Practice Specification
Tree/ Shrub Establishment (Code 612)

Tree/Shrub Establishment – 612 shall be planned and installed in accordance with the NRCS Standard detailed in the Field Office Technical Guide (FOTG) – Section IV – Conservation Practices. This document provides conservation planners with additional guidance and requirements for designing tree or shrub plantings for a variety of purposes. Where appropriate, specific references are noted and hot linked to provide detailed information needed for a successful design.

This practice generally applies to tree and shrub plantings designed primarily for purposes other than windbreaks or wildlife. As with most forestry practices, however, slight modifications of design will enable tree or shrub plantings to serve additional purposes while addressing the main purpose.

SITE SELECTION

When compatible with landowner objectives, locate tree and shrub plantings on soils and in topographic positions most conducive to woody plant survival and vigor. Sites where trees and shrubs tend to grow best include: north aspects, toe-slope positions, riparian areas, and areas that receive additional water through high water tables, deeper snow accumulations, or run-on, etc., or areas where trees and shrubs would be protected from desiccating summer winds.

WINDBREAK SUITABILITY GROUPS

To determine which trees will grow satisfactorily on which soils and to determine the estimated heights after 20 years, refer to the “Expected 20-Year Tree Heights” in FOTG – Section II – Windbreaks and Forest. To determine which soils are present on the planting site, refer to the County Soil Survey for the county in which the planting will occur. Windbreak suitability groups for each component of a soil mapping unit can be found in county specific interpretive tables in FOTG - Section II – Soil Information.

WOODY PLANT STOCK

Tree planting stock may vary depending upon the site and purpose of the planting. Once stock type has been determined, refer to page 2 of “Tree Care and Management” in FOTG – Section I – Reference Subjects – Windbreaks and Woodland for quality of planting stock to use. Use of native species is strongly encouraged. State-listed noxious weeds will be controlled and will not be part of the planting design.

STOCK STORAGE HANDLING AND CARE REQUIREMENTS

To determine proper stock storage, handling and care requirements, refer to pages 3-4 of “Tree Care and Management”.

SITE PREPARATION

To determine an appropriate method of site preparation, refer to pages 4-8 of “Tree Care and Management”.

PLANTING

To determine an appropriate planting technique for a particular stock used in a tree/shrub planting, refer to pages 8-11 of “Tree Care and Management”.

DESIGNS BY PURPOSE

For all purposes

Tree/shrub plantings shall be located no closer than 16 feet to any property line unless a signed agreement between both owners exists that would permit a closer planting.

According to North Dakota Century Code, no trees or shrubs may be placed within 33 feet of a section line unless written permission has first been secured from the county commissioners or township supervisors.

No trees shall be placed within the easement area of overhead transmission lines unless permission has been secured from the appropriate utility company.

As per international treaty, no trees or shrubs shall be planted in a location where the foliage, at maturity, will encroach upon the 20' wide (10' each side) line-of-site vista along the Canadian-US border.

Tree/shrub plantings that are adjacent to, or cross, legal and private drainage ways should be setback at least 100' to prevent snow and ice buildup that will restrict spring drainage.

In all cases, if local units of government have established more restrictive setback distances, then the more restrictive regulations will apply.

Tree and shrub plantings will be positioned to avoid causing visibility problems at road intersections, curves and driveway entrances. Generally speaking, the trees or shrubs at maturity should not spread into the rights-of-ways of roads. Refer to "Tree and Shrub Characteristics" in FOTG – Section I – Reference Subjects – Windbreaks and Woodland for the spread (width) of plants at maturity.

To reduce the chances of catastrophic wildfires, consider planning "Firebreaks" concurrently with the tree/shelterbelt establishment design. All conservation practices are located in FOTG – Section IV – Conservation Practices.

If the depth of disturbance during site preparation, planting or maintenance will exceed 18 inches, notification of various utility companies via the North Dakota One Call System at 1-800-795-0555 is required.

Tree/Shrub Establishment is considered an undertaking per Section 106 of the Federal Historic Preservation Act and will need to be investigated and assessed accordingly.

When compatible with landowner objectives and site capabilities, use native trees and shrubs. Do not use plants considered noxious by the North Dakota Department of Agriculture. To determine which plants are considered native to North Dakota refer to "Tree and Shrub Characteristics".

