Economics and Survival of Hand-Planted Riparian Forest Buffers in West Central Maine

Natural Resources Conservation Service
967 Illinois Avenue, Suite #3
Bangor, ME 04401
www.me.nrcs.usda.gov


J. Long, NRCS

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Sally Butler, New England IRT Forester and John Long, State Economist
U. S. Department of Agriculture
Natural Resources Conservation Service
Bangor, Maine

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Summary

This paper summarizes information on the economics and survival of two Maine sites hand planted to riparian forest buffers. A detailed qualitative and quantitative description of the regeneration process is included from each case study. The data were obtained from field reviews of conservation practices applied by the USDA Natural Resources Conservation Service (NRCS) and its partners in the year 2002.

Introduction

The NRCS Forester for the New England Interdisciplinary Resources Technical (IRT) Team and the NRCS State Economist obtained cost information on previous buffer installations from the Maine NRCS field offices. They also collected field data from two sites planted in 2002 in Somerset County, Maine. The data include information on species planted, planting methods, costs of establishment, and plant survival. General findings and conclusions are presented in this paper with some recommendations for future buffer establishment specifications. Detailed descriptions of two buffer sites are also included in Appendix B.

Background

A research request, FY01-1103 – Natural Regeneration for Establishment of Riparian Buffers, was submitted to the IRT Team seeking information on establishing riparian forest buffers using natural regeneration. Specifically, the request was for information on the use of natural regeneration, either alone or in conjunction with tree plantings, to meet the functions of the buffer. In addition, information was needed on different types of site preparation, including plant protective devices, and their effectiveness in forest buffer establishment.

It was determined that there were two final products that would be the most useful to field personnel. The first product was a literature review of all the information presently available on this subject. The second product was to obtain cost and survival information on previously installed riparian buffers using case studies. The riparian forest buffers in the two case studies discussed in this paper were both established in the spring of 2002.

The forester for the New England IRT has completed and published the first phase, the literature review, Natural and Artificial Regeneration as it Relates to Establishment and Maintenance of Riparian Forest Buffers in the Northeast, and it is available at the Maine NRCS Electronic Field Office Technical Guide (eFOTG) web site (http://efotg.nrcs.usda.gov/) in Section I, Reference file, Conservation Buffers, General folder.

The general climate at both site locations is considered temperate with cool to moderately warm summers, fairly cold winters and generally ample rain fall. Average annual precipitation is 39 inches in rain or snow. Average last frost date in spring is May 20, but may be later in low lying areas such as riparian buffer sites. Plant hardiness zone is 4b, which has an approximate range of average annual minimum temperatures of -20 to -25 degrees Fahrenheit (USDA 1990).

Both artificial and natural regeneration may be used to establish a riparian forest buffer. Artificial regeneration includes the planting of trees and shrubs at an adequate rate per acre to provide a diverse, well-stocked buffer within 15 years. NRCS has a standard for establishing a riparian forest buffer (USDA-NRCS 2001). The Maine state standard and specification (Code 391) describes the stocking and survival rates needed for different purposes, as well as considerations for species to be planted.

Methodology

Survival Protocol

A modified protocol, developed by the University of Washington and Lummi Indian Nation, was used to obtain field data (Wishnie 1999). This protocol includes an initial and annual survey of riparian forest buffer restoration sites. The initial survey was modified for use in our case studies.

Preliminary information was obtained from the local field office indicating that, in both case studies, trees were planted with tree shelters and shrubs were planted with geotextile mats. Therefore, the survey was conducted by locating shelters and mats within the survey plots and gathering specific data on plantings found. Also, in a lot of cases, especially for the shrubs, it was impossible to identify the species planted if they were dead. The dead shrubs were indicated by a mat with no physical stem(s) present. It was possible to identify some of the dead tree species

from the physical presence of a stem in the tree shelter.

The survey was conducted using the procedure as described below for each site:

- Site 1 had sixteen 1/50th acre initial survey plots completed. Plots were laid out in transect lines going from north to south with 100 feet between centers.
- Site 2 had eight 1/50th acre initial survey plots completed. Plots were laid out in transect lines going from north to south with 150 feet between centers.

The surveys noted a variety of plant information for each shelter and/or mat that was located within the survey plot boundaries. Information gathered consisted of species identification, height of plant (alive or dead, if possible), amount of competition from existing woody and non-woody vegetation, presence of plant protection devices, extent of damage from animals and other environmental factors, specific planting location elevation (microsite), existing native/invasive species present, and plant mortality. Other general planting area information obtained included soil types, aspect, site preparation, planting method, and operation and maintenance.

Costs of Establishment

Both plantings were established through the Conservation Reserve Program (CRP). After the buffers were planted, the landowners submitted bills for the materials and labor for installing the buffers, and were reimbursed 50% of the cost by CRP.

