

Proposal of Alternatives to Tree Mitigation in Collaboration with the City of Fayetteville



CITY OF
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ARKANSAS



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Abstract

This project was conducted in collaboration with urban foresters of the City of Fayetteville, Arkansas, as the initial phases of implementation of alternatives to city mandated tree mitigation in applicable cases. The City of Fayetteville requires mitigation when a proposed development removes trees beyond a minimum required canopy area, which is dependent on zoning classification. Preservation is the highest priority, followed by forestation. In scenarios where mitigation is required, but not possible on or off site, the developer is required to pay into a tree escrow account. The implementation of mitigation alternatives would allow developers in approved conditions the opportunity to implement a green roof or green façade that would count toward their mitigation requirement. A literature review was conducted of existing applications of alternative mitigation programs in place throughout the world. The most noteworthy case studied is in place in Seattle, known as the Seattle Green Factor, which uses a point system to assess the ecological benefits and functionality of a parcel of land. The numbers and system utilized by the Seattle Green Factor was used as a starting point in developing ratios to determine an equivalent square footage of alternatives to the services provided by one mitigated tree. These preliminary ratios will be adjusted as seen fit by City of Fayetteville urban foresters and engineers, and implemented into the mitigation calculator and municipal code.

Objective

The objective of this project was to assist the City of Fayetteville in determining alternatives to tree mitigation by proposing two data-supported ratios:

- One mitigated 2” caliper tree : “equivalent” green roof square footage
- One mitigated 2” caliper tree : “equivalent” green façade square footage

Fayetteville Tree Preservation and Protection

Background

Tree preservation and protection during development is laid out in §167.04 of the Fayetteville Municipal Code. If an applicable proposed development fails to meet the minimum required canopy area for its zone classification, mitigation is required. “Compensating for the environmental damage caused by removing tree canopy shall be accomplished by forestation on

a per acre basis”, using a base density formula based on two-inch caliper trees. “The square foot percentage of canopy area required for preservation in new development is based on the total area of the property for which the applicant is seeking approval, less the right-of-way and park land dedications.” Applicants are not required to plant trees in order to reach the percent minimum canopy requirement on land where less than the minimum exists prior to development, unless trees have been removed.

All proposed subdivisions and large scale developments, as well as undeveloped land within the Hillside/Hilltop Overlay District are required to submit a site analysis plan, analysis report, and tree preservation plan with the preliminary plat or site plan. An abbreviated tree preservation plan, as set forth in §167.04(H)(3), is required for grading permits, building permits, and parking lots with five or more spaces, to be submitted with the applications for permits on projects that are not required to go through the subdivision or large scale development process. There shall be no land disturbance, grading, or tree removal until a tree preservation plan has been submitted and approved, and the tree protection measures at the site inspected and approved.

(City of Fayetteville, 2017)

Minimum Canopy and Forestation Requirements

The percent minimum canopy requirements are listed by zoning designation in table 1 of §167.04 of the municipal code. These values range from ten to thirty percent, with a mode value of twenty percent. Ten percent minimum requirements are only allowed in Main Street Center, Downtown General, and Downtown Core zones. Residential and Neighborhood Commercial (C1) districts within the Hillside/Hilltop Overlay District require an additional 5% increase to the minimum value for the corresponding zone.

“The preservation and protection of high priority trees shall be enforced most stringently to meet the minimum percentage of canopy preservation. The preservation and protection of lower priority trees shall not be substituted for that of high priority trees”, except when justification is set forth in the analysis report, and the substitution is approved by the Urban Forester.

Preservation Priorities can be found in Table 2 of §167.04. (City of Fayetteville, 2017)

The City of Fayetteville uses a base density formula to calculate the forestation required for mitigation. The number and species of trees required for forestation is based upon the quality of

the canopy lost: High Priority, Mid-Level Priority, or Low Priority. The forestation required is determined in number of 2-inch caliper trees required per acre of priority canopy removed (Table 1).

