphabetically) bald cypress, bicolor lespedeza, black locust, black walnut, green ash, loblolly pine, northern red oak, pin oak, redbud, red maple, sawtooth oak, southern red oak, sycamore, and white ash. Planted species that were frequently found to be much more commonly unsuccessful include (alphabetically) arrowwood, black gum, black willow, buttonbush, crabapple, eastern redcedar, elderberry, hackberry, holly, river birch, serviceberry, sweet gum, willow oak, winterberry, and yellow-poplar. A number of other species were found to be somewhat neutral in survival, having about an equal number of reports of success and failure, and other species were found too infrequently to consider in this assessment.

Table 3. Species List - top five in each column are bold

Common Name	Scientific Name	Western		Central		Southern		Eastern		Statewide		
		Planted	Natural	Planted	Natural	Planted	Natural	Planted	Natural	Planted	Natural	Total
Loblolly Pine	*Pinus taeda*	33		47		**233**	1	**1713**	**123**	**2026**	124	**2150**
Green Ash	*Fraxinus pennsylvanica*	**357**	**167**	**279**	**60**	27	2	**114**	1	**777**	**230**	**1007**
Sweet Gum	*Liquidambar styraciflua*	2		9	4	7	**223**	**84**	**514**	102	**741**	**843**
Black Walnut	*Juglans nigra*	**265**	45	**193**	**73**		7	21	9	**479**	134	**613**
Box Elder	*Acer negundo*		**198**		**287**		1		4		**490**	**490**
Northern Red Oak	*Quercus rubra*	**194**	6	77	11	9	16	59	13	**339**	46	385
Sycamore	*Platanus occidentalis*	**103**	10	**173**	2		3	50	2	**326**	17	343
Dogwoods	*Cornus spp.* (*stolonifera, florida, amomum, racemosa*)	**94**	2	**141**	17	**31**	5	39		305	24	329
Black Cherry	*Prunus serotina*	17	**51**	13	**86**	1	**26**	4	**124**	35	**287**	322
Hawthorn	*Crataegus spp.*		2						**305**		**307**	307
Bicolor Lespedeza	*Lespedeza bicolor*	38		1		**221**		2		262		262
Eastern White Pine	*Pinus strobus*	49		**83**		21		61		214		214
Ailanthus	*Ailanthus altissima*		**162**		27				9		198	198
Red Maple	*Acer rubrum*	7	9	21	**65**	18	21		56	46	151	197
Pin Oak	*Quercus palustris*	41	1	57	4	26	3	45	1	169	9	178
Black Locust	*Robinia pseudoacacia*	12	36	7	34	19	**32**	3	25	41	127	168
White Ash	*Fraxinus americana*	81	28	13	7	5	1	24	3	123	39	162
Sawtooth Oak	*Quercus acutissima*	17		12				**122**		151		151
Red Mulberry	*Morus rubra*		42		24		9	9	49	9	124	133
Redbud	*Cercis canadensis*	36	1	42		**36**	1	8		122	2	124
Eastern Redcedar	*Juniperus virginiana*		5	5	3	3	**23**	29	50	37	81	118
Bald Cypress	*Taxodium distuchum*	15				1		**99**		115		115
Persimmon	*Diospyros virginiana*			9		1	2	25	**69**	35	71	106
Yellow Poplar	*Liriodendron tulipifera*	11	2	1	40	7	19	8	8	27	69	96
Virginia Pine	*Pinus virginiana*					**85**		9		94		94
Crabapple	*Pyrus malus*	27	19	9	15	2	18		1	38	53	91
Silver Maple	*Acer saccharinum*	16	**63**	1	6	3	1			20	70	90
Black Gum	*Nyssa sylvatica*	1		1	35	1	**23**	10		13	58	71
Hickory	*Carya spp.* (*cordiformis, glabra, ovata*)	1	7		18	12	1		29	13	55	68
Hackberry	*Celtis occidentalis*	11	45	1		3	1		1	15	47	62
Shining Sumac	*Rhus copallina*						16		40		56	56
White Oak	*Quercus alba*	17	1	8			1	19	1	44	3	47
Southern Red Oak	*Quercus falcata*			36	1	3	5			39	6	45
River Birch	*Betula nigra*	4		18	6	3		9	1	34	7	41
White Spruce	*Picea glauca*			32						32		32
Norway Spruce	*Picea abies*	19		23						42		42
Smooth Sumac	*Rhus glabra*						31				31	31
Serviceberry	*Amelanchier spp.*	1		23		5				29		29
Swamp White Oak	*Quercus bicolor*	7		13	1	3				23	1	24
Slippery Elm	*Ulmus rubra*		4	3	11	2	2			5	17	22
Elderberry	*Sambucus canadensis*	8	1	12						20	1	21

continued on next page

Table 3. continued

Common Name	Scientific Name	Western Planted	Western Natural	Central Planted	Central Natural	Southern Planted	Southern Natural	Eastern Planted	Eastern Natural	Statewide Planted	Statewide Natural	Statewide Total
Alder	*Alnus spp.*	15		1	1					16	1	17
Black Oak	*Quercus velutina*			9	1			4	1	13	2	15
Sassafras	*Sassafras albidum*						6	6	3	6	9	15
Pitch Pine	*Pinus rigida*	12								12		12
Black Willow	*Salix nigra*	4		1	7					5	7	12
Sweet Cherry	*Prunus avium*				12						12	12
American Plum	*Prunus americana*	2		5				3		10		10
Indigo Bush	*Amorpha fruticosa*							9		9		9
American Holly	*Ilex opaca*			3		4		1	1	8	1	9
Arrowwood Viburnum	*Viburnum dentatum*			6			2			6	2	8
Maple-leaf Viburnum	*Viburnum acerifolium*	2		4	2					6	2	8
Norway Maple	*Acer platanoides*	1			7					1	7	8
Sugar Maple	*Acer saccharum*	2				5				7		7
Willow Oak	*Quercus phellos*			4		3				7		7
Spicebush	*Lindera benzoin*			1		5	1			6	1	7
Paulownia	*Paulownia tomentosa*		1	5	1					5	2	7
Staghorn Sumac	*Rhus typhina*		1		5		1				7	7
Chestnut Oak	*Quercus prinus*					5				5		5
American Hornbeam	*Carpinus caroliniana*				5						5	5
Buttonbush	*Cephalanthus occidentalis*			2				2		4		4
Mimosa	*Albizzia julibrissin*			1	1				2	1	3	4
White Mulberry	*Morus alba*		3		1						4	4
American Beech	*Fagus grandifolia*		1	1					1	1	2	3
Black Birch	*Betula lenta*					2				2		2
Black Chokeberry	*Pyrus melanocarpa*					1		1		2		2
Black Pine	*Pinus thunbergii*					2				2		2
Highbush Blueberry	*Vaccinium corymbosum*			2						2		2
Winterberry	*Ilex verticillata*			2						2		2
Gooseberry	*Ribes rotundifolium*	1	1							1	1	2
Barberry	*Berberis spp.*			1						1		1
Honey Locust	*Gleditsia triacanthos*	1								1		1
Leyland Cypress	*Cupressocyparis leylandii*							1		1		1
Nannyberry	*Viburnum lentago*			1						1		1
Red Pine	*Pinus resinosa*			1						1		1
Sourwood	*Oxydendrum arboreum*	1								1		1
Yellow Birch	*Betula lutea*			1						1		1
Catalpa	*Catalpa bignonioides*		1								1	1
	Totals:	1525	915	1414	880	815	504	2593	1446	6347	3745	10050
Total # of Species:	79	41	31	53	36	38	33	34	30	70	52	79

Figure 5: Percent of Total Stocking by Species Group -- Statewide

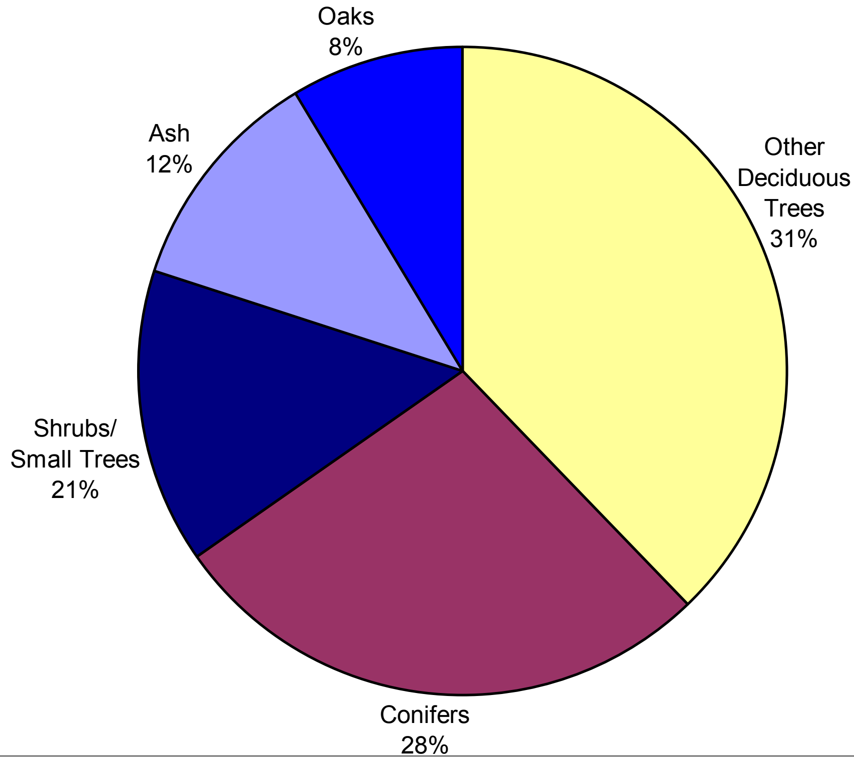
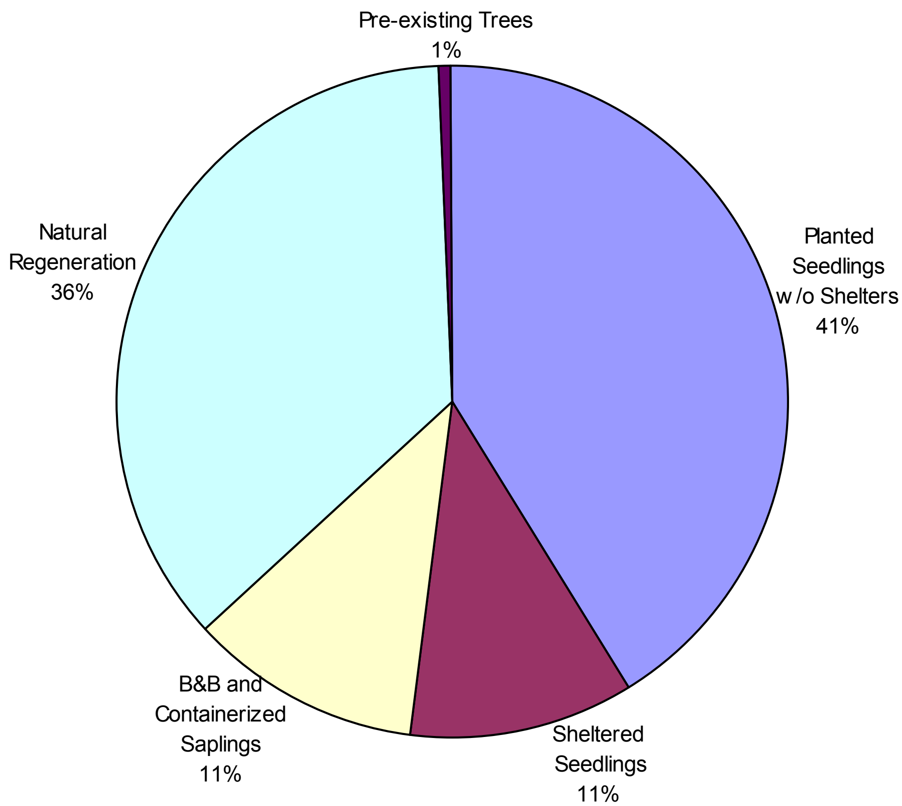


