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Urban Forestry Sustainability Metrics

Building Sustainability into Cities and Towns

Urban Forestry Institute

Nashville, Tennessee

May 6-10, 2013

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"The idea of wilderness needs no defense, it only needs defenders."
The Journey Home, 1991 Edward Abbey

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Articles of Sustainability

A contemporary tree ordinance or better an urban forestry ordinance based upon sustainability should set forth 'guiding principles' in the form of 'sustainability metrics' based upon environmental improvements, public policy toward the environment and shared values toward the city and its resources. These principles must carry through to all actions and decisions in regard to urban forestry and sustainability.

Important sustainability tools highlighting ecosystems services provided by the urban forest should be written into the ordinance to preserve the urban forest canopy, set minimum standards city wide according to zoning districts or land use for establishing

the percentage of the urban forest that must be preserved for posterity. (American Forests) Ecosystem services provide benefits to society but are often not considered as an asset in current developmental economic accounting methods. (SSI ASLA 2007) Habitat preservation, particularly for wetlands, groves, specimen forests, stream banks, steep slopes and transitional meadows should be a major factor in this ordinance as well. Urban forestry derives its position of sustainability by its ability to protect and preserve unique and important environment resources. Tree protection during construction, setting a minimum area of site permeability and placing emphasis on the use of native plants and water conservation are other important articles that should be included of this ordinance. Land clearing and tree removal by all means must be permitted and undertaken in a systematic way that the amount of canopy removed can be recorded and mitigated.

The ordinance should address related issues concerned with open space, wildlife habitat and proximity to parks, trails and forested land. The urban forest must be seen as something that is used for recreation and pleasure in order to help citizens see the values and advantages it preservation.

The technical standards of a sustainable tree ordinance may be written to convey three points. They include guiding *principles*, *sustainability metrics*, and a program for *monitoring and assessment*. Figure 1 below shows a list of these three points. Communities should select the principles, tools and monitoring procedure that are most relevant to their community conditions.

I. Guiding Principles

Management of the Urban Forest- planning, design, maintenance, financing

Habitat preservation-wetlands, groves, forests, transition meadows, steep slopes wildlife corridors etc.

Tree Protection During Construction- three inches for one inch replacement

Minimum Area of Site Permeability-

Native Materials and Ecological Conformity-native plants, exotic plants and lawn grass minimization.

Water Management –storm water control, water conservation, water harvesting, irrigation design and control.

II. Urban Forest Sustainability Metrics (ordinance articles)

Minimum Canopy Standards
Tree Preservation, Preserved Groves and Forest Remnants
Screening, Buffering and Green Connectivity to Parks & Open Space
Green Parking
Appropriate Plant Materials
Locally Produced Construction Materials
Nutrient Cycling
Photosynthesis and the Carbon Sink
Soil Structure
Solar Energy Orientation
Urban Heat Island Effect
Water Balance
Storm Water BMP's
Wetlands
Windbreaks
Steep Slope Protection
Human Health and Well Being

III. Monitoring and Assessing Sustainability

Community Sustainability Plan

Sustainability Director & Staff

Inventory; Mapping; Monitoring; Arboricultural Management.

Setting Sustainability Principles, Goals, and Measurable Results

Progress Reports-indicators, activity, milestones, targets, report to the citizens

Fig. No. 1. Sustainable Components of Urban Forestry, Louisiana State University

In the paragraphs below the sustainability metrics for an urban forestry ordinance will be discussed. Readers are encouraged to respond with thoughts, and suggestions for deletions and additions. It is time for some discussion about urban forest sustainability and this paper may the starting point.

Sustainability Metrics

It was previously stated that the forest in the city is a sustainable feature if properly planned, designed, built and managed. These four elements are the basics of sustainability based tree ordinance. To preserve the urban forest resources into the future it is important for tree ordinances to address these

elements that are essential to developing sustainability metrics by which the success of a sustainable program may be measured.

Forestry sustainability metrics are built around several factors that include green building; tree protection; tree canopy standards; site clearing controls; connectivity and accessibility to open space, parks, and trees; storm water management; irrigation controls; use of regionally appropriate vegetation; and management of the urban forest. The latter factor includes proper inventory control and measurement with computer based GIS systems by an urban forestry management office guided by a citizen tree board or landscape commission. In addition a community must have a well staffed and experienced urban forestry crew that is well equipped to plant, manage, maintain and remove trees and related landscape features found within the urban forest.

To implement this systematic way of husbanding the tree resources of a community it is important for a community to state its tree policy within the community tree ordinance or landscape code. Sustainability metrics must be included in the ordinance as goals or forestry mandates to accomplish the purpose of sustaining the urban forest. Based upon the case studies and ordinance presented here the following sustainability metrics should be built into every community tree ordinance and landscape code with appropriately written code language.

Metric one: Define the forest

The first measure of a sustainable tree ordinance is to support a local urban forest is that the entire natural system is seen as one unit. The urban forest includes not only public treed areas like streets, parks, and preserves but private lands as well. Large institutions, beg landowners and even the person growing oranges in the back yard contribute to the urban forest and its connectivity across the community. Connecting yards, gardens, the corporate campus, forest preserves and wetlands as one linked system of walkable or bike riding urban forest experience is necessary to fully appreciate exactly what will make the urban forest unique. For this reason, the connecting of parts, no two urban forests are the same. This is what will make each community unique.

Representative Urban Forest Sustainability Standard: The urban forest must be inventoried and mapped. Not necessarily to count each tree or determine its DBH, buts its canopy coverage. Area inventory maps can be used to get fine details about trees, their size, health and species. Mapping the urban forest is the first step in allowing the community to see that it is a major aspect of the green infrastructure of a community.