Stocking Rates

Unless specifically noted under a particular purpose, the following designed (initial) stocking rates will apply to all Tree/Shrub Establishment plantings.

435 trees per acre for large trees

680 trees per acre for medium/small trees

907 shrubs per acre

For a successful tree/shrub planting, 75% of the designed stocking rate should be alive and growing well by the summer of the third growing season. This survival percentage only applies to sites established with rooted cuttings, unrooted cuttings, bare-root stock, and container stock.

When direct seeding, design for 15,000 emerged seedlings per acre during the first growing season. Follow the guidance for direct seeding in "Tree Care and Management" pages 10 and 11. Due to moisture stress, sod competition, and high predation losses for most North Dakota tree plantings, this higher initial planting rate is designed to increase the likelihood that the desired trees and shrubs will fully "capture" the site and attain a closed canopy within 5-10 years. *Until more data on the viability of this planting method in North Dakota becomes available, review and approval of each site, planting plan and maintenance schedule shall be obtained from the NRCS State Forester*.

For natural regeneration methods follow the guidance in "Tree Care and Management" pages 6 and 10.

A successful planting for natural regeneration or direct seeding would be 2000 trees or shrubs per acre, inventoried during the summer of the third growing season.

The dense initial stocking rates for all establishment methods are designed to yield a fully stocked stand, provide canopy closure and weed suppression within 5-10 years, improve the form class of the trees, and to greatly increase the value for lumber, wood products and carbon sequestration.

For Forest Products and Carbon Sequestration

- Common to plantings for Forest Products and Carbon Sequestration, unless noted.

  Plantings under this practice will consist of solid blocks of trees and/or shrubs. Initial stocking rates and establishment success shall be adequate to ensure canopy closure within 10 years. Full canopy closure will reduce health and vigor of competing herbaceous weeds, fully utilize the site in producing woody material, maximize carbon storage and increase management and utilization options later in the life of the planting.

  Select species to fit objectives of the landowner and capabilities of the site. Whenever compatible with landowner objectives and site potential use a variety of species.

  To further maximize growth, plantings for lumber production will need to be thinned, probably at 20-30 years of age. Advice on thinning can be obtained from the North Dakota Forest Service field foresters at 701-549-2441 or 701-683-4323 or the NRCS forester at 701-530-2082.

- Lumber and Wood Products

  Species suitable for lumber production in North Dakota include: cottonwood, hybrid poplar, bur oak, basswood, boxelder, aspen, black ash, green ash, hackberry, willow, ponderosa pine, eastern redcedar, and Rocky Mountain juniper. In some scenarios, lumber species may be pattern-planted with shrubs or junipers, where the smaller trees and shrubs will act as trainers to reduce the size, or presence, of limbs and encourage straighter, more valuable trunks. For most situations, these species will take 50 years or more before they are ready for lumber harvest. Material thinned from the stands at 20-30 years may be suitable for lumber, pulp, fuel wood, or specialty wood products.

  Willow, cottonwood, and hybrid poplar grow rapidly and are often ready for harvest between 10-50 years after planting. These species have potential as biofuels, pulp and lumber, depending upon markets. They readily re-grow from cut stumps (coppice). This phenomenon effectively replants a forest after logging for up to 4 cutting cycles. Care must be exercised during the logging operation to minimize root collar, stump and root injury so that adequate re-growth occurs. For specific details on managing a stand for lumber contact NDFS field foresters at 701-549-2441 or 701-683- 4323 or the NRCS staff forester at 701-530-2082.

- Carbon Storage

  Carbon sequestration can be realized through several different mechanisms; cessation of soil tillage, accumulation of carbon in roots and upper tree mass, and accumulation of a duff layer. Generally speaking, maximum carbon sequestration can be expected through:

  - Close spacings maximizing plants per acre without unduly causing plant stress that would lead to early mortality. Use the closer of the initial stocking rates listed in the section above. When different species require different spacings, use the larger of the minimum spacings.
  - Establishing a variety of species to reduce risk of catastrophic loss and improve environmental benefits.
  - Establishing long-lived trees.
  - Planting trees that will grow large with extensive and deep root systems. Species suitable for carbon sequestration are those listed above for lumber and wood products.
  - Harvesting woody material for lumber or alternative fuels.
  - Minimizing of tillage within the planting to that necessary for establishment.

