



**City of Grants Pass
Urban Forestry Plan
for the City of Grants Pass and Urbanizing Area**

**Technical Memorandum #1:
Benefits and Functions of Urban Trees and the Urban Forest**



To: Urban Forestry Advisory Committee
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Date: August 16, 2006
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Introduction

This is the first of eleven Technical Memoranda that will comprise the Urban Forestry Plan for the City of Grants Pass and the Urbanizing Area. It identifies the recognized benefits and functions of urban trees and the urban forest commonly cited in the literature pertaining to urban forestry.

Purpose

By identifying the benefits of urban trees and the urban forest, this memo explains the basis for undertaking an urban forestry plan. In short, it explains *why* the plan is being undertaken and what can potentially be achieved.

In addition, as the plan is developed, recognition and understanding of the functions of urban trees will be used to guide the development of alternatives that maximize the benefits. This will help identify *how* plan elements should be implemented.

Executive Summary

The body of research on urban forestry and urban horticulture continues to grow, providing an already expansive body of literature that identifies the benefits of urban forestry and discussion of best practices to maximize the benefits the urban forest can provide.

This document provides a summary of the key benefits cited in the prominent literature. The benefits are extensive and diverse, and the research continues to reinforce the value trees provide in an urban setting by performing multiple functions. The benefits range from quality of life, health, and well-being to acting as “green infrastructure”, naturally performing functions that would otherwise require more expensive artificial and mechanical solutions, such as pollution removal.

Many of the benefits trees were once intuitively assumed to provide have now been confirmed through research, and benefits which were recognized in a generalized manner have now been

quantified in a detailed manner, identifying the extent to which trees of specific species, size, and age perform certain functions.

This memo provides an overview of the benefits and functions of the urban forest and a sampling of key findings drawn from the extensive body of research. Technical Memo #5 will provide more detailed information about these benefits in preparation for development of alternatives. The most common benefits are summarized in this memo under the following headings. Numbers do not indicate priority, but are rather provided for ease of reference.

1. Aesthetics
2. Stormwater Management
3. Erosion Prevention and Sediment Control
4. Pollution Reduction
5. Energy Conservation
6. Water Conservation
7. Sound Buffers
8. Microclimate Benefits
9. Psychological and Mental Health
10. Sociological Benefits
11. Economic Benefits
12. Economic Development and Tourism
13. Pedestrian Benefits
14. Traffic Calming
15. Habitat
16. Unique Character

In most cases, scientific and empirical studies are referenced in this memo to identify the source of the findings. In the publications consulted in preparation of this memo, a few of the items identified above were not quantified. In those cases, this memo identifies the need to further investigate these items through this planning process.

Additional References

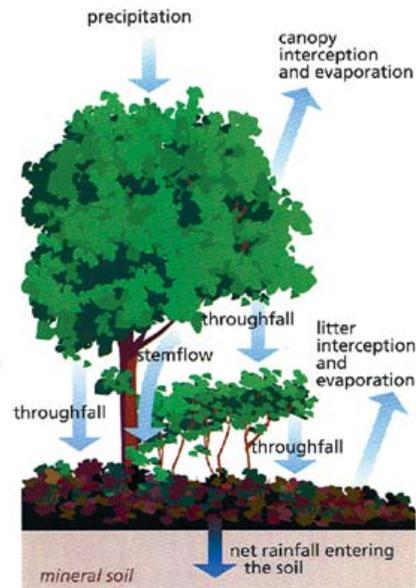
The information contained within this memo is not exhaustive; rather it summarizes the findings from a substantial number of studies. Several sources were consulted in preparation of this memo to identify the benefits of an urban forest. There are many other studies, facts, figures, and considerations pertaining to the field of urban forestry. The sources consulted and cited in this memo are identified with endnotes. As there is a growing need for cities and other organizations to consult research, a number of organizations have begun to compile and format the research in a manner that is accessible for practical application. Additional information is provided in the appendices that summarizes material in a concise manner:

- Appendix 'A' provides a compilation of key findings by topic from the nonprofit organization *Colorado Trees*.
- Appendix 'B' provides a list of brief fact sheets and pamphlets published by the University of Washington Center for Urban Horticulture.

