

Proposal for a Master Street Tree
Plan for Buttolph Acres,
Middlebury, VT

Middlebury College

Biology 1003

The Urban Forest adds to the environment in a myriad of ways. From environmental benefits such as Carbon Sequestration, Stormwater Abatement, and pollution absorption, to economic and personal benefits like higher property values and stronger communities, it is clear that a healthy and large urban forest benefits all.

While there are many metrics for measuring the size of an urban forest, an easy way is to simply measure tree canopy area, or the surface area covered by trees. For example, the entire state of Vermont has a canopy density percentage (CDP) of 68.2%. The Addison County CDP is 51%. On average, urban areas in Vermont have about 30.8% canopy tree cover. Middlebury's CDP is slightly higher, at 33.4% canopy green space, which is comparable to Manchester Center's CDP of 34.8%, but lags behind the CDP's of other communities such as Fair Haven (49.4%) or Brattleboro (58.8%).

A Winter Term Course at Middlebury College, Trees and the Urban Forest, decided to take a section of Middlebury and draft a proposal for a street tree planting project. The area chosen was Buttolph Acres, the development surrounded by Woodland Park and Buttolph Drive. While some trees were originally planted during development, the area is ripe for additional plantings. In particular, given the clay soils endemic to the area, storm water absorption will be greatly increased by an increased tree population.

Areas addressed by our proposal include a map of existing trees where they impact the right of way, as well as a map of potential tree locations. Tree species that would thrive in the area were chosen. Bid specifications, early maintenance requirements, and potential funding sources for the tree planting program were also addressed. Finally, the potential tree planting was run through computer modeling software called iTree (www.itreetools.org) to assess the economic values of the planting to Carbon Sequestration, Pollution Abatement, and others.

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EXISTING STREET TREES



Above: Map of existing street trees in the right-of-way in Buttolph Acres. For a complete list of the name, diameter at breast height (DBH), height, and other notes for each tree, see Appendix pages A1-A4.

Proposed Tree Planting Locations: Buttolph Acres, Middlebury VT



- Proposed street tree locations alongside existing street tree locations in the area of Buttolph Acres in Middlebury Vermont. Analysis performed by undergraduate students at Middlebury College in the winter term course Biology 1003: Trees and the Urban Forest. Existing tree locations were recorded by the use of GPS.

Potential Street Trees for Buttolph Acres

We selected fourteen tree species for the planting at Buttolph Acres according to certain characteristics that will ensure successful tree growth with minimal maintenance. The trees listed below all fall within Middlebury's hardiness zone of 4. Furthermore, given Buttolph Acres' swampy conditions we selected trees with a generally high tolerance to poor drainage. We also limited our selection to native tree species because exotic species have the potential to become invasive. Given that Buttolph Acres does not have wires above ground, we were not limited by the size of the tree. Finally, we avoided tree species that are prone to certain pests or disease. Therefore, we did not select Ash and chose only a disease resistant cultivar of American elm. This way we can most likely ensure the least amount of maintenance required for ecologically and economically viable urban forest in Buttolph Acres.

Our fourteen trees fall within nine arboreal families. While we encourage planting no more than 30% of the urban forest with one family, 20% with one genus, or 10% with one species, we also recognize that our street tree planting is only one part of Buttolph Acres' urban forest, which seems dominated by maples and evergreens. Therefore we followed our guidelines for tree selection rather than seeking true proportions for forest diversity, but we hope that the number of trees planted will contain an even distribution of our selected species.

Family Fagaceae

Swamp White Oak (*Quercus bicolor*)

Mature height is 60 Feet. It is easily transplantable. Autumn leaves turn brown, or yellow brown, sometimes reddish. Tolerates part shade to full sun. Likes swampy conditions, prefers acidic soil. Foliage is dark green, turning reddish bronze in autumn.

Pin Oak (*Quercus palustris*)

Mature height is 70 feet. Naturally a wetland tree, grows well in soils with high clay content. It develops shallow fibrous root system, unlike other oaks. Retains leaves through winter. Intolerant of shade. Should grow as dominant tree, will die as suppressed or intermediate tree. It needs full sun and is fast growing for an oak. This should be planted in a very moist spot. Alkaline soils of the Champlain Valley cause the tree to become chlorotic, so be wary of overplanting of this species. However it does well in soils with low drainage. Low branching may be problematic but the branching tendencies are beautiful. Leaves typically persist into the winter months.

Burr Oak (*Quercus macrocarpa*)

A long-lived shade tree that has a high tolerance for moist soils. It is a large tree with a round form and its mature height is 70 to 90 feet with a crown spread of 60 to 80 feet. It is a massive tree with enormous, spreading limbs. It grows best in full sun and with rich, alkaline soils.

Family Betulaceae

River Birch (*Betula nigra*)

Mature height is 40-70 feet, usually not as tall in urban settings Needs Sun. Native birch does well in wet soils. Cinnamon colored exfoliating bark. Resistant to bronze birch borer. Yellow fall foliage.

Family Rosaceae

Downy Serviceberry (*Amelanchier arborea*)

Small deciduous tree. Mature Height is 15 to 25 feet. Multi-stemmed, rounded crown, medium growth rate. Yellow-orange to red fall color. White flowers blooms early spring. Prefers moist acidic soil. Full sun to partial shade.

Allegheny Serviceberry (*Amelanchier laevis*)

Mature height is 20-25 feet. Need full sun. Prefers wet sites. Transplants easily. Native multi-stemmed plant with spreading branches. White flowers in early spring. Produces purple berries that birds love. Yellow-orange to red fall foliage.

Family Leguminosae

Eastern Redbud (*Cercis canadensis*)

Mature height is 25 feet. Needs sun or partly sunny. Rosy pink flowers before leaves appear. Small deciduous tree with upright branching. Yellow fall foliage. Small purplish pink flowers. Needs full sun to light shade. Likes moist soils that are not permanently wet.

Family Hamamelidaceae

American Sweetgum (*Liquidambar styraciflua*)

Mature height – 60 to 80 feet, but can exceed 100 feet. Medium to fast grower. Showy orange, red, and burgundy fall foliage. Prefers deep moist bottomland soils. Best in full sun. Does okay in partial shade. Use larger plants when transplanting in colder areas.

Family Sapindaceae

Freeman Maple (*Acer x Freemanii*)

Mature height is 50 to 60 feet. Hybrid cross of red and silver maple; orange-red fall foliage. Fast growing columnar tree, does well in narrow spaces.

Red Maple (*Acer rubrum*)

Mature Height 50 to 60 feet. Yellow to scarlet fall foliage, one of first tree to color. Adaptable to many types of soil. Fast growing, easy to transplant and establish. Can tolerate partial shade. Tolerates wet soils.

Family Ulmaceae

Accolade Elm (*Ulmus x Accolade*)

Mature height is 70 feet. Disease resistant cultivar. Needs pruning in early years to prevent growth of co-dominant stems.

Common Hackberry (*Celtis occidentalis*)

Grows to a height of 60 to 80 feet with a crown spread of 40-60 feet in diameter, it is a large tree with a round form. It is tolerant of a wide range of soil conditions and an urban setting. It typically forms a rounded vase shape. It needs a wide greenbelt. A very adaptable, tolerant tree, but needs full sun.

Family Nyssaceae

Black Tupelo (*Nyssa sylvatica*)

With a mature height of 45 to 70 feet with a crown spread of 25 to 40 feet it is a large tree with a pyramidal form. It has incredible branch architecture and brilliant scarlet fall foliage. It is native to only a few places in Vermont. Difficult to transplant. Prefers moist, acidic, deep soils. Needs full sun.

Family Platanaceae

Sycamore (*Platanus occidentalis*)

It grows 75 to 100 feet tall and is very impressive. It has the characteristic gray and white patchy bark, large maple-like leaves, and irregular growth. Needs full sun. Autumn foliage turns yellow-brown. Grows well in moist, deep, rich soil. Moderately salt and drought tolerant.

Bid Specifications

Courtesy of the Middlebury College Facilities Services

Part 1 - General

1.1 DEFINITIONS

A. *Balled and Burlapped Stock*: Exterior plants dug with firm, natural balls of earth in which they are grown, with ball size no less than the diameter and depth recommended by ANSI Z60.1 for type and size of tree or shrub required; wrapped, tied, rigidly supported, and drum-laced as recommended by ANSI Z60.1. Balls are firmly wrapped with non-synthetic, biodegradable burlap and secured with nails and heavy, non-synthetic, biodegradable twine. Trunk flare is apparent at surface of ball.

B. *Container-Grown Stock*: Healthy, vigorous, well-rooted exterior plants grown in a container with well-established root system reaching sides of container and maintaining a firm ball when removed from container. Container shall be rigid enough to hold ball shape and protect root mass during shipping and be sized according to ANSI Z60.1 for kind, type, and size of exterior plant required.

C. *Finish Grade*: Elevation of finished surface of planting soil

D. *Planting Soil*: Native or imported topsoil, manufactured topsoil, or surface soil modified to become topsoil; mixed with soil amendments.

E. *Subgrade*: Surface or elevation of subsoil remaining after completing excavation, or top surface of a fill or backfill, before placing planting soil.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Samples: For each of the following:

1. 1 lb of topsoil for each soil type tested, in labeled plastic bags.
2. 1 lb of organic mulch for each type required, in labeled plastic bags.

C. Product Certificates: For each type of manufactured product, signed by product manufacturer, and complying with the following:

1. Manufacturer's certified analysis for standard products.
2. Analysis of other materials by a recognized laboratory made according to methods established by the Association of Official Analytical Chemists, where applicable.

D. Qualification Data: For landscape installer.

E. Material Test Reports: For existing surface soil, and imported topsoil.

1. Existing Source Soil: 1 material test report for each topsoil type.

2. Imported Topsoil: 1 material test report for each 250 cubic yards (200 cubic meters) of material from random samples.

F. Planting Schedule: Indicating anticipated planting dates for exterior plants.

G. Plant Sources: Indicating nursery locations, and list of plants supplied by each nursery.

H. Maintenance Instructions: Recommended procedures to be established by Owner for maintenance of exterior plants during a calendar year. Submit before expiration of required maintenance periods.

1.3 QUALITY ASSURANCE

A. Installer Qualification: A qualified landscape installer whose work has resulted in successful establishment of exterior plants, and with a minimum of five years of related experience.

1. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on project site when exterior planting is in progress.

B. Soil-Testing Laboratory Qualifications: An independent laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed. Qualified independent soil-testing laboratories include but are not limited to:

1. Keen Consulting Inc., Georgetown, Delaware; telephone: (302) 684-5270; in collaboration with Brookside Laboratories, Inc.; or approved equal.