- Christmas Trees

  Plant spacings may vary to fit landowner objectives. Wider spacings provide easier access at harvest time but reduce the productivity per acre. Generally plantings are quite dense (6x6 to 8x8) with access lanes every 20-40 feet. Two excellent guides for establishing and managing a Christmas tree plantation are listed below:

  “Christmas Trees, a Management Guide” - Nebraska Cooperative Extension EC 76-1741

  http://www.ianr.unl.edu/pubs/Forestry/ec1741.htm#shape or

Iowa State University pamphlet, “Christmas Tree Shearing”
http://www.extension.iastate.edu/forestry/publications/F-348.pdf

In Christmas tree plantings it is advantageous to establish short, warm-season grass species throughout the tree plantation. These grass plantings reduce erosion and greatly simplify access during harvest. Tillage as a weed control method often results in a muddy site at harvest time, since North Dakota usually receives rains or wet snows at that time of year. Refer to the section on native grass cover, pages 7-8 in “Tree Care and Management” for grass cover establishment guidelines.

- Fruit, Nut and Pharmaceutical Production

  Apple, cherry, apricot, buffaloberry, western sandcherry, juneberry, chokecherry, highbush cranberry, and sea-buckthorn fruit production and hazel- and walnut nut production are all possible, or occurring, within North Dakota. Generally, spacings for this type of production resemble spacings found in an orchard (16-20 feet between rows and 3-12 feet between plants) to provide access for harvest and maintenance. As with Christmas tree plantations, management of a fruit or nut orchard is easier if a short, warm-season grass is seeded within the plantation. Refer to the section on native grass cover, pages 7-8 in “Tree Care and Management” for grass cover establishment guidelines. Short, warm-season grasses are usually less competitive to trees and shrubs and ease access and maneuverability around the orchard.

  An excellent beginning reference for designing and managing a fruit-bearing shrub orchard is: “Fruit Bearing Shrubs for Multi-Use Shelterbelts and Orchards”
  http://www.agr.gc.ca/pfra/shelterbelt/fruitshr.htm

  Additional information for design and management of tree and shrub plantings for fruit or nut production can be obtained by contacting the horticultural department at North Dakota State University, 701-231-8478, North Dakota Forest Service (NDFS) field foresters at 701-549-2441 or 701-683-4323 or the NRCS staff forester at 701-530-2082.

- Syrup Production

  Boxelder (Manitoba Maple) have been used for syrup production across the Great Plains and Prairie Provinces since earliest settlement. Initial stocking rates of boxelder for syrup production will be similar to those for lumber production. For a broader genetic base and to increase the environmental value of the planting, include other species of tall trees such as oak, hackberry, basswood, or ash, up to 40 percent of the stand. While reducing the number of boxelder available for syrup production, these other species will add diversity and reduce the risk of complete stand failure. Thinning, as the trees mature will increase the health and vigor of each tree, which improves sap yields and lumber quality. This is a long-term enterprise. Select sites with deep, rich, well-watered soils that are not subject to flooding (Flooding has minimal impact on timber quality but has severe implications to sap collection and syrup production.) A beginning reference on syrup production from boxelder can be found at: http://www.agr.gc.ca/pfra/shbpub/shbpub28.htm For specific details on designing such a planting contact NDFS field foresters at 701-549-2441 or 701-683-4323 or the NRCS staff forester at 701-530-2082.

Air Pollution

Tree and shrub plantings can reduce air pollution in two ways - by reducing the wind velocities across the source of the pollutant and by intercepting pollutants that have moved off site and onto the leaves, twigs, and bark of the woody plants.

Plantings for this purpose shall be as long as possible and perpendicular to the source of the air pollutant to intercept as many pollutants as possible. Utilize the maximum stocking rate compatible with the productivity of the site. Where possible, use the tallest trees appropriate for the site. Tall trees can intercept more of the laterally moving air mass. Multiple rows of tall trees provide additional benefits since they contain more living matter that can intercept drift.