Summary of Benefits and Functions of Urban Trees and the Urban Forest

1. **Aesthetics.** Trees provide a distinct aesthetic purpose. They frame houses and create an edge to streets. Research and surveys indicate people prefer well-treed, landscaped places. It is important to note, however, that most aesthetic impacts from trees come at the time they're mature. Trees help moderate the visual environment, adding complexity to areas that lack interest, and reducing the adverse effects of visual clutter such as overhead utilities.
2. **Stormwater Management.** Trees provide substantial benefits through stormwater runoff mitigation. Trees provide this benefit by reducing the amount of rainfall that reaches the ground and by providing conditions that minimize the "runoff coefficient", reducing the volume and velocity of rainfall that becomes surface runoff rather than being absorbed into the ground. This improves watershed health by recharging groundwater and improving baseflow in streams, decreasing flooding and erosion, and reducing pollutants that are washed into streams from impervious surfaces.¹ Trees provide lower runoff coefficients than turf grass or impervious surfaces. Trees reduce stormwater runoff in the following ways.

- **Rainfall Interception:** "Throughfall" is the term used to describe the portion of the rainfall that reaches the ground directly through gaps in the tree or dripping from leaves, twigs, and stems. The rest of the rainfall is intercepted. Intercepted water is either evaporated directly into the atmosphere, absorbed by the canopy surfaces, or transmitted to the ground via stems, branches, and other tree surfaces ("stemflow"). Interception of rainfall by leaves, branches, and moss can account for as much as 760 gallons per year for a mature deciduous tree and up to 4000 gallons per year for a mature evergreen. Evergreens are able to intercept more rainfall because they intercept rainfall year-round. In the Pacific Northwest, where the predominant rainfall is in the winter season, evergreens are important to perform this function. Rainfall interception for individual trees ranges from 10% to 68% of a rainfall event.²



- **Transpiration:** Transpiration is the process of by which plants take up water from the soil through their root system and release moisture in the form water vapor from their leaves. It is a combination of capillary action and evaporation, moving water from the soil to the leaves and evaporating it. Tree roots create a network of capillaries that "soak up" water. The uptake of soil water by tree roots increases soil water potential,

lengthening the amount of time before rainfall becomes runoff. Evergreens generally have lower transpiration rates because they are more efficient than deciduous trees at retaining moisture due to the structure of their leaves. In general, a mature tree can transpire 100 gallons per day. A mature bald cypress tree can absorb up to 880 gallons of water a day if the conditions are right.³ Redwoods are also excellent absorbers of excess water.

- **Infiltration:** Tree roots and organic matter from leaf litter create soil conditions that increase the capacity to infiltrate rainfall. Tree roots create interconnected pathways in the soil called “macropores”, which aerates the soil and increases infiltration. Leaf litter and other organic matter produced by trees also help reduce the amount of runoff by holding water and promoting infiltration. Organic matter also provides a good environment for microorganisms and earthworms, which helps increase infiltration through the creation of additional macropores.⁴ Macropores also provide a path that helps provide water and nutrients to the roots. In effect, the soil is analogous to a sponge rather than an impervious surface such as concrete.

Studies have also shown the importance of the forest understory and leaf litter for infiltration. Tests in North Carolina found that a medium aged pine-mixed hardwood forest had an infiltration rate of 12.42 inches per hour. When the forest understory and leaf litter were removed, the resulting lawn had an infiltration rate of 4.41 inches per hour.⁵

Soils that are compacted during construction or other activities eliminate the macropores in the soils reducing the infiltration capability of the soils and impacting the soil conditions trees need for survival.

3. **Erosion Prevention and Sediment Control.** Hand-in-hand with stormwater management is erosion control and prevention.