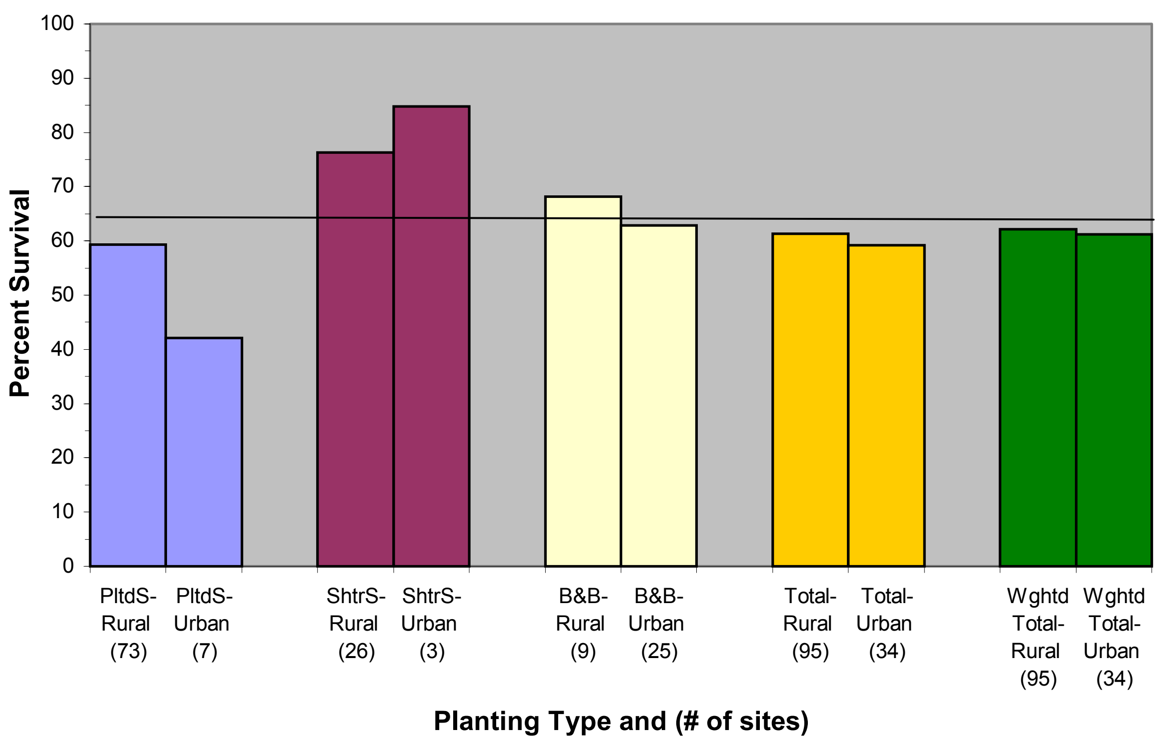
Figure 6: Percent of Total Stocking by Type -- Statewide



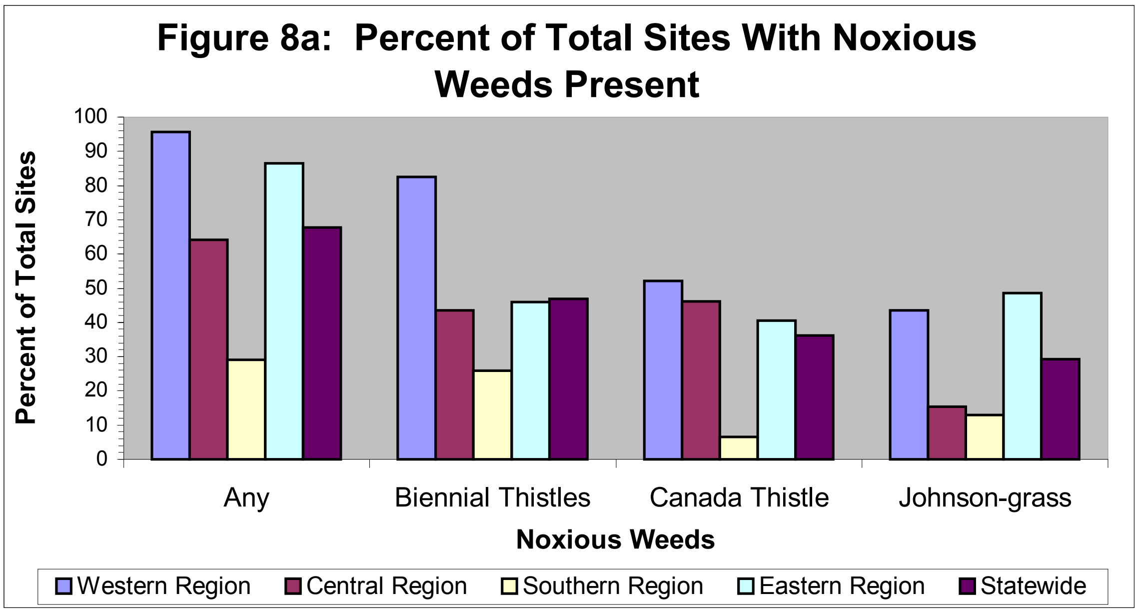
Type of Stocking (Planted Seedlings, Planted Seedlings in Tree Shelters, B&B or Containerized Saplings, Natural Regeneration, Pre-existing Trees)
Expressed as a proportion of total stocking, 41% of trees and shrubs were found as planted seedlings without tree shelters, 11% were planted seedlings with tree shelters, 11% (found on 30 sites) were balled and burlapped or containerized saplings, 36% were natural regeneration, and 1% were pre-existing trees within the planting area (Figure 6). This breakdown is a representation of what was found to be surviving, not necessarily what was planted. Planted trees taken as a whole, discounting natural regeneration and pre-existing trees, made up 63% of stocking.

As a statewide average, each type of planting had near 65% survival or higher, except unsheltered seedlings on urban/community sites that had 42% survival (Figure 7). Seedlings had a significantly higher survival when tree shelters were used. This is especially true for urban/community sites, where survival for sheltered seedlings was 44% higher than those without shelters. The comparison between survival rates for various types of planting was hindered in some cases by insufficient or inconsistent information on the relative numbers of types of planted stock, e.g., what proportion of the trees were initially sheltered vs. unsheltered, the replanting of some sites, and the fact that on some sites tree shelters had been removed. Further information on comparative survival and growth of sheltered vs. unsheltered seedlings will become available upon completion of a study now underway in Maryland at Chino Farms by Stroud Water Research Center in partnership with the USDA – Forest Service and Ducks Unlimited.

Figure 7: Average Percent Survival by Planting Type -- Statewide



Noxious Weeds (Biennial Thistles, Canada Thistle, Johnson-grass)
Statewide, 68% of the sites had noxious weeds on at least one plot, with 35% of the individual plots having one or more species present (Figures 8a & b). Biennial thistles were found on 47% of the sites on at least one plot, and on 18% of the total plots. Canada thistle was found on 36% of the sites and on 13% of the total plots. Johnson-grass was found on 29% of the sites and on 11% of the total plots. Noxious weeds were found in each Region, with Western Region having the highest levels of biennial thistles and Canada thistle, Eastern Region having the most Johnson-grass, and Southern Region being lowest in all noxious species. This information indicates that these weed species were present, not necessarily that they were a violation of state law. On some sites they were being mowed, sprayed, or otherwise managed to prevent their spread. The degree of competition these species were providing was incorporated in the section on vegetative competition.



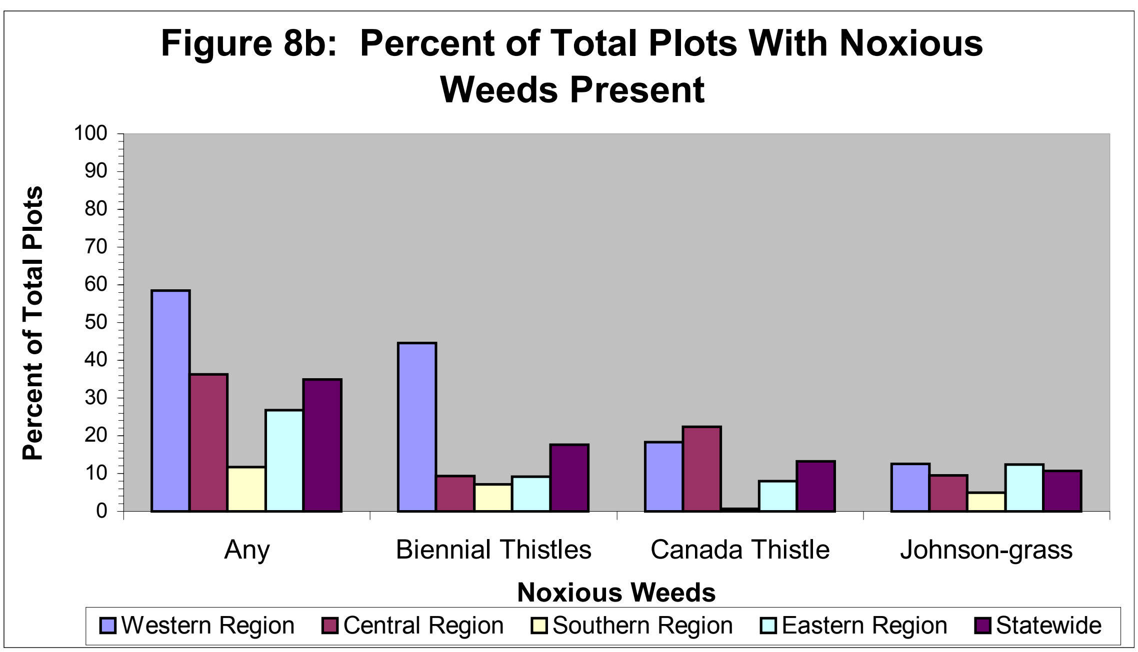


Figure 9a: Noxious Weeds, Proportional Occurrence on Sites -- Statewide

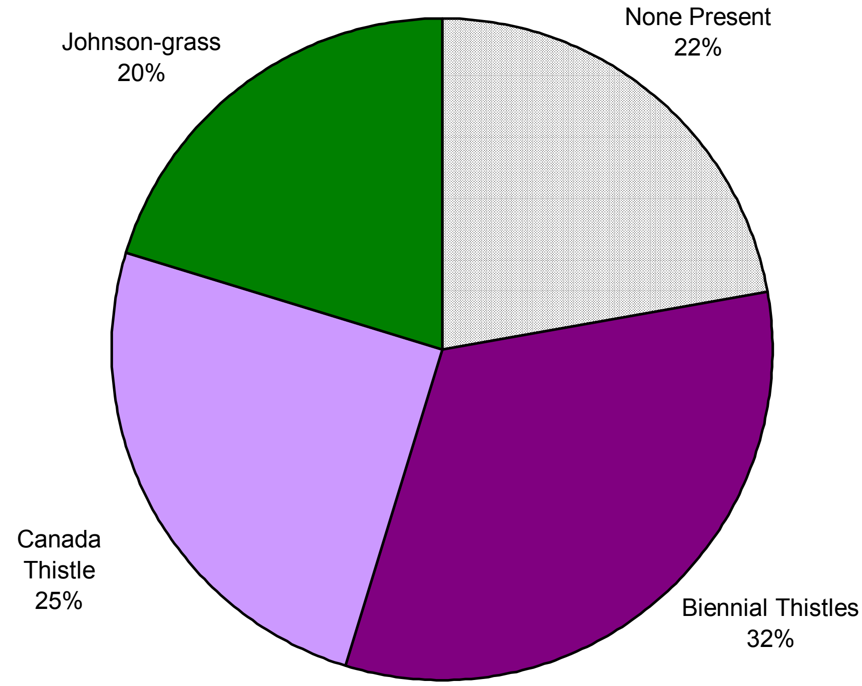
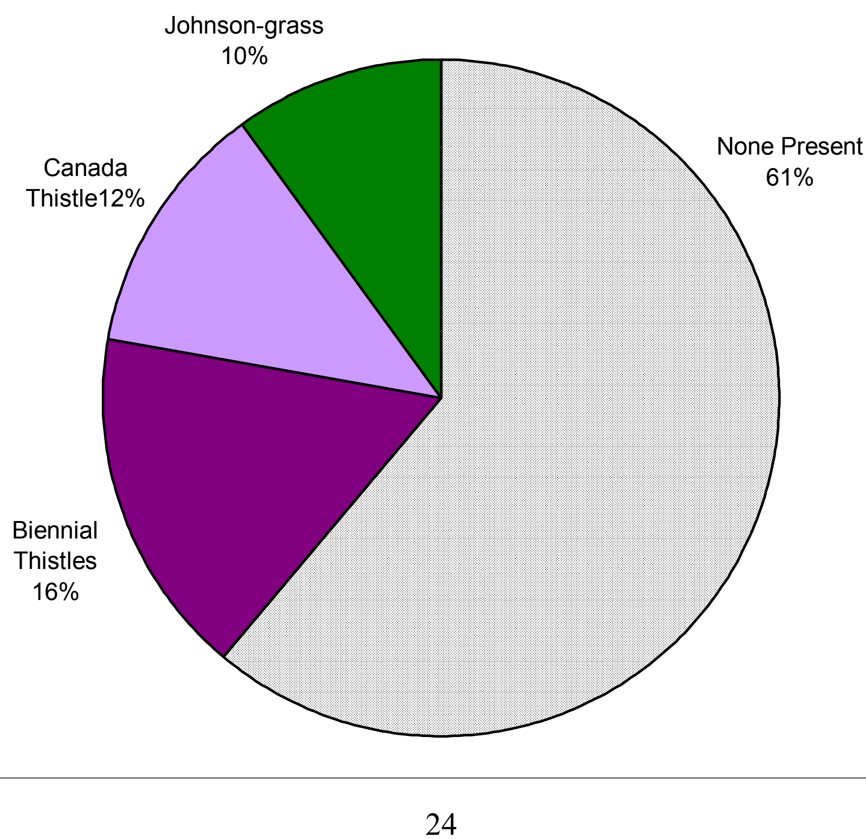
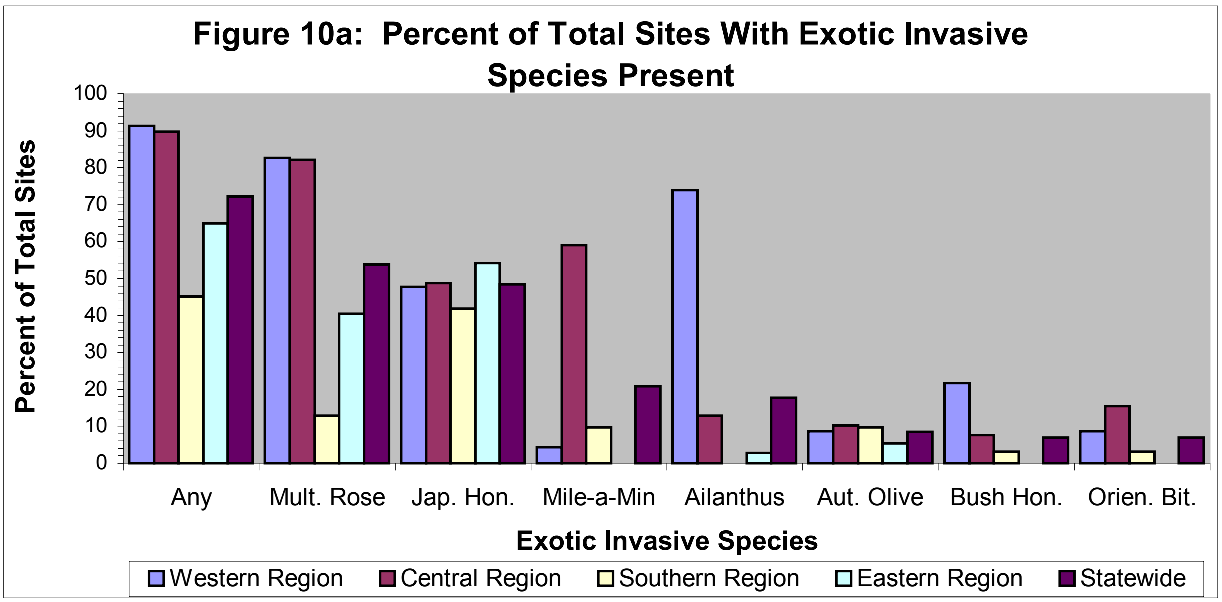