Metric two: Tree Protection & Healthy Environment

Tree protection language included in any tree ordinance or landscape code necessary in any community that wants to draft a sustainable urban forest ordinance. Each and every tree should have some protection but the most important trees and special groves need additional support by stiffer regulations or special forest management. As Santa Monica has demonstrated, drafting local tree protection measures and writing a tree protection manual will help all citizen's, builders and developer see the worth of all trees from pioneer tree growth to a climax forest.

Representative Urban Forest Sustainability Standard: Trees, shrubs, ground covers within urban forests are all important and promote healthy environments. Examples include cleaner air, purer water, productive soils, ameliorated climate, and healthy wildlife and human habitat as well as a potential for food crop production. The urban forest sequesters carbon, produces oxygen, recycles biomass and utilizes the sun for it energy potential. All of these chemical actions make for a sustainable community.

Metric three: Minimum Tree Canopy Standard

American Forests, the nation's oldest conservation organization, as we have seen provide a set tree canopy standards that are reasonable for communities across the county. This part of a sustainable tree ordinance is one of the most critical decisions a community must make to ensure a stable, healthy urban forest for generations yet not born. A community must determine what percent of the community must be covered with tree canopy. A goal should be set that is politically acceptable, affordable and that citizens will work to achieve. Baton Rouge, Rouge for instance currently has forty-two (42) percent canopy coverage on average. Residential areas are higher and commercial and industrial areas are much lower. Perhaps they should adopt standards to bring that average up to fifty-five (55) percent by planting hundreds of young trees each year to

replace the ones that are removed or die from natural causes. Eventually by staying ahead of the mortality rate, managing the urban forest properly Baton Rouge will achieve its goal.

The recently prepared Master Plan for development of the City of New Orleans is based upon sustainability. Chapter 7 of the plan is of interest to those involved with urban forestry. This chapter sets forth a plan for green infrastructure; parks, open space and recreation. The plan gives emphasis to open space, green space connectivity, wetland protection and use, improvements to water cleansing and air quality and continuous tree planting. All of these are factors of urban forestry. But perhaps the most interesting part of the plan is the City is setting a minimum canopy standard goal. This standard is to be 50% coverage. The act of setting a standard is the first step in recognizing that the urban forest is indeed one of the sustainability tools for the city. Other cities would do well too set such a standard and be dedicated to replanting and replacing too keep this minimum canopy in place.

Representative Urban Forest Sustainability Standard: Minimum tree canopy standard for each unit of the urban forest shall be no less than forty (40) percent and the average minimum canopy for the community of the whole and shall be minimum canopy standards per zoning district as recommended by American Forests as measured by either canopy coverage, trees per acre, or caliper inches per acre or by permeability ratio of the development site.

Metric four: Site Clearing Standards

Site clearing controls are often a bug-a-boo with private landowners. Rightly so, since in this country private land ownership is a natural right protected by the U.S. Constitution. Happily, there are more citizens that buy into planting and preserving trees than those that do not want one within sight. For this reason each community should commit its sustainable landscape code or land development regulations to finding better way to clear land. Two approaches are common and both may work for a community. Method one is to move development around existing trees and the other is to replant after development. A good tree or landscape ordinance should recognize each. In addition, there are other strategies that can be added to the ordinance to make it work better with developers and

home owners alike. These might include a tree credit system, incentives, envelope clearing standards, tunneling, tree welling, tree banking, and tree removal mitigation. Many communities across the country already use some of these methods to replace the old fashioned "slick off the land" method.'

Land clearing activities must be permitted and trees that are removed for development must be replaced using a 'removal to replacement ratio' such as 1''**:**1'', (inch per inch) based upon local needs. This type of mitigation with a 'fee in lieu of provision' option is appropriate to maintain a communities minimum tree canopy cover.

Representative Urban Forest Sustainability Standard: Site clearing shall be conducted so that in each particular development site all specimen trees and are identified by inventory, located and protected during construction and that all other native trees removed are mitigated at a proscribed caliper replacement rate. In all instances of clearing, envelope clearing must be used that will retain a minimum fifteen (15) foot width of natural non-disturbed top soil buffer. All clearing shall be permitted.

Metric five: Green Building

Green building is a term that often applied to designing architecture to be green. Green roofs or green walls designed to cut down on energy use in Seattle is one example of a green building practice applied to buildings. But the concept of green building is also applicable to planting and caring for an urban forest. An urban forest is naturally sustainable and that forest's provides eco-services needed by society for a cleaner, healthier environment. Building a green forest, preserving wetlands or managing storm water in buffers are all forms of green building with trees, shrubs and natural ground. Cover. As noted in the discussion of Gwinnett County the urban forest provides a range of natural services including oxygen manufacture, carbon uptake, shade production or nutrient recycling all sustainable practices. Tree ordinances and landscape codes can be greened up by dedicating the ordinance to the concept of green building as a way of informing, that the urban forest is one of the main ways that a city will go green.

Representative Urban Forest Sustainability Standard: All public buildings and parking areas within the urban forested or any forested unit of the urban forest shall have buildings and parking lots designed using

the latest 'green building' standards such as green roofs (green arbors), permeable paving, on-site storm water practices as promulgated by such green building programs as sponsored by the NHBA, LEED, ASLA or other such approved local green building programs or building code associations.