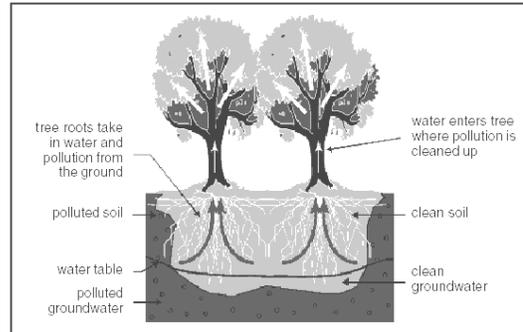
- **Water Erosion:** While trees do have deep roots, the majority of root action occurs within the first six inches of the soil⁶ where they trap moisture and hold the soil in place. An average acre of land that is under construction without proper erosion control measures in place can deliver almost 30 tons of sediment downstream, or almost 50,000 tons per square mile per year. This is why trees are vital to retain during the construction process of a site, especially in a steep-slope area.
- **Wind Erosion:** In addition to erosion affiliated with water, erosion also can occur from wind. On Midwestern farms, it has long been practice to plant windbreaks between sections of land as well as along the northern and western boundaries of the farmstead. This is because the trees act as a filter of sorts that slow down wind; if there was nothing to break the wind, it would whip across the open land and pick up small particles of dust. Lack of shelterbelts in the late 1920s in conjunction with dry seasons, created the dust bowl of the Depression. Richard Olson notes that, as of 1992, 2.1 billion tons of topsoil was being lost to

erosion nation-wide. At this rate, then, an area the size of Connecticut is seriously degraded yearly⁷. And, according to the Natural Resources Conservation Service, wind erosion is a problem in Oregon, with several tons per acre lost every year in cultivated crop land⁸. In urban areas, the windblown erosion is more frequently associated with soils exposed during construction activities. It is in these disturbed areas that wind erosion occurs most rapidly.

4. **Pollution Reduction (Air, Water, and Soil).** Trees and other vegetation act as natural filters for the environment around us.

- **Air Pollution:** Trees have two benefits for purifying air: Absorption of carbon dioxide and reduction of particulate matter.

Carbon Sequestration. Carbon dioxide is converted into cellulose that is “stored” in the woody parts of each tree during photosynthesis. According to Colorado Trees, “A single mature tree can absorb carbon dioxide at a rate of forty-eight pounds a year and release enough oxygen back into the atmosphere to support two human beings⁹.” This carbon sequestering happens at a massive scale in heavily treed areas, where trees store approximately thirteen pounds of carbon a year, mitigating the 2.9 tons of carbon dioxide that each American produces annually.



*An illustration showing the process of Phytoremediation.
United States Environmental Protection Agency*

Reduction of Particulates. Trees also act as air filters for particulate matter (small fragments of material) and pollution in the air we breathe, including dust from construction and roads, soot from exhaust, and other toxics and contaminants in the air. One sugar maple planted alongside a roadway removes 60mg of cadmium, 140mg of chromium, 820mg of nickel, and 5200mg of lead in one growing season¹⁰. Research also shows that the cooling and moisturizing affect of trees limits the amount of pollution that the air can contain¹¹. Because particulates have adverse health affects, they are regulated by the Clean Air Act. Particulates smaller than 10 microns (PM-10), when inhaled into the lungs, accumulate and aggravate respiratory conditions, especially asthma. Fine particles 2.5 microns and smaller (PM-2.5) are associated with heart and lung disease, increased respiratory symptoms and disease, decreased lung function, and premature death. (Grants Pass was previously a non-attainment area for PM-10, and is now a “Maintenance Area”, with a maintenance plan. Standards are being developed for PM-2.5.)

- **Soil Pollution:** Phytoremediation is a term used to define the use of plants as a tool to remove contaminates in water and soil. Everything from heavy metals to

petroleum products can be removed with the use of plants¹². In some instances, then, plants can be harvested and valuable metals removed from the plant.

- **Water Pollution:** Trees and other plant material act as biofilters because they process and retain some items that are seen as expendable, such as excess nitrogen. Stormwater runoff that contains large amounts of nitrogen invariably finds its way into streams, rivers, and lakes, contributing to algae growth and subsequent reduction in oxygen levels, with a detrimental effect on fish and other animals that live in rivers and water bodies. Trees planted in watershed areas intercept this nitrogen (and other contaminants) and uses it as nutrients for growth.

5. **Energy Conservation.** Another important impact of an urban forest is energy conservation, which helps in both the winter and summer months.

