The Production of Sustainable Urban Space:
A Comparative Analysis of Wallingford
and the Carfree Reference District

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A Comparative Analysis of Wallingford
and the Carfree Reference District

Robert S. Matthews

A thesis
submitted in partial fulfillment of the
requirements for the degree of

Master of Urban Planning

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Program Authorized to Offer Degree:
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Graduate School

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Robert S. Matthews

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1. Introduction

Henri Lefebvre's *The Production of Space* is a pivotal work for post-Marxist critical theory and urban geography.[1] By grounding our systems of economic and ideological production in our spatial practice, we can understand both how we shape the urban environment and, in turn, how it shapes us. This is not a linear cause-effect relationship, and thus is not knowable through the methods of hypthetico-deductive science – at least not completely. Instead spatial practice is historical and mutually constitutive. Each and every apparent cause-effect relationship is the product of a historically specific milieu – a milieu that itself experiences constant change through time. Therefore, each moment of spatial practice is bound by spatially and temporally explicit conditions. These myriad cause-effect relationships exist simultaneously in a complex web of interactivity such that a 'chicken-or-egg' type of question finds no meaningful resolution but to identify the limit of such linear thinking. Lefebvre's work provides a powerful framework for understanding the city in terms of spatial production. This study applies these methods to explore the urban environment in terms of the social orientation toward the production of space. Specifically, how might we assess our impact on the planet in light of suggestions from the scientific community that we have imperiled the planetary life-support systems that sustain our entire human enterprise?

For obvious reasons, sustainability has become a major focus for academic and professional inquiry in the past few decades. Key objectives include the attempt to define sustainability and to devise metrics to measure performance toward sustainability goals. The domain of sustainability is broad, increasingly linking environmental, social, and economic issues together. Presently, indicators are utilized to providing a quantifiable metric of such

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[1] Merryfield's *Metromarxism* provides an excellent *precis* of the major post-Marxian thinkers: Benjamin, Lefebvre, Debord, Castells, Harvey, and Berman.

performance by comparing time-series data. For example, we might evaluate sustainability partly based upon the criteria of educational attainment and the amount of lead in drinking water. It is readily apprehended that more education and less lead is better than if the opposite were true – because greater education is correlated with quality of life and lead is correlated with brain damage. The power of indicators is their simplicity in conveying the complex story of sustainability. This information helps us ascertain whether we are trending toward greater sustainability or less, toward a healthier future or not.

Indicators might also be used to compare two existing conditions, such as a downtown area and a low-density suburb. The purpose here would be to expose the similarities and differences between these two forms of urbanism in order to put forth an appropriate, context-specific agenda for change. It also begins to point the way toward understanding how spatial practice and sustainability are linked. For example, if it were found that automobile emissions represent a significant source of CO_2, and that an average suburbanite is responsible for a substantially greater contribution of CO_2 than an urbanite (owing to driving distances, lack of public transportation, jobs/housing balance, etc.), then the suburbs would be indicated as less sustainable. An indicator does not suggest policy choices directly. For example, in the present we might mitigate suburban CO_2 generation through a fuel tax or use of electric vehicles. Or we might alter future land use through zoning to reduce automobile dependency or develop CO_2 sequestration technologies to maintain our current standard of automobility.[2]

The built environment is constantly growing and being transformed by human action. It has been estimated that of the total sum of the built environment today, roughly half was produced in the Modern era. The other half was produced through all remaining

[2] On the topic of reduction vs. transformative technologies, see the conclusion – specifically Costanza's analysis of the potential ramifications of pessimistic and optimistic worldviews with respect to blind technological optimism.

time in human history, i.e. from the beginning of urbanism some ten millennia ago to the dawn of the advanced industrial revolution in the 20th century.[3] This staggering, exponential growth of cities means that we ought to carefully consider our spatial practices in light of sustainability. When we build unsustainably, we burden future generations with needing to mitigate the effects of our decisions today. Undoubtedly, urban design will play an important role in building cities that are more sustainable. To that end, it would be immensely useful to be able to compare an example of the existing built environment to an urban design proposal using sustainability indicators. The goal would be to determine how much more sustainable we could become while balancing other important design goals such as access, safety, public health, financial feasibility, and so forth. This study implements a novel method for such a comparison.

A powerful technique for measuring human impact on natural systems is provided by William Rees and Mathis Wackernagel in their ecological footprint analysis. By reducing our ecological footprint, we are reducing our impact on the planet – by consuming less energy, material, and land. Therefore, as we use Lefebvre's framework to understand how we participate in spatial production, Wackernagel and Rees' techniques for measuring urban performance in terms of ecological footprint provide a methodological approach to measuring spatial practice. When combined with contemporary software tools to manage the large datasets and computationally intensive analysis of the built and proposed environments, it is possible to compare an existing urban area to a sustainable design scheme. The purpose is not only to determine *if* we could build more sustainably, but also *how much* more sustainably. Moreover, it is possible to identify through interpretation the specific compromises in spatial practice that will produce a space of sustainability.

[3] From the Introduction to Leon Krier's *Architecture: Choice or Fate*

2. Purpose of Study

The most fundamental question asked by this research is: *What orientation toward spatial practice creates the best balance between sustainability, social goals, and individual interests?* By looking at the tradeoffs made within each scheme, one can see how values are expressed spatially. Drawing upon Lefebvre's critical theory, the test cases are methodically exposed as the crystallization – real or proposed – of purposive human action in space-time. Following Lefebvre, it is clear that what is enacted physically in the environment has a powerful normative effect on the character of all subsequently interacting spaces – be they physical or conceptual. As a critical theorist, Lefebvre presents at once an explanatory framework for categorizing spatial relationships and a revolutionary project for bending these relationships to the will of human social goals. *The Production of Space* demands that we do more than merely determine how much more sustainable we could be. Rather, alternative orientations toward spatial production are meant to be *enacted* to alter the course of our development, to actualize the desired changes, to allow ourselves to be shaped by our collective conscience in balance with our individual will. Lefebvre's revolutionary call is that planners and designers not simply offer solutions, but strive to implement them. In this way, this study serves to illuminate possibilities for attaining a more sustainable urban future, so that this future may become manifest in reality.