Metric six: Water Management

Irrigation controls is a common metric west of the Mississippi River and in Florida. But even in a wet of state like Louisiana where monsoon type rainfall amounts can reach seventy-five inches of rain a year clean, pure, water from underground sources is not to be wasted but should be seen as a valuable resource. Water harvesting as practiced in Irvine, Homestead or Santa Monica should be used where ever potable water is being pumped to irrigate a garden. Native forests have adopted regionally significant species to survive under native rainfall amounts. Irrigation is a convenience that if use, should be a system based upon water harvesting, recycling, reclaiming or through Xeriscape design practices as we have noted in the communities cited in this paper.

Better irrigation technology and storm water harvesting technology along with the reduction in turf grass planting will easily allow a sustainable community to reduce its irrigation water by at least fifty (50) percent. All communities should draft a sustainable tree ordinance or landscape code that rewards citizens for reducing the amount of grass in a community which in most instances will be covered with trees, shrubs and ground covers that need little of any supplemental watering. It is clearly a sustainable practice to reduce the amount of grass and the use of potable water.

Representative Urban Forest Sustainability Standard: All water used for irrigation purposes shall be grey water or water that is harvested from surface water storm water supplies.

Metric seven: Planting, Management, Removal & Recycling

The use of regionally appropriate vegetation is also a metric of a sustainable landscape law. Many community green laws already recognize the importance of native plants. However, when greening a community landscape ordinance it helps people to understand that using native plants, especially plants that do not need supplemental water, agriculture chemicals and excess maintenance is a sustainable practice. Like wise, limiting the use of

exotics to a marginal amount does allow a little flexibility for landscape design. Invasive plants, are very aggressive exotic plants that get out of control as they do frequently in the Homestead area of Florida. A reasonable sustainable practice calls for their elimination simply because they can outcompete native plants and push them aside. Using native plants that are grow locally, support the local economy and reduce transshipment charges is much better practice than growing them at distant locations. Experience with plants teaches horticulturists that the same species of plant grown in different states or regions will react to transplanting in foreign soil and unfamiliar climate. It is clearly a sustainable practice to use native plant and limit the use of exotics.

A community forest is relatively stable ecologically and can sustain itself for generations to come. However urban forests can be made to be even more ecologically productive by the assistance of mankind. Communities across the nation understand to have the most productive and most diverse urban forest it is well worth the cost to organize a community forestry program based upon sound urban forest management principles and arboricultural practices. A managed urban forest can result in the many sustainable eco-services we have mentioned in this paper. . It is clearly a sustainable practice that should be codified in communities green laws to manage the urban forest.

Taken together, these sustainability metrics including green building; tree protection; tree canopy standards; site clearing controls; storm water management; irrigation use conservation; regionally appropriate vegetation; and management of the urban forest can be used to craft a sustainable tree ordinance. The following sustainability issues are worth thinking about by any community wishing to revise their green laws to being in the concept of sustainability.

Representative Urban Forest Sustainability Standard: Ninety (90) percent of all trees, shrubs and ground covers used in the urban forest shall be native plants genetically suited to the community forest and its natural resource base. The remainder shall be fully adaptive to the site and non invasive, nor toxic to local wildlife or other plants.

Representative Urban Forest Sustainability Standard: One hundred (100) percent of all biomass generated in the urban forest shall be recycled within the urban forest. All trees, tree parts and leaves shall be chipped, composted and recycled into natural planting areas or used for the production of natural fertilizers or energy.

Representative Urban Forest Sustainability Standard: Ninety (90) percent of all trees used as replacement trees in the urban forest shall be geminated and grown as saplings under natural forest conditions, transferred to nursery grounds for further development and then replanted within the urban forest as replacement trees. Excess seedlings not to exceed thirty (30) percent of the developing forest crop may be sold off to commercial tree nurseries for distribution to owners of private properties.

Representative Urban Forest Sustainability Standard: Planting, pruning, removal and management procedures shall be used to ensure a layered urban forest containing ground covers, shrubs, small trees, medium size understory trees and forty (40) percent overstory canopy with a minimum of thirty (30) percent juvenal over tree distribution.

Tree Ordinance Sustainability Issues.

Traditional tree ordinance provisions as described by Wolf (2004), Swiecki (2001), McPherson (2001), Abbey (1998), and Hoefer-Himelick-DeVoto (1990) and others describe that most tree ordinances written prior to the year 2000 were written for several basic purposes. These include ordinances to manage public trees, provide for street tree plantings, successful tree planting & maintenance, tree removal restrictions, landscaping and to organize community forestry programs. Occasionally a tree ordinance was written for some local special purpose such as viewshed protection, designating landmark trees, or to initiate an annual arbor day programs. Others might be written to regulate licensing and arboricultural services.

Tree ordinances have not been written to promote urban forest sustainability but the seeds of this program have been sown in places like *New York City, Atlanta*, *Charleston*, *San Antonio*, *Santa Monica*, *Irvine, Orlando*, and *Chicago*, as well as in *Gwinnette County, Georgia, Volusia County, Florida* and *Mathews, North Carolina*.

Some of these newer ordinances can be casually referred to as '*super tree laws*' due to the fact that the ordinances contain both tree standards, landscape design requirements and habitat preservation standards. Many of them set goals or provide specific requirements based upon sustainable practices. Common sustainability practices contained within ordinances such as these include community education, species selection, minimum canopy requirements, storm water management, solar control, energy production and basic ecosystem services such as oxygen manufacture, carbon sequestration, and shade control. Emphasis on the latter brings the question of sustainability to the front of this discussion. Sustainability and quality of life are inextricable issues and often mean green communities and communities that are healthy and more livable.