Copies of these bills submitted for cost-share reimbursement were collected from NRCS field office records. Based on this documentation, establishment budgets were constructed to itemize the various costs for materials and services.

This information was combined with the survival data in order to see if there were any relationships between establishment cost and plant survival. The establishment cost data will be useful as well for planning future riparian forest buffers, and in setting conservation program cost-share reimbursement rates.

Riparian forest buffer establishment cost data from the University of Maryland was used as a comparison. It was also used to estimate site preparation costs, which were not available for the two sites analyzed in this study.

Survival Rates

Overall, the survival rate within the survey plots was less than 50%, which is the rate that is generally used for designing riparian forest buffers (USDA-NRCS 2003), and, in this case, is indicated by the NRCS soil interpretations for planting in the Somerset County Soil Survey Report (USDA-SCS 1972). The overall survival rate at Site 1 was 44% and at Site 2 was 18%.

Survival rates were calculated using the data and acreage extrapolated from the survey plots and not the total planned acreage. This is because it was very difficult to determine the extent of the area planted within the boundaries identified on the aerial photography. This became evident when survey plots contained lower numbers of shelters and mats or no shelters and mats. Therefore, we were unable to determine accurately the total acreage of the planted area and this would affect the rates calculated for planting and survival.

Overall survival rates were calculated using the general categories of trees and shrubs rather than for individual species because of the significant number of unknown plant species found. At Site 1, the survival rate for trees was 25% and for shrubs was 60%. At Site 2, survival rate for trees was 0% and for shrubs was 35%.

The survey plot data still gives a good indication of what has happened to the remainder of the planted area. The planted shrub species had a higher survival rate than the tree species at both sites. At both sites, no planted red maple trees survived. At the wetter site (Site 2), more redosier dogwood survived than American cranberry. At the drier site (Site 1), some of the white birch survived, and more American cranberry survived than redosier dogwood. No Bankers willow survived. A table listing the number of dead and live plants by species is included in Appendix B, Detailed Description of Sites.

At both sites, some of the factors influencing survival were similar. Information obtained from the field office staff indicated that site

preparation before planting and practice maintenance for the two years after planting were not completed at either of the planting sites. According to the literature review, these two items were considered critical for plant survival.

Other factors that may have played a role in plant survival include the correct planting and the correct placement of seedlings in appropriate locations. This includes planting in the upland rather than the wetland area, and in more elevated or level microsites. For example, most of the white birch, which grows best on well-drained to moderately well-drained soils, was planted in the dryer upland soil at Site 1.

Another major survival factor occurring in both case studies might be the selection of more aggressive species to be planted. These types of plants, like redosier dogwood, are usually able to compete with the existing vegetation for both light and nutrients.

The majority of the trees and shrubs at both sites were in the 1 to 3 foot size range, so height did not seem to be a major factor in survival, as the existing vegetation was as tall or taller.

Planting more than one species of trees and/or shrubs did provide insurance against total failure of either trees or shrubs. This was shown in Site 1, where there were 0 live red maple and 11 live white birch identified in the survey plots.

During the survey, most of the geotextile mats were found to be grown over with existing vegetation, but had not started the process of degrading. Because of this, the mats may have been preventing the more aggressive shrubs from suckering or spreading out more. On the other hand, the mats, in some cases, may have assisted the plants in obtaining an advantage over the existing vegetation for at least the first year.

At both sites all tree species had tree shelters, but they did not appear to be a major factor in seedling survival in the survey plots. In fact, at Site 2, a significant number were found tipped over and may have caused mortality. Also, at Site 1 animal damage was observed in only 2% of the seedlings and at Site 2 animal damage was observed in 13% of the seedlings. In either case, animal damage was not the cause of mortality and the damage was mostly minor in nature.

Trees at Site 1 may have had a higher survival rate than at Site 2 because they had both a shelter and a mat, whereas at Site 2 trees only had a shelter. This is only speculation because the red maple plants did not survive at both sites and birch was only planted at Site 1.

It should be noted that at Site 2, which was previously an old crop/hay field, a noticeable amount of natural regeneration was filling in from nearby hedgerows and woodland. Site 1, which was previously grazed by cattle, did not have a noticeable amount of natural regeneration.

Appendix B provides detailed information on each site. Each site is divided into six different topics. The topics are: general location, aspect and soils; site preparation; species planted, planting method and plant protection devices used; native and invasive vegetation; maintenance; and survival.

Two-year old white birch and redosier dogwood shown growing in fenced buffer area. (J. Long, NRCS)

Costs of Establishment

For the economic portion of this study, an attempt was made to determine if there was any identifiable relationship between survivability and establishment cost at the two sites. Bills submitted for cost-share reimbursement for the installation of the plantings were collected from NRCS field office records.