- **Windbreaks:** In the winter, strategically planted trees act as a windbreak, sheltering structures from chilling northwest winds that strip the microclimate layer from around a heated building. Evergreen trees on the north and west sides afford the best protection from cold winter winds.
- **Shade and Solar Access:** Trees allow access to or shade from radiant heating from sunlight. This allows occupants to rely less on air conditioning in the summer and heating in the winter, reducing energy consumption. Trees can have a canopy large enough to shade roofs, reducing cooling costs and increasing comfort.

A properly located deciduous tree allows access to sunlight in the winter when the tree has lost its leaves and shade in the summer when the trees are leafed out. The best locations for deciduous trees are on the south and east sides of a house. When these trees drop their leaves in the winter, sunlight can reach the house to help in heating the home. Even without leaves, trees can block as much as 60% of the sun, making placement of trees critical to effectiveness. Evergreen trees on the north and west sides afford the best protection from the setting summer sun. Shrubs or small trees can be used to shade outside air-conditioning units, improving the efficiency of the equipment.

- **Microclimate:** Additionally, the shade from a mature tree creates a summer microclimate that is substantially cooler than the surrounding areas. Air temperatures of 4 to 7 degrees Fahrenheit cooler have been recorded in urban areas with substantial tree cover¹³. This is because the tree not only shades the paved surfaces, preventing the well-recorded heat island effect, but transpiration and evaporation of water through the leaves creates a cooler atmosphere in the area around the tree. The more this microclimate can be regulated, the more energy is saved through heating and cooling costs.

6. **Water Conservation.** Trees that are native or well-adapted to a region can survive without artificial irrigation based on the natural rainfall available throughout the year. In drought years, carefully selected native and adapted trees conserve the amount of water they use, and in wetter years, take in as much as they can. When planted in urban conditions, they may rely on artificial irrigation until they are established or if they are in settings that aren't conducive to their natural condition. An article in *Stormwater* says horticulturists note that minimum weekly water needs for a mature tree is 5 gallons plus an additional 5 gallons per caliper inch¹⁴, but trees can take in substantially more water. New trees typically need watering once a week for the first two summers and less often over the next two years. Deep waterings should be applied slowly within the area under the spread of the tree's crown and just beyond. Short frequent waterings wet only the top few inches of soil and encourage roots to grow near the surface.¹⁵ Various slow-drip watering bags are available for newly planted trees in locations that aren't irrigated.

- **Low-Impact Landscaping:** The shade of a tree also helps prevent the baking of groundcover by the sun, allowing shade-loving plants to flourish that may not need as much water to survive. A carefully designed low-impact landscape, including native plants and trees, conserve water by virtue of not using as much as imported species. Shade can also reduce the irrigation needs for more water-dependent groundcovers.
- **Infiltration and Absorption:** Since trees act as natural aerators (see "Soil Aeration, discussed on page 3), loosening soil and preventing it from becoming too compacted, it creates an environment that is ideal for water absorption. This allows water to percolate back into the ground, recharging groundwater, rather than creating run-off.

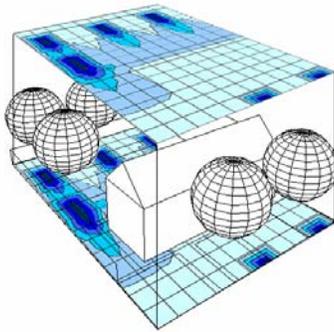
7. **Trees as Sound Buffers/Noise Mitigation.** A row of trees can act as noise suppression. Just as trees screen views, they also screen noise; however, the extent to which vegetation can perform this function is often overestimated. Without reviewing all of the literature in detail, different conclusions about the effectiveness of trees to mitigate noise and different variables can be somewhat confusing.