Sustainable tree ordinances can become the means to bring emphasis to the sustainable nature of the urban forest. The development of these new hybrid, or harmonized tree laws, has been predicted in the recent writings of Chris Deurksen and Suzanne Richman (Duerksen1993). Wolf, has also written about sustainability strategies particularly in regards to parking lots that offer opportunities to do environmental work in the city. (Wolf 2004). But perhaps the best discussion on sustainability and the legal issues associated with tree conservation can be found in the White Paper on Local Ordinance Approaches written for the Montgomery Tree Committee. (Nichols 2007) This paper sets forth baseline ordinance clauses that might be inserted into local ordinances to define the sustainability metrics and permit requirements that might be included. But the gist of this paper suggests that if a community is to regulate trees it is important to base regulations upon environmental concerns that will allow a community to side step the vexing 'takings' issue. When trees are looked at as common property and trees can be proven to provide eco-services benefiting the entire community then the regulating of trees on private property becomes much more defensible.

Work such as climate modification, air and water quality improvements, pollution removal, tree preservation as well as buffering, screening and perimeter plantings can all be a result of an innovative tree ordinance. For some time now visionary communities

such as Broward and Collier Counties in Florida, Raleigh, Durham and Chapel Hill in North Carolina, Mandeville and Covington in Louisiana and Southlake, Denton and Conroe, Texas understand that the urban forest and green infrastructure of a community is indeed one of the sustainable elements of a green community. Forsythe, Gwinnett and Fulton Counties Georgia also understand this. San Antonio, Texas recently amended their zoning code and in the statement of purpose mentions eight (8) sustainable practices that are expected as a result of compliance with the tree ordinance. (San Antonio, Texas Municipal Code 2008) They mention for instance tree preservation, water conservation, air cleansing, heat island reduction, native vegetation protection and drought tolerant design. Olmsted recognized urban forest sustainability in the 1850's. He noted how the London Parks seemed to be the 'lungs of London.' He brought this knowledge to United States when he founded the American Parks movement and the profession of landscape architecture in the 1860's. (Stevenson 1977).

With the development of sophisticated forestry departments, and the use of tree technical manuals and advances in urban forestry research a new era of municipal tree law is on the horizon. This new era beckons sustainability to preserve urban forests for all of the important environmental assistance that a well-treed town can provide to its citizens. It is time that all community's realize that tree ordinances, landscape codes and land development regulations, must be rewritten to include sustainability criteria. Sustainability leads to green communities. Green communities are clean, healthy communities and lead to quality of life. The communities that will be successful in the 21st century will be those with an exceptional quality of life.

The twin concepts of sustainability and environmental balance leading to green communities are a natural addition and useful complement to any tree regulations or urban forest management practices.

Scientists can now measure, the environmental effects of a well diversified and maintained urban forest, it is worth thinking about what a sustainability based tree ordinance actually looks like. How would it be structured?

Appendix – Sustainability Standards

A Sustainable Tree Ordinance.

Ideas and conversations about what comprises a sustainable trees ordinance and how the codes should be greened up is a timely topic. Community, after community are going green and to do that they must build sustainability into their codes. But how to do that is a question few people or communities have taken time to determine. It has been written that sustainable urban forestry practices consist of four principles. These include "species selection and diversity," "inventory and landscape planning," "tree care and wood utilization" and "public relations and support." (Thompson 1994). Many would agree but others think that to green urban forestry, community tree ordinances, landscape codes and tree preservation ordinances must be tailored to illustrate that the urban forest and its green infrastructure system it provides a range of fundamental ecosystem services that will not only green a community but will help to sustain it.

Clark, Matheny, Cross and Wake (1997) in their paper *A Model of Urban Forest Sustainability* have written that urban forestry sustainability must consist of several characteristic that will preserve the green infrastructure of a city for generations not yet born. They point out that the environmental functions of an urban forest are key to its ability to remain stable over a long period of time. They also mention that urban forest provide services and not goods as do normal forests that are used to grow timber and other products. Green infrastructure includes the plants and landscapes of a community and as such they provide ecosystem services that green communities. Ecosystem services provide benefits to society such as oxygen production, air cleansing, water purification, climate modification, food, medicine and organic material production, waste decomposition, soil stability and health, genetic resources, and biological habitat for both trees and living creatures.

They conclude that several ideas must be included in any plan to make urban forests sustainable. First, communities must acknowledge that city trees provide a range of

benefits, they must be managed and therefore require interaction with people. Finally they point out several factors that can be used to measure urban forest sustainability. They include canopy coverage age of tree distribution, species mix of native vegetation, forest management at the local level and cooperation between land owners, government and citizens. The latter involves the adoption of an urban forestry plan. This plan would naturally be implemented by changes to the city code.

The following are suggested elements or sustainability provisions as seen in Fig. 3 above that might be incorporated into an existing tree ordinance to evolve it into a sustainable ordinance.

One or more of these provisions as each city would see as appropriate could be written into their tree ordinance or landscape code. By doing so, the rewritten ordinance and the practices that result from them would bring emphasis to the importance of the urban forest as a community resource to be managed toward making a more sustainable community.

These provisions are derived from some current work, research activity and organizational programming that has been or is being developed by several organizations concerned with green building, smart growth, planned development and sustainable site development. Primary leaders of the green building movement include the US Green Building Council, American Society of Landscape Architects and the Environmental Protection Agency. Other national based organizations are involved but will not be mentioned in this paper with regrets.

The LEED (Leadership in Energy and Environmental Design) Rating System developed for the design of green architecture addresses six major areas one of which is sustainable site development. (LEED 2008) One program, the LEED for Neighborhood Development is particularly important to this discussion. The American Society of Landscape Architects an organization long involved in site sensitive land planning and development is establishing a Sustainable Sites Initiative (SSI) there work is developing many of the tools below to allow design professional to design “sustainable landscapes” to

supplement green buildings. (ASLA 2007) The NHBA (National Home Builders Association) also has a green building program that recommends best practices for site planning and land development that utilize principles of resource, water and energy efficiency to reduce the impact of site development and home construction.