2. NW Hummel & Co., Trumansburg, NY; telephone: (607) 387-5694.

C. Topsoil Analysis: Furnish soil analysis by a qualified soil-testing laboratory stating percentages of organic matter (oven-dried weight), gradation of sand, silt, and clay content; cation exchange capacity; sodium absorption ratio; deleterious material; pH and buffer pH; and mineral and plant-nutrient content of topsoil, including phosphorus, potassium, magnesium, manganese, iron, zinc, and calcium.

1. Provide particle size analysis according to the following gradient of mineral content:

USDA Designation

Size in mm

Gravel	+2 mm
Very coarse sand	1 – 2 mm
Coarse sand	0.5 – 1 mm
Medium sand	0.25 – 0.5 mm
Fine sand	0.1 – 0.25 mm
Very fine sand	0.05 – 0.1 mm
Silt	0.002 – 0.05 mm
Clay	Smaller than 0.002 mm

2. Report suitability of topsoil for plant growth. State recommended quantities of nitrogen, phosphorous, and potash nutrients and soil amendments to be added to produce satisfactory topsoil (for native trees and shrubs) and to comply with the following ideal percentages of base saturation and pH:

<u>Element</u>	<u>Desired Percentage</u> <u>Range</u>	<u>Ideal Percentage</u>
Ca	60 - 70	68
Mg	10 - 20	12
K	2 - 5	5
Na	0.5 - 3.0	0.75
Other Bases (Variable)	2 – 4	3.75
Exchangeable Hydrogen	10 – 15	10.5
pH	6.3 – 6.8	6.7

D. Provide quality, size, genus, species, and variety of exterior plants indicated, complying with applicable requirements in ANSI Z60.1, “American Standard for Nursery Stock.”

1. Selection of exterior plants purchased under allowances will be made by Landscape Architect, who will tag plants at their place of growth before they are prepared for transplanting.

E. Tree and Shrub Measurements: Measure according to ANSI Z60.1 with branches and trunks or canes in their normal position. Do not prune to obtain required sizes. Take caliper measurements 6 inches above ground for trees up to 4-inch caliper size, and 12 inches above ground for larger sizes. Measure main body of tree or shrub for height and spread; do not measure branches or roots tip-to-tip.

F. Observation: Landscape Architect will observe trees and shrubs at place of growth and at site before planting for compliance with requirements for genus, species, variety, size, and quality. Landscape Architect retains right to observe trees and shrubs further for size and condition of balls and root systems, insects, injuries, and latent defects and to reject unsatisfactory or defective material at any time during progress of work. Remove rejected trees or shrubs immediately from project site.

1. Notify Landscape Architect in writing of request for inspection of plants at their place of growth at least twenty days before digging. State place of growth and quantities of plants to be selected. Landscape Architect may refuse request if, in Landscape Architect's judgment, sufficient quantities of plants are not available for inspection.
2. For distant plants, submit photographs for pre-inspection review.

G. Substitutions: Substitutions will only be considered after review of availability with Landscape Architect. If a plant is not obtainable, consideration will be given to nearest available size or similar species or variety.

H. Pre-installation Conference: Conduct conference at Project site.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver exterior plants freshly dug.

1. Immediately after digging up bare-root stock, pack root system in wet straw, hay, or other suitable material to keep root system moist until planting.

B. Do not prune trees before delivery, except as approved by Landscape Architect. Protect bark, branches, and root systems from sunscald, drying, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees in such a manner as to destroy their natural shape. Provide protective covering of exterior plants during delivery. Do not drop exterior plants during delivery.

C. Handle planting stock by root ball.

D. Deliver exterior plants after preparations for planting have been completed and install immediately. If planting is delayed more than six hours after delivery, set exterior trees in shade, protect from weather and mechanical damage, and keep roots moist. Plant trees within three days after delivered to site. If planting is delayed longer than three days, the Landscape Architect reserves the option to reject the plants.

1. Set balled stock on ground and cover ball with soil, sawdust, or other acceptable material.
2. Do not remove container-grown stock from containers before time of planting
3. Water root systems of exterior plants stored on-site with a fine-mist spray.
Water as often as necessary to keep root systems moist.

1.5 COORDINATION

A. Planting Restrictions: Plant during the following periods. Coordinate planting periods with maintenance periods or provide required maintenance from date of Substantial Completion.

1. Deciduous Trees: September 15 to May 30.
2. Evergreen Trees: April 1 to May 30, and August 1 to September 15.
3. Variance: If special conditions exist that warrant a variance in the planting dates, submit a written request to the Landscape Architect stating the special conditions and the proposed variance. Permission for the variance may be given if warranted in the opinion of the Landscape Architect. Any variance in the planting periods will not affect the warranty period.

B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit.

1.6 WARRANTY

A. Special Warranty: Warrant the following exterior plants, for the warranty period indicated, against defects including death and unsatisfactory growth, except for defects resulting from lack of adequate maintenance, neglect, or abuse by Owner, or incidents that are beyond Contractor's control

1. Warranty Period for Trees: One year from date of Substantial Completion.
2. Remove dead exterior plants immediately. Replace immediately unless required to plant in the succeeding planting season.
3. Replace exterior plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.
4. A limit of one replacement of each exterior plant will be required, except for losses or replacements due to failure to comply with requirements
5. Warrant replacement plants for additional year from date of replacement. If replacement is not accepted at end of warranty period, Landscape Architect may elect subsequent replacement or credit for item.

PART 2 – Products

2.1 TREE MATERIAL

A. General: Furnish nursery-grown trees complying with ANSI Z60.1, with healthy root systems developed by transplanting or root pruning. Provide well-

shaped, fully branched, healthy, vigorous stock free of disease, insects, eggs, larvae, and defects such as knots, sunscald, injuries, abrasions, and disfigurement.

1. Provide trees that have been grown at a latitude not more than 200 miles (325 km) north or south of latitude of project unless provenance of plant can be documented to be compatible with latitude and cold hardiness zone of project location.

B. Grade: Provide trees of sizes and grades complying with ANSI Z60.1 for type of trees required. Trees of a larger size may be used if acceptable to Landscape Architect, with a proportionate increase in size of roots or balls.

C. Label each tree with securely attached, waterproof tag bearing legible designation of botanical and common name.

D. Label at least one tree of each variety and caliper with a securely attached, waterproof tag bearing legible designation of botanical and common name.

E. If formal arrangements or consecutive order of trees is shown, select stock for uniform height and spread, and number label to assure symmetry in planting.

2.2 SHADE AND FLOWERING TREES

A. Shade Trees: Branched or pruned naturally according to species and type, with straight trunk (if single trunk), well-balanced crown, and intact leader, of height and caliper indicated, complying with ANSI Z60.1 for type of trees required.

1. Stem Form: Single trunk and multi-stem as indicated on Drawings.
2. Provide balled and burlapped trees.
3. Branching Height: One-third to one-half of tree height.

B. Small Spreading Trees: Branched or pruned naturally according to species and type, with relationship of caliper, height, and branching according to ANSI Z60.1; stem form as follows:

1. Stem Form: Single trunk and multi-stem as indicated on Drawings.
2. Provide balled and burlapped trees.

2.3 CONIFEROUS EVERGREENS

A. Form and Size: Normal-quality, well-balanced, coniferous evergreens, of type, height, spread, and shape required, complying with ANSI Z60.1.

1. Provide balled and burlapped trees.

2.4 TOPSOIL

A. Topsoil: ASTM D 5268, pH range of 5.5 to 6.5, a minimum of 2 percent organic material content (dry weight); free of subsoil, refuse, roots, heavy or stiff clay, stones 1 inch or larger in any dimension, noxious seeds, sticks, brush, litter, and other extraneous materials harmful to plant growth.

1. Soil Texture: Loam soil with the following particle size distribution (approximate):

Gravel	Less than 10%
Coarse to medium sand	30 – 65%
Fine sand	5 – 20%
Very fine sand	0 – 20%
Silt	15 – 25%
Clay	15 – 25%

2. Topsoil Source: Reuse surface soil stockpiled on-site. Verify suitability of stockpiled surface soil to produce topsoil. Clean surface soil of roots, plants, sod, stones, clay lumps, and other extraneous materials harmful to plant growth.

a. Supplement with imported or manufactured topsoil from off-site sources when quantities are insufficient. Obtain topsoil displaced from naturally well-drained construction or mining sites where topsoil occurs at least 4 inches deep; do not obtain from agricultural land, bogs or marshes.

2.5 INORGANIC SOIL AMENDMENTS

A. Inorganic Soil Amendments: As required by Topsoil Analysis.

B. Sand (if needed): ASTM C33, clean, washed, natural or manufactured, free of limestone, shale, and slate particles, free of toxic materials and with the following particle size distribution:

<u>Sieve</u>	<u>Percentage Passing</u>
3/8 in (9.5 mm)	100
No. 4 (4.75 mm)	95-100
No. 8 (2.36 mm)	80-100
No. 16 (1.18 mm)	50-85
No. 30 (0.60 mm)	25-60
No. 50 (0.30 mm)	10-30
No. 100 (0.15 mm)	2-10

2.6 ORGANIC SOIL AMENDMENTS

A. Compost: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 1/2-inch sieve; soluble salt content of 5 to 10 deciSiemens/m; not

exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; commercially prepared with Seal of Testing Assurance Program and as follows:

1. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.

2.7 FERTILIZER

A. Fertilizer: Agricultural fertilizer as required by Topsoil Analysis. Provide organic, slow-release fertilizer whenever applicable.

2.8 MULCHES

A. Organic Mulch: Free from deleterious material and suitable as a top dressing of trees and shrubs, consisting of ground or shredded bark.

2.9 MISCELLANEOUS PRODUCTS

A. Mycorrhizal Inoculant: Mycorrhizal inoculant containing live spores of endomycorrhiza and ectomycorrhiza fungi for wet or dry application.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Mycorrhizal Inoculant:
 - a. Plant Health Care, Inc.
 - b. Roots, Inc.

PART 3 – Execution

3.1 EXAMINATION

A. Examine areas to receive exterior plants for compliance with requirements and conditions affecting installation performance.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities, and lawns and existing exterior plants from damage caused by planting operations.

B. Provide erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

C. Lay out individual tree and shrub locations and areas for multiple exterior plantings. Stake locations, outline areas, adjust locations when requested, and obtain Landscape Architect's acceptance of layout before planting. Make minor adjustments as required.

D. Apply antidesiccant to trees and shrubs using power spray to provide an adequate film over trunks, branches, stems, twigs, and foliage to protect during digging, handling, and transportation.