- A US Department of Energy study reports that trees reduce noise pollution by acting as a buffer and absorbing 50% of urban noise.¹⁶
- According to the International Journal of Agroforestry, a carefully designed screen of trees and shrubs can help reduce noise by five to ten decibels¹⁷. This is because a tree, by virtue of its leaves, acts like a baffle, deflecting and diffusing direct sound waves, lessening their intensity.
- However, even a planting of dense shrubs and trees can only reduce sound by about 3 to 5 decibels per 100 feet.¹⁸
- There may also be some benefits from vegetation masking undesirable noises with white noise such as the sound of a fountain or sound of leaves in the wind.¹⁹

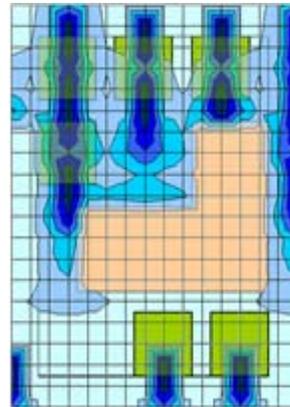
Noise mitigation is an important issue in urban settings. Noise levels are regulated for physiological and psychological health reasons, with maximum decibels levels established. Urban environments may exceed these levels. There are numerous

technical studies on the effects of noise on health and communities. Continuous exposure to noise over 30 decibels often results in complaints, and many communities regulate continuous noise over 40-45 decibels. The City's noise standards are based on DEQ standards, and regulate the amount of time maximum decibel levels are permissible.

- 8. Microclimate Benefits.** As mentioned above, trees conserve energy by having an effect on the microclimate of an area. Integral to this cost-savings is the creation of a microclimate which helps to stabilize temperature spikes and influencing radiant flux²⁰. By offering shade, trees prevent heat islands that occur with dark surfaces absorbing and radiating solar heat from the sun. Once the sun goes down, the hot, unshaded surface still radiates its heat, perpetuating the heat island effect for several hours after dark. Once the heat is expelled, temperatures can plummet. Foliage helps to even out these temperature swings.



Saxena's interpretation of the "moisture island" effect of trees on a residential lot. The darker areas signify greater moisture content which creates an area of lower temperature.



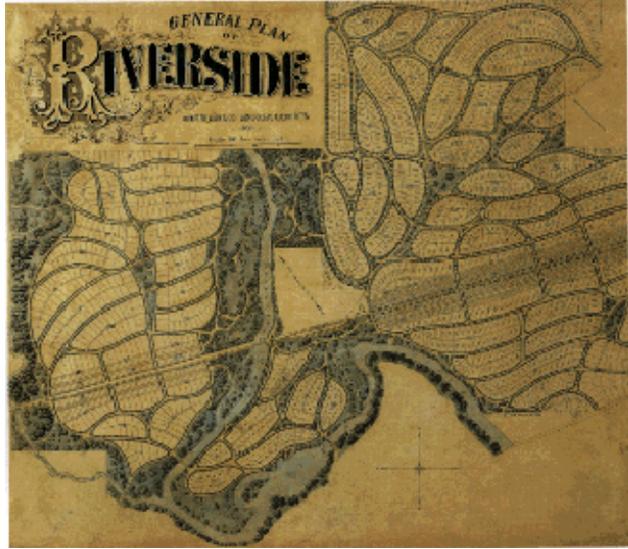
A view from above of Saxena's moisture created by trees. Combination of many trees on adjacent lots in an urban forest creates a substantial amount of moisture, which cools surrounding areas as it evaporates.

- 9. Psychological and Mental Health.** In 1984, Dr. Robert Ulrich published "View Through a Window May Influence Recovery from Surgery" where his research determined that patients who could view trees and other natural items from hospital windows healed more quickly from surgery than patients with similar wounds that did not have a view of nature from their beds. Ulrich's studies confirmed what planners and scholars of the Progressive Era believed: Planners such as Fredrick Law Olmsted were ardent advocates of the role of nature in urban life, and saw nature as the primary way to provide for public health and civilized behavior. Almost without basis, this belief drove the planning of great "natural areas" like Central Park in New York, the park plan for the City of Buffalo, and the city plan for Riverside, Illinois all based their design elements on the necessity of human interaction with nature²¹.

Empirical data supports this, especially if the human environment is examined a bit further. An increased focus is placed on integrating indoor and outdoor spaces in the design of buildings, especially public spaces. This way of thinking has led to the founding of organizations like The Center for Health Design and The Foundation for Hospital Art, both of which look to evidence by studies conducted by Ulrich and others that illustrate that the observation of, and interaction with, the natural environment is necessary for health and healing.