Sustainability provisions with community tree ordinances should address the issues defined by these organizations by including reference to the following tree ordinance sustainability issues.

Minimum Canopy Standards. Perhaps the most important concern of a sustainable tree ordinance is to set canopy standards. These standards can be set for the city as a whole, by zoned land use type or by each lot that is developed. It would not be uncommon for standards to address all three. Canopy standard can be measured in one of four ways. These include canopy coverage area, percent of lot or numbers of tree per development site or caliper inches per lot. One community uses a tree density standard (TDS) based upon caliper inches of the diameter of a tree as well as a site density factor (SDF) which is the number of tree density units per acre. (Forsyth Co. Georgia 2008) City planners, arborists or landscape architects that craft these standards need to keep in mind that quantity is but one metric but that the true controlling factor is root space, not canopy coverage. One is necessarily related the other but this too is dependent upon the root character of any individual species. Having canopy standards as part of a sustainable tree ordinance such as these will allow a community to have a mitigation program to ensure that when existing trees are removed, they get replanted somewhere in the city. Each community should inventory their tree stock periodically to measure canopy coverage and ascertain the composition, health, texture (deciduous vs evergreen, size, height, and age and caliper inches per acre) and economic value. Minimum canopy standards should be set locally based upon each community's specific mix of resource patterns such as climate, topography, rainfall, soil type, land cover, land use patterns and zoning intensity.

American Forests, is one of America's oldest citizen's conservation organizations and a pioneer in science and practice of urban forestry. This organization has set standards for urban canopy coverage based upon zoning and land use. The following numbers are

recommended and have been supplemented by the Author. The first number applies to the arid west and the later number applies east of the Mississippi River and in the Pacific Northwest.

Average tree cover all zoning districts	40% to 25%
Suburban residential zoning districts	35% to 50%
Urban Multi-family residential zoning districts	18% to 25%
Central Business District and commercial zoning districts	9% to 15%
Natural Preserved Woodlands in any zoning district	40% to 90%

It is important to set tree canopy goals because most communities have lost tree cover over the last 30 years due to new urban development. American Forest reports that it is not unusual to see a 30% decline in urban forests in some communities. (American Forests 2008)

To achieve a minimum canopy standard it is necessary for a community to determine the proper balance between green and grey necessary according to local conditions. To sustain this level of canopy it will be necessary to have in place a series of controls to ensure that each development site provides its share of the community wide canopy coverage. These controls might include preservation, replacement or mitigation standards. All standards might be based upon tree species mix, tree counts by acre, DBH counts by building site or canopy coverage or root space availability. Once the minimum canopy is achieved, it is only a matter or replacing every tree that is removed.

Tree Preservation and Preserved Groves and Forest Remnants. Similar to minimum canopy standards but at a smaller scale is the preservation of an individual specimen tree, tree groves and remnant forest floor. Many communities recognize landmark, historic, ancient, unique trees and or protected species of a proscribed size because they understand that these trees provide something special form an environmental or scenic perspective. Forest floors for instance are wonderful storm water traps since a deep rich forest duff developed over many years will infiltrate storm water quickly. Communities

such as Mandeville, Louisiana have established within their tree ordinance a mechanism to protect them during construction and preserve them as important site features. (Mandeville, Louisiana 2008)

Urban Afforestation and Land Stocking of Streets, Parks, Private Land. The planting, maintenance and removal of urban forest trees is an important function of community forestry. It is a well-known fact of botany that natural forest lands have a life cycle. This life cycle begins when land is cleared as result of fire, wind, floor or the activities of development. Pioneer species will soon invade the land as a result of seed dispersal or the activation of seeds that have been dormant in the soil awaiting ample day lighting. Site are colonized by these fast growing plants that consisting of grasses, sedges and rushes, shrubs and fast growing evergreen trees. These early succession species provide habitat for the other plants that will follow the succession cycle through several phases. Quick growing pines provide shade that allows hardwoods to germinate and the growing hardwoods provide shade and filtered light that will allow an understory of highly productive shrubs and small trees to increase the productivity of the forest. Eventually natural selection will thin out and weaken the primary succession materials and replace them with the species that will reach the forest's climax stage many, many years later. With additional sunlight the biodiversity index rises considerable as more species of plants, animals, insects are able to find habitat to their liking. A young growth forest is much more biologically productive than an old growth forest. With age, the forest loses some of its variability to be replaced with older, larger trees that are much more suited to the site and can provide essential environmental services that clean the air, clean the water and stabilize soil and moderate the climate.

Even urban forests have a life cycle. Since this forest also contains the living environment of mankind man rather than nature must the engine of succession. A sustainable urban forest must be managed by the planting and restocking of trees. These trees should be native occurring trees that exhibit the best characteristics of living within urban environment where roots space is at a minimum, soils are poor, moisture is not consistent and human impacts are expected.

Not only is it important to stock the urban forest with replacement trees but it is a necessary function to maintain it through beneficial horticulture and arboricultural practices. Appropriate tree management will allow better growing conditions and structural modifications through pruning that will strengthen the tree which in turn strengthens the urban forest. The forest can also benefit by tree removal and recycling activities. It is important within urban areas to remove trees when they become a liability or health safety issue. Within a natural forest a tree may be allowed to stand until it eventually falls. Within urban areas this is not possible due to injury to person or property. An active program of tree removal and replacement is necessary.