Based on this documentation, establishment budgets were constructed to itemize costs for materials and labor. These were converted to a per plant and a per acre basis for comparison purposes.

Establishment costs per acre can be useful during the early planning stage of installing a riparian forest buffer, when only the potential acreage to be planted is known. Because per acre costs are influenced by the planting rate and the proportional mix of trees and shrubs planted, establishment costs are also presented per plant.

Establishment costs per plant can be useful during the design phase when you know the types and amounts of trees and shrubs that will be planted and are deciding the amount of shelters and mats to install. These figures can be used in estimating how much various mixes of trees, tree shelters, shrubs, and geotextile mats would cost to establish.

A more detailed summary of unit costs is included in Appendix D. Note that all figures are in 2002 dollars.

Establishment Costs Per Plant

Table 1 provides cost per plant ranges at the two sites. The shipping and handling charges for the shelters, stakes, and mats were not broken out for the individual components, so some assumptions were made about how to allocate them among the trees and shrubs.

Table 1. Typical Establishment Costs per Plant

Item	Tree	Shrub
Plant	$1.90 to $2.00	$1.80 to $1.90
Labor for plants, shelters and mats	$1.50	$1.00 to $1.50
Tree shelter and mat[1]	$3.00	------
Mats for shrubs	------	$1.25
Shipping/handling for shelters and mats	$0.20 to $0.30	$0.10

[1] *Mats were not installed on trees on Site 2, although it was charged the same price of $3.00 per plant*.

The planting labor charges for trees and shrubs ($1.00 to $1.50 per plant) included an additional charge for installing the shelters and mats, but the exact amount was not separated out in the bills collected. Typically an additional $0.50 is charged for installing shelters or mats. For example, the total labor cost for a tree receiving a shelter and a mat would be $0.50 for the planting, $0.50 for the installation of the shelter, and $0.50 for the installation of the mat, for a total of $1.50.

The average cost of labor and materials for trees was $2.45. The average additional cost for the materials and labor to install the tree shelters and mats on the trees was $4.25. Therefore, the average total establishment cost per tree is $6.70.

The average cost of labor and materials for shrubs was $2.60. The average additional cost for the materials and labor to install the mats on the shrubs was $1.85. Therefore, the average total establishment cost per shrub was $4.45.

Establishment Costs Per Acre

As indicated earlier in this study, the total planned acreage did not appear to be planted, so the actual cost per acre planted was estimated by extrapolating from sample plot data. Site 1 sample plots totaled .32 acre, while Site 2 sample plots totaled .12 acre.

An average cost per plant for trees and shrubs at the two sites was calculated from the billing documentation. These average costs were multiplied by the number of trees and shrubs planted in the sample plot acreage to estimate establishment costs per acre. Table 2 summarizes these costs.

Table 2. Estimated Establishment Costs per Acre

Item	Site 1	Site 2
Tree and shrub planting (labor)	$358	$550
Plants	$560	$700
Tree shelters and mats[1]	$664	$816
Total Cost	$1,582	$2,066

[1] *Mats were not installed on trees on Site 2, although it was charged the same price of $3.00 per plant*.

Per acre costs differ between the two sites primarily because of differences in planting rates. The other major factor was the different labor costs for shrubs. Generally, unit costs for the same materials (species of plants, shelters, stakes, and mats) at the two sites were identical. For a detailed breakdown of unit costs at the two sites, see Appendix D.

Site 1's planting rate of 297 plants per acre was lower than Site 2's 367 plants per acre. The

proportion of trees and shrubs at both sites were similar. If the planting rate at Site 1 was the same as at Site 2, its total per acre establishment cost would have only been about $100 less than Site 2 ($1,973).

The planting labor cost for shrubs and mats at Site 1 was $0.50 lower per plant ($1 versus $1.50). Site 1 also used a wider variety of plants, some of which were cheaper. For example, in addition to red maple which costs $2.00 per plant, white birch was planted which costs $1.90. It is interesting to note that the white birch had a higher survival rate, even though some were smaller in height than the red maple.

The per acre costs for the shelters and mats varied because of the different proportions of trees and shrubs planted, and the different planting rates at the two sites. The total additional cost for the shelters and mats was approximately $880 and $1,086 per acre at Sites 1 and 2, respectively. These costs represent approximately 55% of the total per acre establishment costs.

Cost and Survival

Table 3 combines cost data with survival data collected from the sample plots in the two buffers. It should be noted that trees at Site 1 received shelters and mats, while trees at Site 2 received a shelter but no mat. However, these trees cost the same ($3.00).

