The PLLUS of Bufferyards
Planned Landscape / Land Use System

Based on the Proposal of Bufferyards by Lane Kendig
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A creative Project Presented to
The Faculty of the Department of Urban Planning
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by
Deborah S. Van Dam
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There are several persons who helped me throughout the research and writing of this project. Thanks to Linda Keys for guiding me through the research phase. Thanks to Anne Henderson for enlightening me in the impacts of such a study, its perspective, and its importance in the natural environment. Much thanks to Jim Segedy who inspired me to create the matrix which unravels the complex interrelationships within the study. Among the faculty involved I owe the most gratitude to Francis Parker, my chairperson, who guided me throughout the creation and completion of this study. And also to my fiancé, Eric Luzier, who over the last eight months, gave me the support and encouragement that I needed to complete this study.
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Forward

The organization of this work has two parts. The first is to examine in detail Lane Kendig's Bufferyard Proposal. The second is to use Kendig's proposal and the realized conclusions to develop the PLLUS of Bufferyards, the Planned Landscape / Land Use System of Bufferyards. PLLUS of Bufferyards is a tool which is meant to pick up where Kendig's proposal leaves off in determining the stronger bufferyard alternative(s) for use based on the identified needs and goals of a given community.
Chapter 1
Introduction

Overview

As unplanned urban and suburban growth overtakes small towns, fertile farm fields, and scenic views, local character quickly disappears. Public values of a regional landscape are becoming ever more obliterated by the cumulative effect of self-interested private decisions for development. The fact that community identity is a composite of landscape, people, institutions, and history is not realized or simply ignored; all contribute to character and to reasons why concern for its protection should exist (Massachusetts, 1988). However, this character and the corresponding natural environmental functions do not need to be displaced as cities expand.

Zoning was one of the first forms of dealing with this problem and is still the primary mitigation strategy in most communities. One of the purposes of conventional zoning is to separate land uses into distinct districts on the basis of their compatibility. Unfortunately, conventional zoning is not always successful in the separation between non-compatible land uses. This failure associated with conventional zoning indicates a need to explore alternative ways of dealing with the juxtaposition of two or more uses that are not equal in intensity or compatibility. Furthermore, zoning by itself is unable to ensure that new development is integrated sensitively into a community and it fails to address visual impacts of development.

Landscape ordinances, in conjunction with zoning, are quickly becoming the new trend to combine the separation of land uses with aesthetic and ecological sensitivity. Such ordinances "are a legalistic way to mandate the use of natural elements in the
development of any town" thereby preserving or improving its character and identity (Robinette, 1992). Although landscape ordinances will not clean up the mess, the idea of establishing such an infrastructure will provide a new and less controversial approach to regional planning by providing a geophysical framework for it rather than roadways (Little, 1990).

Landscape ordinances are directed toward marginal or local builders, developers, or business people who cut corners by scrimping on or deleting landscape development from their projects. After all, developers and builders would not be competitive if they did only what was required; they often go above and beyond minimum requirements to make their projects more appealing and thereby competitive in the marketplace. Contrary to popular belief, they are usually the strongest supporters of such legislation (Robinette, 1992). However, it is obvious that not all developers and builders will conform without some sort of incentives or threats.

One such way of dealing with integrating zoning and a landscape ordinance is through the use of bufferyards. Bufferyards operate to minimize the negative impacts of any use on neighboring uses while providing physical and visual barriers which block out air pollutants, noise, and visual unsightliness between land uses as well as providing functional use of the land they occupy (Kendig, 1980). A nuisance may be expressed as, but not limited to, dirt, litter, noise, lights, signs, air pollution, and unsightly buildings or parking areas (Kendig, 1980). While the magnitude of a nuisance is directly affected by the distance and plant material between it and the benefited land use, the level of visual separation seems to be a predominant factor in determining the effectiveness of the buffer. Lane Kendig has developed a comprehensive bufferyard proposal which benefits both the developer and the adjoining land owner(s). It allows several development options to choose from while insuring each neighbor adequate protection regardless of the alternative choice. The adoption of such a proposal into an
existing community zoning ordinance could potentially improve the performance of contemporary zoning as well as the community aesthetics.

Even more effective than a generic and non-mutable bufferyard proposal, like Lane Kendig’s, would be a similar bufferyard or landscape ordinance that is exclusive to the community it serves. Such an ordinance would serve the needs and desires of the community and attempt to meet the goals of the future. The purpose of this study is to develop such a proposal. The proposed system, in matrix format, would meet these guidelines establishing a hierarchy of concerns and needs to overlay Kendig’s bufferyard proposal in order to derive the bufferyard alternatives with the highest performance potential. The entirety of the evaluative process is intended to mold a distinctive ordinance to not only protect less intensive land uses from highly intensive ones but also to protect the community per se from undesired land use developments in the future, thereby preserving character and identity.

Problem Statement

This study has two integral parts. First it applies the laws of physics to the suggested bufferyards of Lane Kendig's bufferyard proposal to evaluate the alternatives on the basis of their physical capabilities to attenuate noise, improve air quality, and serve as a visual barrier. Second, the results of this research and the examination of other various ordinances will be the basic data for the formation of a matrix system, termed PLLUS of Bufferyards, which stands for Planned Landscape/Land Use System of Bufferyards. This matrix will be a comparative tool designed to compare Kendig's bufferyard alternatives in terms of their effectiveness in separating proposed land uses for the purpose of maintaining quality developmental standards within a community based on identified needs and concerns.
Statement of the Question

Two questions are evident when addressing the given problems. First, how effective are the bufferyards that Kendig has established in his bufferyard proposal in terms of physical performance? And second, how can the observed variations be used to develop an evaluative tool, based on the purpose of the Kendig’s proposal, that conforms to various communities’ needs for performance zoning?

Methodology

This is a study in practical application of research, rather than discovery research. The result of this study is a basic tool to develop a landscape ordinance for use by virtually any local governing body wanting to incorporate quality standards for development within their community.

First, the laws of physics will be applied to each bufferyard proposed by Lane Kendig. By applying physics, the characteristics that distance, plant material, vegetation density, and land forms possess in attenuating noise, reducing air pollution, and visual separation can be realized. The variables can then be compared to each other for the purpose of identifying the elements that distinguish weaker buffers from stronger ones.

Second, the results of this application are then used to evaluate each of Kendig’s proposed bufferyards as a whole in terms of their appropriateness for use between various classes of land use intensities. The bufferyard alternatives will be compared and contrasted for the purpose of identifying the yards which possess the specific characteristics of density, physical barrier, and visual separation exclusive to the needs of the land uses in questions.
Third, a matrix will be formatted to not only display the ideal alternatives for use between land uses, but also to compare these alternatives by their relative value of performance potential based on the identified variable goals.

**Intended Outcome**

The first outcome is the conclusion that the dimensional and density requirements for bufferyards between land uses as described by Kendig do not necessarily meet the desired physical standards of attenuating noise, air, and visual pollutants as suggested. However, the primary goal of the bufferyard is of visual separation, and therefore the physical needs of a bufferyard may be slightly less important.

The second outcome is that the realized physical characteristics of the bufferyard elements can be used to evaluate each alternative for effectiveness of use between different land use intensities.

The third outcome is a matrix established to derive the most appropriate alternatives between land uses and weigh them according to the standards established by the individual community.
Chapter 2
Examining Lane Kendig's Bufferyard Proposal

Introduction

According to Aarne Vesiland, under the common law of land use ownership, the two basic human rights are:

1. a property owner can do whatever he wants with his property
2. A person has the right not to have harm inflicted by others" (Vesiland, 1975).

The ownership of property does not necessarily constitute freedom to do as one wishes with or on that property. Obviously, these basic rights can be in conflict, especially under conventional zoning where non-compatible land uses may be adjacent to one another. The purpose of bufferyards is to minimize the negative impact of any use on neighboring uses while providing physical and visual barriers that block out any nuisances between land uses as well as provide functional use of the land they occupy (Kendig, 1980). A nuisance may be expressed as, but is not limited to, dirt, litter, noise, lights, signs, air pollution, and unsightly buildings or parking areas (Kendig, 1980). While the magnitude of a nuisance is directly affected by the distance and plant material between it and the benefited land use, the level of visual separation seems to be a predominant factor in determining the effectiveness of the buffer.

The concept of Performance Zoning, as addressed by Lane Kendig, attempts to eliminate conventional zoning and replace it with a more sensitive approach to land use management. "The performance approach to zoning regulates development mainly on the basis of four variables: open space, impervious surface, density, and floor area" (Kendig, 1980). These variables determine the intensity of land uses; land use
separation is thereby based on this derived intensity and is limited by the geographical
and natural resources of a given site.

In his bufferyard proposal, Lane Kendig has established guidelines for fourteen
separate bufferyard classifications for different levels of incompatibility as well as street,
fence, berm, and berm wall guidelines. These yards range in size and plant material
density from low (Bufferyard Ag) to high (Bufferyard K) for use between general land
uses. Bufferyards S1 and S2 are for use between a general land use and roadway.
Fence, berm, and berm wall are for use between non-compatible land uses where there
is generally one of high intensity use.