Figure 9b: Noxious Weeds, Poportional Occurrence on Plots -- Statewide



Invasive Exotic Plants

Statewide, 72% of the sites had invasive exotic plants on at least one plot, with 30% of the individual plots having one or more species present (Figures 10a & b). Multiflora rose (*Rosa multiflora*) was the most commonly found species, being found on 54% of the sites on at least one plot, and 16% of the total plots. The other species found, in order of frequency on plots, were Japanese honeysuckle (*Lonicera japonica*), ailanthus (*Ailanthus altissima*), mile-a-minute (*Polygonum perfoliatum*), bush honeysuckle (*Lonicera tartarica* or *maakii*), autumn olive (*Eleagnus angustifolia*), and oriental bittersweet *(Celastrus orbiculatus)* (Figure 11a & b). Species **not** found in any of the plots include kudzu (*Pueria lobata*) and Japanese knotweed (*Polygonum cuspidatum*). Western and Central Regions were very similar in the high frequency of species overall, with Western having more ailanthus and Central having more mile-a-minute. Eastern and Southern Regions had comparatively moderate levels of exotic species.



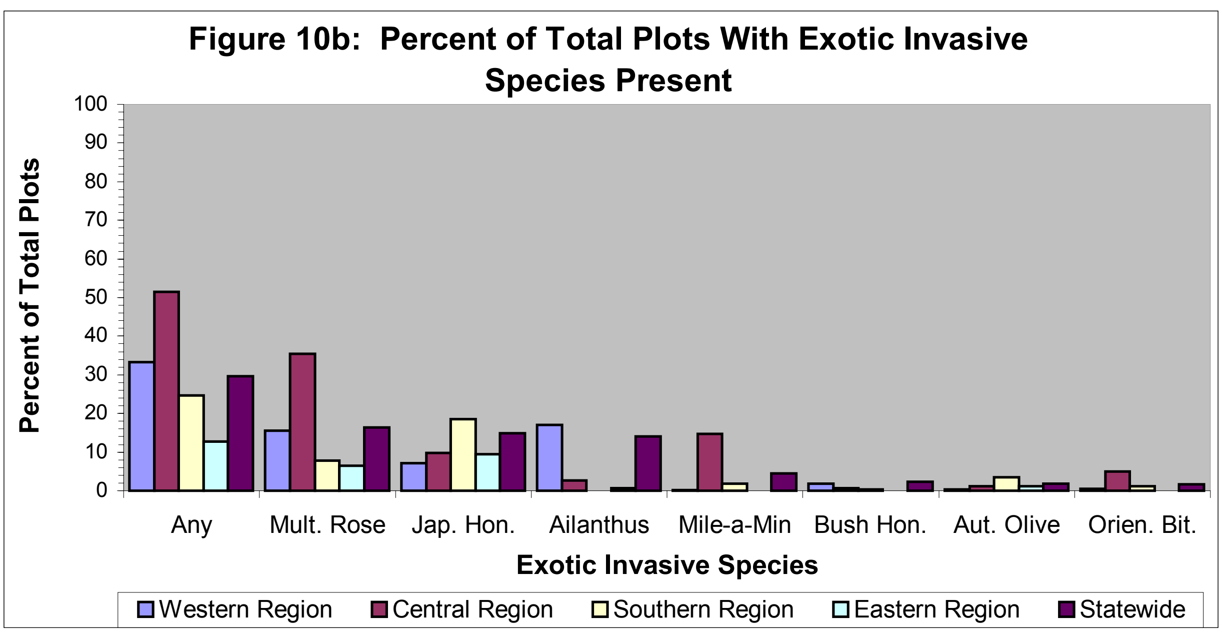


Figure 11a: Exotic Invasive Species, Proportional Occurrence on Sites -- Statewide

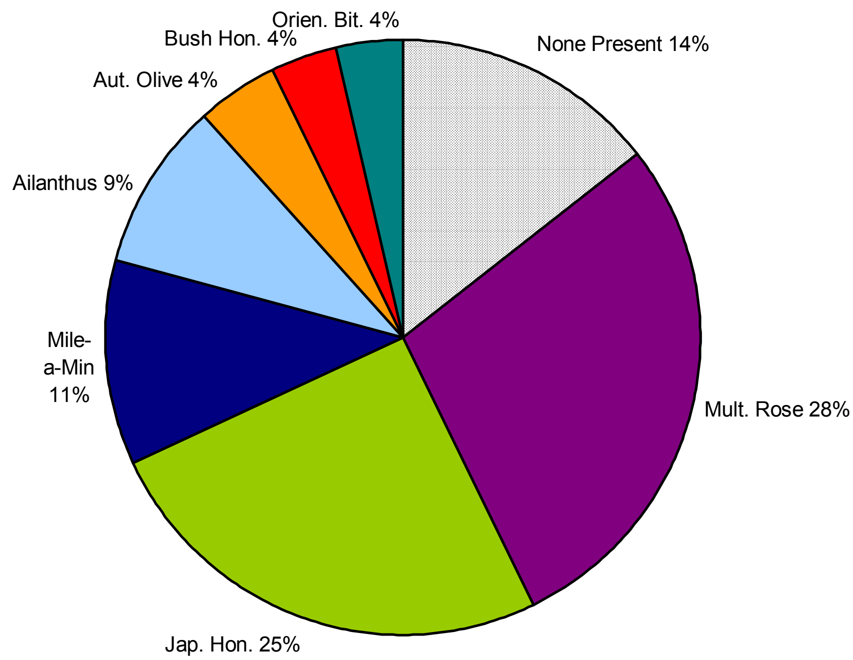
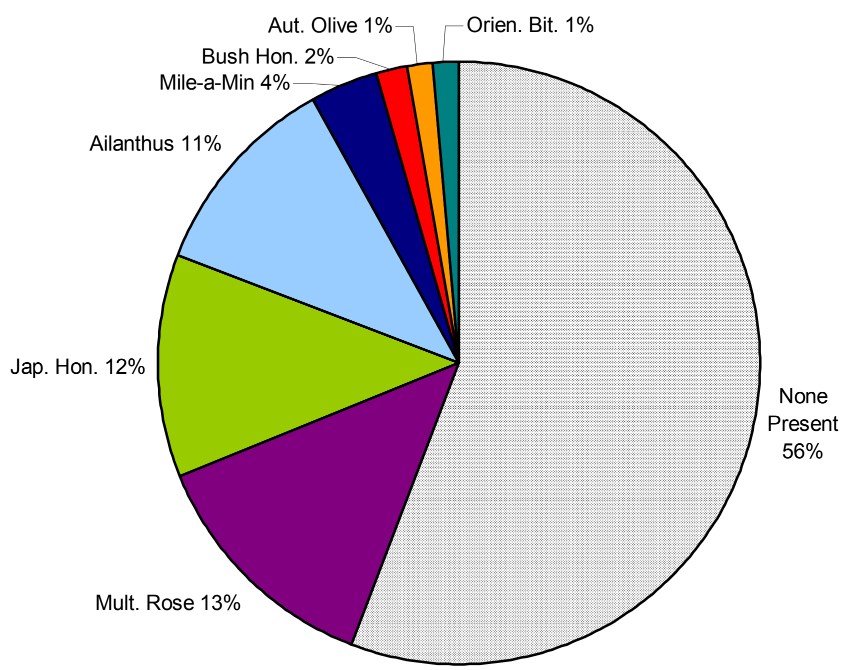


Figure 11b: Exotic Invasive Species, Proportional Occurrence on Plots -- Statewide



Vegetative Competition

Vegetative competition was rated from **0** to **3**, with 0 = no competition, 1 = light competition, 2 = moderate competition, and 3 = heavy competition, based on the species, height and extent of the growth of grasses, broadleaf weeds, and vines. The average rating of vegetative competition across all sites studies was 2.2, near the moderate level. There was quite a lot of variation between sites, with site average ratings ranging from 0.6 to 3.0, and in some cases wide variation between different plots on the same site. The effect of vegetative competition on survival was evident. When the vegetative competition rating was high, the survival was usually low. Conversely, where the vegetative competition low, survival was usually high unless other known problems accounted for poor survival. During data collection, field workers noted that sites which were well maintained, especially if maintained by the landowner, usually had good survival. On some sites where unusually high numbers of trees had been planted, over 1000 per acre, stocking and survival were very poor regardless, due to vegetative competition.

Vegetation competition was inversely related to survival of planted stock (i.e., survival was low where competition was high), but data were very variable (Figure 12a), so correlation was low (r^2 = 0.08). Competition and natural regeneration had a slight positive correlation (Figure 12b), presumably due to the effect of greater numbers of natural regeneration seedlings found on sites with minimal post-planting weed control measures. There was almost no trend and very variable data for total stocking and competition (r^2 < 0.001) (Figure 12c); total stocking combines planted and natural regeneration seedlings, so the contrasting trends essentially cancel each other.