Priority Level	2-inch Caliper Trees Required per Acre of Canopy Removed
High Priority Canopy	200
Mid-Level Priority Canopy	150
Low Priority Canopy	100

Figure 1. Forestation Requirements by Canopy Priority

Mitigation Options

“Tree preservation on-site is always the preferred option, with on-site mitigation, off-site preservation, and off-site forestation to be considered in descending order only if the more preferred option cannot be fully achieved. If none of these options can completely fulfill a developer's obligation under this Tree Preservation and Protection Chapter, the developer shall pay into the City Tree Escrow Account \$250.00 for each tree required to meet the Base Density requirements which fairly represents the costs of material and labor to plant a tree. The developer shall also pay into the Tree Escrow Fund \$425.00 as three (3) years of maintenance costs to ensure each tree survives for that period of time.” (City of Fayetteville, 2017)

This project aims to implement space efficient alternatives in cases where on-site mitigation is not possible. These alternatives may include intensive or extensive green roof systems, or various green façade systems. As stated above, preservation and forestation will always be the top priority; these alternatives will be implemented only in qualifying situations, yet to be determined.

Literature Review – Seattle Green Factor

Background

Initially, a literature review was conducted to examine existing applications of alternative mitigation programs in place in around the world, as well as factors that might influence a ratio

calculation. Qualitative and quantitative factors were considered, including evapotranspiration, indirect cooling, habitat creation, stormwater management, and other components based on objectives stated in chapter 167 of the Fayetteville Municipal Code. Existing applications that were researched include those found in Berlin, Malmo, Chicago, Portland, and Seattle. The most noteworthy and complete resource found was that in place in Seattle. The program is called the Seattle Green Factor (SGF). The SGF was adopted by the City of Seattle in 2006 for implementation of green infrastructure into urban areas. This program was used as the basis for the ratio calculation for this project. Under the SFG system, a minimum target score is required based on plot type, which is calculated as a function of the ecologically effective surface area in weighted proportion to parcel size. The corresponding factor of each landscape feature is multiplied by the area of that feature during score calculation. Further literature review was conducted to ensure that these factors were well-founded and aligned with the goals and objectives of the city of Fayetteville.

Precedent programs to the SGF include the Biotope Area Factor (BAF) in Berlin, Germany (1997), and the Green Space Factor in Malmö, Sweden (2001), both of which utilize a point system to assess the ecological benefits of infrastructure. Seattle began with the Berlin model, which requires a certain BAF score dependent on site type, determined by the amount of “ecologically effective surface area” per total land area. This model was modified to “reflect Seattle context” (Hirst et al., 2008).

Relating the Seattle Green Factor

The important take-away from the SGF in terms of this project were the factors used by the SGF for each landscape element, specifically the factors for various tree sizes, green facades, and intensive and extensive green roofs. These values would be utilized to create preliminary proportions by taking advantage of the point system to establish a common denominator in comparison of trees and mitigation alternatives.

Goals and Objectives

The purpose and intent of Seattle’s Tree Protection code as stated by the municipal code of the city of Seattle (for the sake of comparison to that of Fayetteville chapter 167) is as follows:

- i. Implement the goals and policies of Seattle's Comprehensive Plan especially those in the Environment Element dealing with protection of the urban forest;
- ii. To preserve and enhance the City's physical and aesthetic character by preventing untimely and indiscriminate removal or destruction of trees;
- iii. To protect trees on undeveloped sites that are not undergoing development by not allowing tree removal except in hazardous situations, to prevent premature loss of trees so their retention may be considered during the development review and approval process;
- iv. To reward tree protection efforts by granting flexibility for certain development standards, and to promote site planning and horticultural practices that are consistent with the reasonable use of property;
- v. To especially protect exceptional trees that because of their unique historical, ecological, or aesthetic value constitute an important community resource; to require flexibility in design to protect exceptional trees;
- vi. To provide the option of modifying development standards to protect trees over two (2) feet in diameter in the same manner that modification of development standards is required for exceptional trees;
- vii. To encourage retention of trees over six (6) inches in diameter through the design review and other processes for larger projects, through education concerning the value of retaining trees, and by not permitting their removal on undeveloped land prior to development permit review.