Kendig states that "the planting units required of bufferyards have been
calculated to insure that they do, in fact, function as 'buffers'" (Kendig, 1980). Planting
units are the number of canopy trees, understory trees, shrubbery, or evergreen plants
required for the given width and every 100 feet length of the bufferyard. For example, a
planting unit of .5 for shrubbery used within a bufferyard that is 200' in length means
that one shrub is required (.5 units x [200'/100']). This statement is the only reference to
the basis for the suggested size, density, and plant material of the suggested yards
stated in the proposal. Kendig does mention that distance, plant material, vegetation
density, and land forms are the factors used to develop each bufferyard in his proposal,
but he doesn't discuss the limitations of each of these factors (Kendig, 1980). For
example, would distance be more effective in a bufferyard than vegetation density?
Why or why not, and what is the rationale behind this distinction? Kendig also
suggests that a different combination of these elements (distance, plant material,
vegetation density, and land forms) is needed for use between different juxtapositions
of land uses (Kendig, 1980). Why do these differences exist and what is the rationale
behind these suggested distinctions? Kendig also makes it possible for both the
developer and the adjacent land owner(s) to benefit from the proposal. It allows several
alternatives for the developer to choose from while insuring each neighbor adequate
protection from the other's land use regardless of the alternative choice. Obviously, then, each alternative must be equally as effective as the other. How do these alternatives compare and are they equally effective bufferyards?

The purpose of the following research is to answer those questions that have arisen while reviewing Kendig's bufferyard proposal. It becomes necessary, then, to determine the predominant factors of Kendig's bufferyards and evaluate these factors individually as well as determine how they perform within the bufferyard as a whole. This methodology should not only identify the physical capabilities of the factors, but ultimately differentiate between the most and least effective bufferyards.

**The Factors of Kendig's Bufferyard Proposal**
Distance

The sketch denotes the vocabulary and location of terms associated with the discussion of bufferyards between land uses.

Distance is a major factor in land use separation. Kendig suggests that the greater the difference in intensity between land uses, the wider the bufferyard should be (Kendig, 1980). Therefore the difference in level of land use intensity and suggested bufferyard widths are directly proportional to one another. For example, a low intensity use, such as a residential subdivision, and a high intensity use, such as heavy industry, should be separated by one of the widest bufferyards. Two adjacent low intensity uses, such as two subdivisions, or two adjacent high intensity uses, such as heavy industry and mineral extraction, require minimal bufferyard width because there is little or no difference in their land use intensity. This relationship can be seen in Section 4602: Table of Land Use Intensity Class Standards and Section 4606: Table of Bufferyard Requirements when comparing the width of bufferyard requirements between two different intensity classifications of land use (see appendix).

Plant Material

The type of plant material used is another primary factor within a bufferyard. Frank Lloyd Wright once said, "...greenery hides a multitude of sins" (Wright in Kendig, 1980). For each category of bufferyard requirements, there is a minimum requirement of canopy trees or conifers, understory trees, shrubs, evergreens or conifers, and even thorny shrubs. Each type of foliage has a different purpose within the bufferyard. Canopy trees provide shade, background rustling of leaves, and small animal habitat, but, if well-groomed, at ground level they do not serve as an effective visual barrier, especially in the winter. Large conifers, on the other hand do serve as an effective visual barrier and foliage remains year-round. Understory trees, shrubs, and thorny shrubs serve to fill in the gaps at ground level left by canopy trees, and if densely
planted, can serve as a physical barrier between land uses. The determination of the specific species of each depends on the soil type and climate of the community adopting the ordinance.

Vegetation Density

Not only is distance directly related to land use intensity, but the greater the difference in intensity, the more densely planted the bufferyard should be (Kendig, 1980). Vegetation density may be substituted for a portion of the distance, or width of the bufferyard. This is illustrated in Section 4607: Bufferyard Requirements in the scaled plan drawings of bufferyard requirements. Kendig has devised a plant multiplier method for calculating the number of plant units required for various widths of yards. This system is a density factor based on maintaining a uniform ratio of plant material to bufferyard width (the wider the yard, the less plant material required and the narrower the yard, the more plant material is required). The rationale behind this theory and the effects of the plant multiplier will be examined and analyzed in a later chapter. The density of the vegetation used also has a positive effect on reducing pollution and serving as a visual screen. Heavily planted areas are able to minimize or eliminate nuisances such as particulate matter in the air, dust, dirt, and litter (Kendig, 1980). The relationship between density and the bufferyard's effectiveness as a visual screen is quite obvious; the more dense the bufferyard, the more effective it is as a visual barrier.

Physical Structures and Land Forms

Finally, physical structures and land forms can be incorporated into bufferyards for the most effective means of physical separation. Kendig insists that in the case of very intense land uses abutting considerably less intense ones, structural components, such as fences or berms may be required of a bufferyard (Kendig, 1980). Similar to plant material density, physical structures and land forms may be substituted for a
portion of the width required of a bufferyard. This is necessary where the distance between adjacent land uses is unusually small or there simply isn't enough land available to support the suggested factor of distance. However, as indicated by Kendig, a physical structure or land form cannot be used as a bufferyard alone. The suggested physical structure or land form must be accompanied by dense vegetation on the side facing the lower intensity use. Kendig has included four types of fences, three earthen berms, and guidelines for four berm walls in his proposal. Each physical structure and land form is appropriate for different situations for bufferyards between different land use intensities.
Chapter 3
Evaluation of Bufferyards

Introduction

There must be a method to determining the actual effectiveness of each bufferyard that goes beyond merely suggesting that "...it does, in fact, function as a buffer" (Kendig, 1980). Bufferyard width, plant material, plant density, and physical structures and land forms have been established as factors contributing to the effectiveness of a bufferyard. Different bufferyards have different characteristics and abilities that enable them to eliminate or reduce the negative impacts of a more intense, non-compatible land use. Distance, plant material, vegetation density, and land forms have individual physical abilities that affect the burdened and protected land uses in many ways. The three quantifiable elements to be discussed in this study are the ability of the bufferyard to attenuate noise, reduce air pollution, and serve as a visual barrier.

By applying the laws of physics, it can be shown that the width of the bufferyard, plant material, plant density, and physical barrier each affect noise level, air pollution, and visual separation.

Noise Pollution
Definition and Importance

Noise or noise pollution can be defined as any unwanted sound. Whether it be the annoying loud music the neighbors play or the distant rumbling of a train, noise is a common element in our daily lives. Noise-level is measured in decibels (dB). For
purposes of this study, decibel type dBA will be used which reflects noise loudness as well as sound level. The range of hearing for a human being ranges from the threshold of audibility, 0 dBA, to the threshold of pain, 130 dBA. Any sound level above 70 dBA contributes to hearing impairment after extended exposure. Some common and surprising noise levels in the environment are illustrated by Frank Cross and Aarne Vesilind (Cross, 1974)(Vesiland, 1975).

**Common Noise Levels**

<table>
<thead>
<tr>
<th>Element</th>
<th>dBA</th>
<th>Conversational Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>jet take off 200 ft away</td>
<td>120</td>
<td>shouting in ear</td>
</tr>
<tr>
<td>lawn mower (operator)</td>
<td>110</td>
<td>shouting in ear</td>
</tr>
<tr>
<td>garbage truck</td>
<td>100</td>
<td>shouting in ear</td>
</tr>
<tr>
<td>heavy truck</td>
<td>90</td>
<td>shouting at 2ft</td>
</tr>
<tr>
<td>flushing toilet</td>
<td>85</td>
<td>shouting at 3ft</td>
</tr>
<tr>
<td>alarm clock</td>
<td>80</td>
<td>very loud conversation 2ft</td>
</tr>
<tr>
<td>traffic</td>
<td>70</td>
<td>loud conversation 2ft</td>
</tr>
<tr>
<td>air conditioner 20ft away</td>
<td>60</td>
<td>loud conversation 4ft</td>
</tr>
<tr>
<td>conversational speech 3ft away</td>
<td>60</td>
<td>conversational speech</td>
</tr>
<tr>
<td>movie theater</td>
<td>50</td>
<td>normal conversation</td>
</tr>
<tr>
<td>light auto traffic 100ft away</td>
<td>50</td>
<td>normal conversation 12ft</td>
</tr>
</tbody>
</table>

Unwanted noise in the environment has many negative effects on people, ranging from disturbed sleep and annoyance to causing actual damage to a person's health (Grandjean, 1976). The most common sources of unwanted noise in a community include road traffic and industrial noise (Vesiland, 1975). The control of noise is made possible at three levels: reducing the sound produced; interrupting the path of the sound; and protecting the recipient. Bufferyards act to interrupt the path of the sound thereby protecting the recipient, and/or the burdened land use. There are three primary factors in this study which affect or interrupt the path of sound: distance, vegetation density, and physical barriers.
Distance

Distance plays a major role in attenuating noise level. Width of the bufferyard is directly proportional to the reduction of noise pollution. In other words, the wider the space between land uses the greater the amount of noise reduced reaching the less intense land use. The level of sound produced by a particular land use, such as heavy industry, is measured at the source of the sound; thus, the decibel rating naturally decreases as the distance from the source increases (Cross, 1974). Leaving gaps in the urban environment, regardless of how much vegetation is present, increases the distance that sound has in which to disperse (Grandjean, 1976).