1. If deciduous trees are moved in full leaf, spray with antidesiccant at nursery before moving and again two weeks after plants.

3.3 PLANTING BED ESTABLISHMENT

A. Finish Grading: Grade planting beds to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

B. Till areas that become compacted by construction traffic.

C. Restore planting beds if eroded or otherwise disturbed after finish grading and before planting.

3.4 TREE EXCAVATION

A. Pits and Trenches: Excavate circular pits with sides sloped inward as indicated. Trim base leaving center area raised slightly to support root ball and assist in drainage. Do not further disturb base. Scarify sides of plant pit smeared or smoothed during excavation.

1. Excavate to dimensions indicated for plant stock type stock.

B. Native subsoil removed from excavations shall be used as component of backfill mix.

C. Obstructions: Notify Landscape Architect if unexpected rock or obstructions detrimental to trees are encountered in excavations.

D. Drainage: Notify Landscape Architect if subsoil conditions evidence unexpected water seepage or retention in tree or shrub pits.

E. Fill excavations with water and allow it to percolate away before positioning trees and shrubs.

3.5 TREE PLANTING

A. Set balled and burlapped stock plumb and in center of pit or trench with top of root ball 1 inch above adjacent finish grades.

1. Remove burlap and wire baskets from tops of root balls and partially from sides, but do not remove from under root balls. Remove pallets, if any, before setting. Do not use planting stock if root ball is cracked or broken before or during planting operation.
2. Place mix of equal parts planting soil mix and original subsoil around root ball in layers, tamping to settle mix and eliminate voids and air pockets. When pit is approximately one-half backfilled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed. Place planting soil mix as upper layer of soil to depths indicated. Water again after placing and tamping final layer of planting soil mix.
3. Apply mycorrhizal inoculant. Comply with the manufacturer's written instructions.

B. Set container-grown stock plumb and in center of pit or trench with top of root ball 1 inch above adjacent finish grades.

1. Carefully remove root ball from container without damaging root ball or plant. Cut circling roots.
2. Place planting soil mix around root ball in layers, tamping to settle mix and eliminate voids and air pockets. When pit is approximately one-half backfilled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.

C. Organic Mulching: Apply organic mulch to depths and extents indicated. Do not place mulch within 3 inches of trunks or stems.

3.6 CLEANUP AND PROTECTION

A. During exterior planting, keep adjacent pavings and construction clean and work area in an orderly condition.

B. Protect exterior plants from damage due to landscape operations, operations by other contractors and trades, and others. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged exterior planting.

3.7 DISPOSAL

A. Remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash, and debris, and legally dispose of them off Owner's property.

Early Maintenance Requirements for Trees

What maintenance must be performed?

Mulching (Preferably use organic mulch from local forests)

- Improves appearance of the area around the tree
- Stimulates root growth
- Helps with weed control
- Improves soil moisture infiltration and retention, soil structure and soil fertility
- Increases soil organic matter and number of soil organisms
- Reduces soil erosion
- Prevents or reduces soil compaction from foot and vehicle traffic
- Helps insulate soil from cold and heat
- Protects tree trunk and surface roots from mower and string-trimmer damage
- Provides environment for mycorrhizal fungi

Watering

- Root ball should be moist but not wet
- It is likely that no additional watering will occur in Buttolph acres due to placement of ditches and the generally wet nature of the soil

Pruning (If low budget, prune young trees which need help in growth direction and prune hazardous deadwood and limbs in older trees)

- Improve and maintain health
- Eliminate and reduce risks, such as limbs falling and interference with utility lines and vehicles
- Enhance appearance
- Improve views

Fertilizing

- Only if trees look unhealthy
- Only fertilize if foliar and soil analysis has been done to prevent over-fertilization and root burn

Disease and Pest Control

- Plant appropriate trees and space trees well
- Prune or remove diseased trees

Removal

- Only if trees are hazardous

Who should perform this maintenance?

Proper maintenance will depend on a coalition of individual homeowners, the community, and certified tree crews. Individual homeowners can be responsible for applying mulch, watering, and fertilizing young trees. These simpler tasks can be augmented by community collaboration with school groups, religious organizations, sports teams, etc. As the trees grow, the fire department could prove to be a valuable asset for watering the trees.

Pruning must be conducted by certified tree crews, but could be augmented by community groups. Certified arborists could lead community service groups around to prune normally and to remove diseased limbs. This would not only draw on a free work force, it would educate the community on the merits and care of trees while fostering tree appreciation. Due to safety and liability concerns, tree removal should only be performed by certified arborists.

Properly training and organizing a volunteer community base to care for urban trees is vital for maintaining a healthy urban forest. This can be done using the Vermont S.O.U.L. (Stewardship of the Urban Landscape) program, which trains urban tree stewards to maintain community trees. Stewards take an eight-week course to initially certify and take more courses to specialize in certain realms of tree care. Information on this stellar program can be found at http://www.vtfpr.org/urban/for_urbcomm_soul.cfm.

Resources Available for the Tree Planting Program in the Town of Middlebury

Personnel

Peg Martin, Tree Warden (pmartin@middlebury.edu)

Fred Dunnington, Town Planner (fdunnington@town.middlebury.vt.us)

Ted Dunakin, Planning & Zoning Assistant (tdunakin@town.middlebury.vt.us)

Financing

Town Tree Budget for Fiscal 2010: \$5,050

Local Ordinances

The Town of Middlebury has a 50-foot Right-of-way along Meadow Way, Harrow Way, Swanage Court, and most of Buttolph Drive in the Buttolph Acres area. At the far southern section of Buttolph Drive, approaching the intersection with Munroe Street, the Right-of-way expands to 60 feet. The paved road surface in Buttolph Acres is between 15 and 20 feet, while ditches on either side of the road vary between 3 and 5 feet wide.

Side Note

The existing utility lines in the Buttolph Acres area have not been properly mapped or marked, so any planting holes must be carefully selected and hand-dug.

Financial Resources Available for the Tree Planting Program

Currently there is not much grant money available from the VT Department of Forestry for planting and maintaining trees. However, there are still creative options available for financing. It would be useful to get together a Tree Planting Committee for Buttolph Acres that would be in charge of, among other things, financing.

Donations

The Committee could set up a donation fund, to which the neighborhood residents could contribute.

Cost-Share

One way to go about funding the tree project would be a cost-share plan between homeowners and the town of Middlebury. Each homeowner would pay for at least one of his/her street trees, either in full or in part (augmented by grant and fundraising money). The homeowners that choose to pay for their trees will agree to plant and care for the tree for a set period of time (for example, 3 years), even though the tree will be in the public right of way. After that designated period of time is up, care of the tree will pass over to the town. Buttolph Acres could organize a neighborhood-wide tree order in which each of the participating homeowners could choose from a selection of tree species. Vermont's Urban & Community Forestry Program is available to help with providing training and organizational assistance for community citizen groups who choose to undertake tree maintenance projects.

Memorial Trees

Citizens could donate money for the planting of a tree by purchasing a memorial tree in honor of a loved one. A dedication plaque could be placed next to the tree, or if the plaque is too expensive, there could be a scrapbook of some sort kept in Ilsley Library with pictures of the Memorial Trees, possibly a map of their locations, and the associated dedications.

Fundraising Ideas

- Silent auction/raffle
- Buttolph Acres community yard sale
- Sponsor a screening of *Taking Root: The Vision of Wangari Maathai*. Either sell Tickets, or give a short talk before or after film asking for donations for neighborhood tree planting project.
See <http://takingrootfilm.com/>

Grants

The Association of VT Conservation Commission offers mini-grants of up to \$500. Applications for 2010 grants are due March 1st, 2010. More information about the grants can be accessed at http://www.vlct.org/d/mac/AVCC_Grant_Information_2010.pdf.

Other Ideas

Free Oak Trees (Burr Oak, Red Oak, Swamp White Oak, White Oak, Pin Oak, and Black Oak) are available from the Living Lands & Waters' Million Trees Project. Contact Denise Mitten, 309.496.9848.

iTree Simulated Benefits of Planting Trees in Buttolph Acres

Using, iTree Streets, a peer-reviewed software from the USDA Forest Service, we ran an analysis of the street trees currently located in or near the public right-of-way in Buttolph Acres. The iTree Street program estimates the economic benefits of street trees based off of the species and diameter-at-breast-height (dbh) of each individual tree. To calculate dollar values, it uses national average figures, such as the cost of certain energy sources or the physical and psychological benefits received from street trees. We found that the trees currently lining the streets of Buttolph Acres provide the town with a total annual benefit of \$20,390 (Table: Summary of Annual Benefits- Existing). A significant portion of these benefits results from annual energy cost savings of \$9,085, which are derived from the reduction in electricity and natural gas use due to wind protection in the winter and shade production in the summer (Table: Annual Energy Benefits- Existing).

Additionally, we analyzed the potential benefits that would be realized from following the proposed planting. Assuming around an inch of growth per year (dbh) for the average tree, we estimated that each proposed tree would measure around 25 inches (dbh) 25 years after planting. We analyzed the proposed distribution of 8 Swamp White Oaks, 7 Pin Oaks, 7 Burr Oaks, 11 Sycamores, 6 Freeman Maples, 6 Red Maples, 12 Black Tupelos, 12 American Sweetgums, 14 Eastern Redbuds, 14 Accolade Elms, 14 River Birches, 10 Downy Serviceberries, 10 Allegheny Serviceberries, and 14 Common Hackberries. We found that 25 years following the plantings, the total annual benefits received from the planted trees would be \$28,883 (Table: Summary of Annual Benefit- 25 years). The energy benefits was again notable at \$13,141 while the aesthetic benefits also contributed significantly, generating \$9,515 in annual benefits. Also very significant to Buttolph Acres, is the projects \$3,509 annual benefits in stormwater control, with each tree contributing an average of \$24.40 per year (Table: Annual Stormwater Benefits- 25 years).

We extended this analysis of the proposed trees to 50 years following the plantings, estimating an average dbh of 35 inches. We found that 50 years in the future, the annual received benefits from the suggested planting would be \$33,680 (Table: Summary of Annual Benefits- 50 years). Again, the energy benefits, aesthetic benefits, and stormwater benefits were notable, as the larger trees would provide more benefit. However, also significant in this time period is the amount of carbon stored in the trees over their lifespan and annual carbon dioxide reduction benefits. Results of the analysis showed that the annual net total of carbon dioxide sequestration of the 145 proposed trees totaled to 123,406 lbs, accounting for both the sequestration through photosynthesis and the release through decomposition and maintenance (Table: Annual CO₂ Benefits- 50 years). Additionally, in the 50 years of growth these proposed trees would hold 2,427,960 lbs of stored carbon dioxide (Table: Stored CO₂ Benefits- 50 years).