Table 3. Establishment Cost and Survival

Item	Site 1	Site 2
Average cost per tree	$6.75	$6.69
Survival Rate	25%	0%
Average cost per shrub	$4.15	$4.67
Survival Rate	60%	35%
Average cost per acre	$1,583	$2,065
Overall survival Rate	44%	18%

The average total cost per tree (including all materials and labor) at the two sites differed because of different species used, and different shipping and handling costs. The average cost per shrub differs primarily because of the lower planting cost ($1.00 versus $1.50) at Site 1. If the shrub planting charges were the same at both sites, per plant costs would be very similar.

Eleven of 43 trees survived at Site 1, while 0 of 21 trees survived at Site 2. Because Site 2 was charged the same amount as Site 1 for shelters and mats on trees, although it did not receive any mats for the trees, comparison is difficult. If Site 2's costs were adjusted to account for this, its average cost per tree would be reduced from $6.69 to $4.94. Comparing the $4.94 to Site 1's cost of $6.75 is a more accurate comparison because it accounts for the fact that mats were not installed on trees at Site 2.

Comparing $4.94 to $6.75, with respective survival rates of 0% and 25%, it appears that the additional $1.81 increased survival at Site 1. However, it should be pointed out that the 25% survival rate at Site 1 is still very low.

Site Preparation Costs

For the purposes of this study, site preparation refers to any combination of mowing, tillage, and herbicide application. As indicated in other sections of this case study, site preparation is essential to the survival of riparian forest buffer plants. An actual site preparation scenario might include a broadcast application of an herbicide or a combination of mowing and a band application of herbicide.

No data was available on the costs of tilling individual plant locations. Mowing costs per acre generally range from $10 to $50, depending on labor, fuel, and machinery costs. Herbicide application costs per acre for grass control in tree buffer plantings in the state of Maryland have ranged from $30 to $50 for band application, and $80 to $120 per acre for broadcast application (Lynch and Tjaden 2000).

Adding these costs together, total costs for site preparation using mowing and/or herbicide application could range from $40 to $120 per acre. If a site preparation cost of $120 per acre is assumed, including this in the establishment would raise the total per acre costs in these two sites by about 7%.

Conclusions

Site 1 had better survival at lower total cost per acre. Site 1's total per acre costs were lower primarily because of a lower planting rate and some savings on planting labor costs for the shrubs.

Per plant costs for the two sites were much more similar. Site 1 realized some savings because of a lower shrub planting cost, and some savings on the actual plants by using an additional species of tree that was less expensive.

Site 1 also had the benefit of geotextile mats on every tree. Site 2 did not have these on the trees, yet it was apparently charged the same unit price of $3.00 per tree. If this was accounted for cost-wise (by subtracting out mat costs), the per tree cost at Site 2 would be $1.81 cheaper. However, the money spent there ($4.94 per tree) results in no benefit, because of the 0% survival rate.

Although survival at Site 1 was higher than at Site 2, it was still very low. Regardless of comparisons between the two sites, without an adequate planting rate, site preparation, seedling placement and maintenance, and low incidence of animal damage, the added considerable expense for tree tubes and mats does not appear to be justified. Considering the relatively low cost of site preparation and its importance to the survivability of the buffer, it should strongly be encouraged in riparian buffer establishment (USDA-NRCS 2003).

Considering the high additional cost of shelters and mats at the two sites, it might be beneficial to consider cutting this additional cost by installing them on a portion of the plants, instead of on all of them (Palone and Todd 1997).

For example, if shelters and mats were installed on every other plant on Site 1, the total per acre cost would be $1,149, a savings of $434 per acre. This more than offsets the additional cost of site preparation of $120 per acre.

If the planting rate for trees at Site 1 was increased to 400 plants per acre (recommended minimum from the literature review), and 50% of these were set up with shelters and mats (along with the original planting rate for shrubs and 50% of them installed with mats), the total cost would be about $2,370 per acre, an increase of $787. Adding the site preparation would bring the total to $2,490 per acre. This estimate does not assume any discount savings by purchasing more plants or planting labor. Therefore, planting at least 400 trees per acre and installing mats and shelters on every plant could be cost prohibitive.

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Buffer Design and Establishment Specifications to Improve Survival and Establishment

The literature review completed in 2003 provides a number of suggestions for improving and establishing a riparian forest buffer and the case studies reported on in this technical paper also provide a means to emphasis the critical elements needed to ensure survival and establishment of a functioning buffer.

The following standards and specifications should be considered when designing a riparian forest buffer (USDA-NRCS 2001):

Planting Location, Aspect, and Soils

In situations where there is no obvious stream channel, a closer soils investigation is needed to determine the wetland-buffer boundary. This will provide a clear-cut location for the buffer planting in the upland and should increase the survival of the plantings. Plants and soil characteristics should always be matched to increase survival of the seedlings.