Traffic noise is one of the main sources of noise pollution in the urban environment. The following chart illustrates the effects that distance has on reducing the sound level of common traffic at 58 dBA and 90 dBA (Grandjean, 1976). Notice that the level of noise is reduced as one moves away from the source.
According to the previous exhibit, there is a distance plateau that must be met before attenuation begins and also a distinct slope of attenuation. Unfortunately, there is no simple answer or pattern that can be used to determine the promulgation point of attenuation, except to say that lower frequencies require a greater distance before attenuation begins. The reduction point is reliant upon the sound itself, the pitch of the sound, and external factors such as ground cover and surrounding structures which might reflect or amplify the sound.

For new developments adjacent to vacant land or existing land uses, appropriate land use selection can be made and a sufficient distance can be measured to reduce noise (Fabos, 1977). There are some noises which have been analyzed and for which a distance to attenuation relationship has been established, such as industrial noise. When dealing with an established industrial noise source, for example, it has been determined that noise-level from a single source is reduced by nearly 6 dB each time the distance away is doubled (beginning about 10 feet from the source) (Grandjean, 1976). Such figures, however, are not available for every land use.

In order to evaluate and compare the bufferyard alternatives, one cannot go out and measure every single land use under every possible condition in order to calculate the distance needed to exactly attenuate noise to an accepted level. An average attenuation to distance must be used to evaluate all alternatives at a common level. Grandjean suggests an average calculated reduction of all noise by distance to be 2 dBA reduction per every 100 meters width between a noise source and the receiver (Grandjean, 1976). Referring back to the chart Common Noise Levels, a 2 dBA reduction does not seem to have much of an impact, but if combined with that of vegetation and any physical barrier, it can make quite a difference.
Plant Material and Vegetation Density

Although not as effective as distance, plant material density also attenuates noise. For the most part, the effect of vegetation is over-rated, but when combined with distance, vegetation has the potential to reduce the intensity of noise by absorbing the high frequencies it possesses. E. Grandjean notes that even "...a single row of trees leads to a mitigation of noise by filtering out the hard and brilliant components of noise" (Grandjean, 1976). Trees may also add their own form of "background noise" to the environment. Lane Kendig makes this connection by suggesting that coniferous and deciduous wooded areas not only reduce noise, but introduce the background sounds of trees, wind, and birds and other animals (Kendig, 1980).

It has already been established that the effect of noise reduction is related to bufferyard width and vegetation density, but there is also a distinction between the vegetation density of the bufferyard and the type of vegetation used. For example, a bufferyard 50 feet wide and composed of large shade trees or conifers will reduce the intensity of noise more than a bufferyard made up of shrubbery and ground cover of equal width. Therefore, the height of the bufferyard must be at least five feet, the average height of a person receiving the sound, before it can begin to attenuate noise. Grandjean sets out average attenuation figures that reflect this differentiation. Barriers of trees only or trees and shrubs together claim an average diminution of noise by 2 dBA for each separate screen or 100m of bufferyard width (Grandjean, 1976). Heavily built up areas made up of large trees, understory trees, shrubs, and ground cover diminish sound by 5 dBA per 100m width of bufferyard (Grandjean, 1976). Compared to the chart Common Noise Levels, 2-5 dBA attenuation begins to make a slight impact on noise levels.

Within Kendig's bufferyard proposal, the density of the bufferyard alternatives varies by classification as well as within each classification. The density of each bufferyard will be measured in terms of plant units per square foot of bufferyard. Noise
attenuation by each alternative will then be approximated by the above figures in terms of this calculated density. For example, the first interval of density would diminish sound by 2 dBA per 100m width, the second interval by 3 dBA, and so on.

Physical Structures and Land Forms

The best form for attenuating noise is a physical structure or an obtrusive land form. E. Grandjean notes that obstacles of all kinds are the best sound-barriers and Vesiland claims that the most effective bufferyards at attenuating noise are those with physical barriers to screen the noise (Grandjean, 1976) (Vesilind, 1988).

A physical barrier not only reflects and absorbs some of the sound, but it also forces the sound around and/or over the structure. The height of the barrier is what actually determines the attenuation of noise. The following chart is a complex set of calculations performed by E. Grandjean illustrating how a physical barrier, such as a wall, affects the level of noise between the producer and the receiver, taking into consideration the distance the producer is from the barrier, the height of the sender and receiver, and the shadow angle (the angle of noise blocked) (Grandjean, 1976).

![Reduction of noise-level by an obstacle](image)

**Figure 2.11.** Reduction of noise-level by an obstacle. $h/\lambda$ = ratio of obstacle-height to wave-length of sound. The scale marked $h$, 'effective height of wall', is approximately correct for a wave-length of 2 metres. After Lauber (14).
According to the data illustrated, there is a direct relationship between barrier height and noise level reduction. The higher the barrier, the greater the noise attenuation. There is another relationship between the height of the barrier, the distance the sender is from the barrier, and noise level reduction. The closer the sender is to the barrier, the greater the noise level reduction to the receiver. The shadow angle, as pictured above, is the angle in which sound makes traveling over a physical barrier between the barrier and the receiver. It is a function of the distance the source is from the barrier and the height of the barrier. The minimum height for noise attenuation is five feet, the average height of the receiver. Metric readings converted to feet yield a decibel reduction per proposed structure as follows:

<table>
<thead>
<tr>
<th>Barrier Height</th>
<th>Decibel Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.67'</td>
<td>0</td>
</tr>
<tr>
<td>4'</td>
<td>0</td>
</tr>
<tr>
<td>6'</td>
<td>11</td>
</tr>
<tr>
<td>8'</td>
<td>12</td>
</tr>
</tbody>
</table>

From the established data as it pertains to Kendig's proposed physical barriers, the higher the physical barrier, the greater the reduction of noise. A barrier that is most effective is constructed as a continuous barrier with as few openings as possible to reduce noise (Grandjean, 1976) Vegetation, which is required on the receiver's side of the physical barrier in Kendig's proposal, will contribute only slightly to further reduction in noise level, but measurements for decibel attenuation only pertains to the physical barrier.
Summary

Despite the presence of noise pollution in our day-to-day environment, the levels of noise can be controlled somewhat by the use of bufferyards between land uses. Distance, vegetation height and density, and physical barriers are elements of the bufferyard that contribute to this reduction in noise level. The following is a summary of the amount of noise pollution that is reduced by each of these elements based on the given data that will be used in the Detailed Bufferyard Information Chart in the following chapter:

Noise Attenuation of Elements Within Bufferyards

<table>
<thead>
<tr>
<th>Element</th>
<th>Noise Reduction by Width (dBA/ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance</td>
<td>2 dBA per 100m 0.01 dBA per 1ft</td>
</tr>
<tr>
<td>Vegetation</td>
<td>2-5 dBA per 100m 0.01-.02 dBA per 1ft</td>
</tr>
<tr>
<td>Barrier</td>
<td>varies with width and height</td>
</tr>
</tbody>
</table>

By combining the appropriate noise levels of land uses with the realized noise reduction effects of the bufferyard elements, the overall effectiveness of attenuating noise pollution by the use of bufferyards can be realized for each yard proposed by Kendig.

Air Pollution
Introduction

The most common liability when dealing with air pollution lies with negligence. In private land uses, such as industry, it must be proven that the land use is knowingly polluting the air at the expense of the surrounding land uses. Legislative problems lie in the fact that air pollution is quantifiable, but hasn’t yet been established what the monetary value of environmental damage has occurred.
Even though direct cause and effect relationships are unknown, we do know that air pollution can be detrimental to human health (Vesiland, 1975) We also know that automobiles constitute a major source of air pollution in almost all communities. Aarne Vesiland suggests that often the easiest solution to an air pollution problem is to stop the guilty process, however, this is one of the most difficult methods of reduction to implement, let alone one of the most costly (Vesiland, 1975). Fortunately, there are ways to reduce or minimize air pollution by manipulating the environment. A. Grandjean suggests that "...at the planning level the following objectives should be pursued to limit air pollution:

1. separation of residential areas from sources of pollution such as traffic, trade, and industry.
2. siting industry downwind of residential.
3. provision of open space, lawns, and parks" (Grandjean, 1976).

For the purpose of this study, it is assumed that conventional zoning has already performed the task of separating residential and other vulnerable land uses from sources of pollution and providing open spaces within the environment. The adoption of Kendig's bufferyard proposal will contribute to conventional zoning by providing even more open spaces, lawns, and/or parks. The bufferyard width, vegetation type, and vegetation density are the elements within a bufferyard that contribute to this reduction of air pollution.

Distance

It is essential to consider air pollution when working out the building plan and land use location for an area. The first requirement is that residential areas be protected against industrial pollution and road pollution through distance (Cross, 1976). The further away from a source of air pollution, the more protected a vulnerable land use
may be. For example, according to Frank Cross, the average distance a residential area should be from industrial land use, and vice versa, is 1,500 feet (Cross, 1976).

When combined with distance, limiting the density of vegetation in the form of open space also affects air pollution. Open space in the urban environment has many purposes: recreation, purifying air, reducing noise, affecting weather, psychological benefits, and aesthetic pleasure (Grandjean, 1976). Frank Cross explains that open space affects air pollution by encouraging the mixing of air to help dilute the impurities present (Cross, 1976). Aarne Vesiland agrees and notes that the extent of air pollution dispersion is dependent upon the distance from the source (Vesiland, 1975). Therefore, broad open space acts as a settling-place for particles and thus has a direct effect on reducing air pollution.