This analysis suggests that while the initial costs of this proposed tree planting may seem prohibitive, the received benefits from the planted trees would greatly benefit the residents of Buttolph Acres and the town. In addition to reducing private energy costs

and public costs such as stormwater control, the proposed street trees, if planted, will also help contribute to the global effort to slow climate change, through carbon sequestration.

Below are tables detailing the total annual benefits of the street trees of Buttolph Acres today, in 25 years, and in 50 years. Tables detailing the effects of the street trees on carbon sequestration, aesthetics, energy, air quality, and stormwater runoff today, in 25 years, and in 50 years can be found in the Appendix (Pages A5-A13).

Existing Total Annual Benefits

Middlebury

Total Annual Benefits of Public Trees by Species (\$)

1/25/2010

Species	Energy	CO ₂	Air Quality	Stormwater	Aesthetic/Other	Total (\$)	Standard Error	% of Total \$
Norway maple	1,978	54	346	359	1,757	4,495	(±0)	22.0
Maple	965	27	169	184	921	2,266	(±0)	11.1
Blue spruce	509	10	96	145	425	1,185	(±0)	5.8
Crabapple harvest gold	215	4	34	29	199	481	(±0)	2.4
Red maple	746	14	134	194	624	1,711	(±0)	8.4
Pine	638	12	122	183	350	1,306	(±0)	6.4
Silver maple	1,290	30	245	370	653	2,587	(±0)	12.7
European white birch	217	4	33	49	374	677	(±0)	3.3
Spruce	222	4	42	64	185	517	(±0)	2.5
Northern red oak	449	11	78	105	264	908	(±0)	4.5
Littleleaf linden	185	3	30	36	112	367	(±0)	1.8
Boxelder	153	4	27	26	128	337	(±0)	1.7
Ash	286	6	54	66	177	589	(±0)	2.9
Amur corktree	80	2	12	18	140	252	(±0)	1.2
Atlas cedar	31	1	7	6	42	87	(±0)	0.4
Honeylocust	174	4	30	33	145	386	(±0)	1.9
Austrian pine	98	2	19	27	48	194	(±0)	1.0
Cottonwood	156	3	27	34	187	406	(±0)	2.0
Plum	26	0	4	3	20	53	(±0)	0.3
Oak	115	3	20	27	127	292	(±0)	1.4
American elm	226	5	44	58	220	552	(±0)	2.7
Other street trees	327	8	65	94	246	739	(±0)	3.6
Citywide Total	9,085	213	1,636	2,111	7,345	20,390	(±0)	100.0

25-Year Projection of Total Annual Benefits

Total Annual Benefits of Public Trees by Species (\$)

1/26/2010

Species	Energy	CO ₂	Air Quality	Stormwater	Aesthetic/Other	Total (\$)	Standard Error	% of Total \$
River birch	1,509	30	312	469	1,493	3,814 (±0)		13.2
Eastern redbud	666	12	110	120	92	1,002 (±0)		3.5
Northern hackberry	1,509	30	312	469	1,493	3,814 (±0)		13.2
American elm	1,639	40	322	428	1,572	4,002 (±0)		13.9
Sweetgum	1,269	24	150	323	736	2,503 (±0)		8.7
Black tupelo	1,140	23	213	306	481	2,161 (±0)		7.5
American sycamore	1,165	28	202	298	767	2,460 (±0)		8.5
Serviceberry	476	9	79	86	66	715 (±0)		2.5
Downy serviceberry	476	9	79	86	66	715 (±0)		2.5
Swamp white oak	790	27	152	230	698	1,897 (±0)		6.6
Bur oak	691	23	133	201	611	1,660 (±0)		5.7
Pin oak	691	23	133	201	611	1,660 (±0)		5.7
Maple	550	21	106	137	588	1,400 (±0)		4.8
Red maple	570	11	107	153	240	1,081 (±0)		3.7
Other street trees	0	0	0	0	0	0 (±0)		0.0
Citywide Total	13,141	310	2,409	3,508	9,515	28,883 (±0)		100.0

50-Year Projection of Total Annual Benefits

Total Annual Benefits of Public Trees by Species (\$)

1/26/2010

Species	Energy	CO ₂	Air Quality	Stormwater	Aesthetic/Other	Total (\$)	Standard Error	% of Total \$
River birch	1,784	38	404	696	937	3,859 (±0)		11.5
Eastern redbud	666	6	110	120	0	903 (±0)		2.7
Northern hackberry	1,784	38	404	696	937	3,859 (±0)		11.5
American elm	2,069	69	462	662	1,909	5,171 (±0)		15.4
Sweetgum	1,588	28	182	504	477	2,778 (±0)		8.2
Black tupelo	1,388	27	281	418	331	2,445 (±0)		7.3
American sycamore	1,424	39	264	452	960	3,138 (±0)		9.3
Serviceberry	476	4	79	86	0	645 (±0)		1.9
Downy serviceberry	476	4	79	86	0	645 (±0)		1.9
Swamp white oak	1,056	41	228	369	864	2,558 (±0)		7.6
Bur oak	924	36	199	323	756	2,238 (±0)		6.6
Pin oak	924	36	199	323	756	2,238 (±0)		6.6
Maple	690	32	142	218	898	1,980 (±0)		5.9
Red maple	694	13	140	209	165	1,223 (±0)		3.6
Other street trees	0	0	0	0	0	0 (±0)		0.0
Citywide Total	15,945	412	3,172	5,161	8,990	33,680 (±0)		100.0

Proposal for a Master Street Tree
Plan for Buttolph Acres,
Middlebury, VT

APPENDIX

Point Number of Existing Tree	Common Name	Latin Name	DBH	Height	Notes
1	red oak	quercus rubra	18	50	
2	red oak	quercus rubra	16	50	
3	pin oak	quercus palustris	24	50	
4	norway maple	acer platinoides	8	25	
5	sugar maple	acer saccharum	1.5	10	
6	sugar maple	acer saccharum	10	35	codominant trunks
7	silver maple	acer saccharinum	35	45	
8	silver maple	acer saccharinum	30	50	
9	silver maple	acer saccharinum	35	50	
10	white pine	pinus strobus	12	45	
11	white pine	pinus strobus	14	45	
12	sugar maple	acer saccharum	20	40	
13	sugar maple	acer saccharum	18	30	
14	blue spruce	picea pungens	22	35	
15	white poplar	populus alba	10	40	codominant trunks
16	silver maple	acer saccharinum	24	40	
17	crab apple	malus x	8	20	codominant trunks
18	norway maple	acer platinoides	10	25	
19	birch	betula	8	25	
20	norway maple	acer platinoides	20	30	
21	red maple	acer rubrum	40	40	
22	sugar maple	acer saccharum	12	25	
23	norway maple	acer platinoides	18	25	
24	little leaf linden	tilia cordata	24	25	braced
25	red oak	quercus rubra	20	30	
26	little leaf linden	tilia cordata	10	25	
27	little leaf linden	tilia cordata	10	25	
28	little leaf linden	tilia cordata	12	25	
29	birch	betula	10	30	codominant
30	norway maple	acer platinoides	12	20	
31	norway maple	acer platinoides	12	25	
32	red maple	acer rubrum	14	25	
33	norway maple	acer platinoides	15	25	
34	norway maple	acer platinoides	10	20	
35	norway maple	acer platinoides	12	20	
36	silver maple	acer saccharinum	15	25	
37	river birch	betula nigra	8	25	codominant
38	river birch	betula nigra	10	30	codominant
39	red maple	acer rubrum	35	40	
40	crab apple	malus x	3	15	
41	crab apple	malus x	2	10	
42	sugar maple	acer saccharum	12	35	
43	norway maple	acer platinoides	10	25	
44	crab apple	malus x	4	15	
45	silver maple	acer saccharinum	40	60	
46	ash	fraxinus	18	45	
47	sugar maple	acer saccharum	5	20	
48	thornless honeylocust	gleditsia triacanthos	12	35	codominant
49	juniper	juniperous	4	15	

50	spruce	picea	8	25	
51	cork	phellodendron	8	25	
52	cork	phellodendron	8	25	
53	norway maple	acer platinoides	14	25	
54	blue spruce	picea pungens	14	30	
55	blue spruce	picea pungens	16	30	
56	blue spruce	picea pungens	12	30	
57	blue spruce	picea pungens	14	30	
58	norway maple	acer platinoides	18	30	
59	sugar maple	acer saccharum	12	30	
60	ash	fraxinus	22	45	
61	cedar	cedrus	10	25	codominant
62	norway maple	acer platinoides	18	30	
63	norway maple	acer platinoides	18	30	
64	eastern white cedar	thuja occidentalis	8	25	
65	blue spruce	picea pungens	12	40	
66	austrian pine	pinus nigra	12	35	
67	red maple	acer rubrum	35	40	
68	sugar maple	acer saccharum	30	35	
69	norway maple	acer platinoides	20	30	
70	sugar maple	acer saccharum	10	25	
71	silver maple	acer saccharinum	25	35	
72	plum	prunus	3	10	
73	plum	prunus	4	15	
74	silver maple	acer saccharinum	18	35	
75	red oak	quercus rubra	10	30	
76	norway maple	acer platinoides	16	30	
77	sugar maple	acer saccharum	10	30	
78	white oak	quercus alba	12	30	
79	spruce	picea	3	10	
80	norway maple	acer platinoides	20	35	
81	white oak	quercus alba	14	30	
82	white pine	pinus strobus	12	30	
83	white pine	pinus strobus	18	35	
84	spruce	picea	18	30	
85	spruce	picea	12	25	
86	red maple	acer rubrum	16	35	
87	red maple	acer rubrum	6	15	
88	crab apple	malus x	6	15	
89	silver maple	acer platinoides	16	40	
90	silver maple	acer platinoides	18	40	
91	apple	malus domestica	4	15	
92	norway maple	acer platinoides	12	20	
93	norway maple	acer platinoides	16	25	
94	red maple	acer rubrum	6	25	
95	blue spruce	picea pungens	10	25	
96	crab apple	malus x	2	8	
97	red maple	acer rubrum	3	15	
98	norway spruce	picea abies	14	30	
99	spruce	picea	1	8	
100	spruce	picea	2	7	