Trees and shrubs have proven effective at reducing air pollution by intercepting and trapping dust and the pollutants attached to the dust. The foliage of trees and shrubs can also intercept airborne vapors and drift. Encourage landowners to use methods and machinery that minimize wind erosion, chemical drift and generation of objectionable odors, thereby reducing the amount of filtering that the tree or shrub planting is expected to accomplish.

The most difficult part of designing tree plantings for reducing chemical drift is determining what species of tree or shrub will be resistant to the chemical drift 20 years from now. Based on nearly 50 years of herbicide application in North Dakota, phenoxy herbicides have been the most damaging to trees. Conifers are most resistant to these types of herbicides, except during periods of rapid, succulent growth.

- Odor Control
  Trees and shrubs can have an impact on odor concentrations or the perception of odor intensities. Some of the mechanisms by which woody plants affect odor are:
  - Certain combinations of density and plant heights at certain distances from the odor source can cause winds to move the odor higher into the atmosphere where it can be diluted. This may dilute the odor, but because of the higher dispersion, the odor may be noticeable for a greater distance downwind.
  - Planting densities and heights may reduce the wind blowing across the odor site and limit the distance to which the odor will travel. This often results in higher concentrations near the odor source.
  - Dense foliage of trees and shrubs will physically intercept dust-borne odor particles and adsorb/absorb some of the chemicals that cause the odors. This function may be enhanced where frequent precipitation events wash the foliage to allow for additional adsorption and absorption.
  - Trees and shrubs can act as a visual screen. Sometimes odors are not perceived as severe if the source is not visible.

Long-Term Erosion Control and Water Quality Improvement

Dense forest plantings control erosion through several mechanisms.

- Canopies intercept raindrops and minimize the erosive force of the splash.
- Established forests develop a duff layer that effectively protects the soil surface from the erosive energy of rain.
- Extensive root systems can act to reinforce the soil creating a site less prone to slumping or mass movement.
- Tree and shrub plantings can protect stream banks from the force of moving water and strengthen the soil of the stream bank with extensive root systems. (See Riparian Forest Buffer – 391)

On a short-term basis, tree planting will have a negligible effect on the quantity of surface or ground water. As the stand becomes established and the tree root systems expand, more water will be absorbed by the trees during their growth cycles. The long-term effect will be reduced runoff from the site, a greater amount of surface storage in the forest duff and more infiltration, without a great increase in the amount of water that is percolating below the root zone. The actual conditions that result from tree planting will depend upon the species planted, stocking rates, soil types and topographic conditions that exist at the site.

As the stand becomes established, there should be a decrease in the surface runoff from the site accompanied be a reduction in soil erosion. This reduces the sediment yield from the site along with pollutants attached to the sediment or dissolved in the runoff, thereby improving the quality of the water reaching the receiving water body. Reduced quantities of water percolating below the root zone will reduce the potential for dissolved pollutants to reach the ground water.

Studies indicate herbaceous ground cover (grasses and legumes) within the tree and shrub planting account for the bulk of the sediment trapping when sheet flows pass through a tree planting. If sheet flows

will pass through the tree planting site or if topography of the site is conducive to sheet and rill erosion, consider including grass seedings or filter strips as part of the design. Trees and or shrubs should be planted on the contour to minimize erosion risks. Follow the guidelines for establishing native grasses in a tree planting found on pages 7-8 of “Tree Care and Management”. Filter strip specification is found in FOTG – Section IV – Conservation Practices – Filter Strip - 393. For sheet and rill erosion control purposes only, a tree/shrub survival count of 300-500 plants per acre- measured the first growing season- is appropriate. Weed control should not include tillage, except for localized tillage around each plant during the establishment period.

Fully established tree plantings have been shown to be very effective at filtering nutrients and other dissolved contaminants from the soil water that is within reach of the tree roots. Nitrate filtering efficiencies have been shown as high as 97%. Atrazine- and alachlor-contaminated ground water has shown a 10-30 % concentration reduction after passing through established root systems. If the purpose of the planting is to improve near-surface ground water, then the higher stocking rates listed earlier should be followed. For most situations, material grown on the site must be harvested and removed to realize long-term water quality improvements.

When ground water quality and surface water quality are both concerns on a site, establish a grassed filter strip on the up-slope side of the planting to trap sediment. Refer to Filter Strip - 393 for design considerations to address sheet and rill erosion. Establish a dense forest planting down-slope of the filter strip to address ground water quality.