Trees and vegetation are effective at providing places for which people express preference. Research has shown that people have a preference for the level of “ordered complexity”

that trees provide, helping to screen and mitigate the “sensory overload” of jumbled items such as overhead utilities and signs, and trees also mitigate the “sensory deficit” where visual interest is lacking, such as with large blank walls or paved areas.



Olmsted & Vaux. Riverside, Illinois, 1870. The need for access to nature in urban life has been validated by research.

10. Sociological Benefits. Some research has been conducted to evaluate the effects of trees on crime and other sociological issues. There are correlations between trees and social service issues and some crime. One study concluded that “trees have the potential to reduce social service budgets, decrease police calls for domestic violence, strengthen urban communities, and decrease the incidence of child abuse.”²² Staff hasn’t investigated whether there is more research to corroborate these conclusions, but the City of Chicago’s decision to spend \$10 million to plant 20,000 trees was influenced by this research. Other research may help explain such conclusions, including the research that found trees help create relaxation and well-being, the research on the healing and mental health benefits of trees, and their ability to have mitigate urban noise and visual clutter.

11. Economic Benefits. As previously mentioned, trees have a great value in the reduction of energy costs because of their effect on the microclimate of an urban area.

- **Property Values:** As if this economic benefit isn’t enough, trees also increase property values. Different studies have slightly different outcomes; however a common theme is that trees boost property values. According to the Christian Science Monitor, property values for treed properties are generally higher than similar properties without any trees and can increase by 7 to 25 percent²³.

- **Consumer Behavior:** Trees also boost consumer confidence. Studies by the University of Washington suggest that consumers rank business districts with tree cover as more inviting places to spend time and shop. In fact, some consumers are willing to pay *more* for products sold at stores in treed business districts. The Christian Science Monitor reports that consumers spend, on average, 13 percent more at shops in green areas²⁴. Consumers also reported that they are willing to travel further, stay longer, and more frequently visit a well landscaped business district.²⁵

12. Economic Development and Tourism. Rural forests, some of which fall under the umbrella of national forests, are spectacular places for individuals and families to recreate, get close to nature, and vacation. The *Grants Pass Development Code* recognizes the need for an attractive community to create a positive impression on visitors. It notes “Major gateways to the City and key travel routes through the City and urbanizing area give a lasting impression to the visitor for good or ill, an impression critical to our tourist economy. The knowledgeable use of plant materials by experienced professionals can achieve these extraordinary benefits at very little cost.” Tourists remember places, and a community that is well landscaped, including trees, will stand out in minds as a nice place to visit.

13. Pedestrian Benefits. A street lined with mature trees provides several benefits for people in the pedestrian realms. First, it shades the sidewalk from the summer sun, creating a better pedestrian experience. Second, it provides a psychological and physical barrier between vehicular and pedestrian traffic. Third, trees planted in a sidewalk zone or planter strip adjacent to the street provides an area for necessary services like street signs and fire plugs. This creates a clear delineation between the pedestrian zone and vehicular traffic.



Las Vegas is the United States' fastest growing city. Apparently they are also near the bottom of the list for providing a pleasant pedestrian experience.



Proposed new street development in Atlanta. Note the trees and how they help buffer the person from the traffic.

14. Traffic Calming. Trees also serve as natural traffic control. On streets with few visual obstructions, traffic often flows fairly freely, slowing only for traffic lights. Tree-lined streets, on the other hand, create a visually narrower street that causes drivers to slow down and be more aware of their surroundings. This effect is further emphasized with the canopy created by streets lined with mature trees.

15. Habitat. One of the most tangible by-products of urban trees is the creation of wildlife habitat, which also provides several direct human benefits. Isolated trees are good, but large areas of contiguous forest provide for the best habitat, as do urban areas with large areas of tree canopy. Some animals are able to freely move from place to place through these corridors of urban trees; with the construction of houses and cities in a manner that doesn't preserve or perpetuate an urban forest, the free movement of nature can be interrupted. Reforesting urban areas can help restore some of this movement and add the amenity of tree-bound wildlife to the urban fabric, providing recreational opportunities for residents as well as a chance to lesson the human impact on his environment. The presence of this urban wildlife can also provide beneficial effects such as management of the insect population.