Site Preparation

Site preparation is essential to the survival of the planted trees and shrubs. At the minimum, the site should be prepared by mowing, or mowing in combination with herbiciding or tilling, at the individual planting location (USDA-NRCS 2003). Depending on the abundance and aggressiveness of the existing vegetation, this should be done in the fall before planting and in the spring right before planting. The use of geotextile mats is a supplement to this and should not be the only means of weed control.

Species Planted, Planting Method, and Plant Protective Devices Used

At a minimum, two or more species of trees and two or more species of shrubs should be planted in case of large scale plant mortality of one or more species. Tree and shrub planting rates (stems per acre and plant spacing) should be developed separately, according to the table provided in the Riparian Forest Buffer, Code 391 Standard and Specification (USDA-NRCS 2001). Planting rates and species should be developed by also taking into account types and amounts of existing trees and shrubs. The research literature has shown that a minimum of 400 trees per acre (also assuming a 50% survival rate) is necessary to achieve a full stocking rate for tree species (USDA-NRCS 2003) and provide a functioning buffer.

Species planted need to be healthy and climate-adapted to the site for best chance of survival. Plants need to be properly taken care of prior to and during the planting so that roots do not dry out.

The planting of larger-sized plants is not a guarantee of survival and in general fewer are planted. This would reduce the chances of having an adequately functioning buffer. Planting a larger number of smaller-sized plants appears to be more effective because the survival rates may be lower but still have a well-stocked, functioning buffer.

Plant protective devices, such as tree shelters, are principally for animal damage control. The use of tree shelters should be used only when a need for animal damage control has been identified. Tree shelters should be used with geotextile mats to prevent small mammal damage.

Since some geotextile fabric mats may girdle or prevent desirable growth habits, such as shrub suckering, they may not be appropriate for certain types of plantings, including dogwood and willow establishment (Stange, 2003).

Maintenance

According to various published studies cited in the literature review (USDA-NRCS, 2003), maintenance is essential to the survival of the planted trees and shrubs. Competition from other plants for light and food is intense if not controlled. Seedlings can quickly be overwhelmed by larger and more aggressive plants already well established in the buffer planting area. At a minimum, larger and more aggressive existing, competing plants should be controlled, using mowing and/or herbiciding/ tilling, for at least three years after establishment of the buffer. This includes any invasive type plants that may be threatening the site. Tree shelters should be inspected to make sure they are still upright and not girdling the tree. Mats should be inspected to make sure that they are not girdling trees or shrubs or inhibiting the suckering of shrubs.

Survival

The literature review showed that survival of the plantings is directly related to obtaining healthy, climate-adapted seedlings and properly placing and planting them. Site preparation before planting and maintenance after planting is critical. Indirectly, survival is influenced by the weather after planting, so timing of the planting can be another critical factor. A survival rate of 50% or better with a stocking rate of 400 trees per acre or better is needed to ensure the proper functioning of the riparian forest buffer (USDA-NRCS 2003). Tree shelters ensure survival if there is a problem with animal damage. Several studies have shown that geotextile mats may help to ensure survival, but are not a substitute for good site preparation and maintenance.

Riparian forest buffers can provide economic benefits to the public by improving downstream water quality and providing wildlife habitat. If the buffer is not functioning properly, these benefits will not be realized. In order to protect the investment of public money in conservation plantings and receive the greatest return, adequate dollars should be spent to ensure these benefits.

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Appendix A. Detailed Establishment Cost Information

Site 1 Detailed Establishment Budget

Item	Quantity	Unit Price	Cost
Planting - trees, shelters, mats	780	$ 1.50	$ 1,170.00
- shrubs & mats	520	$ 1.00	$ 520.00
Hardwoods - Red Maple	560	$ 2.00	$ 1,120.00
- White Paper Birch	220	$ 1.80	$ 396.00
Shrubs - Red Osier Dogwood	220	$ 1.80	$ 396.00
- American Cranberry	220	$ 1.85	$ 407.00
- Bankers Willow	100	$ 1.90	$ 190.00
Tree shelters and mats	780	$ 2.50	$ 1,950.00
Hardwood stakes	780	$ 0.50	$ 390.00
Mats/Pins for shrubs	540	$ 1.25	$ 675.00
Shipping and Handling	----	----	$ 297.00
Total Cost			$ 7,511.00

Site 2 Detailed Establishment Budget

Item	Quantity	Unit Price	Cost
Planting	1,490	$ 1.50	$ 2,235.00
Hardwood - Red Maple	200	$ 2.00	$ 400.00
Shrub - Red Osier Dogwood	645	$ 1.80	$ 1,161.00
- American Cranberry	645	$ 1.85	$ 1,193.25
Tree shelters	200	$ 2.50	$ 500.00
Hardwood stakes	200	$ 0.50	$ 100.00
Mats/Pins for shrubs	1,290	$ 1.25	$ 1,612.50
Shipping and Handling	----	----	$ 158.50
Total Cost			$ 7,360.25

The cost of individual trees ranged from $1.80 for the 1 to 2-foot birch to $2.00 for 1 to 2-foot and 2 to 3-foot maple plants. The cost of individual shrubs ranged from $1.80 for 1 to 2-foot plants (dogwood and cranberry) to $1.90 for 1 to 3-foot plants (willow).