Figure 12a. Comparison of Vegetative Competition to Survival of Planted Trees

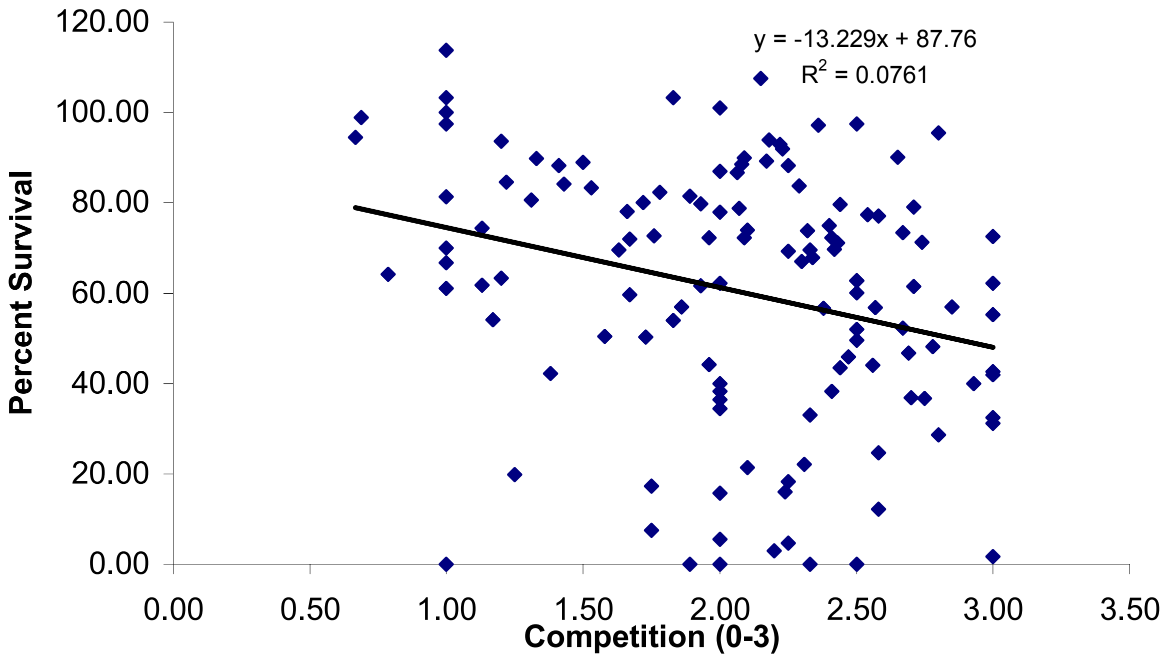


Figure 12b. Comparison of Vegetative Competition to Natural Regeneration

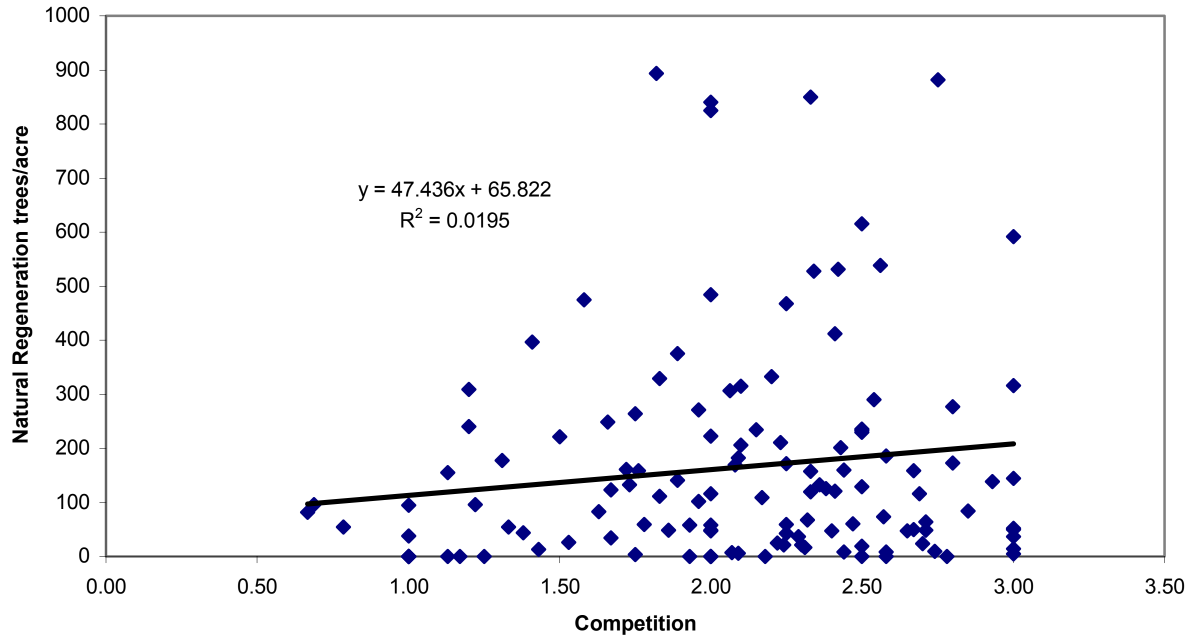
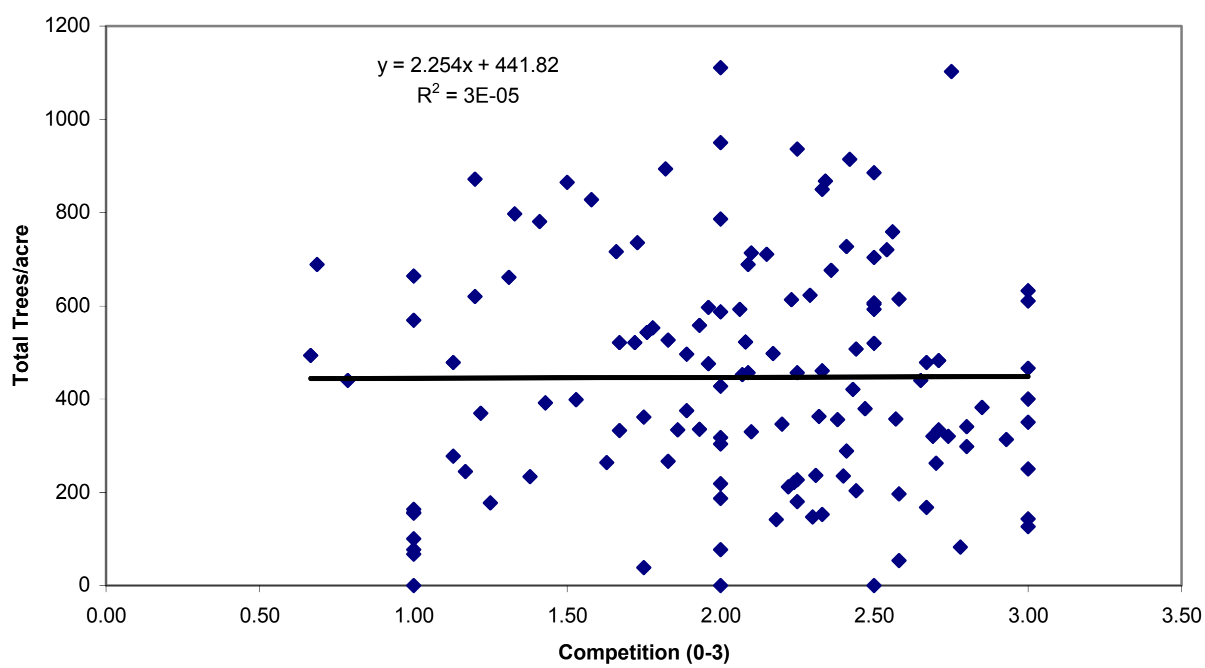


Figure 12c. Comparison of Vegetative Competiton to Total Stocking



Problems
Almost all sites (95%) had a problem on at least one plot, and most of the plots (71%), had one or more problems (Figures 12a & b). The most common problem was weed competition from broadleaf weeds and grasses. On 35% of the plots weeds were deemed to be impairing or have impaired the growth and survival of planted trees. Other problems (4-12% of plots) were drought, deer browse, unknown problems, vines, machinery, and insects. Minor problems (1-4% of plots) were wet sites, shade, rodents, tree shelters, and poor planting. Very minor problems (<1% of plots) were disease, herbicides, dry sites, flooding, vandalism, deer rubbing, and other problems. No problems were identified on any plot from beaver or livestock. While we have reliable reports of beaver damage on riparian buffer plantings, the problem is apparently not very common. This may be of little consolation to those landowners and managers who experience the localized but severe damage that beaver can inflict. The absence of damage from livestock is reassuring, since a generation ago livestock damage was a very common problem on afforestation sites (Maryland Dept. of Forests and Parks, 1965).

It was sometimes difficult to determine what past problems had caused trees to be absent. When vine and weed problems are combined, 39% of the plots had problems with competing vegetation sufficient to affect survival and growth. This is consistent with the findings for vegetative competition, above. It is interesting that deer browsing or rubbing combined were found to be a problem on only 10% of plots, even though the great majority of counted trees were not protected by tree shelters or similar measures. While 10% is not insignificant, and the degree of damage varied from site to site, deer browse appears to be less of an overall problem in the study area than was thought, possibly because of the young seedling age and tall weed growth. Mechanical damage could sometimes be catastrophic. On at least four sites the trees had been completely mowed off, presumably by accident. On urban & community sites that were regularly maintained by mowing, mower and trimmer damage was commonly observed.

The principle rodents affecting trees on afforestation sites in Maryland are white-footed deer mice, meadow voles and pine voles. Beaver, although a rodent, were recorded separately. Damage from rodents was fairly minor, 2.5% of plots. However, widespread and severe damage from mice and voles on riparian planting sites in Western and Central Region has been reliably reported during the fall and winter since the sites were measured. These are mostly sites having heavy grass cover, and vole populations may have greatly increased due to the wet weather in the summer of 2000.

The effects of drought were hard to measure. It is very difficult to look at a seedling and determine that it died from drought as opposed to poor handling prior to planting or some other problem. First-hand information from landowners and foresters was sometimes used in determining drought effects. Any drought mortality would most likely have occurred the first year. The buffers surveyed in this study were established from 1997 to 1999, with three-fourths during 1998 and1999. These were years of severe summer droughts; precipitation between July 1998 and July 1999 ranged from 10 to 21 inches below normal and made seedling survival very difficult except on the most poorly drained sites. The summer of this survey, 2000, had plentiful rainfall, which helped survival on those areas being replanted from the prior years. The USDA Farm Services Agency reports that during the four years covered in this phase of the study, drought emergencies activating some FSA assistance program were declared in many Maryland counties in 1997, 1998 and 1999. (Laura Schlote, 2000). A range of stocking and survival could be found between sites in each year of planting, e.g., for trees planted in 1999, a severe drought year, some sites had poor survival while other sites nearby had good survival. This indicates that drought was more likely a contributing factor to mortality rather than a primary cause; and site to site differences in survival may be due to drought effects combined with soil conditions, seedling handling or planting practices, drought tolerance of species planted, vegetative competition, or other variables.