A diverse, mixed age urban forest provides maximum ecoservices. To get the most productive urban forest, a community needs an actively managed urban tree program where all phases of the life cycle of the urban forest are husbanded for maximum productivity.

Screening, Buffering and Green Connectivity. Since well-written tree ordinances must be part of a community's zoning ordinance the importance of screening and buffers becomes apparent. Physical, visual or intensity conflicts between land uses are resolved with the use of buffers or screens. These planting or natural preserved buffer areas can add a significant amount of canopy coverage on private land and private upkeep to any city. Having standards for buffers within the landscape code or tree ordinance for defined jurisdictional areas (riparian, zoning, visual etc) species, size, spacing and growth cycle for these plants is a necessity.

Buffers within a community serve several environmental purposes. First buffers reduce land use conflicts between zoning districts of divergent land use and intensity. Zoning has long upheld the right of property owners to be sheltered from noise, congestion, and un-peaceful disturbance from adjoining parcels of land. Zoning buffers make better neighbors due to the oft quoted rule attributed to Robert Frost that "good fences make good neighbors" by "walling in or walling out" such distractions as smell, sight, sound

and commotion all of which can change the character of someone's private property. Buffers within built up areas in a city can be used for tree preservation, providing habitat for local wildlife and as a genetics bed for the seeds and other reproductive parts of native plants. Planted or preserved buffers between properties serve as wildlife corridors that can allow creatures access to huge areas of a community where them might find shelter, food, water and the cohorts of others of their species.

Since some buffers, especially 'fence row buffers' between zoned districts zig zag across the community these buffers and screen planting areas form a pattern of green connectivity as well as spatial organization. This pattern, planted with trees and shrubs, which is not only functional and visual, but will support the movement of urban wildlife and will link other parts of the urban forest together.

Secondly, buffers are often used along man made systems within the city for aesthetics, screening or to improve public safety. Stream bank buffers for instance protect fresh water supplies from sediments and urban water borne pollutants. Buffers along major arterial streets in the community help shield passersby from the distraction of parking lots and curb cuts both of which decrease public safety along roadways. Power line buffers keep trespassers at bay while street tree buffers simply improve the view of the public roadway and increase curb appeal of fronting properties. A system of wetland buffers or forest preserves not only provide tremendous environmental services to a community, they provide identity and special character to neighborhoods that are lucky enough to have them nearby.

Community landscape codes provide several kinds if site buffers and screens all of which designate specific site areas that will provide some environmental service to the property owner or the general public.

Buffers used as storm water buffers increase a site's permeability ratio that will allow the infiltration, detention or filtering of storm water run off. Also, these buffers can serve urban run off requirements as well by detaining storm run off thereby reduce the

time of concentration and peak flow of storm water. It they are properly graded, and the proper species of plants are used, each buffer can also act as a micro-detention area, infiltration zone or storm water management facility. The urban forest and its trees needs water, cities must manage their urban run off not merely speed it movement to the sea. Buffers and screens provide the land area necessary to do this.

Green Parking. It is time for 'gray parking' to be replaced. Parking lots today that comprise the majority of space in most urban areas has zero ecology. They are unhealthy and serve one purpose. The storage of cars is the primary function. Green parking is a better alternate. Green parking lot design means designing, constructing and operating parking lots to be environmentally supportive, healthy for people and wildlife and low in energy impact.

Green parking lots do environmental work that eliminate or reduce impact to site resources including vegetation, soil, climate and water while optimizing resource efficient materials, minimizing waste, and improving ecosystem biodiversity. Parking lots as we know them do not environmental work. They should be looked at as an opportunity to do one or more environmental services that will improve the climate, infiltrate storm water or remove water carried pollutants from downstream flow. Modifying a tree or landscape code to be more sustainable might be as simple as adding slotted curb concave tree planters, interior bioswales, exterior storm water buffers, porous paving or enhanced shade canopy coverage. Interior rain garden tree groves within parking lots could do multiple environmental services from storm water capture, nutrient cycling, air filtering to carbon sequestration. Each of these tree ordinance ideas could add to the sustainability of a development site by making the parking lot do environmental work.

The best way to make improvements to the environment of any large city is rethink automobile parking lots. If additional green space is desired there are two places to look in order to acquire more. They include rooftops and parking lots. Parking lots must be rethought if a community wants more open space and greening of their community.

Appropriate Plant Materials. Species selection refers to the use of native plants, use of drought tolerant plants, and banishment of invasive plants is an important accord of a sustainable tree ordinance. Native plants are well adapted to the climate, soil, moisture and temperature of many micro-climates and are very sustainable. These plants provide birthing habitat, shelter, food and other ecosystem services without any influence of mankind. Native plants that are adaptable to climate, drought, heat and cold need little if any support by mankind for their survival. They certainly do not need artificial irrigation, cold protection or fertilization to survive in their native habitat. To introduce exotic plant materials will just require additional energy use, husbandry and cost and often will lead to the failure of the plant anyway. Many plants will not flower if not given a happy mate or a willing propagator. White pine in Wisconsin, cabbage palm in South Carolina, canyon live oak in California or grizzly bear prickly pear cactus in Arizona are all well adapted to their climate and should be used in landscape design rather than the exotics, many of which can be cheaply imported to national chain retail plant outlets. Native habitat and native plants are protected as a result of land clearing standards the protect site areas that are to be undisturbed in communities such as Orlando, Florida. (Orlando, Florida Code 2008)

Locally Produced Construction Materials. One often-overlooked sustainable practice is the use of locally produced construction materials, especially if they come from unlimited sustainable resources. There are several reasons why this is so but one of the most obvious is transportation. Modern methods of building material commerce often will use products that are harvested in one location. These products have value added by being transported to one or more locations where they are enhanced, fabricated, sizes and finished. From this location they are often sent to distribution points and from here can be transported to just about any place in the world. The market place has come to prefer this system because it builds economic value usually at the expense of the environment. The carbon footprint of these various transactions can add up and the environmental costs of these products are borne by taxpayer and not the buyer.