(Seattle Municipal Code 25.11.010)

Comparison

The purpose and intent of Seattle's Tree Protection code is less specifically goal oriented than that of the city of Fayetteville's, which has laid out specific objectives regarding benefits resulting from improved or maintained forestry and green infrastructure. However, *Assessing Elements of the Seattle Green Factor*, an internship report published on the Seattle Green Factor web page, states that it "has been designed to allow development of new projects a higher degree of flexibility while increasing ecological function and aesthetic qualities of the landscape" (Hirst et al., 2008). These

ecological functions include increasing stormwater infiltration to shift the ecological function to pre-development conditions.

Validity

As previously stated, the SGF was originally based on and modified from the BAF from Berlin. *Assessing Elements of the Seattle Green Factor* (Hirst et al., 2008) lays out in detail each category included on the SGF scoresheet, describing how and why each factor was calculated. These state the element, the functional benefits, environmental considerations, and the factor decided upon. The functional benefits listed as considerations largely correspond to those listed as objectives of the city of Fayetteville, including evapotranspirative cooling, habitat creation, reduced stormwater runoff, and air cleansing, among others.

The Seattle Green Roof Evaluation Project (GREP) was a study conducted by local engineers Magnusson Klemencic Associates (MKA). This study was conducted on three green roof test plots in Seattle, collecting over 1.5 million data points in order to quantify the value of green roof systems in retaining stormwater. This study found that the implementation of a green roof has the ability to mitigate runoff by at least 65% and up to 94% (Gangnes, 2007). The reduction in both volume and peak flow of runoff are important benefits of low impact development and are a major factor in the multifaceted value of a green space.

Value Determination

Minimum required score

A minimum score of 0.3 is required for all sites, with up to 0.6 being required for Lowrise Multifamily Residential Zones (Figure 2). This score is found by multiplying the equivalent square footage of elements by corresponding factors and dividing by the total parcel square footage, also known as the sum of square footage. A score of 0.3 equates to 30% of the parcel's total area being ecologically effective. However, very few surfaces are 100% ecologically effective, so 30% could require as much as 75% of surface area, depending on the effectiveness of landscape features used.

Zone	Minimum Scores
Commercial and Neighborhood Commercial (NC1, NC2, NC3, C1, C2)	0.3
Industrial Commercial (IC)	0.3
Development in South Downtown for development with 20,000 gross square feet or more	0.3
Midrise and Highrise Multifamily Residential (MR,HR)	0.5
Lowrise Family Residential (LR)	0.6
Yesler Terrace (MPC-YT)	0.3
Seattle Mixed (SM)	0.3

Figure 2. Minimum SGF Score by Zone (Seattle Department of Planning and Development, 2015)

Score Factors

Assessing Elements of the Seattle Green Factor (Hirst, 2008) lays out in detail each category included on the SGF scoresheet, describing how and why each factor was calculated. These state the element, its functional benefits and environmental considerations, and the resulting factor decided upon. The functional benefits listed as considerations largely correspond to those listed as objectives of the city of Fayetteville. For green roof systems, these benefits are listed as reduction of runoff, reduction of heat island effects, habitat creation, and improved insulation. For vegetated wall systems, listed benefits include evapotranspirative cooling, slowing stormwater events, air cleansing, habitat creation, and reduction of heat island effects. All of these are listed in Fayetteville’s objectives.

Ratio Calculation

The ratio determination was dependent on establishing comparative units to correlate trees to green walls and facades; the SGF score system provided a good starting point as a medium for comparison. Factors for each tree size were listed in a table. These include size, equivalent square footage, and multiplying factor. For the SGF calculations, a given tree size based is based on its canopy and is assigned a square foot value. For example, a tree with canopy of 16 to 20 feet in diameter is categorized as a Small/Medium tree, which is assigned an equivalent value of 150

square feet, with a multiplying factor of 0.4. Under these parameters, if two small/medium trees were present on the site, the SGF spreadsheet would multiply the 150 square feet per tree by two trees, then multiply this total by the factor, 0.4, to obtain the “score” for this category, i.e. $(150 \times 2 \times 0.4) = 120$. The sum of the scores of all categories acts as the numerator in determining the overall project score, with the parcel size as the denominator. (This effectively determines a weighted comparison of ecologically effective area to total area, using weighted values for more effective landscape elements.) Using this information, a “1 tree score” was determined for each size category. For the Small/Medium tree, this value is 60 ($150 \times 1 \times 0.4 = 60$).