Figure 13a: Percent of Total Sites and Plots With Problems -- Statewide

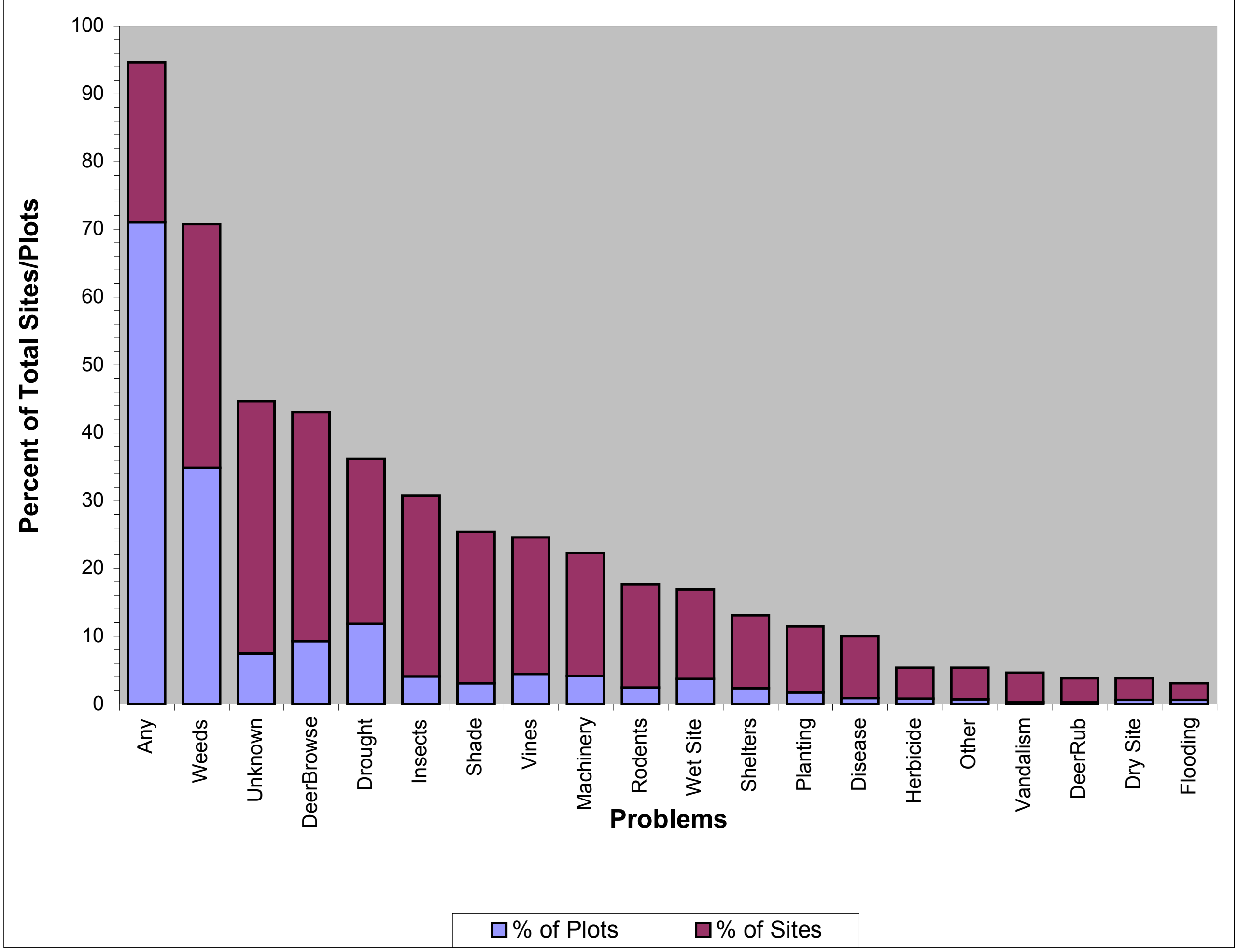


Figure 13b: Percent of Total Sites and Plots With Problems --- Western Region

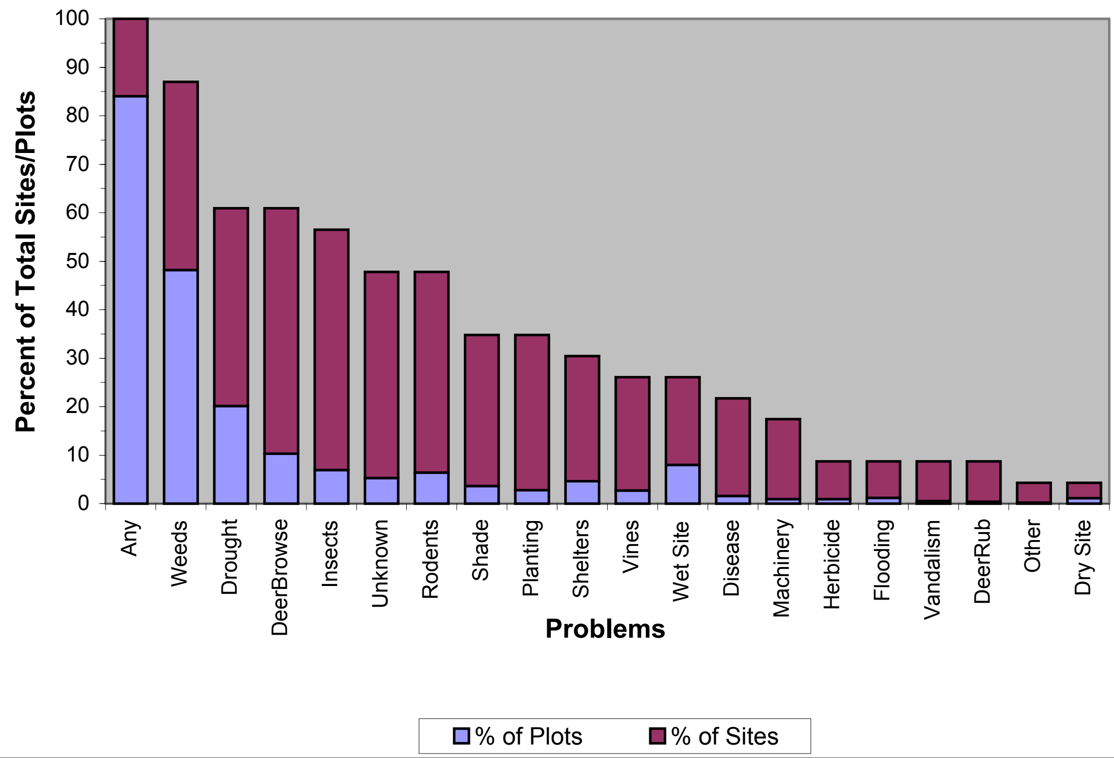
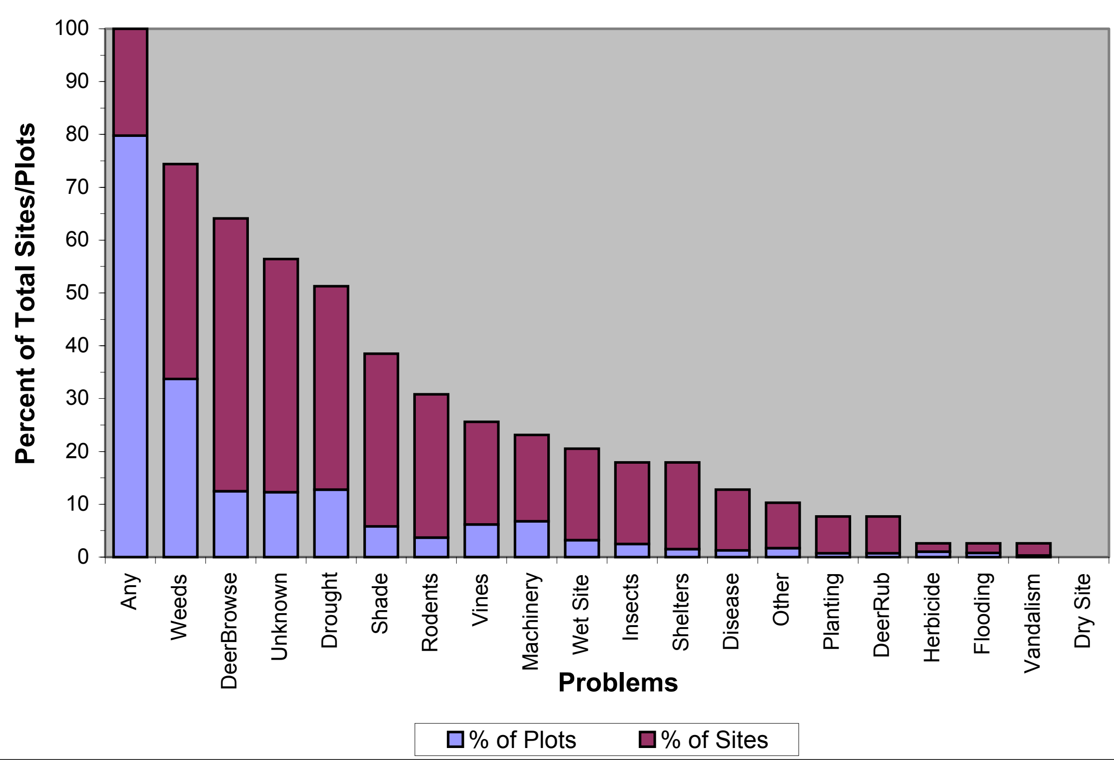


Figure 13c: Percent of Total Sites and Plots With Problems -- Central Region



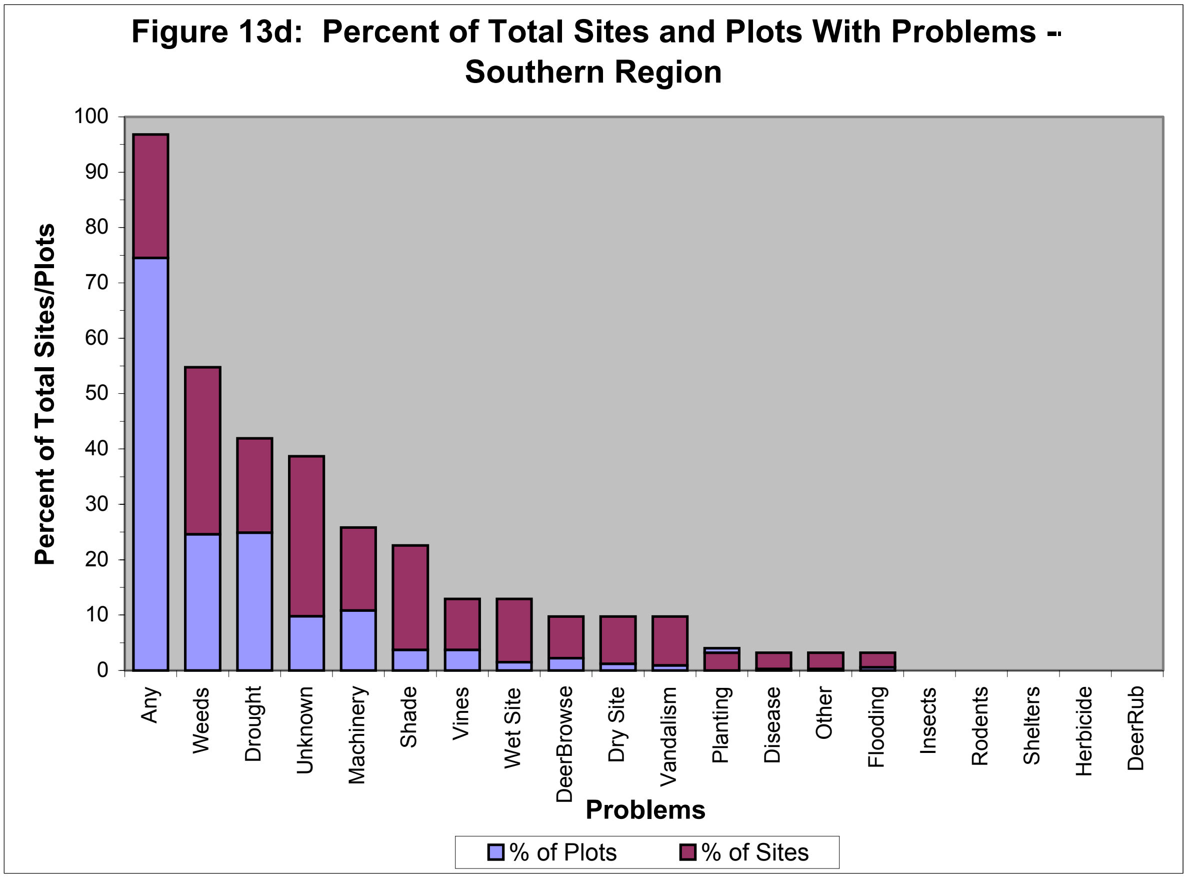


Figure 13d: Percent of Total Sites and Plots With Problems -- Southern Region
Percent of Total Sites/Plots
100
90
80
70
60
50
40
30
20
10
0
Any
Weeds
Drought
Unknown
Machinery
Shade
Vines
Wet Site
DeerBrowse
Dry Site
Vandalism
Planting
Disease
Other
Flooding
Insects
Rodents
Shelters
Herbicide
DeerRub
Problems
% of Plots
% of Sites

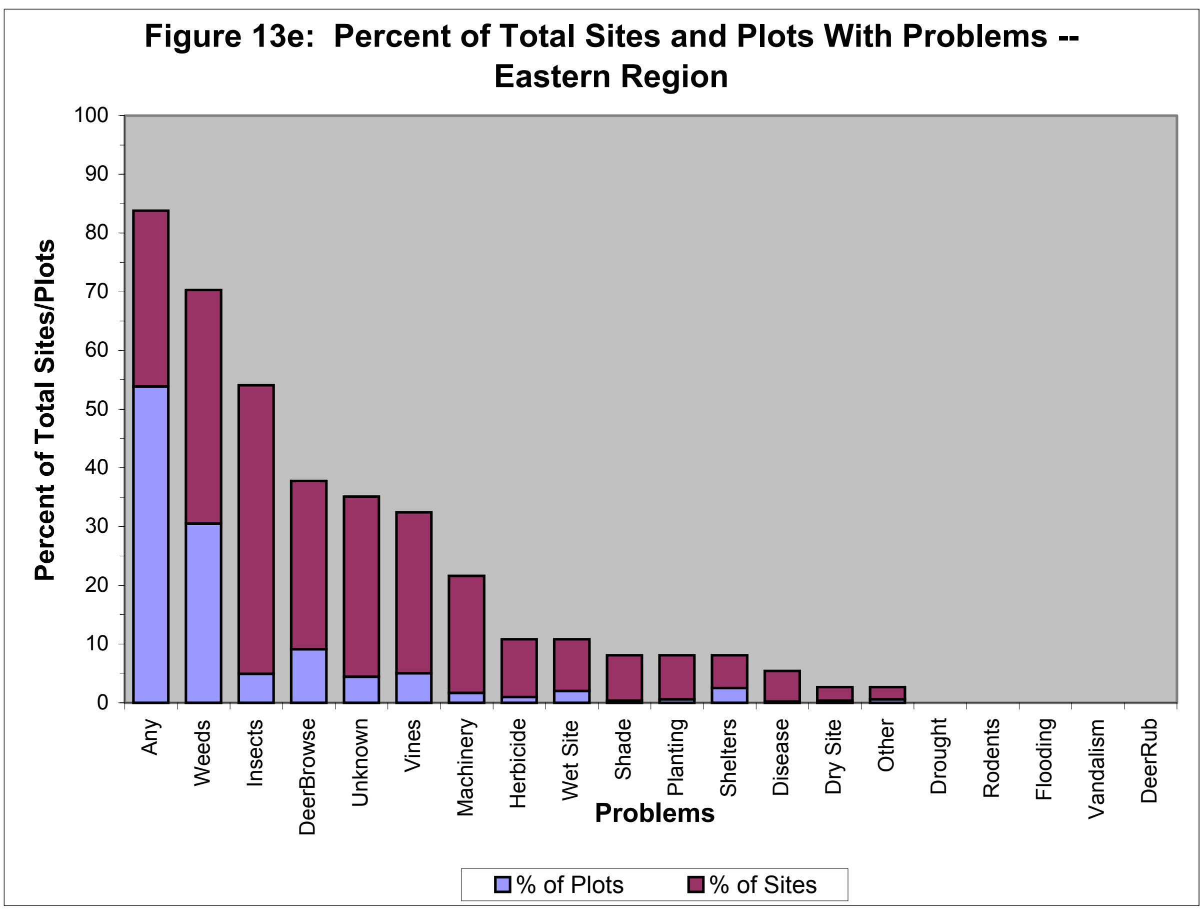


Figure 13e: Percent of Total Sites and Plots With Problems -- Eastern Region
Percent of Total Sites/Plots
100
90
80
70
60
50
40
30
20
10
0
Any
Weeds
Insects
DeerBrowse
Unknown
Vines
Machinery
Herbicide
Wet Site
Shade
Planting
Shelters
Disease
Dry Site
Other
Drought
Rodents
Flooding
Vandalism
DeerRub
Problems
% of Plots
% of Sites