Tree shelter set-ups including mats and shelters cost $2.50 each. Hardwood stakes cost $0.50. Geotextile mats with pins cost $1.25 each. The labor costs for hand planting the trees, including placement of the mats and shelters with stakes, was $1.50 each. Trees at Site 2 did not receive mats, but were charged the same as at Site 1. The labor costs for hand planting the shrubs, including placement and pinning of the mats, was $1.00 each at Site 1, and $1.50 at Site 2.

As indicated earlier, the additional labor charge to install the shelters, stakes, and mats was not separated out in the bills for these two plantings. Additional research by the local office confirmed that an additional $0.50 is charged for these items. For example, a tree receiving a shelter and a mat would cost $0.50 for the planting, $0.50 for the installation of the shelter, and $0.50 for the installation of the mat, for a total of $1.50.

Appendix B. – Detailed Descriptions of Sites

Site 1

General Location, Aspect, and Soils

This 7.0-acre buffer site is located on a beef farm that has been using intensive rotational grazing. It is immediately surrounded by pasture and hayland, with forest beyond. The forest is not close. The aspect is east – west. The drainage way is not well-defined, with no obvious stream channel.

In the drainage way and lower buffer planting area, the soil consists of Scantic silt loam. This soil is a poorly-drained, nearly level to slightly-undulating soil that occurs on swales or plains. It is formed in marine or lacustrine sediments. The water table is at a depth of 1 foot or less during the wettest periods. Runoff is slow. Permeability is moderately slow in the surface layer and subsoil, and very slow in the underlying material. This soil is wet for long periods and is very slow to warm up in the spring. Natural fertility is low. The clayey underlying material restricts the penetration of roots. Hayland, pasture and woodland are historical land uses. Plant competition is severe, indicating that competition prevents adequate natural or artificial regeneration, unless the site is prepared properly and maintenance practices are used. Seedling mortality is severe, indicating that a loss of more than 50% of seedlings will most likely occur due to wetness (USDA-SCS 1972).

In the upper planting area, the soils consist of Buxton silt loam or Melrose fine sandy loam. Buxton is a moderately well-drained, gently undulating to sloping soil that formed in lacustrine or marine sediments or both, and is mainly under cover of spruce, fir, and pine. Depth to water table is 1 to 2 feet, and permeability is moderately slow to moderate to a depth of about 18 inches, and is slow to very slow below a depth of 18 inches. In spring this soil warms up one to two weeks later than the coarser textured soils and it is slow in drying out after a rain. Deep-rooted plants may be damaged by frost heaving (USDA-SCS 1972).

Hayland and pasture are historical land uses. Plant competition is slight for hardwoods and moderate for conifers, indicating that competition either does not prevent natural regeneration of hardwoods or that competing plants delay, but do not prevent the establishment of a desirable stand of conifers by natural regeneration or planting. Seedling mortality is slight, indicating that less than 25% of the seedlings are expected to die. It should be noted though that there is a problem with frost heaving, which may cause a higher mortality rate than indicated (USDA-NRCS 1972).

Melrose is a well-drained, nearly level to sloping soil that occurs in valleys, and was formed in lacustrine and marine sediments. Depth to water table is 5 feet or more. This soil has slow to medium runoff. Permeability is rapid in the surface layer and subsoil, but is very slow in the underlying material. Available moisture capacity is moderate to high. Deep-rooted plants may be damaged by frost heaving. Cropland, hayland and pasture are historical land uses. Lime and fertilizer are needed. Plant competition and seedling mortality is the same as for the Buxton silt loam (USDA-NRCS 1972).

Site Preparation

According to the local NRCS field office staff, the cattle were fenced out of the drainage way and buffer planting area. No other site preparations, such as mowing, tilling or herbiciding, were performed prior to planting (White 2004).

Species Planted, Planting Method, and Protective Devices Used

There were two species of trees and three species of shrubs planted according to the bills submitted to the Farm Service Agency (see Appendix D). Trees were hand planted on 10-foot centers and shrubs were planted on 6-foot centers. Trees and shrubs were both planted in a random pattern with no set rows. The table below contains a summary of the use of protection devices by species.

Table 1. Number of Species Planted by Protection Device Used

Species	Tubes	Mats	Both
red maple			560
white birch			220
redosier dogwood		220	
Amer. cranberry		220	
Bankers willow		100	

Trees were planted in 2-foot square black geotextile mats and 2-foot tubes. The plants ranged in height from 1 to 2 feet and 2 to 3 feet for red maple, to 1 to 3 feet for white birch. The tree planting rate using the combined number of trees planted in all the survey plots for this study equals 134 trees per acre. Trees represented 45% of the total plants found in the survey plots with an average of two trees per plot. Plots contained a range of one to five trees per plot with one plot containing no trees.