**Plant Material and Vegetation Density**

Plant material also contributes to air pollution reduction. Open spaces incorporated with vegetation replenish the oxygen in the air, but only at a minimal scale. Because most of a community's pollution overpowers the replenishing action of vegetation, this process is often over-rated (Cross, 1976).

Trees and shrubs have proved to have a filtering action upon particles in the air (Cross, 1976). Frank Cross explains that the process is similar to that of an air filtration system. Deciduous vegetation exposes a huge surface area of foliage, which traps much of the dust in the air. Vegetation reduces wind, causes turbulence, absorbs particles, and then rain and snow cleanse the vegetation of the particulates by returning it into the soil (Cross, 1976). Deciduous trees, with their broad leaves, are more effective air filters than conifers in the summer months, but conifers prevail in the process during the winter months. The most effective filtering vegetation is high trees with layers of ground cover and understory foliage beneath (Grandjean, 1976).
The density of vegetation and separation of bufferyards also has an effect on reducing air pollution. Kendig states that heavily planted areas reduce air pollution, dust, dirt, and litter (Kendig, 1980). The effect of density on pollution reduction is quite simple, as explained by Frank Cross. Scattered areas with dense vegetation divide the air into smaller streams and micro climates, breaking the large process of air filtration into several smaller processes, and thus having a beneficial effect on reducing pollution across large areas (Cross, 1976).

**Summary**

At the level of community planning and design, the effects of air pollution can be minimized by separating vulnerable land uses from air polluting land uses. However, the incorporation of bufferyards into the design process can provide the community with open space, lawns, and park systems that contribute to air cleansing at a smaller scale. Distance is the predominant factor in reducing air impurities. The further away from a source of air pollution, the more protected a vulnerable land use may be. Vegetation also plays a role in air pollution reduction. Vegetation reduces wind, causes turbulence, absorbs particles in the air; the rain and snow then cleanse the vegetation of the particulates. Scattered areas with dense vegetation break up the air into smaller streams and micro climates, breaking the large process of air filtration into several smaller processes.

By combining distance, vegetation type, and vegetation density, a bufferyard system can act at a lower level to cleanse the air of impurities caused by air pollution. However, particulates are no longer our biggest concern in air quality, and the impacts on particulates are very minute. Therefore, the effect of bufferyards on reducing air pollution is not a powerful enough process to seriously consider as a strategy for air pollution mitigation.
Visual Separation

Introduction

When discussing Kendig's proposal in the previous chapter, it was suggested that while the magnitude of a nuisance is directly affected by the distance and plant material between it and the benefited land use, the level of visual separation seems to be a predominant factor in determining the effectiveness of the buffer. There is no doubt that this assumption is directly related to the cliché "out of sight, out of mind." There may indeed be some truth in this suggestion, but the key, perhaps, is simply distracting one's attention from the nuisance. The following discussion of distance, plant type and density, and physical barriers is meant to describe the desired level of visual separation as well as to examine ineffective methods of separation. Exhibits are incorporated to more clearly convey the meaning of both effective and ineffective methods.
Distance

Distance, alone, is not an effective element of visual separation, as one can obviously imagine. However, distance from an undesirable land use may serve some sort of psychological purpose of separation.

Exhibit 1

In Exhibit 1, the broad distance from the industrial complex appears to draw more attention to the land use than distracting one's attention from it. This choice of bufferyard is not an appropriate form of separation that is desired by Kendig's proposal. This premise is obvious because Kendig does not even suggest a bufferyard alternative without vegetation. Therefore, combining distance with vegetation and/or a physical barrier has evident effects as seen below.
Plant Material and Vegetation Density

Visual separation between land uses is dependent upon the type of plant material and the vegetation density used in a bufferyard. Groomed deciduous trees alone do not block vision, especially in the winter months.

Exhibit 2a

The broad leaves and branches of well-groomed, mature, deciduous vegetation begin about six feet above ground level as indicated in Exhibit 2a. If one was seven or eight feet tall, this method would prove effective, but in reality, only the trunks of the trees block the vision.
If deciduous trees were left to grow without pruning or trimming, then lower branches and leaves are effective in blocking vision below the previous six-foot level, as seen in Exhibit 2b. Coniferous trees, planted close together do indeed block vision, as well as introduce the background sound of wind whispering through the needles.
Notice in Exhibit 3 that the land use is not even visible, although it is within ten feet of the buffer. The obstructed land use is that of a professional building, but for practicality's sake, it could be any land use. Deciduous trees combined with shrubbery and understory vegetation is a little more effective, even in the winter months because this combination often forms a physically impassable barrier (Kendig, 1980).
The buffer in Exhibit 4 is of this composition; it may not be the most beautiful of bufferyards, but it certainly does block vision, even without leaves.
A mixture of deciduous foliage and conifers is also effective as shown in Exhibit 5. The conifer foliage fills in the spaces left by the seasonal change in the deciduous foliage.
Physical Structures and Land Forms

Physical barriers are obviously the most effective visual barriers. A barrier, such as a brick wall, doesn't have to be an eyesore by any means just to serve its purpose.

Exhibit 6

One example of a physical structure used as a buffer yard in a residential neighborhood is seen in Exhibit 6. Note how the structure is part of the design and landscape of the home.
Land forms are also effective visual barriers. Exhibit 7 is a combination of an earthen berm with a dense ground cover, edged with a wall of shrubbery, and topped with adolescent deciduous trees. This exhibit combines an earthen berm and vegetation to hide a campus parking lot, just as Kendig might suggest. The berm camouflages most of the cars behind it and as the understory trees mature they will merge with the shrubbery and eventually completely hide the land use.
Summary

Visual separation between land uses may depend on personal preference, but several methods have been discussed. Distance alone does not function as an effective visual barrier, but combined with different types of vegetation and vegetation density, an effective barrier can be achieved. Physical barriers are evidently the most effective of visual barriers and may be incorporated into the design process of the land use. Combining vegetation and physical structures or land forms appears to be the most aesthetically pleasing as well as the most effective visual separator.
Chapter 4
Evaluating Kendig's Proposed Bufferyards

Introduction

On the basis of the preceding research, each of Kendig's proposed bufferyards can be evaluated in terms of its physical limitations. It is important to verify quantifiable components of evaluation before attempting to establish the variables to be used. The reason for this is that one may be a derivative of the other, and cannot be evaluated without the establishment of the other. The purpose of this evaluation is not to determine if each bufferyard classification is good or bad in comparison to another classification, but to compare and contrast the alternatives within each classification. This will verify how well each alternative separates the specified land use classifications it has been assigned to.

The charts which follow illustrate and display the outcome of this evaluation. They include the calculations for noise attenuation of each alternative and their rank of visual separation. Each section of the charts and relative calculations are explained in detail for process clarity.

Noise Attenuation

Distance, vegetation density, and physical barriers are elements of the bufferyard that contribute to the reduction in noise level. However, calculating the attenuation by each can be rather confusing without the explanation. The calculations for noise attenuation by each bufferyard alternative is in the form of two charts. The first chart, the primary chart, calculates noise attenuation for distance and vegetation and displays
the physical barrier attenuation values. The second chart performs the calculations for the noise attenuation of the physical barriers that are displayed in the primary chart.

Noise Attenuation by Distance

As mentioned earlier, distance plays a major role in attenuating noise. Thus, the width of a bufferyard is proportional to noise reduction. The average level of attenuation for distance alone (with no vegetation) is .01 dBA per linear foot of width. This means that for every lateral foot width of the bufferyard, .01 decibel of noise is lost. While all of the proposed bufferyards have some vegetation required within them, the vegetation must be at least five feet tall before it is able to attenuate noise. Nevertheless, this figure puts into perspective how much of an impact that vegetation within a bufferyard has versus an empty yard. If one was to calculate the level of noise reduction for a bufferyard based on distance alone without vegetation or for vegetation that is under five feet tall, the width of the bufferyard in lateral feet would be multiplied by .01 dBA.

Noise Attenuation by Vegetation

As previously stated, all of the bufferyard alternatives designed by Kendig contain some sort of vegetation within them. The density of each bufferyard alternative varies within each classification, therefore the level of noise attenuation varies as well. The density of each bufferyard alternative is determined by calculating the number of plant units per square foot of bufferyard. While this number is diminutive, it is significant in that it distinguishes dense bufferyards from the sparsely planted alternatives. To approximate the level of noise attenuation for each alternative, the range of noise attenuation is evenly distributed over the range of density in the following intervals:
Vegetation Density as a Determinant of Noise Attenuation

<table>
<thead>
<tr>
<th>Plant units per sqft</th>
<th>Noise attenuation per lateral foot depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-.0086</td>
<td>.012 dBA</td>
</tr>
<tr>
<td>.0087-.0167</td>
<td>.014 dBA</td>
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<tr>
<td>.0168-.0248</td>
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<td>.0249-.0329</td>
<td>.018 dBA</td>
</tr>
<tr>
<td>.0330-.0410</td>
<td>.020 dBA</td>
</tr>
</tbody>
</table>

To calculate the level of noise reduction for each bufferyard alternatives with vegetation, the width of the bufferyard in linear feet for each interval of density is multiplied by the corresponding level of noise attenuation.

Noise Attenuation by Physical Barrier

As mentioned above, calculating noise attenuation can be rather confusing, especially for physical barriers. Noise attenuation by a physical barrier is a function of the height of the barrier, the distance the barrier is from the sender (or noise creator), and the height of the sender and receiver (the one hearing the noise).