Figure 14a: Problems, Proportional Occurrence on Sites -- Statewide

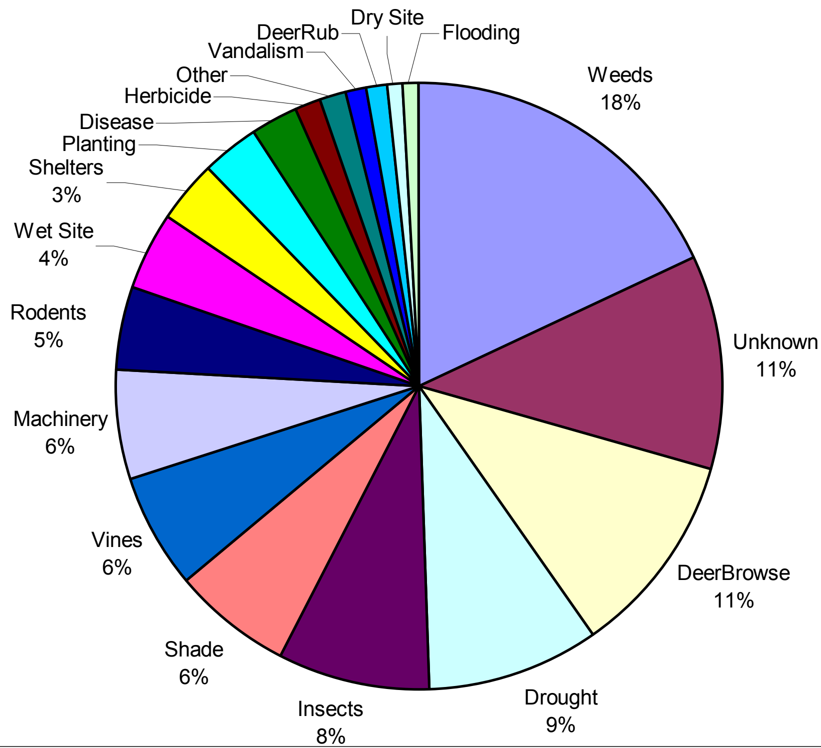
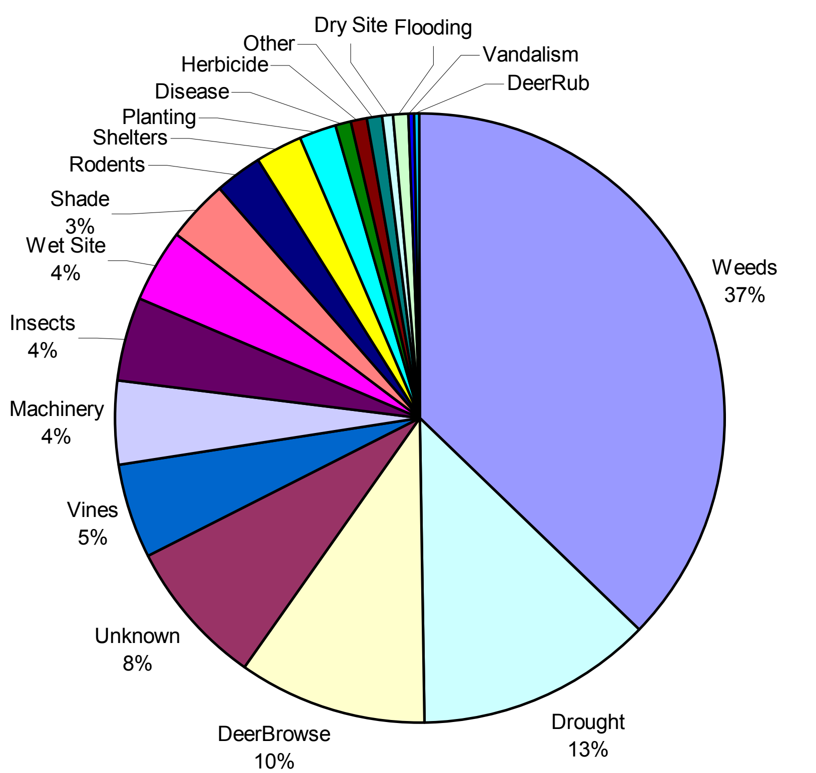


Figure 14b: Problems, Proportional Occurrence on Plots -- Statewide



Conclusions

Stocking

This study used stocking as the primary factor to determine success of newly created buffers because it could be directly measured and relates most strongly to canopy cover. The average weighted stocking of 488 trees per acre and median stocking of 434 trees per acre are above the preferred stocking level of 400 trees per acre. Overall, 82% of sites met the minimum stocking level of 200 trees per acre, while 52% of sites met the more desirable stocking level of 400 trees per acre. Natural regeneration made an important contribution to meeting these stocking levels on many sites and made up 36% of the total stocking. Data from the pilot phase of this study indicates that crown closure should occur within 10 years on the 82% of sites with stocking over 200 per acre.

Survival

Percent survival of planted seedlings is a frequently used measure of success, although it depends on initial planting density, which varies depending on stock type and species. The weighted mean survival of planted trees was 60%, with a median survival of 67%. Although the overall stocking level is more important in determining success, survival in the range of 60 - 67% for planted trees on a typical site may be considered a fairly good indicator of success. Some cautions associated with this, however, are the potential masking of practices that allow poor survival by repeatedly replanting, and the fact that 12% of sites were found to have very low survival rates (0-20%), with a disproportionate number of these being urban/community sites.

Species Richness

A wide variety of trees were found, 79 species total, with an average of over 8 species per site. Loblolly pine was the most commonly found tree due its frequent use in Eastern and Southern Regions and its high survival rate. Green ash was the second most common tree, and was found both as planted stock and natural regeneration. Planted species tended to differ from the natural regeneration species (other than green ash) and included many important native species, such as oaks, which were not well represented as volunteer seedlings. Although natural regeneration helped contribute additional species in planted buffers, it included some undesirable, invasive, or low-value species such as boxelder and *Ailanthus*. Planting survival could be increased by avoiding species reported as frequently unsuccessful, unless adequate protection measures are used and the species is desired for its particular wildlife or aesthetic value.

Planting Design

The data give a good representation of the stocking level of the different types of planting found (41% unprotected seedlings, 11% seedlings with tree shelters, 11% containerized, 46% natural regeneration, 1% pre-existing trees). Tree shelters were found to distinctly improve survival. Sites where shelters seemed to play an especially important role were urban/community sites and where damage from deer or other herbivores was common. This study was intended to capture the ranges and average of conditions in the field rather than separate effects of planting design and maintenance practices; the trends observed in practice should be evaluated for significance based on studies with designs that permit replicates and controls.

Weed Competition

Commonly found weeds on buffer plantings were Canada thistle, a state noxious weed, and multiflora rose, an invasive exotic plant. Their prevalence indicates the need to always prepare for these species in plans for site preparation and maintenance. The inverse relationship between vegetative competition and survival points out that one of the most obvious ways to improve survival is to control competition. Weed control, however, must be weighed against the possibility of increasing deer browse on sites with high deer activity or a desire to encourage natural regeneration on sites where it is likely to occur.

Other Mortality Factors

Problems sufficient to affect the survival and growth of planted trees were very common. Weeds or vines were the most significant problem, found on half the plots. Other problems affecting 3% to 6% of plots were deer, mechanical damage from mowing, shading from adjacent trees, insects, and poor planting practices. Various measures may be needed on a site-specific basis to prevent or reduce the impacts of these problems.

The effects of drought were difficult to determine, though it no doubt was a contributing factor in mortality, if not a primary cause. The frequency of summer droughts means that decisions on species selection, site preparation, type of planting stock, time of planting, and maintenance should be made to ensure that the planted trees will succeed despite dry weather.

Summary

The results from this study, which are similar in most respects to the findings of the pilot phase of the study, indicate that the overall effort in afforesting riparian forest buffers in Maryland in recent years has been successful. On most sites, an adequate number of trees of a good diversity of species are being established. However, there is still room for improvement in certain aspects, most notably the survival of planted trees and weed management. Changes in species selection, site preparation, planting practices, protection, and maintenance could be made to increase survival to preferred levels and save the expenditure of resources required for replanting.

Recommendations

Management Considerations

Results of this study reveal the importance of natural regeneration in buffer creation. While natural regeneration has limitations such as invasive exotic species and very patchy seedling density, it can offer inexpensive regeneration with native seed sources, desirable for wildlife and biodiversity. Buffer management plans could take this element into consideration more specifically, either as replacement for or augmentation of planting. Currently, there is no specific guidance on field conditions appropriate to support desirable natural regeneration or practices to minimize potential undesirable attributes or risks. Also, many incentive programs do not accept natural regeneration as an eligible practice, either as cost-share for site preparation and weed control or paying rent on land set aside as buffers. While the uncertain nature of natural regeneration stocking may not appeal to some landowners, it can be a very cost-effective means of buffer establishment.

The distinctly greater survival of trees protected by tree shelters supports the strategic use of shelters, which must be balanced by the expense of materials and installation. Use of greater numbers of shelters may be particularly justifiable for seedlings planted on urban/community sites or in areas with high density of herbivores. Shorter shelters (3-ft instead of 4-ft) may be one way to minimize expense and maximize survival. Some species such as oaks tend to respond more positively to shelters, and may vary depending on site conditions.

Results of the study also suggest that maintenance practices such as mowing and herbicide spraying are important for adequate survival, with a combination offering the greatest survival. Not all landowners choose to use herbicides, but when properly used, they are one of the few effective and cost-effective means to control noxious and invasive weeds, especially for large sites. Where herbicides are intended for weed control, species choice should include tolerance for overspraying. A variety of native species have tolerance to some common herbicides, including several of the species found to be commonly successful in this study. Herbicide use also may be an important tool to encourage additional natural regeneration or random planting patterns because it can allow adequate survival with limited mowing.

The site preparation practices known in this study did not offer a well-distributed base of information for management decisions, being dominated by mowing alone. There is some evidence that, as with maintenance, a combination of chemical use and mowing can offer the greatest survival. Site preparation other than mowing or herbicides applied at the time of planting often involves more logistics and can easily result in having to wait an additional planting season before a buffer is established. Although the time lag involved may pay off in much superior noxious and invasive weed control and limit future maintenance needs, the delay is often undesirable to the landowner and technical staff, both of whom would rather see the buffer established soon after the decision is made, rather than much later. If the landowner is participating in a cost-share program, the costs would have to be carried for a longer time before reimbursement and it may be more difficult to establish the practice during the required time limit. Clearer data on the effect of site preparation on growth and survival would be needed to make a decision on when the increased cost and logistical difficulty was worthwhile. Herbicide use has had variable results in the field among regions, with invasion by undesirable weeds on exposed sites being a problem in some areas, which may depend on soil types and seed sources. One promising method of site preparation is the establishment of a cover crop of non-sod-forming grasses, which precludes noxious weeds and dies back in summer.

The area-plot method used in this study allowed the contribution of natural regeneration to be quantified and accommodated the random planting pattern used on some sites. Row-count methods can give more rapid estimates of planted seedling survival, conserving scarce technical staff time, but do not offer as comprehensive of information on buffer survival. Overall success of the Stream ReLeaf program may be best served by pursuing a combination of the methods.

Further Study Needed

A number of the issues discussed above indicated that further study is needed for conclusive or more detailed information. This study was designed as an empirical snapshot of existing field conditions over the entire state, and could not simultaneously provide controlled and replicated experimental design. Our study includes some sites where the exact details of the planting and management on each of the 130 sites are not completely known. Other variables that may affect survival and growth could not be discounted. A well-planned study or studies would need to be set up and maintained on selected sites for answering specific questions. A review of previous or ongoing studies may also provide adequate answers to these issues.

1. The relative merits of unsheltered seedlings vs. seedlings with tree shelters vs. containerized or balled-and-burlap saplings, with responses by species.

2. The relative merits (in terms of survival, growth, or environmental benefits) of using certain species of trees and/or shrubs, including interaction with site conditions such as soil drainage class or herbivore density.

3. The effect of various methods of (or lack of) site preparation, weed control, or other maintenance practices, and influence of previous land use on growth and survival.

4. Comparison of the various planting methods (hand vs. machine, volunteers vs. contractors, etc.) on survival and success.

Further Action Needed

This study quantifies existing conditions of tree survival in Maryland's Stream ReLeaf buffers, and provides an excellent initial database. The study also was intended to provide information that could guide buffer design to improve survival, some of which is outlined above. A more comprehensive treatment would require integration with field experience, and would be a useful follow-up step. The area plot methodology has proven valuable for providing some types of data not previously available, and that would be useful as an ongoing data source. The study also raises some questions about the potential for natural regeneration in buffer creation, which bears further investigation for its ecological and economic benefits. Consequently, the following actions are recommended:

1. Develop a set of recommendations for improvement in practices used in planning, planting, and maintaining riparian forest buffers. These recommendations should address some of the problems and concerns identified in this study, and should be based on the consensus of a group of experienced foresters on a regional basis. They could take the form of a decision tree to guide management options based on site characteristics and landowner goals.

2. Pursue a means of annual data collection with the methodology developed here. Develop for distribution a very user-friendly version of the procedures and software used in the data collection and analysis. This would be available for use by other organizations and agencies (in Maryland and other eastern states) for collecting and analyzing afforestation survival and success information. There may be two versions, simple and detailed, depending on the capabilities and needs of the user group, or options to pick and choose the data desired. This would involve some field-testing and critique by other agencies and organizations.

3. Develop a set of guidelines that would assist in using natural regeneration to establish or augment planting of forest buffers. This would include means to minimize undesirable attributes of naturally regenerated sites such as noxious or invasive weeds or poor species diversity. Guidelines would identify site characteristics that allow or make successful natural regeneration difficult (such as existing sod).