101	birch	betula	2	20	
102	norway spruce	picea abies	8	25	
103	white pine	pinus strobus	6	20	
104	silver maple	acer saccharinum	10	35	codominant
105	silver maple	acer saccharinum	12	35	codominant
106	crabapple	malus	1	6	
107	blue spruce	picea pungens	10	20	
108	crabapple	malus	5	15	
109	blue spruce	picea pungens	2	10	
110	thornless honeylocust	gleditsia triacanthos	14	35	
111	silver maple	acer saccharinum	14	35	
112	norway maple	acer platanoides	18	35	
113	blue spruce	picea pungens	10	25	
114	blue spruce	picea pungens	8	25	
115	silver maple	acer saccharinum	25	40	
116	norway maple	acer platanoides	14	35	
117	blue spruce	picea pungens	10	25	
118	red oak	quercus rubra	24	40	
119	tulip tree	liriodendron	18	40	
120	norway maple	acer platanoides	16	35	
121	cork	phellodendron	3	20	
122	crabapple	malus	8	20	
123	norway maple	acer platanoides	14	35	
124	red maple	acer rubrum	3	20	
125	red maple	acer rubrum	4	25	
126	red maple	acer rubrum	6	25	
127	box elder	acer negundo	6	25	
128	norway maple	acer platanoides	12	30	
129	norway maple	acer platanoides	10	35	
130	blue spruce	picea pungens	1	10	
131	blue spruce	picea pungens	2	12	
132	blue spruce	picea pungens	1	7	
133	box elder	acer negundo	12	35	
134	box elder	acer negundo	12	35	
135	crabapple	malus	4	10	
136	sugar maple	acer saccharum	10	35	
137	crabapple	malus	3	10	
138	norway maple	acer platanoides	4	20	
139	blue spruce	picea pungens	6	20	
140	red maple	acer rubrum	10	35	
141	scotch pine	pinus sylvestris	12	40	
142	red maple	acer rubrum	1	10	
143	sugar maple	acer saccharum	22	40	
144	white pine	pinus strobus	10	35	
145	white pine	pinus strobus	12	35	
146	white poplar	populus alba	18	55	
147	weeping willow	salix babylonica	30	45	
148	white pine	pinus strobus	20	40	
149	american elm	ulmus americana	18	60	
150	american elm	ulmus americana	25	40	
151	white pine	pinus strobus	18	40	

152	blue spruce	picea pungens	3	15	
153	red maple	acer rubrum	12	35	
154	sugar maple	acer saccharum	8	25	
155	norway maple	acer platinoides	12	30	
156	norway maple	acer platinoides	8	25	
157	sugar maple	acer saccharum	6	30	
158	birch	betula	4	20	
159	austrian pine	pinus nigra	14	25	
160	sugar maple	acer saccharum	6	20	
161	white pine	pinus strobus	10	20	
162	norway maple	acer platinoides	10	25	
163	sugar maple	acer saccharum	10	25	
164	norway maple	acer platinoides	10	20	
165	sugar maple	acer saccharum	4	20	
166	crabapple	malus	4	15	
167	red maple	acer rubrum	10	35	
168	apple	malus domestica	8	15	
169	ash	fraxinus	20	35	
170	apple	malus domestica	4	10	
171	norway maple	acer platinoides	8	25	
172	sugar maple	acer saccharum	4	20	
173	norway maple	acer platinoides	8	25	
174	sugar maple	acer saccharum	10	30	
175	norway maple	acer platinoides	6	25	
176	norway maple	acer platinoides	8	25	
177	norway maple	acer platinoides	10	25	
178	sugar maple	acer saccharum	6	20	
179	norway maple	acer platinoides	8	25	
180	blue spruce	picea pungens	12	25	
181	norway maple	acer platinoides	8	20	
182	sugar maple	acer saccharum	3	15	
183	norway maple	acer platinoides	10	20	
184	sugar maple	acer saccharum	2	10	
185	norway maple	acer platinoides	6	15	
186	white pine	pinus strobus	14	30	
187	crabapple	malus	1	8	
188	white pine	pinus strobus	8	15	
189	white pine	pinus strobus	8	15	
190	sugar maple	acer saccharum	16	35	
191	white pine	pinus strobus	8	10	
192	birch	betula	6	25	codominant
193	birch	betula	8	30	codominant

Existing Benefits of Street Trees in Buttolph Acres

Annual Aesthetic/Other Benefits of Public Trees by Species

1/25/2010

Species	Total (\$)	Standard Error	% of Total Trees	% of Total \$	Avg. \$/tree
Norway maple	1,757	(N/A)	20.2	23.9	45.06
Maple	921	(N/A)	12.4	12.5	38.38
Blue spruce	425	(N/A)	9.3	5.8	23.62
Crabapple harvest gold	199	(N/A)	8.3	2.7	12.45
Red maple	624	(N/A)	7.8	8.5	41.58
Pine	350	(N/A)	7.8	4.8	23.33
Silver maple	653	(N/A)	7.3	8.9	46.61
European white birch	374	(N/A)	4.2	5.1	46.79
Spruce	185	(N/A)	4.2	2.5	23.15
Northern red oak	264	(N/A)	2.6	3.6	52.87
Littleleaf linden	112	(N/A)	2.1	1.5	28.05
Boxelder	129	(N/A)	1.6	1.8	42.83
Ash	177	(N/A)	1.6	2.4	58.87
Amur corktree	140	(N/A)	1.6	1.9	46.81
Atlas cedar	42	(N/A)	1.0	0.6	21.12
Honeylocust	145	(N/A)	1.0	2.0	72.50
Austrian pine	48	(N/A)	1.0	0.7	24.02
Cottonwood	187	(N/A)	1.0	2.5	93.35
Plum	20	(N/A)	1.0	0.3	9.76
Oak	127	(N/A)	1.0	1.7	63.39
American elm	220	(N/A)	1.0	3.0	109.85
Other street trees	246	(N/A)	2.1	3.4	61.46
Citywide total	7,345	(N/A)	100.0	100.0	38.05

Annual Air Quality Benefits of Public Trees by Species

1/25/2010

Species	Deposition (lb)				Total Depos. (\$)	Avoided (lb)				Total Avoided (\$)	BVOC Emissions (lb)	BVOC Emissions (\$)	Total (lb)	Total (\$)	Standard Error	% of Total Trees	Avg. \$/tree
	O ₃	NO ₂	PM ₁₀	SO ₂		NO ₂	PM ₁₀	VOC	SO ₂								
Norway maple	15.5	6.7	7.6	2.5	174	25.4	1.7	1.0	12.8	177	-2.1	-5	71.1	346	(N/A)	20.2	8.87
Maple	7.7	3.3	3.8	1.3	86	12.3	0.8	0.5	6.1	85	-1.1	-3	34.6	169	(N/A)	12.4	7.04
Blue spruce	5.7	2.7	3.6	1.6	75	6.9	0.4	0.3	3.7	49	-11.9	-28	13.0	96	(N/A)	9.3	5.32
Crabapple harvest gold	1.5	0.6	0.7	0.3	17	2.5	0.2	0.1	1.1	17	0.0	0	7.0	34	(N/A)	8.3	2.10
Red maple	6.2	2.7	3.1	1.0	70	9.7	0.6	0.4	4.9	68	-1.6	-4	27.0	134	(N/A)	7.8	8.92
Pine	7.4	3.5	4.7	2.0	96	8.6	0.6	0.3	4.6	61	-14.9	-34	16.6	122	(N/A)	7.8	8.12
Silver maple	12.0	5.2	5.9	2.0	134	17.0	1.1	0.7	8.8	119	-4.0	-9	48.6	245	(N/A)	7.3	17.48
European white birch	1.4	0.6	0.7	0.2	16	2.6	0.2	0.1	1.2	18	-0.4	-1	6.7	33	(N/A)	4.1	4.13
Spruce	2.5	1.2	1.6	0.7	33	3.0	0.2	0.1	1.6	21	-5.3	-12	5.6	42	(N/A)	4.1	5.22
Northern red oak	4.0	1.7	2.0	0.7	45	5.9	0.4	0.2	3.0	41	-3.4	-8	14.4	78	(N/A)	2.6	15.63
Littleleaf linden	1.4	0.6	0.7	0.2	15	2.4	0.2	0.1	1.2	17	-0.7	-2	5.9	30	(N/A)	2.1	7.53
Boxelder	1.1	0.5	0.6	0.2	13	2.0	0.1	0.1	1.0	14	-0.1	0	5.5	27	(N/A)	1.6	8.84
Ash	2.5	1.1	1.2	0.4	28	3.7	0.2	0.1	1.9	26	0.0	0	11.1	54	(N/A)	1.6	17.88
Amur corktree	0.5	0.2	0.3	0.1	6	1.0	0.1	0.0	0.4	7	-0.2	0	2.4	12	(N/A)	1.6	4.04
Atlas cedar	0.3	0.2	0.2	0.1	4	0.4	0.0	0.0	0.2	3	-0.1	0	1.4	7	(N/A)	1.0	3.50
Honeylocust	1.4	0.6	0.7	0.2	15	2.3	0.2	0.1	1.2	17	-0.6	-1	6.0	30	(N/A)	1.0	15.12
Austrian pine	1.1	0.5	0.7	0.3	14	1.4	0.1	0.1	0.8	10	-2.2	-5	2.7	19	(N/A)	1.0	9.49
Cottonwood	1.2	0.5	0.6	0.2	13	2.0	0.1	0.1	1.0	14	0.0	0	5.7	27	(N/A)	1.0	13.65
Plum	0.2	0.1	0.1	0.0	2	0.3	0.0	0.0	0.1	2	0.0	0	0.8	4	(N/A)	1.0	1.94
Oak	0.9	0.4	0.5	0.2	11	1.6	0.1	0.1	0.9	12	-0.9	-2	3.8	20	(N/A)	1.0	10.08
American elm	2.1	0.8	1.0	0.3	23	3.0	0.2	0.1	1.6	21	0.0	0	9.1	44	(N/A)	1.0	21.85
Other street trees	3.3	1.4	1.6	0.5	37	4.4	0.3	0.2	2.3	31	-1.3	-3	12.7	65	(N/A)	2.1	16.16
Citywide total	79.8	35.1	41.6	14.9	925	118.4	7.7	4.5	60.6	828	-50.8	-117	311.7	1,636	(N/A)	100.0	8.48