These variables and their place within a bufferyard are illustrated below. The height of the barrier has already been established by Kendig. The distance the barrier is from the sender has also been identified as the width of the bufferyard. The height of the sender and receiver has been established at 5 feet, an average height of a person who may be hearing the noise. Each has been set at the same height to simplify calculations. Based on these variables, a shadow angle can be calculated (theta), which is the angle the noise is deflected by the barrier.
Components for Deriving Noise Attenuation by a Physical Barrier

The trigonometric function for deriving the angle (theta) is the tangent of the angle, or the height divided by the base (American Bridge Co.). For purposes of this study, the height is the distance the barrier stands above the height of the sender and the base is the width of the bufferyard (see illustration). Unfortunately, once this angle is found, there is no simple formula for this calculation and thus a chart, established by E. Grandjean, will be used to find the approximate decibel attenuation for each barrier based on the bufferyard width and the angle itself. This chart follows.

Reduction of Noise-Level by an Obstacle

FIGURE 2.11. Reduction of noise-level by an obstacle. \( h/\lambda \) = ratio of obstacle-height to wave-length of sound. The scale marked \( h \), 'effective height of wall', is approximately correct for a wave-length of 2 metres. After Lauber (34).
The Physical Barrier Noise Attenuation Chart calculates noise attenuation by the presence of a physical barrier exclusively. The elements involved in this chart and the corresponding calculations are explained in the following descriptions.

*given* denotes that the value has been determined by Kendig
*conversion* denotes that the value has been converted from metric to a customary value
*calculation* denotes that the value has been derived from a calculation
*charting* denotes that the value has been derived from a chart

**Barrier** *(given)*: The identified barrier as defined by Kendig.

**Height** *(ft)* *(given)*: The height of the barrier measured in feet.

**Height Above Sender & Receiver** *(calculation)*: = (Height *(ft)* - 5 ft): The portion of the barrier that is above the height of the sound producer and receiver. The sender and receiver are established at 5 feet.

**Height Above Sender & Receiver** *(m)* *(conversion)*: = (Height Above Sender / 3): The height of the barrier above the sender and receiver converted to meters.

**Distance from sender** *(ft)* *(given)*: The distance between the sender and the barrier measured in feet.

**Distance from sender** *(m)* *(conversion)*: = (Distance *(ft)* / 3): The distance from sender converted to meters.

**theta** *(calculation)*: = [180/pi * Arc tangent of (Height *(m)* / Distance *(m)*)]: The shadow angle.

**Charted dBA** *(charting)*: Using the coordinates Distance From Sender *(m)*, theta, and the Reduction of Noise-Level by an Obstacle chart created by E. Grandjean, the attenuation of noise by the barrier can be found.
### Physical Barrier Noise Attenuation (dBA)

<table>
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<th>Barrier Height (ft)</th>
<th>Height above Sender (ft)</th>
<th>Height above Sender (m)</th>
<th>Distance from sender (ft)</th>
<th>Distance from sender (m)</th>
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<th>Charted dBA attenuation</th>
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<td>x</td>
</tr>
<tr>
<td>B2</td>
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<td>16.67</td>
<td>x</td>
<td>x</td>
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<td>B3</td>
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<td>BW1</td>
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<td>BW2</td>
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<td>0.67</td>
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</tr>
<tr>
<td>BW3</td>
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<td>3</td>
<td>1.00</td>
<td>50</td>
<td>16.67</td>
<td>3</td>
<td>13</td>
</tr>
</tbody>
</table>

1. source and receiver are set at 50°.
2. x denotes that source is above the barrier, and therefore barrier has no impact.
Rank as a Visual Separator

Visual separation is not a commensurable value. Therefore, the level of visual separation created by a bufferyard alternative can only be ranked in comparison with other alternatives. Visual separation is, however, a function of vegetation density and/or the presence of a physical barrier. In other words, the more dense a bufferyard, the more effective as visual separator it is.

Each bufferyard alternative established by Kendig has a different width and density. A common denominator for all alternatives is the number of plant units per square foot of bufferyard. This is derived by adding the number of plant units required for each alternative and then dividing by the area in square feet.

Evaluation Chart for Kendig's Proposed Bufferyards

The Evaluation Chart for Kendig's Proposed Bufferyards displays all the Classified Bufferyards and their alternatives simultaneously. Calculations for noise attenuation and visual separation rank for each are shown, so that comparison of the alternatives to each other and other classifications can easily be observed.

The definition and calculation explanations for each of the elements within the chart are given below.

given denotes that the value has been determined by Kendig
conversion denotes that the value has been converted from metric to a customary value
calculation denotes that the value has been derived from a calculation
observation denotes that the value was derived by comparing other values

Bufferyard Classification (given): The classification of the bufferyard as defined by Kendig.

Classification Alternatives (given): The alternatives for each classified bufferyard as defined by Kendig.
Plant Unit Multiplier (given): The multiplier used to determine the number of required plant units for 100 linear feet length of each bufferyard based on the given width.

Width (feet) (given): The required width of the bufferyard alternatives as defined by Kendig.

Canopy Tree units per 100 feet linear length (given): The required number of canopy trees required for 100 feet linear length of each alternative multiplied by the plant unit multiplier.

Understory Tree units per 100 feet linear length (given): The required number of understory trees required for 100 feet linear length of each alternative multiplied by the plant unit multiplier.

Shrubbery units per 100 feet linear length (given): The required number of shrubs required for 100 feet linear length of each alternative multiplied by the plant unit multiplier.

Conifer/Evergreen units per 100 feet linear length (given): The required number of conifers or evergreens required for 100 feet linear length of each alternative multiplied by the plant unit multiplier.

Physical Structure (Alternative A) (given): The first alternative physical structure required to be placed in the bufferyard nearest the burdened use.

Physical Structure (Alternative B) (given): The second alternative physical structure required to be placed in the bufferyard nearest the burdened use.

Attenuation by Distance (per linear foot) (given): The quantity of noise attenuated exclusively by distance measured in decibels per linear foot. Value = .10 dBA per foot.

Total Attenuation by Distance (dBA) (calculation): = (Width * Attenuation by Distance) The total amount of noise attenuated by distance for each alternative. For comparison to the impact that vegetation makes.
Total Attenuation by Vegetation (per linear foot) (given): The quantity of noised attenuated by the combination of distance and vegetation measured in decibels per lateral foot.

<table>
<thead>
<tr>
<th>Value = Plant units per sqft</th>
<th>Noise attenuation per lateral foot</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-.0086</td>
<td>.012 dBA</td>
</tr>
<tr>
<td>.0087-.0167</td>
<td>.014 dBA</td>
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<td>.0249-.0329</td>
<td>.018 dBA</td>
</tr>
<tr>
<td>.0330-.0410</td>
<td>.020 dBA</td>
</tr>
</tbody>
</table>

Vegetation Attenuation (dBA) (calculation) := (Width * Attenuation by Vegetation): Total noise attenuation by vegetation in a bufferyard with vegetation that stands above 5 feet high (the established height of the sender).

For bufferyard alternatives with shrubbery requirements only (vegetation less that 5 feet tall), the noise attenuation by distance is used (Width * Attenuation by Distance).

Attenuation (dBA) Alternative A (calculation): The attenuation by the first alternative physical structure as calculated and charted in the previous chart.

Attenuation (dBA) Alternative B (calculation): The attenuation by the second alternative physical structure as calculated and charted in the previous chart.

Total Attenuation Alternative A, B (calculation): The higher of the two calculations for Vegetation Attenuation and Physical Barrier.

Density Factor (calculation) := (sum of all vegetation units) / (Width * Length) The number of plant units per square foot of each bufferyard alternative.

Rank as a Visual Separator (Barrier Alt. A) (observation): A value of "1" is the best visual separator of the bufferyard alternatives using Barrier alternative A. (Alternative with highest Density Factor to lowest factor (1-4)).

Rank as a Visual Separator (Barrier Alt. B) (observation): A value of "1" is the best visual separator of the bufferyard alternatives using barrier alternative B. (Alternative with highest Density Factor to lowest factor (1-4)).
## Evaluation Chart for Kendig's Proposed Bufferyards