Caution: Dense forest plantings by themselves are effective at reducing runoff from a site but may be ineffective in addressing concentrated flows that originate offsite and flow through the tree and shrub planting. Gullies may develop in this situation and have to be addressed with other conservation practices. Gully formation is greatly accelerated with unregulated animal, people, or vehicle trails.

Energy Conservation

“Trees can save energy many ways: (1) through shade, reducing the need for air conditioning, (2) through breaking the force of the winter winds, lowering heating costs, and (3) by serving as a renewable source of fuel - and one that burns with less air pollution than other fuels when the right equipment is used.” Quoted from “How Trees Save Energy, “Tree City USA Bulletin No. 21, published by the National Arbor Day Foundation.

- About 75% of the solar heat gain in a house is through the windows. Proper location of large, spreading, deciduous trees can reduce this heat gain through the summer while not detracting from heat gain in the winter. Generally trees for this purpose shall be planted on the east or west sides of the building. Be sure tree(s) are spaced far enough from the house to prevent problems as the tree matures.
- Planting trees or shrubs to shade the air conditioner can save up to 10% in cooling costs. Be sure that trees or shrubs do not block airflow to the conditioner.
- Trees can reduce surface temperatures of decks, patios and driveways by nearly 20 degrees.
- Trees in suburban settings can reduce air temperatures by up to 12 degrees from nearby built- up areas.
- Contact city foresters, extension agents, NDFS foresters, or the NRCS forester for information on tree and shrub plantings to reduce cooling costs.
- Windbreaks can reduce winter heating costs by 10-40 percent.
- Even widely scattered trees in urban settings can reduce heating costs by 3-4 percent.
- Windbreaks and living snow fences can save hundreds of dollars in snow removal costs for the average rural landowner during years of heavy snow events.
- For living snow fences and windbreak designs refer to Windbreak/Shelterbelt Establishment – 380.

Waste Treatment

Waste treatment systems utilizing trees historically consist of hybrid poplar, cottonwood, or willow plantations located within irrigation distance of the waste source. This technique has the potential to yield large quantities of wood, pulp, or biofuels while effectively treating municipal and agricultural wastes-while potentially saving extensive waste treatment plant modifications. This technology is rapidly changing and involves a wide array of specialists and community leaders. Ensure that the most recent information is used for the planting and design of the planting. Some of the considerations for this type of planting are:

- Market potential for woody material
- Commitment of an interdisciplinary team, community leaders, and involved landowners
- Permitting requirements (national, state, and local)
- Effluent quality (nutrient and contaminant analysis) and quantity
- Irrigation requirements and nutrient uptake requirements of the trees on a given site
- Water delivery system, (source, distance, type, size)
- Irrigation system capability and maintenance requirements
- Soil and site conditions
- Suitability of particular clones of hybrid poplars or other species
- Stocking rates
- Site preparation
- Planting and maintenance
- Management

Since each of these systems is different, considerable background information is needed before the feasibility of the project can be determined. One document that gives a bit more detail about the items listed above is http://www.unl.edu/nac/afnotes/spec-3/spec-3.pdf. The information listed above was gleaned from the linked document authored by Gary A. Kuhn, Agroforester, NRCS. Since this use of a tree planting is so new to North Dakota, all plans and designs for this purpose must be reviewed and approved by the NRCS staff forester, along with other specialists.

For Aesethics

Plans for landscape and beatification plantings should consider foliage color, season and color of flowering, and mature plant height. Refer to “Tree and Shrub Characteristics.” Contact local nursery, community forestry, University Extension personnel, or the NRCS Forester for species suitability in landscaping and beautification.