Locally produced materials often will have a longer life span, reduce maintenance and are more acclimated to its native environment. Granite rock being used in New England, Texas Pearl limestone in Texas, sugar sand in Florida, glacial stone in Michigan and red cypress in Louisiana makes a lot of practical sense from a sustainability point of view. Recycling of construction materials, such as wood products from the urban forest is a variation of this component. Using materials over and over is a sustainable practice that can be implemented in community tree ordinances.

Nutrient Cycling. This occurs in all urban forest and is necessary and desirable for both growth and biological development. Nutrient cycling is the transformation of chemical elements from inorganic form in the environment to organic form in living organisms, and then back to inorganic forms. It includes the exchange of elements between the biotic and abiotic components of a healthy ecosystem. Plants, animals, soils and nutrients all connected.

Closely related to this is recycling of any material. This may take the form of composting organic matter, recycling yard waste or storm damage material into garden mulch or forest enrichment products. The recycling of captured storm water from roofs or parking lots has been mentioned. This when filtered tanked and mixed with household wash water (not sewage water) creates what is called gray water that can be recycled in an irrigation system to water lawns, trees, shrubs and ground covers. Most plants will soak up soapy water and readily accept it phosphorus content. When domestic washing water is mixed with roof water and parking lot water the concentration of soap chemicals, preservatives and stabilizers become non harmful to plants. The main ingredients of body soap such as manufactured by the Dial Corporation consist of water, water vapor, tallow, coconut and vegetable product and this is quite agreeable with plants. Anti-bacterial agents in soap is suspect however due to triclocarbons that may concentrate in fish and bio-accumulate in the food chain. Studies are on going at this time to determine if this is so.

We have mentioned that storm water collected from rooftops and parking lots can be recycled through an irrigation system to prevent the use of potable water. Clean, clear, pure potable water that has taken hundreds or thousands of years to be made in underground reservoirs should not be used to water the grass. This is not a sustainable practice.

Recycling is a sustainable practice that could be included within any urban forestry program and the nutrient matter so collected could be placed back within the urban forest itself to enrich the soil, capture the energy produced by the sun and to provide organic matter for a growing forest.

Photosynthesis and the Carbon Sink. One of the most sustainable ideas in urban forestry occurs with every tree. That is every tree in a community forest is involved with providing ecosystem services. The primary service is photosynthesis where trees manufacture carbohydrates from carbon dioxide and water. The reaction is driven by energy from sunlight, catalyzed by chlorophyll and releases oxygen as a byproduct. The oxygen is needed by most life forms, yet many people do not realize this. A well layered urban forest can produce a sustainable supply of oxygen.

In addition, urban forests become carbon sinks, places where carbon is trapped and stored. Carbon dioxide, which is one of the green house gases and is a suspect agent of global warming is pulled from the atmosphere by trees Urban forests over American cities proved many services for a healthy planet.

Soil Structure. The way soil particles are organized into aggregates and held together is called soil structure. Urban soils can be a real limiting factor in the quality of an urban forest. Soils in most cities are classified by the Natural Resources Conservation Service (NRCS) formerly the Soil Conservation Service

(SCS) as urban soils. Urban soils often have poor structure, less organic matter, manufactured chemicals including compounds that might be called pollutants.

According to the NRCS horizons in urban soils may not be fully related to the natural soil-forming factors but are often manmade layers formed by the deposition of dredge, pump sand fill, and/or mixed materials. Human debris, such as broken brick, fractured bottle glass, chunks of concrete, and remnant plastics, traces of pesticides, petroleum derivatives, chemical compounds, other pollutants, and human garbage are components of urban soils.

Urban soils are not the same as natural soils because they have been altered. Urban soils may have been excavated, compacted, disturbed, and mixed and may no longer possess their natural soil properties and features. Normal soil horizons O, A, B, C and R may not exist in urban soils.

Many highly disturbed soils may be contain salts or be acidic and will often lack organic matter.

In some urban areas former construction site soils may have been in place long enough for soil forming factors to significantly change them almost to the point of forming soil horizons.

Most urban soils must be amended to get proper drainage and nutrients needed for plant growth. Healthy urban forests need rich, clean soil with the best tilth possible. This structuring of the soil gives it the ability to drain and hold air and water in the proportions needed for plant and animal life.

Solar Energy Orientation. Energy derived from the radiant energy of the sun can be converted into other forms of energy, such as heat or electricity. Therefore, a sustainable tree ordinance must address this tool so that access to sun is not totally denied by high level canopy trees. A certain percentage of canopy space

must be made available through the ordinance to allow solar penetration to solar power converter panels.

Urban Heat Island Effect. A measurable increase in ambient urban air temperatures results from the replacement of vegetation and native soils with buildings, roads, and other heat-absorbing urban structures. The heat island effect results in significant temperature differences between rural and urban areas. Even within urban sites a temperature variation exists between shady areas and paved areas fully exposed to the sun. A sustainable tree ordinance must encourage the replanting of shade trees within urban areas, especially parking lots and urban plazas. Green roofs can be used to reduce reflectivity and heat gain in those locations where tree planting is not practical.