Stored CO2 Benefits of Public Trees by Species

1/25/2010

Species	Total Stored CO2 (lbs)	Total (\$)	Standard Error	% of Total Trees	% of Total \$	Avg. \$/tree
Norway maple	129,604	433	(N/A)	20.2	20.6	11.10
Maple	73,051	244	(N/A)	12.4	11.6	10.17
Blue spruce	14,087	47	(N/A)	9.3	2.2	2.61
Crabapple harvest gol	5,109	17	(N/A)	8.3	0.8	1.07
Red maple	52,187	174	(N/A)	7.8	8.3	11.62
Pine	20,851	70	(N/A)	7.8	3.3	4.64
Silver maple	176,417	589	(N/A)	7.3	28.1	42.09
European white birch	4,879	16	(N/A)	4.2	0.8	2.04
Spruce	7,008	23	(N/A)	4.2	1.1	2.93
Northern red oak	36,294	121	(N/A)	2.6	5.8	24.24
Littleleaf linden	10,063	34	(N/A)	2.1	1.6	8.40
Boxelder	8,349	28	(N/A)	1.6	1.3	9.30
Ash	14,093	47	(N/A)	1.6	2.2	15.69
Amur corktree	1,735	6	(N/A)	1.6	0.3	1.93
Atlas cedar	956	3	(N/A)	1.0	0.2	1.60
Honeylocust	6,074	20	(N/A)	1.0	1.0	10.14
Austrian pine	2,818	9	(N/A)	1.0	0.5	4.71
Cottonwood	5,753	19	(N/A)	1.0	0.9	9.61
Plum	349	1	(N/A)	1.0	0.1	0.58
Oak	7,081	24	(N/A)	1.0	1.1	11.82
American elm	17,908	60	(N/A)	1.0	2.9	29.91
Other street trees	15,564	115	(N/A)	2.1	5.5	28.65
Citywide total	628,981	2,101	(N/A)	100.0	100.0	10.88

Annual CO Benefits of Public Trees by Species

1/25/2010

Species	Sequestered (lb)	Sequestered (\$)	Decomposition Release (lb)	Maintenance Release (lb)	Total Released (\$)	Avoided (lb)	Avoided (\$)	Net Total (lb)	Total Standard (\$)	% of Total Trees	% of Total \$	Avg. \$/tree
Norway maple	9,540	32	-1,769	-396	-7	8,778	29	16,152	54 (N/A)	20.2	25.3	1.38
Maple	5,022	17	-804	-203	-3	4,194	14	8,209	27 (N/A)	12.4	12.9	1.14
Blue spruce	810	3	-255	-134	-1	2,531	8	2,953	10 (N/A)	9.3	4.6	0.55
Crabapple harvest gold	528	2	-114	-59	-1	759	3	1,113	4 (N/A)	8.3	1.8	0.23
Red maple	1,435	5	-446	-160	-2	3,396	11	4,225	14 (N/A)	7.8	6.6	0.94
Pine	964	3	-284	-158	-1	3,137	10	3,659	12 (N/A)	7.8	5.7	0.81
Silver maple	4,148	14	-1,083	-251	-4	6,058	20	8,872	30 (N/A)	7.3	13.9	2.12
European white birch	551	2	-109	-46	-1	834	3	1,230	4 (N/A)	4.2	1.9	0.51
Spruce	341	1	-96	-58	-1	1,082	4	1,268	4 (N/A)	4.2	2.0	0.53
Northern red oak	1,552	5	-248	-71	-1	2,081	7	3,314	11 (N/A)	2.6	5.2	2.21
Littleleaf linden	384	1	-117	-46	-1	823	3	1,044	3 (N/A)	2.1	1.6	0.87
Boxelder	667	2	-187	-30	-1	706	2	1,157	4 (N/A)	1.6	1.8	1.29
Ash	737	2	-64	-48	0	1,289	4	1,914	6 (N/A)	1.6	3.0	2.13
Amur corktree	208	1	-39	-17	0	306	1	458	2 (N/A)	1.6	0.7	0.51
Atlas cedar	165	1	-21	-14	0	134	0	264	1 (N/A)	1.0	0.4	0.44
Honeylocust	388	1	-136	-23	-1	854	3	1,083	4 (N/A)	1.0	1.7	1.81
Austrian pine	150	1	-63	-23	0	524	2	588	2 (N/A)	1.0	0.9	0.98
Cottonwood	403	1	-129	-23	-1	698	2	950	3 (N/A)	1.0	1.5	1.59
Plum	72	0	-8	-7	0	91	0	148	1 (N/A)	1.0	0.2	0.25
Oak	570	2	-159	-23	-1	617	2	1,006	3 (N/A)	1.0	1.6	1.68
American elm	990	3	-401	-37	-1	1,078	4	1,630	5 (N/A)	1.0	2.6	2.72
Other street trees	1,263	4	-251	-65	-1	1,586	5	2,533	8 (N/A)	2.1	4.0	2.12
Citywide total	30,888	103	-6,784	-1,890	-29	41,556	139	63,770	213 (N/A)	100.0	100.0	1.10

Annual Energy Benefits of Public Trees By Species

1/25/2010

Species	Total Electricity (MWh)	Electricity (\$)	Total Natural Gas (Therms)	Natural Gas (\$)	Total (\$)	Standard Error	% of Total Trees	% of Total \$	Avg. \$/tree
Norway maple	2.9	408	1,115.1	1,570	1,978	(N/A)	20.2	21.8	50.73
Maple	1.4	195	546.6	770	965	(N/A)	12.4	10.6	40.20
Blue spruce	0.8	118	278.1	392	509	(N/A)	9.3	5.6	28.30
Crabapple harvest gold	0.3	35	127.6	180	215	(N/A)	8.3	2.4	13.44
Red maple	1.1	158	417.3	588	746	(N/A)	7.8	8.2	49.71
Pine	1.0	146	349.7	492	638	(N/A)	7.8	7.0	42.55
Silver maple	2.0	282	716.0	1,008	1,290	(N/A)	7.3	14.2	92.14
European white birch	0.3	39	126.7	178	217	(N/A)	4.2	2.4	27.15
Spruce	0.4	50	121.6	171	222	(N/A)	4.2	2.4	27.69
Northern red oak	0.7	97	250.1	352	449	(N/A)	2.6	4.9	89.78
Littleleaf linden	0.3	38	104.5	147	185	(N/A)	2.1	2.0	46.36
Boxelder	0.2	33	85.0	120	153	(N/A)	1.6	1.7	50.83
Ash	0.4	60	160.8	226	286	(N/A)	1.6	3.2	95.48
Amur corktree	0.1	14	46.8	66	80	(N/A)	1.6	0.9	26.71
Atlas cedar	0.0	6	17.6	25	31	(N/A)	1.0	0.3	15.54
Honeylocust	0.3	40	95.3	134	174	(N/A)	1.0	1.9	86.94
Austrian pine	0.2	24	52.3	74	98	(N/A)	1.0	1.1	49.03
Cottonwood	0.2	32	87.5	123	156	(N/A)	1.0	1.7	77.82
Plum	0.0	4	15.2	21	26	(N/A)	1.0	0.3	12.85
Oak	0.2	29	61.4	86	115	(N/A)	1.0	1.3	57.60
American elm	0.4	50	124.7	176	226	(N/A)	1.0	2.5	112.82
Other street trees	0.5	74	179.5	253	327	(N/A)	2.1	3.6	81.64
Citywide total	13.8	1,933	5,079.7	7,152	9,085	(N/A)	100.0	100.0	47.07

Annual Stormwater Benefits of Public Trees by Species

1/25/2010

Species	Total rainfall interception (Gal)	Total (\$)	Standard Error	% of Total Trees	% of Total \$	Avg. \$/tree
Norway maple	44,920	359	(N/A)	20.2	17.0	9.22
Maple	23,008	184	(N/A)	12.4	8.7	7.67
Blue spruce	18,132	145	(N/A)	9.3	6.9	8.06
Crabapple harvest gold	3,640	29	(N/A)	8.3	1.4	1.82
Red maple	24,264	194	(N/A)	7.8	9.2	12.94
Pine	22,923	183	(N/A)	7.8	8.7	12.23
Silver maple	46,239	370	(N/A)	7.3	17.5	26.42
European white birch	6,097	49	(N/A)	4.2	2.3	6.10
Spruce	8,016	64	(N/A)	4.2	3.0	8.02
Northern red oak	13,181	105	(N/A)	2.6	5.0	21.09
Littleleaf linden	4,493	36	(N/A)	2.1	1.7	8.99
Boxelder	3,227	26	(N/A)	1.6	1.2	8.60
Ash	8,276	66	(N/A)	1.6	3.1	22.07
Amur corktree	2,278	18	(N/A)	1.6	0.9	6.08
Atlas cedar	786	6	(N/A)	1.0	0.3	3.14
Honeylocust	4,142	33	(N/A)	1.0	1.6	16.57
Austrian pine	3,341	27	(N/A)	1.0	1.3	13.37
Cottonwood	4,206	34	(N/A)	1.0	1.6	16.82
Plum	390	3	(N/A)	1.0	0.2	1.56
Oak	3,335	27	(N/A)	1.0	1.3	13.34
American elm	7,208	58	(N/A)	1.0	2.7	28.83
Other street trees	11,748	94	(N/A)	2.1	4.5	23.50
Citywide total	263,851	2,111	(N/A)	100.0	100.0	10.94

25-Year Projection of Benefits of Street Trees in Buttolph Acres

Annual Aesthetic/Other Benefits of Public Trees by Species

1/26/2010

Species	Total (\$)	Standard Error	% of Total Trees	% of Total \$	Avg. \$/tree
River birch	1,493	(N/A)	9.7	15.7	106.66
Eastern redbud	92	(N/A)	9.7	1.0	6.58
Northern hackberry	1,493	(N/A)	9.7	15.7	106.66
American elm	1,573	(N/A)	9.7	16.5	112.32
Sweetgum	736	(N/A)	8.3	7.7	61.37
Black tupelo	481	(N/A)	8.3	5.1	40.04
American sycamore	767	(N/A)	7.6	8.1	69.69
Serviceberry	66	(N/A)	6.9	0.7	6.58
Downy serviceberry	66	(N/A)	6.9	0.7	6.58
Swamp white oak	698	(N/A)	5.5	7.3	87.30
Bur oak	611	(N/A)	4.8	6.4	87.30
Pin oak	611	(N/A)	4.8	6.4	87.30
Maple	588	(N/A)	4.1	6.2	97.94
Red maple	240	(N/A)	4.1	2.5	40.04
Other street trees	0	(±NaN)	0.0	0.0	0.00
Citywide total	9,515	(N/A)	100.0	100.0	65.62