In SGF calculation, vegetated walls and green roofs are input as square feet. This value is then multiplied by the corresponding factor to determine the weighted score for these categories. As was with the tree categories, a unit “1 square foot score” was determined for these elements. After establishing a 1-tree score and a 1-square-foot score for each category of interest, these values could be directly compared by dividing the 1-tree-score by the 1-square-foot-score to calculate the square footage of green roof or vegetated wall that equates one tree of given size.

"Standard Tree" size	Sq. Ft.			1 tree score
	Canopy	Per tree	Factor	
Small/Medium	16'-20'	150	0.4	60

Veg. Wall	Sq ft	SGF Factor	Points/sq ft	Sq ft/tree	Trees/sq ft
		1	0.7	0.7	85.7

Green Roof	Sq ft	SGF Factor	Points/sq ft	Sq ft/tree	Trees/sq ft
	2"-4" Growth Medium	1	0.4	0.4	150
>4" Growth Medium	1	0.7	0.7	85.7	0.0116667

Figure 3. Ratio Calculation

For the example of the small/medium tree, the table above shows the calculation, yielding that one small/medium tree is equivalent to roughly 86 square feet of vegetated wall or Green Roof with more than 4 inches of growth medium, or 150 square feet of green roof with 2 to 4 inches of growth medium.

Ratios were determined for each size of tree on the Seattle Green Factor Scoresheet. These values were established as a starting point, and can easily be adjusted as seen fit by the city in order to establish a ratio that may be deemed more appropriate for our climate and mitigation objectives (figure 4). This can be done by adjusting the “equivalent square footage” of the standard 2” dbh (diameter at breast height) mitigated tree as required by the City of Fayetteville, or by adjusting the multiplying factor to achieve a more appropriate unit score.

Objectives
Preserve Tree Canopy
Create Healthful Environment
Moderate Sun, Wind, & Temperature Changes
Buffer Noise, Air, and Visual Pollution
Filter Pollutants from Air
Reduce Stormwater Runoff
Stabilize Soil and Prevent Erosion - Maintaining Tree Canopy on Hillsides
Provide Habitat for Birds and Wildlife
Preserve Riparian Banks and Beds, Prevent Sedimentation
Screen Incompatible Land
Promote Energy Conservation
Protect and Enhance Property Values

Figure 4. Mitigation objectives laid out in Chapter 167 of Fayetteville Municipal Code

Details required for Development/Maintenance Review

After the ratio calculation was performed, a further literature review was conducted to identify design and maintenance requirements of green roofs and green facades. The following summary of the requirements implemented in Seattle is not necessarily a suggestion for Fayetteville, but does have the potential to serve as a guideline. Requirements will be modified and established to best fit the unique goals, values, and opportunities of the City of Fayetteville.

Green Roof

Green roofs are defined in the City of Seattle Director’s Rule as plantings on top of a structure at least 10 feet above grade with a minimum of 2 inches of soil. Intensive green roofs contain 2 to 4 inches of growth medium, while extensive systems (Figure 5) contain at least 4 inches of growth medium and are eligible in the City of Seattle for both Green Factor and stormwater credit (Seattle Department of Planning and Development, 2015). A licensed architect or landscape architect must approve green roof specifications and designs “must include plans to provide supplemental water for a minimum of two growing seasons” (Seattle Department of Planning and Development, 2015).