Water Balance. An accounting of the inflow to, outflow from, and storage in a hydrologic unit should be a standard tool of any sustainable tree ordinance. A complete tree ordinance must be concerned with water flows, water capture, permeability and infiltration of water into the ground where trees and other vegetation can use it. Rooftop water, captured and recycled through an irrigation system is a sustainable tree practice. Water collected in this manner will not only feed the plants but will disconnect from the storm water flows a proscribed percentage of rainfall that under normal conditions would carry non-point pollutants downstream.

Studies using a mass and energy balance rainfall interception model from Santa Monica's urban forest show that trees intercept rainfall and reduce run off and reduce the cost of water management by a factor of $3.60 per tree. Quantitative analysis show interception rates vary based upon tree species, size, leaf, twig structure and rainfall event. For example this study indicated that rainfall interception varied from 15% to 80% in two different storm based upon seasonal weather conditions. (Xiao, Q. & McPherson, E.G. 2003)

Storm Water BMP's. Storm Water Best Management Practice (BMP) means a structural device or nonstructural practice using vegetation in many instances designed to temporarily store or treat stormwater runoff in order to mitigate flooding, reduce pollution, and provide other amenities. (State of Maryland 2000) Storm water BMP's treat water in a various way. These decentralized storm water facilities can infiltrate, filter, slow, detain, retain, disconnect, recharge, clean, evaporate, transpirate, capture, collect, store, pump, sprinkle and dispose rainwater. BMP's go by such names as rain gardens, vegetated swales, bio-swales, micro-detentions, detention ponds, wet ponds, constructed wetlands, sand filters and riparian buffers. In all instances drainage facilities are designed to modify the actions of water in such a manner that water quality is increased. Storm water BMP's treat water as a resource and are used to capture rainwater to sustain pure water from human kind. Tree ordinances can be crafted to recognize the importance of water and how water is important to both plants and people.

Wetlands. Urban wetlands, especially wooded wetlands, such as swamps, and stream banks must be protected by the tree ordinance. These special habitats may be protected and preserved not only for the trees that grow within them, but for their storm water processing and water quality cleansing abilities. Areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, a prevalence of vegetation typically adapted for life in saturated soil conditions makes a wonderful urban forest. Wetlands may include marshes, bogs, flooded grassed meadows, wet ponds, constructed wetlands and similar water infiltration features within a community.

Windbreaks & Fence Rows. One or more rows of trees or shrubs planted in such a manner as to provide shelter from the wind and to protect soil from erosion. If designed properly, windbreaks around a home can reduce the cost of heating and cooling and save energy. Windbreaks, in the North are also planted to help keep snow from drifting onto roadways and even yards. Fence rows or 'hedge rows' are an important element of the landscape that serve much like a windbreak. But they do more. They give texture and patter too a community and are natural

conduits for wildlife in the city. These features, created primarily by bird droppings often consist of only native plants whose seeds, drupes and berries are attractive native birds. Other benefits include providing nesting habitat for wildlife, visual screens and privacy barriers in neighborhoods.

Steep Slope Preservation. Steep slopes provide special habitats for specific biology's. Preserving natural steep slopes, and the plants and creatures that live there provide is important. So to is the value of having topographic and orientation variation on a development site. Steep slopes have their purpose in complex urban forest and help define spaces for people in a way unmatched by any other means.

Open Space For Human Well Being and Health. Planted open spaces not only serve nature and sustainability but serve the needs of mankind as well. Society in most climates spend a great deal of their time out of doors. Outdoor spaces sustain the relationship between humans and more importantly, sustain the relationship between humans and their environment.

Summary Sustainable Sites and Sustainable Tree Ordinances

Tree ordinances must change with the times. The old 'tree centered' ordinances of the 1970-1990s must give way to up dated ordinances that include some or most of the metrics cited above. Presently the country is moving into greening and sustainability is not only the watchword of the moment but is taking root in the way we build community. We see it in architecture, community design and even in engineering.

Since it is widely known by the urban forest community that urban forests play a major role in make a city livable and sustainable, it behooves those who administer community tree ordinances to modify them. This will not only make tree ordinances more purposeful but will help the public understand that nature in the city in the form of the urban forest

plays a major role in making the city sustainable in regard to air, water, soils, vegetation and urban wildlife.

The American Society of Landscape Architects (ASLA) Sustainable Sites Initiative (SSI) Program is being developed the landscape architecture profession to guide "sustainable land development and management practices" that will support sustainable building sites, opens spaces and preserved natural areas like buffer zones, parks, conservation preserves.

The SSI provides design and land management tools for landscape architects and others who influence land development who shall address environmental concerns such as "climate change, loss of biodiversity, and resource depletion." These tools can also be used by planners, engineers, developers, horticulturists and local governments all of who offer or promulgate green building standards, codes and ordinances affecting the environment.

During the next few years as this program is developed in full, the leaders of the Initiative will provide "standards and guidelines", a LEED style site performance "rating system", and a testing "pilot program" to compile, analyze, and refine best practices for sustainable site planning, construction and management. The rating system may even be folded into the present LEED® (Leadership in Energy and Environmental Design) program that issues certification or silver, gold and platinum ranking for environmentally well designed projects.

This sustainability focused program will also provide a "reference guide" that will assist designers and builders in understanding the program. The reference guide will help them convert guideline information about hydrology, soils, vegetation, construction materials and human well being into usable into built landscapes that respect the earth and allow people to live without causing substantial change to the earth's ecosystems for those generations who will follow. This reference guide can also be used to upgrade tree ordinances as well.

Community planners are very likely to use the SSI reference guide to modify local tree, landscape, storm water, irrigation, construction material utilization and recycling codes. This information that brings science to planning, design, and art must be codified within community ordinances to guide the way we will build and sustain the places where we live.

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Biography

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