For wildlife

When the primary purpose of a tree/shrub planting is to improve conditions for wildlife, it is best to refer to Upland Wildlife Habitat Management – 645 for specific details appropriate for the wildlife specie(s) of interest. However, the designs of tree/shrub plantings for other purposes can be modified to make the practice more beneficial to wildlife while still addressing the original purpose of the planting. Considerations for improving the wildlife value of tree/shrub plantings include, but are not limited to:

- Provide dense areas (thickets) of suckering shrubs or conifers, especially spruce and juniper for winter thermal protection. For this purpose suckering shrubs shall be planted at a 4x4 or 5x5-foot spacing, juniper and redcedar at a 6x6 or 8x8 foot spacing and spruce at a 10x10 to 12x12 foot spacing.
- Choose a variety of plants that will provide food throughout the growing season, especially during mid and late winter. Refer to “Tree and Shrub Characteristics” for individual species value as a food source. Plantings shall consist of at least one food source that provides food from mid through late winter.
- Using tall grasses, standing corn, trees or shrubs, establish a snow trap or windbreak 50-100 feet upwind of the planting to prevent snow from covering the food sources and shelter areas. Refer to

"Windbreak/Shelterbelt Establishment" for windbreak design detail.

- Add additional plantings of trees or shrubs that provide food or cover on the lee side of the main planting.
- Connect isolated plantings together and provide travel corridors by extending windbreaks for the additional distance or by installing a Hedge Row Planting.

Summary

Tree and shrub plantings can be managed in a way to offer potential economic returns in the future while still meeting the original design purpose of the planting. Plantings for carbon sequestration, air pollution control, energy conservation, erosion control, and syrup production can fully meet those purposes while the stand is managed in a way to improve the value for lumber and wood products. Even wildlife plantings and aesthetic plantings can sometimes be managed for lumber without adversely affecting the original purpose of the planting.

OPERATION AND MAINTENANCE

Establishment

During the establishment period (usually 3 years), timely application of supplemental water can greatly improve tree and shrub survival. Refer to Irrigation System, Microirrigation – 441 for details on irrigating a tree/shrub planting. Even with irrigation, plants must still match the windbreak suitability groups of the soils on which they are planted. (Nursery studies indicate that adding 1 gallon of water at planting, when the soil is dry can increase survival by 30%.)

Regularly examine the planting to check on growth rates, health and vigor of trees and shrubs, disease or insect problems, weed control needs, level of animal damage, and the need for pruning or thinning. Pages 15-19 of "Tree Care and Management" give information and a host of links to sites with information on how to address most problems or potential management options that can occur within tree and shrub plantings. These regular inspections should be conducted throughout the life of the planting.

Weed Control

Weed pressure, usually during the establishment period, causes a high percentage of stand failures. Since trees and shrubs are so vulnerable at this stage, allowing weeds to attain 8-10 inch heights may be all that is necessary for stand failure. To determine an appropriate form of weed control refer to pages 10-14 of "Tree Care and Management".

Replanting

When survival counts indicate a stand with less than the minimum survival, replanting shall occur to ensure that an adequate stand results. Replants shall maintain the intended function of the planting and be compatible with soils and climate. Growth rates of replants (within 3 years) are usually such that little if any size difference is noted after 10 years.

Disease, Insects, Weather and Animals

To determine ways to prevent or control damage due to disease, insects, weather or animals, refer to "Tree Care and Management" pages 14-16. These pages also list several links that provide more in-depth guidance.

Fire Protection

Windbreaks can be damaged or destroyed by wildfires. In some situations, windbreaks can aggravate the fire risk to a building site. One key component to reduced fire risk is sanitation of the forested site. Do not allow tall herbaceous cover to get established or to remain standing. Remove "tumble weeds" that may have become wind-rowed on the upwind sides of the planting. To further reduce fire risk, do not plant conifers in the 3-4 rows that are nearest the source of fire ignition. Refer to Conservation Practice Firebreak – 394 for information on constructing and maintaining effective firebreaks.

REFERENCES

Direct Seeding; Forestry Extension Notes, F-363, Iowa State University, 1999

Fruit-bearing Shrubs for Multi-use Shelterbelts and Orchards, Prairie Farm Rehabilitation Administration, 1999

“How Trees Save Energy,”Tree City USA Bulletin No. 21, published by the National Arbor Day Foundation

Tree/Shrub Establishment, Texas NRCS, Field Office Technical Guide, Section IV

Wastewater Management Using Hybrid Poplar, USDA-National Agroforestry Center, 2000

Wight, Bruce, National Agroforester, Natural Resources Conservation Service, (Personal Communication)

Woody Plant Seed Manual, USDA Ag Handbook No. 450, 1994

Table 1: Trees Per Acre at Various Spacings (feet)

Yellow highlights and Italics indicate initial stocking rates to fully capture a site, depending upon soil capabilities, species, or predation problems.