Shrubs were planted in 2-foot square black geotextile mats. The dogwood and cranberry plants were 1 to 2 feet in height, and the willow were 1 to 3 feet in height when planted. The shrub planting rate for this site using the combined number of shrubs planted in all the survey plots equals 162 shrubs per acre. Shrubs represented 55% of the total plants found in the survey plots with an average of three shrubs per plot. Plots contained a range of one to six shrubs per plot with two plots containing no shrubs.

This gives a combined planting rate of 297 plants per acre for this site using the data from the survey plots. This planting rate is lower than 400 trees and 1,200 shrubs per acre recommended in the literature review.

Seven of the tree shelters were tipped over and many of them, especially those without live seedlings, had grass and other herbaceous weeds growing out of them. Sixty-seven percent of the geotextile mats were completely covered over with herbaceous weeds or grasses in the two years since the planting. Only 10% had no weeds or grass within 2 feet of the stem. Twenty-two percent had weeds or grass within 5 inches of the stem.

Seventy-four percent of the live seedlings were planted in an elevated location. Twenty-four percent of the live seedlings were planted in a level location and only one live plant was planted in a depression.

Only white birch, redosier dogwood, and American cranberry were found alive in the survey plots. None of the survey plots contained live willow or red maple seedlings. The species could not be identified for 43 dead seedlings. We know, however, that of the 43 dead plants, there were 20 shrubs and 23 trees planted.

Native and Invasive Vegetation

In the lower, wetter sections of the buffer, plants like cattail, tearthumb, sedge/rushes, sensitive fern, and reed canarygrass were abundant. Larger native vegetation included trees such as red maple, black willow, hawthorn, and alder shrubs, but they are all rare. On the upper, dryer sections of the buffer, plants like foxtail grass, thistle, white aster, and goldenrod were abundant. Most of the herbaceous species were doing so well that they out-competed the trees and shrubs planted. The average height of the competing vegetation was 36 inches or more and the average height of planted species was 36 inches or less after two years.

Invasive plants, such as purple loosestrife, were found in the buffer area, but not in abundance. A noxious weed, wild parsnip, was also found growing in a few areas of the buffer.

Maintenance

According to the local NRCS field office staff, the fence has been maintained so that beef cattle are excluded from the buffer area. No other maintenance, such as mowing or straightening of tree shelters, was completed since planting two years previously (White 2004).

Survival

In general, the planted shrub species survived much better than the tree species at this site.

There were a total of 95 plants located within the 16 plots at this site.

The table on the next page contains a summary of the survival data for each species.

Table 2. Number of Species in plots by Condition

Species	Number Live	Number Dead
red maple	0	6
white birch	11	3
redosier dogwood	12	1
Amer. cranberry	19	U
Bankers willow	0	U
unknown tree	0	23
unknown shrub	0	20
Total Plants	**42**	**53**

U = Unknown

Red maple and Bankers willow have 0% survival. White birch had 85% survival, American cranberry had 100% survival, and redosier dogwood had 92% survival. Unknown trees and shrubs had 0% survival.

Please note that individual survival rates are misleading. For example, American cranberry appears to have a survival rate of 100%, but actually a number of the unknown shrubs could have been cranberry, which would give that species a lower survival rate. At this site, more cranberry than dogwood survived, so cranberry has a higher survival rate than dogwood.

Red maple seedling planted with tree shelters and geotextile mat in 2002. (J. Long, NRCS).

Site 2

General Location, Aspect, and Soils

This 5.5-acre buffer site is located on a dairy farm and is surrounded by cropland on three sides and forest on one side. Cropland consists of alfalfa/timothy hay and silage corn. The aspect is east – west. There are hedgerows and/or forest on the north, east and south sides. The drainage way is not well-defined, with no obvious stream channel.

In the drainage way, the soil consists of Biddeford silt loam which is very poorly drained, nearly level to concave, and it lacks natural drainage outlets. It was formed in marine or lacustrine sediments. The water table is at the surface for most of the year. Runoff is slow and permeability is slow to very slow. Pasture or woodland is the historical land use (USDA-SCS 1972). Soil interpretations for planting were not developed due to the poor drainage.

In the buffer area, the soil consists of Scantic silt loam which is a poorly drained, nearly level to slightly undulating soil that occurs on swales or plains. This soil formed in marine or lacustrine sediments. The water table is at a depth of 1 foot or less during the wettest periods. Runoff is slow. Permeability is moderately slow in the surface layer and subsoil, and very slow in the underlying material. This soil is wet for long periods and is very slow to warm up in the spring. Natural fertility is low. The clayey underlying material restricts the penetration of roots (USDA-SCS 1972).