| Bufferyard Classification | Plant Unit Multipliers | Length (ft) | Width (ft) | Area (square ft) | Canopy Trees (units per 100 ft lateral length) | Understory Trees (units per 100 ft lateral length) | Shrubbery (units per 100 ft lateral length) | Arbour Height (Alternative A) | Physical Structure (Alternative A) | Physical Structure (Alternative B) | Arbour Height (Alternative B) | Barrier Height (Alternative A) | Barrier Height (Alternative B) | Total Attenuation by Distance (dBA) | Total Attenuation by Vegetation (dBA) | Attenuation (dBA) Alternative A | Attenuation (dBA) Alternative B | Rank of A Visual Separator (Barrier Alt A) | Rank of B Visual Separator (Barrier Alt B) | Density: plant units per square foot of bufferyard |
|---------------------------|------------------------|-------------|------------|-----------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------|-------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|
| **A**                     |                        |             |            |                 |                                               |                                               |                                               |                                   |                               |                                   |                                   |                                   |                                   |                                   |                                   |                                   |                                   |                                   |                                   |                                   |
| 1                         | 1.00                    | 100         | 30.00      | 3,000           | 0                                              | 0                                              | 36                                             | 0.15                             | 0.04                          | 0.15                             | 0.04                             | 0.09                             | 0.09                             | 0.15                             | 0.15                             | 0.09                            | 0.09                             | 3                                | 3                                |
| 2                         | 1.00                    | 200         | 25.00      | 2,500           | 0                                              | 0                                              | 36                                             | 0.15                             | 0.04                          | 0.15                             | 0.04                             | 0.09                             | 0.09                             | 0.15                             | 0.15                             | 0.09                            | 0.09                             | 3                                | 3                                |
| 3                         | 1.00                    | 200         | 20.00      | 2,000           | 0                                              | 0                                              | 36                                             | 0.15                             | 0.04                          | 0.15                             | 0.04                             | 0.09                             | 0.09                             | 0.15                             | 0.15                             | 0.09                            | 0.09                             | 3                                | 3                                |
| 4                         | 1.00                    | 150         | 15.00      | 1,500           | 0                                              | 0                                              | 36                                             | 0.15                             | 0.04                          | 0.15                             | 0.04                             | 0.09                             | 0.09                             | 0.15                             | 0.15                             | 0.09                            | 0.09                             | 3                                | 3                                |
| **B**                     |                        |             |            |                 |                                               |                                               |                                               |                                   |                               |                                   |                                   |                                   |                                   |                                   |                                   |                                   |                                   |                                   |                                   |                                   |
| 1                         | 1.00                    | 100         | 12.50      | 1,250           | 0.24                                           | 0.04                                           | 1                                              | 0.15                             | 0.09                          | 0.15                             | 0.09                             | 0.09                             | 0.09                             | 0.06                             | 0.06                             | 0.06                            | 0.06                             | 1                                | 1                                |
| 2                         | 1.00                    | 200         | 10.00      | 2,000           | 0.36                                           | 0.06                                           | 1                                              | 0.15                             | 0.09                          | 0.15                             | 0.09                             | 0.09                             | 0.09                             | 0.06                             | 0.06                             | 0.06                            | 0.06                             | 1                                | 1                                |
| 3                         | 1.00                    | 150         | 7.50       | 1,125           | 0.48                                           | 0.08                                           | 1                                              | 0.15                             | 0.09                          | 0.15                             | 0.09                             | 0.09                             | 0.09                             | 0.06                             | 0.06                             | 0.06                            | 0.06                             | 1                                | 1                                |
| 4                         | 1.00                    | 100         | 5.00       | 500             | 0.6                                            | 0                                              | 1                                              | 0.15                             | 0.09                          | 0.15                             | 0.09                             | 0.09                             | 0.09                             | 0.06                             | 0.06                             | 0.06                            | 0.06                             | 1                                | 1                                |
| **C**                     |                        |             |            |                 |                                               |                                               |                                               |                                   |                               |                                   |                                   |                                   |                                   |                                   |                                   |                                   |                                   |                                   |                                   |                                   |
| 1                         | 1.00                    | 100         | 15.00      | 1,500           | 0.8                                            | 0                                              | 1                                              | 0.15                             | 0.09                          | 0.15                             | 0.09                             | 0.09                             | 0.09                             | 0.06                             | 0.06                             | 0.06                            | 0.06                             | 1                                | 1                                |
| 2                         | 1.00                    | 200         | 10.00      | 2,000           | 0.6                                            | 0.1                                              | 1                                              | 0.15                             | 0.09                          | 0.15                             | 0.09                             | 0.09                             | 0.09                             | 0.06                             | 0.06                             | 0.06                            | 0.06                             | 1                                | 1                                |
| 3                         | 1.00                    | 150         | 7.50       | 1,125           | 0.8                                            | 0.1                                              | 1                                              | 0.15                             | 0.09                          | 0.15                             | 0.09                             | 0.09                             | 0.09                             | 0.06                             | 0.06                             | 0.06                            | 0.06                             | 1                                | 1                                |
| 4                         | 1.00                    | 100         | 5.00       | 500             | 0.6                                            | 0                                              | 1                                              | 0.15                             | 0.09                          | 0.15                             | 0.09                             | 0.09                             | 0.09                             | 0.06                             | 0.06                             | 0.06                            | 0.06                             | 1                                | 1                                |
| **D**                     |                        |             |            |                 |                                               |                                               |                                               |                                   |                               |                                   |                                   |                                   |                                   |                                   |                                   |                                   |                                   |                                   |                                   |                                   |
| 1                         | 1.00                    | 100         | 3.00       | 300             | 0.8                                            | 1.6                                              | 1                                              | 0.15                             | 0.09                          | 0.15                             | 0.09                             | 0.09                             | 0.09                             | 0.06                             | 0.06                             | 0.06                            | 0.06                             | 1                                | 1                                |
| 2                         | 1.00                    | 200         | 2.50       | 250             | 1.2                                            | 1.3                                              | 1                                              | 0.15                             | 0.09                          | 0.15                             | 0.09                             | 0.09                             | 0.09                             | 0.06                             | 0.06                             | 0.06                            | 0.06                             | 1                                | 1                                |
| 3                         | 1.00                    | 150         | 1.50       | 150             | 1.3                                            | 1.3                                              | 1                                              | 0.15                             | 0.09                          | 0.15                             | 0.09                             | 0.09                             | 0.09                             | 0.06                             | 0.06                             | 0.06                            | 0.06                             | 1                                | 1                                |
| 4                         | 1.00                    | 100         | 1.00       | 100             | 1.3                                            | 1.3                                              | 1                                              | 0.15                             | 0.09                          | 0.15                             | 0.09                             | 0.09                             | 0.09                             | 0.06                             | 0.06                             | 0.06                            | 0.06                             | 1                                | 1                                |
## Evaluation Chart for Kendig's Proposed Buffer Yards

<table>
<thead>
<tr>
<th>Bufferyard Classification</th>
<th>Plant Unit Multiplier</th>
<th>Length (feet)</th>
<th>Width (feet)</th>
<th>Area (square feet)</th>
<th>Canopy Trees units per 100 ft linear width</th>
<th>Understory Trees units per 100 ft linear width</th>
<th>Shrubs units per 100 ft linear width</th>
<th>Ground Cover units per 100 ft linear width</th>
<th>Penetration of Physical Structure (Alternative A)</th>
<th>Physical Structure (Alternative A)</th>
<th>Penetration of Physical Structure (Alternative B)</th>
<th>Physical Structure (Alternative B)</th>
<th>Total Attenuation by Distance (dBA per linear foot)</th>
<th>Total Attenuation by Vegetation (dBA)</th>
<th>Alternation (dBA) Alternative A</th>
<th>Alternation (dBA) Alternative B</th>
<th>Total Attenuation (Barrier Alt A) (dBA)</th>
<th>Total Attenuation (Barrier Alt B) (dBA)</th>
<th>Density (plant units per square foot of bufferyard)</th>
<th>Rank as a Visual Separator (Barrier Alt A)</th>
<th>Rank as a Visual Separator (Barrier Alt B)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**Notes:**
- The chart details the evaluation of Kendig's proposed buffer yard designs, including the number of plant units, their linear width coverage, and the resultant attenuation and density for different bufferyard classifications.
- The attenuation values are calculated based on the distance and vegetation density.
- The density values are determined per square foot of bufferyard area.
- The ranks are assigned based on the visual impact of each bufferyard design alternative.
## Evaluation Chart for Kendig's Proposed Bufferyards