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Appendix

Spreadsheet Tabulation of Statewide Data

Key to Abbreviations used on spreadsheet

Avg = average
Wghtd = weighted; averages pro-rated on a per acre basis, giving proportionally greater weight to a value for larger sites than smaller sites
Stkg = stocking
PltdS = planted seedlings without tree shelters
ShtrS = sheltered seedlings
B & B = balled and burlap or containerized saplings
Sum Pltd = sum of all planted trees including PltdS, ShtrS, and B&B
NatR = natural regeneration
Other = typically pre-existing trees found within the planting site
Pltg Dns = planting density, the number of trees planted per acre
Surv = survival
Aut. Olive = autumn olive
Bush Hon = bush honeysuckle
Jap Hon = Japanese honeysuckle
Mile-a-Min = mile-a-minute vine
Mult. Rose = multiflora rose
Orien Bit = oriental bittersweet

Riparian Forest Buffer Monitoring Study - Statewide Results, page 1

	Data Summary					
County / Region	**# of Sites**	**Acres**	**# of Plots**	**Avg.% Sample**	**Avg Wghtd % Sample**	**Avg. # of Species**
Allegany	1	0.8	13	15.3	15.3	4.0
Washington	8	59.8	222	4.4	3.6	13.1
Frederick	14	95.4	327	4.5	3.2	10.9
Western Region	23	156.0	562	4.9	3.4	11.4
Carroll	5	47.3	109	4.4	2.2	11.8
Baltimore	8	30.4	139	6.1	4.3	9.4
Howard	4	5.3	38	11.5	6.5	10.5
Montgomery	8	6.1	69	12.0	10.7	5.4
Harford	13	57.2	233	5.2	3.9	8.5
Cecil	1	2.1	12	5.1	5.1	8.0
Central Region	39	148.4	600	7.3	3.8	8.7
Prince George's	13	31.2	126	6.2	3.8	6.0
Anne Arundel	2	15.1	47	5.2	2.0	14.0
Calvert	7	2.1	45	65.0	18.9	2.9
Charles	4	34.0	70	7.6	1.9	6.5
St. Mary's	5	6.6	37	6.8	5.3	5.0
Southern Region	31	89.0	325	19.7	3.2	5.7
Kent	7	36.2	124	3.7	3.2	8.9
Queen Anne's	3	15.7	55	3.6	3.4	6.7
Talbot	14	89.9	280	4.8	2.9	7.5
Dorchester	2	5.5	41	0.2	0.2	9.0
Wicomico	3	14.3	75	7.6	5.1	7.0
Somerset	5	27.2	97	4.0	3.4	8.4
Worcester	3	51.5	130	3.2	2.5	6.7
Eastern Region	37	240.3	802	4.2	3.0	7.8
Statewide Totals	130	633.63	2289	9.0	3.3	8.2
Standard Deviation		6.59		14.01		13.88
95%Confidence Interval(+/-)		1.13		2.41		2.39

Riparian Forest Buffer Monitoring Study - Statewide Results, page 2

	Average Stocking								
County / Region	Stkg PltdS	Stkg ShtrS	Stkg B&B	Sum Pltd	Stkg NatR	Stkg Other	Stkg Total	Median	Wtd. Stkg
Allegany	221	0	0	221	16	0	237	237	237.0
Washington	99	201	0	300	223	5	528	570	503.4
Frederick	80	202	0	282	157	5	443	434	442.4
Western Region	93	193	0	285	173	5	464	478	464.7
Carroll	114	38	157	310	116	2	427	334	342.0
Baltimore	177	20	25	222	127	11	360	360	346.1
Howard	0	0	349	349	169	6	524	463	345.5
Montgomery	41	0	87	128	29	2	159	174	183.0
Harford	267	53	1	320	214	5	539	483	578.4
Cecil	419	0	0	419	186	9	614	614	614.0
Central Region	159	27	79	265	140	5	410	351	431.5
Prince George's	63	0	174	237	90	0	327	266	415.7
Anne Arundel	302	0	97	398	202	6	606	606	519.0
Calvert	0	0	91	91	5	7	103	100	99.1
Charles	204	0	25	229	537	6	772	827	709.1
St. Mary's	132	0	56	187	330	0	518	346	528.2
Southern Region	94	0	112	205	174	3	382	278	546.3
Kent	362	0	0	362	205	6	573	620	462.6
Queen Anne's	340	0	0	340	42	0	382	332	377.2
Talbot	442	34	0	476	144	0	620	605	679.9
Dorchester	148	89	0	237	266	0	503	503	528.3
Wicomico	355	0	0	355	297	0	652	521	735.3
Somerset	236	35	0	270	101	0	372	370	332.4
Worcester	150	0	0	150	246	0	396	356	350.3
Eastern Region	344	22	0	367	169	1	537	553	517.2
Statewide Totals	184	49	50	283	162	3	449	434	488.3
Standard Deviation				126.89			10.09	250.70	
95%Confidence Interval(+/-)				21.81			1.73	43.10	

Riparian Forest Buffer Monitoring Study - Statewide Results, page 3

	Average Planting Density		Average Survival of Planted Stock					
County / Region	**Pltg Dns.**	**Wtd PltgDns.**	**%SurvPltdS**	**%SurvShtrS**	**%SurvB&B**	**%Surv Total**	**Median**	**Wtd. % Surv**
Allegany	1000	1000	22.1			22.1	22.1	22.1
Washington	463	443	57.0	72.3		63.7	65.7	63.4
Frederick	438	428	68.2	69.6		64.6	72.8	67.9
Western Region	471	437	59.7	70.6		62.4	72.3	65.9
Carroll	434	476	56.0	58.2	97.3	72.2	69.5	56.0
Baltimore	397	370	59.7		82.5	59.9	70.3	59.3
Howard	552	443			61.0	61.0	60.8	44.2
Montgomery	509	553	11.3		73.1	49.9	50.3	47.1
Harford	523	364	64.9		36.0	65.2	78.9	67.8
Cecil	544	544	77.0			77.0	77.0	77.0
Central Region	485	414	54.8	75.5	71.8	61.7	69.5	59.8
Prince George's	527	592	46.2		53.5	51.8	61.6	58.9
Anne Arundel	818	562	50.3		44.3	47.3	47.3	45.3
Calvert	121	120			71.2	71.2	70.0	71.3
Charles	545	729	40.3		40.0	40.2	38.3	58.9
St. Mary's	742	720	23.0		61.8	30.8	19.8	14.9
Southern Region	491	638	36.5		59.0	51.0	61.1	53.6
Kent	541	478	66.6			66.6	63.3	61.2
Queen Anne's	457	445	75.1			75.1	71.3	77.0
Talbot	602	589	77.1	114.0		79.8	80.2	75.9
Dorchester	640	657	28.2	86.8		37.3	37.3	37.2
Wicomico	550	550	64.5			64.5	69.6	69.0
Somerset	451	489	62.2	77.4		64.6	72.6	57.3
Worcester	903	577	24.8			24.8	16.0	47.0
Eastern Region	580	548	65.0	95.8		66.9	71.3	64.2
Statewide Totals	511	502	57.8	77.2	64.3	60.7	66.7	60.5
Standard Deviation	242.48					28.41		
95%Conf. Int.(+/-)	41.68					4.88		

Riparian Forest Buffer Monitoring Study - Statewide Results, page 4

	Average Percent of Total Plots / Sites with Noxious Weeds Present								
	Biennial Thistles		Canada Thistle		Johnson-grass		% with any		
County / Region	% Plots	% Sites	% Plots	% Sites	% Plots	% Sites	% Plots	% Sites	Avg % per Site
Allegany	7.7	100.0	7.7	100.0	0.0	0.0	15.4	100.0	15.4
Washington	48.6	75.0	23.9	50.0	17.1	62.5	71.2	100.0	65.7
Frederick	43.1	85.7	15.0	50.0	9.8	35.7	51.7	92.9	50.7
Western Region	44.5	82.6	18.3	52.2	12.5	43.5	58.5	95.7	54.4
Carroll	10.1	60.0	13.8	60.0	36.7	40.0	52.3	80.0	30.8
Baltimore	8.6	50.0	28.8	50.0	1.4	12.5	35.3	62.5	29.0
Howard	7.9	50.0	28.9	50.0	0.0	0.0	34.2	50.0	21.9
Montgomery	7.2	37.5	13.0	25.0	7.2	12.5	20.3	62.5	20.5
Harford	10.7	38.5	25.3	53.8	3.9	7.7	36.1	61.5	34.2
Cecil	0.0	0.0	0.0	0.0	8.3	100.0	8.3	100.0	8.3
Central Region	9.3	43.6	22.3	46.2	9.5	15.4	36.3	64.1	28.0
Prince George's	9.5	30.8	0.0	0.0	11.9	23.1	19.0	38.5	17.4
Anne Arundel	10.6	100.0	2.1	50.0	0.0	0.0	12.8	100.0	12.8
Calvert	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Charles	8.6	50.0	1.4	25.0	1.4	25.0	11.4	50.0	8.1
St. Mary's	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Southern Region	7.1	25.8	0.6	6.5	4.9	12.9	11.7	29.0	9.2
Kent	8.1	28.6	14.5	71.4	3.2	28.6	22.6	71.4	20.1
Queen Anne's	1.8	33.3	20.0	100.0	18.2	33.3	36.4	100.0	30.5
Talbot	14.3	64.3	12.5	50.0	9.3	42.9	30.4	85.7	21.9
Dorchester	0.0	0.0	0.0	0.0	7.3	100.0	7.3	100.0	9.5
Wicomico	0.0	0.0	0.0	0.0	45.3	100.0	45.3	100.0	47.3
Somerset	15.5	60.0	0.0	0.0	5.2	40.0	20.6	80.0	17.7
Worcester	5.4	66.7	0.0	0.0	13.1	66.7	18.5	100.0	20.9
Eastern Region	9.1	45.9	8.0	40.5	12.3	48.6	26.7	86.5	23.0
Statewide Totals	17.6	46.9	13.2	36.2	10.6	29.2	34.9	67.7	23.5

Riparian Forest Buffer Monitoring Study - Statewide Results, page 5

	Percent of Total Plots / Sites with Exotic Invasive Species Present, part 1 of 2									
	Ailanthus		Aut. Olive		Bush Hon.		Jap. Hon.		Mile-a-Min	
County / Region	% Plots	% Sites	% Plots	% Sites	% Plots	% Sites	% Plots	% Sites	% Plots	% Sites
Allegany	7.7	100.0	0.0	0.0	0.0	0.0	7.7	100.0	0.0	0.0
Washington	13.5	87.5	0.9	25.0	2.7	37.5	5.4	50.0	0.0	0.0
Frederick	19.9	64.3	0.0	0.0	1.2	14.3	8.3	42.9	0.3	7.1
Western Region	17.1	73.9	0.4	8.7	1.8	21.7	7.1	47.8	0.2	4.3
Carroll	4.6	20.0	0.0	0.0	0.0	0.0	6.4	40.0	1.8	40.0
Baltimore	6.5	25.0	0.0	0.0	2.2	25.0	10.8	75.0	6.5	50.0
Howard	0.0	0.0	2.6	25.0	0.0	0.0	23.7	50.0	39.5	50.0
Montgomery	0.0	0.0	7.2	25.0	1.4	12.5	7.2	37.5	17.4	50.0
Harford	0.9	15.4	0.0	0.0	0.0	0.0	6.4	38.5	21.9	84.6
Cecil	0.0	0.0	8.3	100.0	0.0	0.0	66.7	100.0	0.0	0.0
Central Region	2.7	12.8	1.2	10.3	0.7	7.7	9.8	48.7	14.8	59.0
Prince George's	0.0	0.0	0.0	0.0	0.0	0.0	7.9	38.5	0.8	7.7
Anne Arundel	0.0	0.0	21.3	100.0	2.1	50.0	36.2	100.0	10.6	100.0
Calvert	0.0	0.0	0.0	0.0	0.0	0.0	13.3	14.3	0.0	0.0
Charles	0.0	0.0	0.0	0.0	0.0	0.0	25.7	75.0	0.0	0.0
St. Mary's	0.0	0.0	2.7	20.0	0.0	0.0	24.3	40.0	0.0	0.0
Southern Region	0.0	0.0	3.4	9.7	0.3	3.2	18.5	41.9	1.8	9.7
Kent	4.0	14.3	0.0	0.0	0.0	0.0	10.5	57.1	0.0	0.0
Queen Anne's	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Talbot	0.0	0.0	3.2	14.3	0.0	0.0	8.6	50.0	0.0	0.0
Dorchester	0.0	0.0	0.0	0.0	0.0	0.0	2.4	50.0	0.0	0.0
Wicomico	0.0	0.0	0.0	0.0	0.0	0.0	13.3	66.7	0.0	0.0
Somerset	0.0	0.0	0.0	0.0	0.0	0.0	10.3	60.0	0.0	0.0
Worcester	0.0	0.0	0.0	0.0	0.0	0.0	13.1	100.0	0.0	0.0
Eastern Region	0.6	2.7	1.1	5.4	0.0	0.0	9.4	54.1	0.0	0.0
Statewide Totals	14.0	17.7	1.8	8.5	2.3	6.9	14.9	48.5	4.5	20.8