Hayland, pasture and woodland are historical land uses. Plant competition is severe, indicating that competition prevents adequate natural or artificial regeneration, unless the site is prepared properly and maintenance practices are used. Seedling mortality is severe, indicating that a loss of more than 50% of seedlings will most likely occur (USDA-SCS 1972).

Site Preparation

According to the local NRCS field office staff, the buffer planting area had no site preparation, such as mowing, tilling, or herbiciding, prior to planting (White 2004).

Species Planted, Planting Method, and Protective Devices Used

There was one tree species and two shrub species planted. Trees were hand planted on 10-foot centers and shrubs were planted on 6-foot centers. Trees and shrubs were both planted in a random pattern with no set rows.

There were two survey plots at this site that had no shelters or mats located within them, which indicates that there were no plants established in those locations. The table below contains a summary of the use of protection devices by species.

Table 3. Numbers of Species Planted by Protection Device Used

Species	Tubes	Mats	Both
red maple	200		
redosier dogwood		645	
Amer. cranberry		645	

The red maples were planted in 3-1/2 or 4-inch diameter, 2-foot high shelters. The plants ranged in height from 1 to 2 feet to 2 to 3 feet high. The tree planting rate using the combined number of trees planted in all the survey plots that had been planted (6) for this study equals 175 trees per acre. Trees represented 47% of the total plants found in the survey plots with an average of three trees per plot. Plots contained a range of one to twelve trees per acre with three out of six plots containing no trees.

The shrubs were planted in 3-foot square black geotextile mats. Both plants were 1 to 2 feet in height when planted. The shrub planting rate for this site using the combined number of shrubs planted in all the survey plots that had been planted equals 192 shrubs per acre. Shrubs represented 53% of the total plants found in the survey plots with an average of four shrubs per plot. Plots contained a range of one to ten shrubs per acre with all plots having shrubs, but four out of six plots only had one shrub.

This gives a combined 367 plants per acre for this site using the data from the six planted survey plots. As in Site 1, this planting rate is lower than 400 trees and 1,200 shrubs per acre recommended in the literature review.

The red maple trees appeared to be planted only on the east side and none in the survey plots were found alive. Twenty-nine percent of the planted trees in the survey plots had shelters that were tipped or lying on their sides. Shrubs were planted on both the east and west sides. One hundred percent of the geotextile mats in the survey plots were completely covered over (to the seedling stem) with herbaceous weeds or grasses in the two years since the planting.

One hundred percent of the live seedlings in the survey plots were planted in a level location.

Only redosier dogwood and American cranberry were found alive in the survey plots. None of the survey plots contained live red maple seedlings. The species could not be identified for 14 dead seedlings, although we do know that all 14 were shrubs.

Native and Invasive Vegetation

Existing native vegetation has started to come into this buffer area. White pine seedlings were growing in abundance on the southeast corner of the planting area. Large mature white pines were growing within the forest edge adjacent to the site on the southeast corner of the buffer area. Other tree species present in much smaller numbers included green ash, balsam poplar, and hawthorn. Mature balsam poplar and green ash were growing within the forest edge adjacent to the site on the southwest corner of the buffer area. Mature hawthorns were growing in the field hedgerows on the north and east sides of the buffer area. Some native shrub species present include spirea and were quite abundant on the east side of the planting area.

Other herbaceous species present include goldenrod, reed canarygrass, tearthumb, white aster, and Jerusalem artichoke. There were also many species of grass and sedges/rushes. Most of the herbaceous species were doing so well that they out-competed the trees and shrubs planted. The average height of the competing vegetation was 30 inches and the average height of planted species was 20 inches or less.

Maintenance

According to the local NRCS field office staff, no maintenance, such as mowing or straightening of tree shelters, was completed since planting two years previously (White 2004).

Survival

The planted shrub species were the only survivors in the surveyed plots.

There were a total of 44 plants, dead or alive, located within the eight plots at this site. Table 4 contains a summary of the survival data for each species.

Table 4. Number of Species in Plots by Condition

Species	Number Live	Number Dead
red maple	0	21
redosier dogwood	7	1
Amer. cranberry	1	U
unknown shrub	0	14
Total plants	**8**	**36**

U = Unknown

The only tree species planted, red maple, had 0% survival. American cranberry had 100% survival and redosier dogwood had 88% survival. The unknown shrubs had 0% survival.

Please note that individual survival rates are misleading. For example, American cranberry appears to have a survival rate of 100%, but actually a number of the unknown shrubs could have been cranberry, which would give that species a lower survival rate. Also, more dogwood than cranberry survived at this site, so the survival rate of dogwood is higher than cranberry.