Spacing	Trees/ac
5 x 3	2904
5 x 4	2178
5 x 5	1742
6 x 3	2420
6 x 4	1815
6 x 5	1452
6 x 6	1210
7 x 3	2074
7 x 4	1556
7 x 5	1245
7 x 6	1037
7 x 7	889
8 x 3	1815
8 x 4	1361
8 x 5	1089
8 x 6	908
8 x 7	778
8 x 8	681
9 x 3	1613
9 x 4	1210
9 x 5	968
9 x 6	807
9 x 7	691
9 x 8	605
9 x 9	538
10 x 3	1452
10 x 4	1089
10 x 5	871
10 x 6	726
10 x 7	622
10 x 8	545
10 x 9	484
10 x 10	436

Spacing	Trees/ac
11 x 3	1320
11 4	990
11 5	792
11 6	660
11 7	566
11 8	495
11 9	440
11 10	396
11 11	360
12 x 3	1210
12 x 4	908
12 x 5	726
12 x 6	605
12 x 7	519
12 x 8	454
12 x 9	403
12 x 10	363
12 x 11	330
12 x 12	303
13 x 3	1117
13 x 4	838
13 x 5	670
13 x 6	558
13 x 7	479
13 x 8	419
13 x 9	372
13 x 10	335
13 x 11	305
13 x 12	279
13 x 13	258
14 x 3	1037
14 x 4	778
14 x 5	622
14 x 6	519
14 x 7	444
14 x 8	389
14 x 9	346
14 x 10	311
14 x 11	283
14 x 12	259
14 x 13	239
14 x 14	222

Spacing	Trees/ac
15 x 3	968
15 x 4	726
15 x 5	581
15 x 6	484
15 x 7	415
15 x 8	363
15 x 9	323
15 x 10	290
15 x 11	264
15 x 12	242
15 x 13	223
15 x 14	207
15 x 15	194
16 x 3	908
16 x 4	681
16 x 5	545
16 x 6	454
16 x 7	389
16 x 8	340
16 x 9	303
16 x 10	272
16 x 11	248
16 x 12	227
16 x 13	209
16 x 14	194
16 x 15	182
16 x 16	170
18 x 5	484
18 x 6	403
18 x 7	346
18 x 8	303
18 x 9	269
18 x 10	242
18 x 11	220
18 x 12	202
18 x 13	186
18 x 14	173
18 x 15	161
18 x 16	151
18 x 17	142
18 x 18	134

Spacing	Trees/ac
19 x 3	764
19 x 4	573
19 x 5	459
19 x 6	382
19 x 7	328
19 x 8	287
19 x 9	255
19 x 10	229
19 x 11	208
19 x 12	191
19 x 13	176
19 x 14	164
19 x 15	153
19 x 16	143
19 x 17	135
19 x 18	127
19 x 19	121
20 x 3	726
20 x 4	545
20 x 5	436
20 x 6	363
20 x 7	311
20 x 8	272
20 x 9	242
20 x 10	218
20 x 11	198
20 x 12	182
20 x 13	168
20 x 14	156
20 x 15	145
20 x 16	136
20 x 17	128
20 x 18	121
20 x 19	115
20 x 20	109

Spacing	Trees/ac
22 x 3	660
22 x 4	495
22 x 5	396
22 x 6	330
22 x 7	283
22 x 8	248
22 x 9	220
22 x 10	198
22 x 11	180
22 x 12	165
22 x 13	152
22 x 14	141
22 x 15	132
22 x 16	124
22 x 17	116
22 x 18	110
22 x 19	104
22 x 20	99
22 x 21	94
22 x 22	90
24 x 3	605
24 x 4	454
24 x 5	363
24 x 6	303
24 x 7	259
24 x 8	227
24 x 9	202
24 x 10	182
24 x 11	165
24 x 12	151
24 x 13	140
24 x 14	130
24 x 15	121
24 x 16	113
24 x 17	107
24 x 18	101
24 x 19	96
24 x 20	91
24 x 21	86
24 x 22	83
24 x 23	79
24 x 24	76

Specific Site Requirements

Reset