<table>
<thead>
<tr>
<th>Bufferyard Classification</th>
<th>Plant Unit Multiplier</th>
<th>Length (feet)</th>
<th>Width (feet)</th>
<th>Area (square feet)</th>
<th>Cherry Tree units per 100ft lateral width</th>
<th>Understory Tree units per 100ft lateral width</th>
<th>Strawberry units per 100ft lateral width</th>
<th>Conifer Evergreen units per 100ft lateral width</th>
<th>Physical Structure (Alternative A)</th>
<th>Barrier Height (Alternative A)</th>
<th>Total Alternation (Barrier Alt A) (dB)</th>
<th>Total Alternation (Barrier Alt B) (dB)</th>
<th>Density (plant units per square root of bufferyard)</th>
<th>Rank as a Visual Separator (Barrier Alt A)</th>
<th>Rank as a Visual Separator (Barrier Alt B)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>80</td>
<td>100</td>
<td>100</td>
<td>6</td>
<td>9</td>
<td>56</td>
<td>18</td>
<td>B1 4.00 ft</td>
<td>F3 6.00 ft</td>
<td>0.01</td>
<td>0.90</td>
<td>0.50</td>
<td>0.70</td>
<td>11.00</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>80</td>
<td>100</td>
<td>50</td>
<td>4</td>
<td>8</td>
<td>50</td>
<td>4</td>
<td>B2 5.00 ft</td>
<td>F4 6.00 ft</td>
<td>0.01</td>
<td>0.70</td>
<td>0.50</td>
<td>0.48</td>
<td>11.00</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>80</td>
<td>100</td>
<td>40</td>
<td>4</td>
<td>8</td>
<td>50</td>
<td>4</td>
<td>F5 6.00 ft</td>
<td>F5 6.00 ft</td>
<td>0.01</td>
<td>0.70</td>
<td>0.40</td>
<td>0.48</td>
<td>11.00</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>80</td>
<td>100</td>
<td>30</td>
<td>3</td>
<td>8</td>
<td>48</td>
<td>38</td>
<td>B1 8.00 ft</td>
<td>F6 8.00 ft</td>
<td>0.01</td>
<td>0.70</td>
<td>0.40</td>
<td>0.48</td>
<td>11.00</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>80</td>
<td>100</td>
<td>25</td>
<td>3</td>
<td>8</td>
<td>48</td>
<td>48</td>
<td>B2 8.00 ft</td>
<td>F7 8.00 ft</td>
<td>0.01</td>
<td>0.90</td>
<td>0.40</td>
<td>0.48</td>
<td>11.00</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>80</td>
<td>100</td>
<td>20</td>
<td>2</td>
<td>8</td>
<td>48</td>
<td>48</td>
<td>B3 8.00 ft</td>
<td>F8 8.00 ft</td>
<td>0.01</td>
<td>1.05</td>
<td>0.40</td>
<td>0.48</td>
<td>11.00</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>80</td>
<td>100</td>
<td>15</td>
<td>1</td>
<td>8</td>
<td>48</td>
<td>48</td>
<td>B4 8.00 ft</td>
<td>F9 8.00 ft</td>
<td>0.01</td>
<td>1.05</td>
<td>0.40</td>
<td>0.48</td>
<td>11.00</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>80</td>
<td>100</td>
<td>10</td>
<td>1</td>
<td>8</td>
<td>48</td>
<td>48</td>
<td>B5 8.00 ft</td>
<td>F10 8.00 ft</td>
<td>0.01</td>
<td>1.05</td>
<td>0.40</td>
<td>0.48</td>
<td>11.00</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>80</td>
<td>100</td>
<td>5</td>
<td>1</td>
<td>8</td>
<td>48</td>
<td>48</td>
<td>B6 8.00 ft</td>
<td>F11 8.00 ft</td>
<td>0.01</td>
<td>1.05</td>
<td>0.40</td>
<td>0.48</td>
<td>11.00</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>80</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>48</td>
<td>48</td>
<td>B7 8.00 ft</td>
<td>F12 8.00 ft</td>
<td>0.01</td>
<td>1.05</td>
<td>0.40</td>
<td>0.48</td>
<td>11.00</td>
</tr>
</tbody>
</table>

Note: The table above represents the evaluation chart for Kendig's proposed bufferyards, detailing various parameters such as plant unit multipliers, length, width, area, and various units per 100 feet, along with the total alternation and density rankings.
Example

In order to more clearly explain the detailed bufferyard information chart and illustrate the calculation procedure, one of Kendig’s bufferyard alternatives will be examined in detail.

The following graphic is the description of Bufferyard H as established by Kendig:

Description of Bufferyard H

BUFFERYARD H
<table>
<thead>
<tr>
<th>Bufferyard Classification</th>
<th>Classification Alternatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planet Unit Multiplier</td>
<td></td>
</tr>
<tr>
<td>Length (feet)</td>
<td></td>
</tr>
<tr>
<td>Width (feet)</td>
<td></td>
</tr>
<tr>
<td>Area (square feet)</td>
<td></td>
</tr>
<tr>
<td>Canopy Tree units per 1000 lateral width</td>
<td></td>
</tr>
<tr>
<td>Understory Tree units per 1000 lateral width</td>
<td></td>
</tr>
<tr>
<td>Shrubby units per 1000 lateral width</td>
<td></td>
</tr>
<tr>
<td>Conifer Evergreen units per 1000 lateral width</td>
<td></td>
</tr>
<tr>
<td>Physical Structure (Alternative A)</td>
<td></td>
</tr>
<tr>
<td>Barrier Height (Alternative A) (feet)</td>
<td></td>
</tr>
<tr>
<td>Physical Structure (Alternative B)</td>
<td></td>
</tr>
<tr>
<td>Barrier Height (Alternative B) (feet)</td>
<td></td>
</tr>
<tr>
<td>Attenuation by Distance (dBA per linear foot)</td>
<td></td>
</tr>
<tr>
<td>Total Attenuation by Distance (dBA)</td>
<td></td>
</tr>
<tr>
<td>Total Attenuation by Vegetation (dBA)</td>
<td></td>
</tr>
<tr>
<td>Attenuation (dBA) Alternative A</td>
<td></td>
</tr>
<tr>
<td>Attenuation (dBA) Alternative B</td>
<td></td>
</tr>
<tr>
<td>Total Attenuation (Barrier Alt A) (dBA)</td>
<td></td>
</tr>
<tr>
<td>Total Attenuation (Barrier Alt B) (dBA)</td>
<td></td>
</tr>
<tr>
<td>Density plant units per square foot of bufferyard</td>
<td></td>
</tr>
<tr>
<td>Rank as a Visual Separator (Barrier Alt A)</td>
<td></td>
</tr>
<tr>
<td>Rank as a Visual Separator (Barrier Alt B)</td>
<td></td>
</tr>
</tbody>
</table>
Bufferyard Classification: The classification of the selected example is Bufferyard H.

Classification Alternatives: Bufferyard H has four alternatives: 1, 2, 3, and 4.

Plant Unit Multiplier: The Plant Unit Multiplier for each alternative is given below:

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.6</td>
</tr>
<tr>
<td>2</td>
<td>0.8</td>
</tr>
<tr>
<td>3</td>
<td>1.0</td>
</tr>
<tr>
<td>4</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Width: The width of each alternative is measured in linear feet as follows:

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Width (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>50</td>
</tr>
<tr>
<td>2</td>
<td>40</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>4</td>
<td>20</td>
</tr>
</tbody>
</table>

Canopy Trees: The number of canopy trees for each alternative follows:

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Canopy Trees</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

Understory Trees: The number of understory trees for each alternative follows:

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Understory Trees</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.5</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>7.5</td>
</tr>
<tr>
<td>4</td>
<td>4.5</td>
</tr>
</tbody>
</table>
**Shrubs:** The number of shrubs for each alternative follows:

- Alternative 1: 18 shrubs
- Alternative 2: 24 shrubs
- Alternative 3: 30 shrubs
- Alternative 4: 318 shrubs

**Conifers:** The number of conifers for each alternative follows:

- Alternative 1: 9 conifers
- Alternative 2: 12 conifers
- Alternative 3: 15 conifers
- Alternative 4: 9 conifers

**Physical Structure (Alternative A), Height:** There is no physical structure required for Alternative 1. The required structures for the remaining alternatives and their height are as follows:

- Alternative 2
  - B1 Earth Berm 1: 4 feet
- Alternative 3
  - B2 Earth Berm 2: 5 feet
- Alternative 4
  - F5 Masonry Wall: 6 feet

**Physical Structure (Alternative B), Height:** Bufferyard alternatives 2 and 3 have a second choice of physical structure. Their description and height are as follows:

- Alternative 2
  - F3 Wood Stockade Fence: 6 feet
- Alternative 3
  - F4 Wood Stockade Fence: 8 feet

**Attenuation by Vegetation:** Alternative 1 is the only alternative that does not require a physical structure. Noise attenuation is therefore a function of vegetation. The noise attenuation by vegetation is calculated as:

\[
\text{attenuation for Alternative 1} = 50 \text{ feet} \times 0.012 \text{ dBA} = 0.60 \text{ dBA}
\]
Attenuation (Alternative A): The remaining alternatives require a physical structure. When calculating noise attenuation, a physical barrier outweighs vegetation. Referring back to the Physical Barrier Noise Attenuation Chart, the charted decibel reduction for each barrier is as follows:

- Alternative 2  B1  40 feet width  no affect on noise
- Alternative 3  B2  30 feet width  6 dBA
- Alternative 4  F5  20 feet width  10 dBA

Because the first alternative physical barrier for bufferyard Alternative 2 is not tall enough to have an affect on noise attenuation, the attenuation by vegetation is used:

\[
\text{attenuation for Alternative 2} = 40 \text{ feet} \times (0.014) \\
= 0.56 \text{ dBA}
\]

Attenuation (Alternative B): The charted decibel reduction for the second alternative physical barrier for Alternatives 2 and 3 are as follows:

- Alternative 2  F3  40 feet  10 dBA
- Alternative 3  F4  30 feet  14 dBA

Total Attenuation (Alternative A): Considering the first alternative physical barrier or no presence of a barrier, the overall attenuation for each Alternative are as follows:

- Alternative 1  0.6 dBA
- Alternative 2  0.56 dBA
- Alternative 3  6.0 dBA
- Alternative 4  10.0 dBA

Total Attenuation (Alternative B): Considering the second alternative physical barrier, the overall attenuation for Alternatives 2 and 3 changes, while Alternatives 1 and 4 remain unchanged:

- Alternative 1  0.6 dBA
- Alternative 2  10.0 dBA
- Alternative 3  14.0 dBA
- Alternative 4  10.0 dBA
**Density Factor:** The average density of the Alternatives is the number of plant units per square foot of bufferyard. This is calculated below:

\[(\text{canopy trees + understory trees + shrubs + evergreens}) / \text{area}\]

The average density for each Alternative is as follows:

- Alternative 1 \((34.5)/5,000\) feet = \(.0069\) plant units per foot
- Alternative 2 \((46)/4,000\) feet = \(.0115\) plant units per foot
- Alternative 3 \((57.5)/3,000\) feet = \(.0192\) plant units per foot
- Alternative 4 \((34.5)/2,000\) feet = \(.0173\) plant units per foot