Annual Air Quality Benefits of Public Trees by Species

1/26/2010

Species	Deposition (lb)				Total Depos. (\$)	Avoided (lb)				Total Avoided (\$)	BVOC Emissions (lb)	BVOC Emissions (\$)	Total (lb)	Total Standard (\$)	Standard Error	% of Total Trees	Avg. \$/tree
	O ₃	NO ₂	PM ₁₀	SO ₂		NO ₂	PM ₁₀	VOC	SO ₂								
River birch	15.4	6.5	7.4	2.4	171	20.1	1.3	0.8	10.5	141	0.0	0	64.3	312	(N/A)	9.7	22.26
Eastern redbud	4.8	2.1	2.4	0.8	54	8.2	0.5	0.3	3.9	56	0.0	0	22.9	110	(N/A)	9.7	7.88
Northern hackberry	15.4	6.5	7.4	2.4	171	20.1	1.3	0.8	10.5	141	0.0	0	64.3	312	(N/A)	9.7	22.26
American elm	15.4	6.2	7.3	2.4	168	21.9	1.4	0.8	11.5	154	0.0	0	66.9	322	(N/A)	9.7	23.02
Sweetgum	11.1	4.5	5.3	1.7	121	16.7	1.1	0.6	8.6	117	-38.0	-88	11.6	150	(N/A)	8.3	12.52
Black tupelo	10.2	4.4	5.1	1.7	115	14.8	1.0	0.6	7.6	104	-2.5	-6	42.8	213	(N/A)	8.3	17.75
American sycamore	11.0	4.6	5.3	1.7	122	15.4	1.0	0.6	8.0	108	-12.1	-28	35.5	202	(N/A)	7.6	18.38
Serviceberry	3.5	1.5	1.7	0.6	39	5.8	0.4	0.2	2.8	40	0.0	0	16.4	79	(N/A)	6.9	7.88
Downy serviceberry	3.5	1.5	1.7	0.6	39	5.8	0.4	0.2	2.8	40	0.0	0	16.4	79	(N/A)	6.9	7.88
Swamp white oak	8.2	3.6	4.1	1.4	93	10.7	0.7	0.4	5.7	76	-7.2	-17	27.6	152	(N/A)	5.5	19.01
Bur oak	7.2	3.1	3.6	1.2	81	9.4	0.6	0.4	5.0	66	-6.3	-15	24.1	133	(N/A)	4.8	19.01
Pin oak	7.2	3.1	3.6	1.2	81	9.4	0.6	0.4	5.0	66	-6.3	-15	24.1	133	(N/A)	4.8	19.01
Maple	5.1	2.2	2.5	0.8	57	7.2	0.5	0.3	3.7	50	-0.9	-2	21.4	106	(N/A)	4.1	17.59
Red maple	5.1	2.2	2.5	0.8	57	7.4	0.5	0.3	3.8	52	-1.2	-3	21.4	107	(N/A)	4.1	17.75
Other street trees	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0	0.0	0	0.0	0	(N/A)	0.0	0.00
Citywide total	123.1	52.0	59.9	19.6	1,370	172.8	11.2	6.6	89.4	1,212	-74.7	-173	459.8	2,409	(N/A)	100.0	16.62

Annual CO Benefits of Public Trees by Species

1/26/2010

Species	Sequestered (lb)	Sequestered (\$)	Decomposition Release (lb)	Maintenance Release (lb)	Total Released (\$)	Avoided (lb)	Avoided (\$)	Net Total (lb)	Total Standard (\$ Error)	% of Total Trees	% of Total \$	Avg. \$/tree
River birch	4,770	16	-2,644	-267	-10	7,211	24	9,071	30 (N/A)	9.7	9.8	2.16
Eastern redbud	1,941	6	-629	-224	-3	2,648	9	3,737	12 (N/A)	9.7	4.0	0.89
Northern hackberry	4,770	16	-2,644	-267	-10	7,211	24	9,071	30 (N/A)	9.7	9.8	2.16
American elm	7,316	24	-3,089	-267	-11	7,925	26	11,886	40 (N/A)	9.7	12.8	2.84
Sweetgum	1,828	6	-323	-228	-2	5,900	20	7,177	24 (N/A)	8.3	7.7	2.00
Black tupelo	2,549	9	-767	-228	-3	5,209	17	6,763	23 (N/A)	8.3	7.3	1.88
American sycamore	3,393	11	-377	-209	-2	5,499	18	8,306	28 (N/A)	7.6	9.0	2.52
Serviceberry	1,387	5	-449	-160	-2	1,892	6	2,669	9 (N/A)	6.9	2.9	0.89
Downy serviceberry	1,387	5	-449	-160	-2	1,892	6	2,669	9 (N/A)	6.9	2.9	0.89
Swamp white oak	5,049	17	-870	-152	-3	3,931	13	7,957	27 (N/A)	5.5	8.6	3.32
Bur oak	4,418	15	-761	-133	-3	3,440	11	6,963	23 (N/A)	4.8	7.5	3.32
Pin oak	4,418	15	-761	-133	-3	3,440	11	6,963	23 (N/A)	4.8	7.5	3.32
Maple	4,082	14	-333	-114	-1	2,523	8	6,158	21 (N/A)	4.1	6.6	3.43
Red maple	1,275	4	-384	-114	-2	2,605	9	3,381	11 (N/A)	4.1	3.6	1.88
Other street trees	0	0	0	0	0	0	0	0	0 (N/A)	0.0	0.0	0.00
Citywide total	48,583	162	-14,480	-2,657	-57	61,325	205	92,771	310 (N/A)	100.0	100.0	2.14

Stored CO2 Benefits of Public Trees by Species

1/26/2010

Species	Total Stored CO2 (lbs)	Total (\$)	Standard Error	% of Total Trees	% of Total \$	Avg. \$/tree
River birch	118,024	394	(N/A)	9.7	8.7	28.16
Eastern redbud	137,846	460	(N/A)	9.7	10.2	32.89
Northern hackberry	118,024	394	(N/A)	9.7	8.7	28.16
American elm	137,918	461	(N/A)	9.7	10.2	32.90
Sweetgum	70,915	237	(N/A)	8.3	5.2	19.74
Black tupelo	89,704	300	(N/A)	8.3	6.6	24.97
American sycamore	82,600	276	(N/A)	7.6	6.1	25.08
Serviceberry	98,462	329	(N/A)	6.9	7.3	32.89
Downy serviceberry	98,462	329	(N/A)	6.9	7.3	32.89
Swamp white oak	104,773	350	(N/A)	5.5	7.7	43.74
Bur oak	91,676	306	(N/A)	4.8	6.8	43.74
Pin oak	91,676	306	(N/A)	4.8	6.8	43.74
Maple	73,010	244	(N/A)	4.1	5.4	40.64
Red maple	44,852	150	(N/A)	4.1	3.3	24.97
Other street trees	0	0	(N/A)	0.0	0.0	0.00
Citywide total	1,357,941	4,536	(N/A)	100.0	100.0	31.28

Annual Energy Benefits of Public Trees By Species

1/26/2010

Species	Total Electricity (MWh)	Electricity (\$)	Total Natural Gas (Therms)	Natural Gas (\$)	Total (\$)	Standard Error	% of Total Trees	% of Total \$	Avg. \$/tree
River birch	2.4	335	833.5	1,174	1,509	(N/A)	9.7	11.5	107.78
Eastern redbud	0.9	123	385.8	543	666	(N/A)	9.7	5.1	47.60
Northern hackberry	2.4	335	833.5	1,174	1,509	(N/A)	9.7	11.5	107.78
American elm	2.6	369	902.5	1,271	1,639	(N/A)	9.7	12.5	117.10
Sweetgum	2.0	274	706.2	994	1,269	(N/A)	8.3	9.7	105.73
Black tupelo	1.7	242	637.4	897	1,140	(N/A)	8.3	8.7	94.98
American sycamore	1.8	256	645.6	909	1,165	(N/A)	7.6	8.9	105.89
Serviceberry	0.6	88	275.6	388	476	(N/A)	6.9	3.6	47.60
Downy serviceberry	0.6	88	275.6	388	476	(N/A)	6.9	3.6	47.60
Swamp white oak	1.3	183	431.2	607	790	(N/A)	5.5	6.0	98.75
Bur oak	1.1	160	377.3	531	691	(N/A)	4.8	5.3	98.75
Pin oak	1.1	160	377.3	531	691	(N/A)	4.8	5.3	98.75
Maple	0.8	117	307.1	432	550	(N/A)	4.1	4.2	91.63
Red maple	0.9	121	318.7	449	570	(N/A)	4.1	4.3	94.98
Other street trees	0.0	0	0.0	0	0	(N/A)	0.0	0.0	0.00
Citywide total	20.4	2,853	7,307.3	10,289	13,141	(N/A)	100.0	100.0	90.63

Annual Stormwater Benefits of Public Trees by Species

1/26/2010

Species	Total rainfall interception (Gal)	Total (\$)	Standard Error	% of Total Trees	% of Total \$	Avg. \$/tree
River birch	58,671	469	(N/A)	9.7	13.4	33.53
Eastern redbud	15,042	120	(N/A)	9.7	3.4	8.60
Northern hackberry	58,671	469	(N/A)	9.7	13.4	33.53
American elm	53,482	428	(N/A)	9.7	12.2	30.56
Sweetgum	40,394	323	(N/A)	8.3	9.2	26.93
Black tupelo	38,188	306	(N/A)	8.3	8.7	25.46
American sycamore	37,273	298	(N/A)	7.6	8.5	27.11
Serviceberry	10,744	86	(N/A)	6.9	2.5	8.60
Downy serviceberry	10,744	86	(N/A)	6.9	2.5	8.60
Swamp white oak	28,780	230	(N/A)	5.5	6.6	28.78
Bur oak	25,183	201	(N/A)	4.8	5.7	28.78
Pin oak	25,183	201	(N/A)	4.8	5.7	28.78
Maple	17,082	137	(N/A)	4.1	3.9	22.78
Red maple	19,094	153	(N/A)	4.1	4.4	25.46
Other street trees	0	0	(N/A)	0.0	0.0	0.00
Citywide total	438,532	3,509	(N/A)	100.0	100.0	24.20

50-Year Projection of the Benefits of Street Trees in Buttolph Acres

Annual Aesthetic/Other Benefits of Public Trees by Species

1/26/2010

Species	Total (\$)	Standard Error	% of Total Trees	% of Total \$	Avg. \$/tree
River birch	937	(N/A)	9.7	10.4	66.96
Eastern redbud	0	(N/A)	9.7	0.0	0.01
Northern hackberry	937	(N/A)	9.7	10.4	66.96
American elm	1,909	(N/A)	9.7	21.2	136.33
Sweetgum	477	(N/A)	8.3	5.3	39.71
Black tupelo	331	(N/A)	8.3	3.7	27.58
American sycamore	960	(N/A)	7.6	10.7	87.28
Serviceberry	0	(N/A)	6.9	0.0	0.01
Downy serviceberry	0	(N/A)	6.9	0.0	0.01
Swamp white oak	864	(N/A)	5.5	9.6	107.98
Bur oak	756	(N/A)	4.8	8.4	107.98
Pin oak	756	(N/A)	4.8	8.4	107.98
Maple	898	(N/A)	4.1	10.0	149.66
Red maple	166	(N/A)	4.1	1.8	27.58
Other street trees	0	(±NaN)	0.0	0.0	0.00
Citywide total	8,990	(N/A)	100.0	100.0	62.00