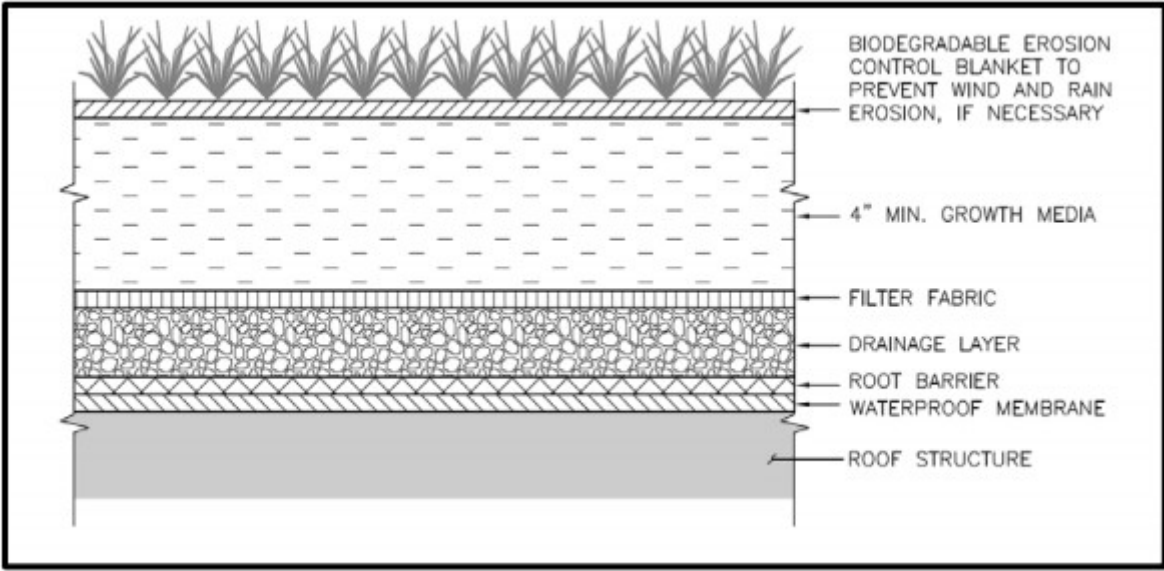


Figure 5. Intensive Green Roof Design Detail, Adopted from Seattle Stormwater Manual, 2016

Vegetated Wall

A vegetated wall is defined as a vertical surface covered by plants. This includes walls or screens with climbing vines, trailing plants, espaliered trees, or modular “green wall” planting systems (Seattle Department of Planning and Development, 2008). Green Factor credit is determined by measuring the height and width to be covered by vegetation within 5 years. They are only eligible for credit where they are 5 or more feet from adjacent structures (Seattle Department of Planning and Development, 2015). There are minimum size requirements for planting strips at the base or top of the wall to allow space for rooting area and drainage. Vines growing on trellises or walls are required to have at least a 1-foot-wide planting strip (Seattle Department of Planning and Development, 2015). Additional requirements and restrictions are available on Director’s Rule document DR2015-30, but the documents contain no illustrated examples of green façade designs. Example plans from various projects that incorporate green facades are provided on the Seattle Green Factor Website (Figure 6, Figure 7).

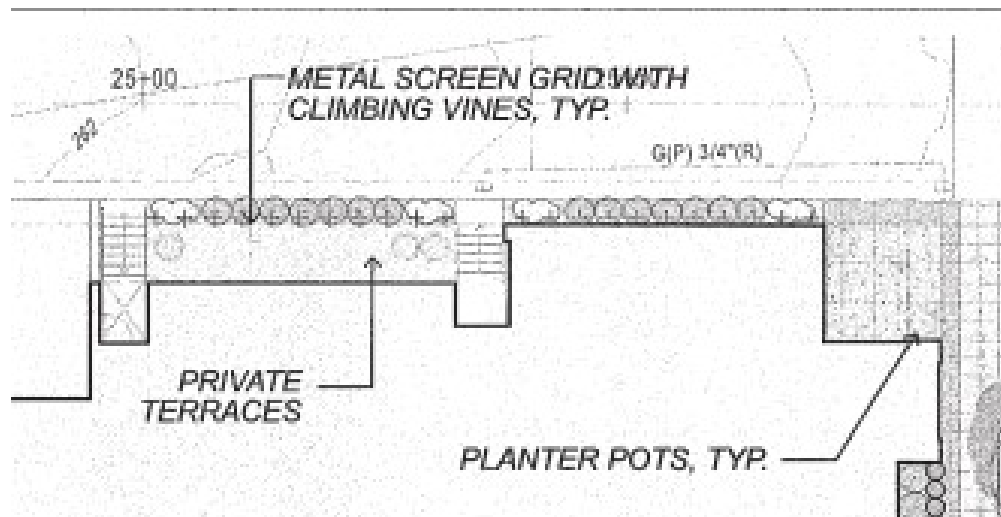


Figure 6. Green Façade Design example, adopted from SGF case study, Link Apartment Landscape Plans