Riparian Forest Buffer Monitoring Study - Statewide Results, page 6

	% of Total Plots/Sites w/Exotic Invasive Species, 2 of 2								
	Mult. Rose		Orien. Bit.		% w/ any			Average Competition	
County / Region	% Plots	% Sites	% Plots	% Sites	% Plots	% Sites	Avg % per Site	Competition	Wghtd Comp.
Allegany	7.7	100.0	0.0	0.0	23.1	100.0	23.1	2.31	2.31
Washington	11.3	75.0	0.0	0.0	26.1	87.5	26.4	2.37	2.46
Frederick	18.7	85.7	0.9	14.3	38.5	92.9	40.1	2.16	2.27
Western Region	15.5	82.6	0.5	8.7	33.3	91.3	34.6	2.24	2.35
Carroll	19.3	80.0	0.0	0.0	25.7	80.0	32.4	2.25	2.13
Baltimore	34.5	87.5	13.7	37.5	55.4	100.0	56.5	2.16	2.27
Howard	50.0	100.0	18.4	50.0	78.9	100.0	71.6	2.30	2.69
Montgomery	20.3	37.5	0.0	0.0	37.7	62.5	37.6	2.26	2.25
Harford	42.9	100.0	1.7	7.7	58.8	100.0	64.5	2.19	2.14
Cecil	91.7	100.0	0.0	0.0	91.7	100.0	91.7	2.58	2.58
Central Region	35.5	82.1	5.0	15.4	51.5	89.7	54.7	2.23	2.19
Prince George's	0.0	0.0	3.2	7.7	11.9	46.2	18.3	2.26	2.08
Anne Arundel	48.9	100.0	0.0	0.0	63.8	100.0	61.6	1.85	1.92
Calvert	2.2	14.3	0.0	0.0	13.3	14.3	7.8	1.00	1.00
Charles	0.0	0.0	0.0	0.0	25.7	75.0	33.0	2.34	2.49
St. Mary's	2.7	20.0	0.0	0.0	29.7	40.0	25.7	1.83	2.09
Southern Region	7.7	12.9	1.2	3.2	24.6	45.2	21.8	1.89	2.19
Kent	27.4	57.1	0.0	0.0	16.1	85.7	39.4	1.95	2.51
Queen Anne's	3.6	33.3	0.0	0.0	3.6	33.3	7.4	1.69	1.92
Talbot	2.9	42.9	0.0	0.0	13.2	57.1	13.1	1.76	1.76
Dorchester	2.4	50.0	0.0	0.0	4.9	50.0	3.6	2.00	2.00
Wicomico	4.0	33.3	0.0	0.0	16.0	66.7	21.9	2.20	2.15
Somerset	1.0	20.0	0.0	0.0	11.3	60.0	19.5	2.07	2.05
Worcester	1.5	33.3	0.0	0.0	14.6	100.0	18.3	2.54	2.40
Eastern Region	6.4	40.5	0.0	0.0	12.8	64.9	19.1	1.94	2.08
Statewide Totals	16.4	53.8	1.6	6.9	29.7	72.3	33.2	2.07	2.19

Riparian Forest Buffer Monitoring Study - Statewide Results, page 7

	Percent of Total Plots / Sites with Problems, part 1 of 4									
	Unknown		Shade		Weeds		Vines		Shelters	
County / Region	% Plots	% Sites	% Plots	% Sites	% Plots	% Sites	% Plots	% Sites	% Plots	% Sites
Allegany	23.1	100.0	0.0	0.0	15.4	100.0	0.0	0.0	0.0	0.0
Washington	0.9	12.5	4.5	25.0	72.1	100.0	5.0	37.5	1.8	25.0
Frederick	7.6	64.3	3.1	42.9	33.3	78.6	1.2	21.4	6.7	35.7
Western Region	5.3	47.8	3.6	34.8	48.2	87.0	2.7	26.1	4.6	30.4
Carroll	5.5	40.0	10.1	60.0	38.5	80.0	0.9	20.0	1.8	40.0
Baltimore	19.4	75.0	7.2	50.0	23.7	75.0	7.2	37.5	0.0	0.0
Howard	5.3	25.0	5.3	25.0	52.6	75.0	5.3	25.0	0.0	0.0
Montgomery	15.9	37.5	0.0	0.0	15.9	50.0	0.0	0.0	4.3	25.0
Harford	11.2	69.2	4.3	46.2	39.5	84.6	8.2	30.8	1.7	23.1
Cecil	16.7	100.0	16.7	100.0	33.3	100.0	41.7	100.0	0.0	0.0
Central Region	12.3	56.4	5.8	38.5	33.7	74.4	6.2	25.6	1.5	17.9
Prince George's	7.9	38.5	4.0	30.8	44.4	92.3	3.2	15.4	0.0	0.0
Anne Arundel	0.0	0.0	4.3	50.0	2.1	50.0	0.0	0.0	0.0	0.0
Calvert	2.2	14.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Charles	24.3	100.0	5.7	25.0	30.0	75.0	11.4	50.0	0.0	0.0
St. Mary's	10.8	40.0	2.7	20.0	5.4	20.0	0.0	0.0	0.0	0.0
Southern Region	9.8	38.7	3.7	22.6	24.6	54.8	3.7	12.9	0.0	0.0
Kent	1.6	28.6	0.0	0.0	54.8	57.1	4.8	42.9	0.0	0.0
Queen Anne's	7.3	66.7	0.0	0.0	47.3	33.3	14.5	33.3	0.0	0.0
Talbot	3.9	21.4	0.4	7.1	11.4	57.1	2.9	14.3	0.4	7.1
Dorchester	19.5	100.0	0.0	0.0	19.5	100.0	0.0	0.0	39.0	50.0
Wicomico	0.0	0.0	0.0	0.0	34.7	100.0	1.3	33.3	0.0	0.0
Somerset	6.2	40.0	0.0	0.0	18.6	100.0	7.2	60.0	3.1	20.0
Worcester	3.1	66.7	1.5	66.7	51.5	100.0	7.7	66.7	0.0	0.0
Eastern Region	4.4	35.1	0.4	8.1	30.5	70.3	5.0	32.4	2.5	8.1
Statewide Totals	7.5	44.6	3.1	25.4	34.9	70.8	4.5	24.6	2.4	13.1

Riparian Forest Buffer Monitoring Study - Statewide Results, page 8

County / Region	Insects % Plots	Insects % Sites	Disease % Plots	Disease % Sites	DeerBrowse % Plots	DeerBrowse % Sites	DeerRub % Plots	DeerRub % Sites	Rodents % Plots	Rodents % Sites
	Percent of Total Plots / Sites with Problems, part 2 of 4									
Allegany	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Washington	8.6	50.0	2.3	12.5	7.2	50.0	0.0	0.0	4.1	37.5
Frederick	6.1	64.3	1.2	28.6	12.8	71.4	0.6	14.3	8.3	57.1
Western Region	6.9	56.5	1.6	21.7	10.3	60.9	0.4	8.7	6.4	47.8
Carroll	0.0	0.0	0.9	20.0	12.8	80.0	0.0	0.0	4.6	40.0
Baltimore	4.3	37.5	0.7	12.5	12.2	50.0	1.4	25.0	7.2	62.5
Howard	0.0	0.0	0.0	0.0	28.9	100.0	0.0	0.0	2.6	25.0
Montgomery	2.9	25.0	0.0	0.0	18.8	62.5	2.9	12.5	0.0	0.0
Harford	3.0	15.4	2.6	23.1	8.6	61.5	0.0	0.0	2.1	23.1
Cecil	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.3	100.0
Central Region	2.5	17.9	1.3	12.8	12.5	64.1	0.7	7.7	3.7	30.8
Prince George's	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Anne Arundel	0.0	0.0	0.0	0.0	2.1	50.0	0.0	0.0	0.0	0.0
Calvert	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Charles	0.0	0.0	0.0	0.0	8.6	50.0	0.0	0.0	0.0	0.0
St. Mary's	0.0	0.0	2.7	20.0	0.0	0.0	0.0	0.0	0.0	0.0
Southern Region	0.0	0.0	0.3	3.2	2.2	9.7	0.0	0.0	0.0	0.0
Kent	1.6	28.6	0.8	14.3	3.2	28.6	0.0	0.0	0.0	0.0
Queen Anne's	5.5	33.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Talbot	6.8	57.1	0.4	7.1	4.3	35.7	0.0	0.0	0.0	0.0
Dorchester	2.4	50.0	0.0	0.0	2.4	50.0	0.0	0.0	0.0	0.0
Wicomico	1.3	33.3	0.0	0.0	2.7	66.7	0.0	0.0	0.0	0.0
Somerset	7.2	100.0	0.0	0.0	3.1	40.0	0.0	0.0	0.0	0.0
Worcester	4.6	66.7	0.0	0.0	39.2	66.7	0.0	0.0	0.0	0.0
Eastern Region	4.9	54.1	0.2	5.4	9.1	37.8	0.0	0.0	0.0	0.0
Statewide Totals	4.1	30.8	0.9	10.0	9.3	43.1	0.3	3.8	2.5	17.7

Riparian Forest Buffer Monitoring Study - Statewide Results, page 9

	Percent of Total Plots / Sites with Problems, part 3 of 4									
	Machinery		Herbicide		Planting		Flooding		Wet Site	
County / Region	% Plots	% Sites	% Plots	% Sites	% Plots	% Sites	% Plots	% Sites	% Plots	% Sites
Allegany	0.0	0.0	0.0	0.0	0.0	0.0	7.7	100.0	0.0	0.0
Washington	0.5	12.5	0.5	12.5	2.3	25.0	0.0	0.0	18.0	50.0
Frederick	1.2	21.4	1.2	7.1	3.4	42.9	1.8	7.1	1.5	14.3
Western Region	0.9	17.4	0.9	8.7	2.8	34.8	1.2	8.7	8.0	26.1
Carroll	0.9	20.0	5.5	20.0	2.8	40.0	0.0	0.0	0.9	20.0
Baltimore	22.3	25.0	0.0	0.0	0.0	0.0	3.6	12.5	2.9	12.5
Howard	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Montgomery	5.8	12.5	0.0	0.0	0.0	0.0	0.0	0.0	5.8	12.5
Harford	1.7	30.8	0.0	0.0	0.4	7.7	0.0	0.0	4.3	38.5
Cecil	8.3	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Central Region	6.8	23.1	1.0	2.6	0.7	7.7	0.8	2.6	3.2	20.5
Prince George's	1.6	15.4	0.0	0.0	0.0	0.0	0.0	0.0	1.6	15.4
Anne Arundel	21.3	50.0	0.0	0.0	27.7	50.0	0.0	0.0	0.0	0.0
Calvert	0.0	0.0	0.0	0.0	0.0	0.0	4.4	14.3	4.4	14.3
Charles	7.1	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
St. Mary's	48.6	60.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7	20.0
Southern Region	10.8	25.8	0.0	0.0	4.0	3.2	0.6	3.2	1.5	12.9
Kent	4.0	28.6	4.8	42.9	0.0	0.0	0.0	0.0	0.0	0.0
Queen Anne's	3.6	33.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Talbot	2.5	35.7	0.7	7.1	0.4	7.1	0.0	0.0	1.1	7.1
Dorchester	0.0	0.0	0.0	0.0	7.3	50.0	0.0	0.0	0.0	0.0
Wicomico	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Somerset	0.0	0.0	0.0	0.0	1.0	20.0	0.0	0.0	13.4	60.0
Worcester	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eastern Region	1.7	21.6	1.0	10.8	0.6	8.1	0.0	0.0	2.0	10.8
Statewide Totals	4.2	22.3	0.8	5.4	1.7	11.5	0.6	3.1	3.7	16.9

Riparian Forest Buffer Monitoring Study - Statewide Results, page 10 (last)

	Percent of Total Plots / Sites with Problems, part 4 of 4										
	Dry Site		Drought		Vandalism		Other		% w/ any		
County / Region	%Plots	%Sites	%Plots	%Sites	%Plots	%Sites	%Plots	%Sites	%Plots	%Sites	Avg. % per Site
Allegany	0.0	0.0	76.9	100.0	0.0	0.0	0.0	0.0	100.0	100.0	100.0
Washington	0.0	0.0	24.3	50.0	0.0	0.0	0.0	0.0	96.8	100.0	97.1
Frederick	1.8	7.1	15.0	64.3	0.9	14.3	0.3	7.1	74.6	100.0	77.8
Western Region	1.1	4.3	20.1	60.9	0.5	8.7	0.2	4.3	84.0	100.0	85.5
Carroll	0.0	0.0	13.8	20.0	0.0	0.0	0.0	0.0	66.1	100.0	59.2
Baltimore	0.0	0.0	10.1	62.5	1.4	12.5	0.7	12.5	90.6	100.0	88.0
Howard	0.0	0.0	21.1	75.0	0.0	0.0	0.0	0.0	89.5	100.0	83.2
Montgomery	0.0	0.0	15.9	62.5	0.0	0.0	13.0	37.5	78.3	100.0	81.6
Harford	0.0	0.0	11.2	38.5	0.0	0.0	0.0	0.0	78.1	100.0	78.4
Cecil	0.0	0.0	25.0	100.0	0.0	0.0	0.0	0.0	91.7	100.0	91.7
Central Region	0.0	0.0	12.8	51.3	0.3	2.6	1.7	10.3	79.8	100.0	79.4
Prince George's	2.4	15.4	23.8	23.1	1.6	15.4	0.0	0.0	81.0	100.0	88.4
Anne Arundel	2.1	50.0	55.3	100.0	0.0	0.0	2.1	50.0	78.7	100.0	77.3
Calvert	0.0	0.0	20.0	57.1	2.2	14.3	0.0	0.0	28.9	85.7	39.8
Charles	0.0	0.0	12.9	50.0	0.0	0.0	0.0	0.0	81.4	100.0	93.2
St. Mary's	0.0	0.0	18.9	40.0	0.0	0.0	0.0	0.0	89.2	100.0	87.5
Southern Region	1.2	9.7	24.9	41.9	0.9	9.7	0.3	3.2	74.5	96.8	77.2
Kent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	66.1	71.4	44.8
Queen Anne's	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	63.6	100.0	50.7
Talbot	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.1	71.4	26.0
Dorchester	7.3	50.0	0.0	0.0	0.0	0.0	0.0	0.0	80.5	100.0	79.5
Wicomico	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.0	100.0	43.4
Somerset	0.0	0.0	0.0	0.0	0.0	0.0	5.2	20.0	52.6	100.0	60.3
Worcester	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	96.2	100.0	96.9
Eastern Region	0.4	2.7	0.0	0.0	0.0	0.0	0.6	2.7	53.9	83.8	46.2
Statewide Totals	0.6	3.8	11.8	36.2	0.3	4.6	0.7	5.4	71.0	94.6	70.5