Annual Air Quality Benefits of Public Trees by Species

1/26/2010

Species	Deposition (lb)				Total Depos. (\$)	Avoided (lb)				Total Avoided (\$)	BVOC Emissions (lb)	BVOC Emissions (\$)	Total (lb)	Total (\$)	Standard Error	% of Total Trees	Avg. \$/tree
	O ₃	NO ₂	PM ₁₀	SO ₂		NO ₂	PM ₁₀	VOC	SO ₂								
River birch	20.9	8.8	10.1	3.2	232	24.3	1.6	0.9	13.1	172	0.0	0	82.9	404	(N/A)	9.7	28.82
Eastern redbud	4.8	2.1	2.4	0.8	54	8.2	0.5	0.3	3.9	56	0.0	0	22.9	110	(N/A)	9.7	7.88
Northern hackberry	20.9	8.8	10.1	3.2	232	24.3	1.6	0.9	13.1	172	0.0	0	82.9	404	(N/A)	9.7	28.82
American elm	23.4	9.5	11.1	3.6	256	28.9	1.9	1.1	16.1	207	0.0	0	95.5	462	(N/A)	9.7	33.02
Sweetgum	16.0	6.5	7.6	2.5	175	21.5	1.4	0.8	11.6	152	-63.0	-146	4.9	182	(N/A)	8.3	15.19
Black tupelo	13.9	6.0	6.9	2.3	157	18.6	1.2	0.7	9.9	132	-3.4	-8	56.2	281	(N/A)	8.3	23.38
American sycamore	15.5	6.5	7.5	2.4	171	19.4	1.2	0.7	10.5	138	-19.7	-45	44.1	264	(N/A)	7.6	23.96
Serviceberry	3.5	1.5	1.7	0.6	39	5.8	0.4	0.2	2.8	40	0.0	0	16.4	79	(N/A)	6.9	7.88
Downy serviceberry	3.5	1.5	1.7	0.6	39	5.8	0.4	0.2	2.8	40	0.0	0	16.4	79	(N/A)	6.9	7.88
Swamp white oak	13.1	5.7	6.5	2.2	148	14.8	1.0	0.6	8.3	106	-11.6	-27	40.6	228	(N/A)	5.5	28.46
Bur oak	11.5	5.0	5.7	1.9	130	13.0	0.8	0.5	7.2	93	-10.1	-23	35.5	199	(N/A)	4.8	28.46
Pin oak	11.5	5.0	5.7	1.9	130	13.0	0.8	0.5	7.2	93	-10.1	-23	35.5	199	(N/A)	4.8	28.46
Maple	7.2	3.1	3.5	1.2	81	9.2	0.6	0.4	4.9	65	-1.6	-4	28.5	142	(N/A)	4.1	23.73
Red maple	6.9	3.0	3.5	1.2	78	9.3	0.6	0.4	4.9	66	-1.7	-4	28.1	140	(N/A)	4.1	23.38
Other street trees	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0	0.0	0	0.0	0	(N/A)	0.0	0.00
Citywide total	172.7	72.9	84.1	27.5	1,921	216.3	13.9	8.2	116.1	1,531	-121.3	-280	590.2	3,172	(N/A)	100.0	21.88

Annual CO Benefits of Public Trees by Species

1/26/2010

Species	Sequestered (lb)	Sequestered (\$)	Decomposition Release (lb)	Maintenance Release (lb)	Total Released (\$)	Avoided (lb)	Avoided (\$)	Net Total (lb)	Total Standard (\$ Error)	% of Total Trees	% of Total \$	Avg. \$/tree
River birch	3,713	12.4030149	-1,081	-352	-5	8,968	30	11,248	38 (N/A)	9.7	9.1	2.68
Eastern redbud	0	0.00010308	-629	-224	-3	2,648	9	1,796	6 (N/A)	9.7	1.5	0.43
Northern hackberry	3,713	12.4030149	-1,081	-352	-5	8,968	30	11,248	38 (N/A)	9.7	9.1	2.68
American elm	11,438	38.2014717	-1,324	-362	-6	11,029	37	20,780	69 (N/A)	9.7	16.8	4.96
Sweetgum	1,412	4.71755648	-647	-311	-3	7,931	26	8,385	28 (N/A)	8.3	6.8	2.33
Black tupelo	2,298	7.67494289	-740	-311	-4	6,788	23	8,036	27 (N/A)	8.3	6.5	2.24
American sycamore	5,506	18.3916162	-825	-285	-4	7,202	24	11,598	39 (N/A)	7.6	9.4	3.52
Serviceberry	0	7.3634308E	-449	-160	-2	1,892	6	1,283	4 (N/A)	6.9	1.0	0.43
Downy serviceberry	0	7.3634308E	-449	-160	-2	1,892	6	1,283	4 (N/A)	6.9	1.0	0.43
Swamp white oak	7,945	26.5369894	-1,019	-207	-4	5,684	19	12,403	41 (N/A)	5.5	10.1	5.18
Bur oak	6,952	23.2198657	-892	-181	-4	4,974	17	10,853	36 (N/A)	4.8	8.8	5.18
Pin oak	6,952	23.2198657	-892	-181	-4	4,974	17	10,853	36 (N/A)	4.8	8.8	5.18
Maple	7,093	23.6908329	-674	-155	-3	3,358	11	9,622	32 (N/A)	4.1	7.8	5.36
Red maple	1,149	3.83747144	-370	-155	-2	3,394	11	4,018	13 (N/A)	4.1	3.3	2.24
Other street trees	0	0	0	0	0	0	0	0	0 (N/A)	0.0	0.0	0.00
Citywide total	58,173	194.296892	-11,071	-3,396	-48	79,701	266	123,406	412 (N/A)	100.0	100.0	2.84

Stored CO2 Benefits of Public Trees by Species

1/26/2010

Species	Total Stored CO2 (lbs)	Total (\$)	Standard Error	% of Total Trees	% of Total \$	Avg. \$/tree
River birch	237,162	792	(N/A)	9.7	9.8	56.58
Eastern redbud	137,846	460	(N/A)	9.7	5.7	32.89
Northern hackberry	237,162	792	(N/A)	9.7	9.8	56.58
American elm	290,280	970	(N/A)	9.7	12.0	69.25
Sweetgum	141,939	474	(N/A)	8.3	5.9	39.51
Black tupelo	162,215	542	(N/A)	8.3	6.7	45.15
American sycamore	180,930	604	(N/A)	7.6	7.5	54.94
Serviceberry	98,462	329	(N/A)	6.9	4.1	32.89
Downy serviceberry	98,462	329	(N/A)	6.9	4.1	32.89
Swamp white oak	223,525	747	(N/A)	5.5	9.2	93.32
Bur oak	195,584	653	(N/A)	4.8	8.1	93.32
Pin oak	195,584	653	(N/A)	4.8	8.1	93.32
Maple	147,701	493	(N/A)	4.1	6.1	82.22
Red maple	81,108	271	(N/A)	4.1	3.3	45.15
Other street trees	0	0	(N/A)	0.0	0.0	0.00
Citywide total	2,427,960	8,109	(N/A)	100.0	100.0	55.93

Annual Energy Benefits of Public Trees By Species

1/26/2010

Species	Total Electricity (MWh)	Electricity (\$)	Total Natural Gas (Therms)	Natural Gas (\$)	Total (\$)	Standard Error	% of Total Trees	% of Total \$	Avg. \$/tree
River birch	3.0	417	971.1	1,367	1,784	(N/A)	9.7	11.2	127.46
Eastern redbud	0.9	123	385.8	543	666	(N/A)	9.7	4.2	47.60
Northern hackberry	3.0	417	971.1	1,367	1,784	(N/A)	9.7	11.2	127.46
American elm	3.7	513	1,105.0	1,556	2,069	(N/A)	9.7	13.0	147.78
Sweetgum	2.6	369	865.8	1,219	1,588	(N/A)	8.3	10.0	132.33
Black tupelo	2.3	316	761.7	1,072	1,388	(N/A)	8.3	8.7	115.69
American sycamore	2.4	335	773.5	1,089	1,424	(N/A)	7.6	8.9	129.46
Serviceberry	0.6	88	275.6	388	476	(N/A)	6.9	3.0	47.60
Downy serviceberry	0.6	88	275.6	388	476	(N/A)	6.9	3.0	47.60
Swamp white oak	1.9	264	562.3	792	1,056	(N/A)	5.5	6.6	132.01
Bur oak	1.7	231	492.0	693	924	(N/A)	4.8	5.8	132.01
Pin oak	1.7	231	492.0	693	924	(N/A)	4.8	5.8	132.01
Maple	1.1	156	379.1	534	690	(N/A)	4.1	4.3	114.99
Red maple	1.1	158	380.9	536	694	(N/A)	4.1	4.4	115.69
Other street trees	0.0	0	0.0	0	0	(N/A)	0.0	0.0	0.00
Citywide total	26.5	3,707	8,691.3	12,237	15,945	(N/A)	100.0	100.0	109.96

Annual Stormwater Benefits of Public Trees by Species

1/26/2010

Species	Total rainfall interception (Gal)	Total (\$)	Standard Error	% of Total Trees	% of Total \$	Avg. \$/tree
River birch	86,971	696	(N/A)	9.7	13.5	49.70
Eastern redbud	15,042	120	(N/A)	9.7	2.3	8.60
Northern hackberry	86,971	696	(N/A)	9.7	13.5	49.70
American elm	82,724	662	(N/A)	9.7	12.8	47.27
Sweetgum	62,944	504	(N/A)	8.3	9.8	41.97
Black tupelo	52,289	418	(N/A)	8.3	8.1	34.86
American sycamore	56,497	452	(N/A)	7.6	8.8	41.09
Serviceberry	10,744	86	(N/A)	6.9	1.7	8.60
Downy serviceberry	10,744	86	(N/A)	6.9	1.7	8.60
Swamp white oak	46,112	369	(N/A)	5.5	7.2	46.12
Bur oak	40,348	323	(N/A)	4.8	6.3	46.12
Pin oak	40,348	323	(N/A)	4.8	6.3	46.12
Maple	27,191	218	(N/A)	4.1	4.2	36.26
Red maple	26,144	209	(N/A)	4.1	4.1	34.86
Other street trees	0	0	(N/A)	0.0	0.0	0.00
Citywide total	645,068	5,161	(N/A)	100.0	100.0	35.59