**Rank as a Visual Separator (Alternative A):** The rank as a visual separator is a function of either the height of the physical barrier or the density. For the first alternative physical barrier or with no required barrier, the rank as visual separator is as follows:

<table>
<thead>
<tr>
<th>Rank</th>
<th>Alternative</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Alternative 1</td>
<td>lowest density of alternatives without barrier</td>
</tr>
<tr>
<td>3</td>
<td>Alternative 2</td>
<td>highest density of alternatives without barrier</td>
</tr>
<tr>
<td>2</td>
<td>Alternative 3</td>
<td>physical barrier at 5 feet</td>
</tr>
<tr>
<td>1</td>
<td>Alternative 4</td>
<td>tallest physical barrier at 6 feet</td>
</tr>
</tbody>
</table>

**Rank as a Visual Separator (Alternative B):** Considering the second alternative physical barrier for Alternatives 2 and 3, the rank as a visual separator is as follows:

<table>
<thead>
<tr>
<th>Rank</th>
<th>Alternative</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Alternative 1</td>
<td>lowest density and without barrier</td>
</tr>
<tr>
<td>3</td>
<td>Alternative 2</td>
<td>physical barrier at 6 feet and density of .0115</td>
</tr>
<tr>
<td>1</td>
<td>Alternative 3</td>
<td>tallest physical barrier at 8 feet</td>
</tr>
<tr>
<td>2</td>
<td>Alternative 4</td>
<td>physical barrier at 6 feet and density of .0173</td>
</tr>
</tbody>
</table>

The alternatives of Bufferyard H can be compared to each other. Of the four alternatives using the first alternative physical barrier, Alternative 4 has the highest level of noise attenuation and ranks first as a visual separator. Using the second alternative physical barrier, Alternative 3 has the highest level of noise attenuation and ranks first as a visual separator.
Chapter 5
Variable Identification

Introduction

In analyzing landscape ordinances across the country, Gary Robinette notes that "one obvious characteristic of the most prestigious, exclusive, and desirable places to live and work is that they are quiet, attractive, are free of pollution, and have well maintained, mature landscape development" (Robinette, 1992). These characteristics did not evolve coincidentally, but happened over time as a result of careful and tedious planning. Robinette also reasons that if these qualities are replicated in other communities, then they too will become more attractive, more environmentally balanced, and ultimately become more environmentally sound (Robinette, 1992). Thus evolves the need for landscape ordinances.

There are many reasons for adopting or creating a landscape ordinance for a community. Underlying these reasons is one primary premise. Landscape ordinances are directed toward marginal or local builders, developers, or business people who cut corners on project costs by scrimping on or deleting landscape development from their projects (Robinette, 1992). From this premise, the more specific aspects or components of an ordinance evolve.

Ordinance formation is built around a framework of aesthetic, economic, and environmental concerns specific to each community adopting the ordinance. Each community focuses on different elements, whether they are within the same county or across the country. These elements differ in the persons drafting the language, the
administration, political considerations, regional variations, environmental sensitivities, and community concerns (Robinette, 1992).

Drafting the language of an ordinance may not seem difficult, but the persons doing the actual writing can have quite an impact on the final product. The document may be difficult to read and comprehend if there is too much legalistic jargon. The ordinance may be too simplistic and full of loopholes if composed by one who is inexperienced in such writing. Worst of all, the final report may not contain exactly what the community needs if the author is an outsider and not familiar with the environmental concerns of the community.

Just as important, the administration process and political framework has an impact on the performance of the ordinance. If no one is available to assess project landscaping or knowledgeable about plant species, the ordinance will not be effectively enforced. If the ordinance is too specific and hard to comprehend, the administration has no choice but to continually modify the rules of the game as they go along.

Regional and environmental variations affect the vegetation and climatic components of an ordinance. Plant species that are native to an area of the country may need to be preserved and thus need to be mentioned within the ordinance. Communities in areas of the country that experience warm weather year-round will have different needs and concerns than those of colder climates, and therefore the elements within the ordinance vary. Citizens within each specific community also have certain standards or visions of what their community is or can be in terms of parks, green spaces, and landscape preservation. These standards can affect the specificity of the ordinance.

Despite these variations and concerns, by accepting a landscape ordinance into a community, one premise is realized. It is possible to regulate and control levels and types of landscape installation within a community and the resulting landscape will be better than it would otherwise be without an ordinance.
The Variables

The first step in formulating P.L.U.S. Bufferyard Comparison Matrix is the determination of the variables used for comparing the classified bufferyards. These variables are derived from the elements of existing landscape ordinances. Every community has a completely different mix of problems, personalities, and politics which determines the intent, purpose, and content of their landscape ordinance (Robinette, 1992). While regional and environmental variations are known to exist, there are many common elements within various landscape ordinances. By reviewing several community ordinances from various states, such as Florida, Texas, Kentucky, Colorado, and others, these elements have been identified and are discussed below.

The following table entitled Various Ordinances and the Concerns They Address lists the various landscape ordinances that were examined and the all of the elements mentioned verbatim within them. The far right hand column of the table is a measurement of how specific the language of the ordinance was. Along the bottom row of the table is a tally of how often the element per se was mentioned. For example, the Landscape Ordinance for St. Petersburg, Florida, lists a few of the identified elements: Adds to Aesthetic Quality, Improves the Quality of Life, Adds to Property Value, Improves the Overall Community Appearance, and Screens/Buffers Land Uses. The right hand column shows that this ordinance specifically mentions five (5) of the elements. Along the bottom row, one specific element, "Adds to Aesthetic Quality", was mentioned in 72% of the ordinances examined. What each of these elements is interpreted to mean or includes is briefly described.
Promotes Quality Development

Promoting quality development was a need expressed in only one of the ordinances, or 4% of them. Landscape amenities, proper setbacks, and screening are said to promote a positive city image reflecting order, harmony, and pride in new developments. Therefore, new development meeting the specific standards set by the community as established by the landscape ordinance is to be considered quality development.

Adds to Aesthetic Quality

The aesthetic quality of the community was a common concern among 72% of the landscape ordinances. Aesthetic quality is a combined measurement of several factors including the reduction of impervious surface cover, preservation of existing landscape and native vegetation, complimenting the community architecture, and the separation of roadways from other less intense land uses.

Improves Quality of Life

Improving the quality of life is another element that is a measurement of several factors. This element was mentioned in 52% of the ordinances. The quality of life is improved by landscape standards because they promote immediate and long-term public health, safety, economic stability, and general welfare of the community. Landscape standards achieve this by preventing reduction in the community's urban tree canopy, protecting land uses from each other, adding to property value, improving overall community appearance, attenuation of noise, establishing wind breaks, and facilitating pedestrian movement and safety. The landscape also affects the psychological well-being of residents. Trees are physiologically, psychologically, sociologically, and aesthetically necessary counterpoints to the man-made urban setting.
Adds to Property Value

The fact that landscaping adds to property value was mentioned in 56% of the ordinances. Landscaping not only enhances the appearance and customer attraction of commercial areas, but the aesthetics of the landscape is a vital ingredient to maintaining and creating cultural and economic value for the community. Furthermore, landscaping between incompatible land uses protects, and preserves, and enhances the value of the land, which ultimately adds to property value within the community.

Improves Overall Community Appearance

The overall appearance of the community was a concern within 48% of the ordinances. Appearance is a function of visual interest, variety, and integral harmony. Vegetation can help to add variety to the urban landscape by providing contrast and relief from the built-up environment.

Increases Overall Landscaping

Increasing the amount of landscaping was suggested in 20% of the ordinances. Not only does increased vegetation aid in stabilizing the environment's ecological balance, but it protects the atmosphere, lands, and waters from pollution, impairment, and destruction. Suggesting that an ordinance must increase the amount of landscaping ultimately prevents damage to and unnecessary removal of vegetation during land development process.

Screen / Buffers Land Uses

Screening and buffering land uses from one another is the whole purpose of Lane Kendig's ordinance, and it is mentioned in 64% of the ordinances examined. Landscaping between land uses protects incompatible land uses from nuisances,
minimizes potential conflicts between land uses, and ensures that a natural area of appropriate size exists between incompatible land uses.

Shades / Heat Abatement / Glare Reduction

The concern for heat abatement was noted in 64% of the ordinances. It is obvious that trees create shade by reducing the amount of direct sunlight within an area. This same effect also promotes energy efficiency within buildings and homes by reducing the need for air conditioning and heating.

Noise Attenuation

The attenuation of noise was a concern contained within 60% of the ordinances. Vegetation is able to absorb or block some forms of noise pollution, especially along roadways and within industrial areas. During the winter months, however, deciduous vegetation loses most of its ability to filter noise. Conifers and evergreens are the most effective trees and shrubs in the reduction of noise pollution year round.

Vibration Attenuation

Only 4% of the ordinances listed the attenuation of vibration. Vibration caused by industrial machinery, railroads, and speeding traffic can be absorbed or mediated by tall and dense vegetation, especially when the distance between land uses is substantial.

Air Purification

Air purification was mentioned in 60% of the landscape ordinances. Dense vegetation along roadways and other intense land uses contributes to air purification by filtering dust particles from the air. Deciduous vegetation also regenerates oxygen. This is important because human and animal life depend on the capacity of trees and other vegetation to absorb carbon dioxide and supply oxygen in our atmosphere.