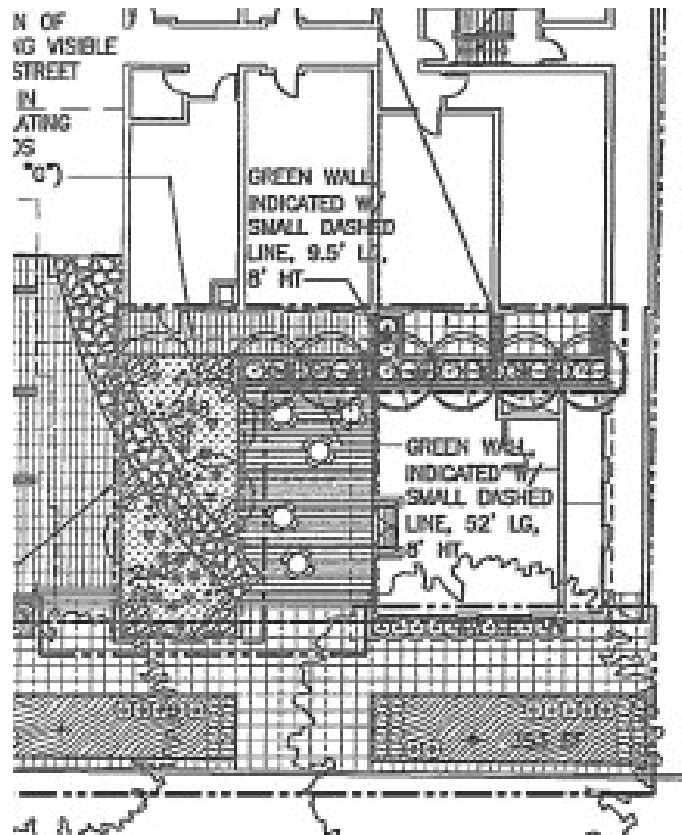


Figure 7. Green Façade Design example, adopted from SGF case study, Chloe Apartments Landscape Plans

Maintenance requirements for green facades/roofs in Seattle

The City of Seattle requires that all plantings and landscape elements required as part of a land use permit or building permit must be maintained for the life of the project. If the feature fails and is reduced to a level below the minimum planting area that is required, new features must be added to compensate. (Seattle Department of Planning and Development, 2015)

The City of Seattle necessitates that for sites required to comply with the Green Factor, a Landscape Management Plan must be prepared to ensure that landscapes are established and maintained at a functional level over time. This is intended to address both safety and the successful implementation of environmental goals. It should provide clear direction on the care and maintenance of plantings, including components such as soil preparation, use of compost, plant replacement, irrigation, weed and pest control, control of invasive species, and care and maintenance of water or hardscape features. The project's landscape professional must sign the

Landscape Improvement Checklist verifying that a Landscape Management Plan has been prepared and submitted. (Seattle Department of Planning and Development, 2015)

An example landscape maintenance plan (Figure 8) is provided by the Seattle Department of Planning and Development. This example is intended to serve as guideline of requirements for planning and maintenance, but which can be edited and improved to meet the needs of each project. The example maintenance schedule provided by the Seattle Department of Planning and Development contains a list of activities required by month, including mulch mowing, pruning, cleaning, etc. All subsequent sections contain detailed instructions and requirements of these listed items by area type and activity.

For example, in the example the Green Roof section of the Special Landscape Categories lists the following:

“Weeds may be introduced by birds or wind-dispersed seeds. This area will require low but ongoing maintenance after it is established, and may need frequent weeding until desired vegetation covers the planted surface.

“Green roofs are exposed to extremes of wind, sun, and temperature. The green roof planting plan uses hardy, drought-resistant plants, but some initial irrigation will be required in this harsh microclimate. Manual watering about every two weeks will be necessary during the first two summers after installation.” (Seattle Department of Planning and Development, 2015)

Example Landscape Maintenance Plan

This Landscape Management Plan is a generalized example, intended to be edited and improved by the designer to meet the particular needs of each project.

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 - Rain garden
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Seattle Green Factor

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Figure 8. Example Landscape Management Plan Table of Contents, Adopted from Seattle Department of Planning and Development, 2010

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