Trees are also important to aquatic life. They provide leaf litter and large woody debris, which create habitat for fish, macroinvertebrates, amphibians, and reptiles. Leaf litter is important to aquatic food webs. Leaves blown into a stream form packs that are broken down by fungi and bacteria. The fungi are an important food source for insects such as caddisflies and stoneflies, which are a good food source for small fish and other aquatic life. In urban watersheds, much of the organic matter that ends up in streams comes from upland areas, so they are also important for contributing organic matter to streams.²⁶

Riparian trees also provide shade which reduces summer air and water temperatures which are critical to fish and aquatic insects. Impervious area and lack of forest cover can increase summer stream temperatures by 2 to 10 degrees. Trees can also cool stormwater runoff, preventing thermal shock to streams.²⁷

16. Unique Character. Trees play a significant role in defining the character of a place, whether natural, or designed. Many people choose to live in the Pacific Northwest because of its natural beauty, mountains, and forests. Southern Oregon has a unique climate all its own. With an urban forestry plan, a community has the opportunity to use the pallet of the native vegetation and trees in its planting scheme. By using these



native species in the urban environment, a community can help retain its natural character as the community grows, rather than displacing the character that contributes to the

attractiveness as a place to live and visit. There tends to be greater community support for attractive, well-managed growth that retains the unique characteristics to which residents and visitors are drawn.

Trees and landscaping can also be used to generate a desired “designed” look that may differ from or contrast with the natural surroundings in a manner that is complementary. Many historic neighborhoods have uniformly-spaced streets trees that define their character, providing a natural element that relates to the grid pattern of streets and lots. This repetition can provide a pleasing rhythm that unifies disparate elements, tying them together.

Additionally, it is important to consider how provision and utilization of open space affects the character of the community. Pockets of open space and trees can provide visual relief in areas that are intensively developed.

Finally, it is important to consider how infill development affects the character of the community. Grants Pass, like other southern Oregon towns, has neighborhoods that capitalize on the uniqueness of the natural environment. For example, the Lawnridge Park neighborhood incorporates hills, mature trees, and Gilbert Creek into its design. Stately street trees can also define the character of a neighborhood, complementing the unique natural features. As infill development occurs, it can be important to neighborhood character that the new developments contribute to, rather than detract from, the elements that make the neighborhood special. As infill development occurs and as the city grows outward, continued expansion of the urban forest that keeps pace with new development can be important to ensure new development fits in with the existing physical fabric of the city and contributes the vital functions provided by the urban forest as the community grows.

¹ Capiella, et al., at 9

² Capiella, et al., at 9

³ Capiella, et al., at 10

⁴ Capiella, et al., at 11

⁵ Capiella, et al., at 11

⁶ Johnson, at 22

⁷ Olson, et al, at 37.

⁸ <http://www.or.nrcs.usda.gov/technical/nri/geoarea/state/weq/stweqratea.html>

⁹ www.coloradotrees.org/benefits.htm

¹⁰ ibid

¹¹ Scott, et al, at 130.

¹² Capiella, et al, at 12.

¹³ Scott, et al. , at 129.

¹⁴ www.forester.net/sw_0203_trees.html

¹⁵ City of Ashland, at 5.

¹⁶ www.coloradotrees.org/benefits.htm

¹⁷ <http://www.agroforestry.net/overstory/overstory60.html>

¹⁸ Thompson and Sorvig, at 270.

¹⁹ Thompson and Sorvig, at 271.

²⁰ Skelton

²¹ Peterson “Frederick Law Olmsted Sr. and Frederick Law Olmsted Jr.” Sies, et al, eds Planning the 20th Century American City, 1996.

²² www.coloradotrees.org/benefits.htm

²³ Gilsdorf

²⁴ Ibid

²⁵ www.coloradotrees.org/benefits.htm

²⁶ Capiella, et al., at 12.

²⁷ Capiella, et al., at 12.

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