Such an undertaking requires substantial high-quality urban data. Detailed data provided through a Geographic Information System (GIS) greatly enhances the resolution and functionality of land use analysis. For example, we can address the notion of 'open' space with information regarding what actually comprises specific 'open' spaces on the ground in the urban environment as opposed to abstraction or generalization. Through this higher resolution, we are also able to see the 'bigger picture' of many interactive variables.

For example, impervious surfaces may be categorized by coverage type (pavement or building footprints) or by functional purpose (conveyance of automobiles or pedestrians). Each categorization tells a different story of why impervious surfaces exist and how they might be mitigated. By looking at the constellation of these empirical breakdowns, we can interpret the story being enacted via the spatial practice, whether in actuality or as designed. The story of the present sheds light on how we currently live. The story of the future intends to explicate how we could live – in this case, how we might achieve sustainability by simultaneously increasing our commonwealth and decreasing our ecological footprint. Section 3 examines the selected urban environments and presents the tools and data that supports the spatial comparison. Before comparison can ensue, the potential for evaluating a design scheme against the built environment must also be addressed. Section 4 details assesses these conditions of plausibility. Section 5 begins with an overview of use of indicators in general and follows with the specific methods required to support the comparative analyses for the selected indicators.

By using the analytical techniques presented herein, we may compare alternative urban design and planning strategies – intended to lessen the negative human impact on natural systems – against an example from current practice. The information generated through this process creates the opportunity for intersubjective agreement about *how* – as planners, policy-makers, and citizens – we might act to achieve sustainability goals. In brief, this study compares the ecological footprints associated with two cases – the existing Wallingford neighborhood of Seattle, Washington, and the proposed Carfree City Reference District.[4]

[4] See Appendix B for a detailed morphological and spatial description of both cases.

3. Selection and Evaluation of Cases

A basic tenet of this study is that urban schemes designed primarily for pedestrians are inherently more sustainable than those designed primarily for automobiles. This is in part due to the efficiencies gained by compact development and by the reduction of energy inputs and pollution outputs that arise through automobile use. Morphologically, density and dominant mode of transportation are interrelated. Interpreting the ecological footprint analysis of each case in terms of spatial production will demonstrate that the automobile is an important determinant of land use, and that land-use patterns are directly related to ecological footprint. More importantly, it suggests an alternative approach to urbanism that is more sustainable.

Transportation is connected to dwelling unit configuration in several ways. For one, the provision of private yards of any size increases the distances between two points. Larger yards increase these distances geometrically as the expansion occurs two-dimensionally. Before long, distances are too great to be traversed on foot, so some mechanized form of transportation is utilized to increase speed and therefore distance over a given time. These mechanized forms require greater energy consumption and amounts of space for efficient and safe service – with the greatest energy and space devoted to the highest speed and most private form of transportation, the automobile. But just as larger single-family parcels exacerbate a functional dependency upon the automobile, the automobile itself becomes a technological means that allows for additional development of land in the same manner. This is the essence of sprawl, a positive-feedback mechanism that pushes low-density development ever outward.

To address sprawl, we look to how land and dwellings are combined. The dwelling unit configuration describes the density relationship between dwelling unit to land: single-family units, both attached and detached, and multi-family structures, from walk-ups to high-rise towers. These descriptions are often used for building type, but technically this is a distinct categorization, as the following 'grey areas' describe. Duplexes and triplexes, for example, are both typologically single-family, but present themselves as a multifamily configuration – two or three dwellings under one roof. Detached single-family houses may contain an attached accessory dwelling unit (ADU). And large single-family houses are often converted to multiple units later on. The space requirements of dwelling unit configuration define housing density, as expressed in dwelling units per acre (du/a). Detached structures utilize more space than attached ones; single-family structures occupy a greater per unit land coverage (as building footprint) than multifamily structures. Thus, per Figure 1, we can chart dwelling unit configuration from highly dispersed to highly compact along a horizontal axis. On one end of the spectrum would be homes sited on multi-acre parcels, often at 1 dwelling unit per 5 acres (0.2 du/a) or even more. In U.S. practice, these developments are sometimes called 'estate-lands' and find their origin in the 'bourgeois utopias' of late 19th century England, to use Robert Fishman's term.[5] On the other end are very high-density developments such as Hong Kong (figure), or even more extreme, Paolo Soleri's Arcologies (600 du/a or more).[6]

How people move through space is part of this context as well. Higher densities are required to support the financial feasibility of public transportation. Fortunately, public transportation requires significantly less land than private means and therefore dwelling densities can be higher. So there exists a link between the two. Conversely, automobile transportation requires greater land and therefore greater distribution of dwelling units. Traversing longer distances requires the automobile. In this way, when the automobile becomes the dominant mode of mobility, pedestrianism ceases to be practical. The dominant

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[5] Fishman, p11

[6] Soleri's designs for Babel Canyon and Arcodiga are good examples from *Arcology: The City in the Image of Man.*

mode of transportation is plotted along the vertical axis of Figure 1. In general, it may be seen that there is high correlation between dwelling unit density and dominant transportation mode.

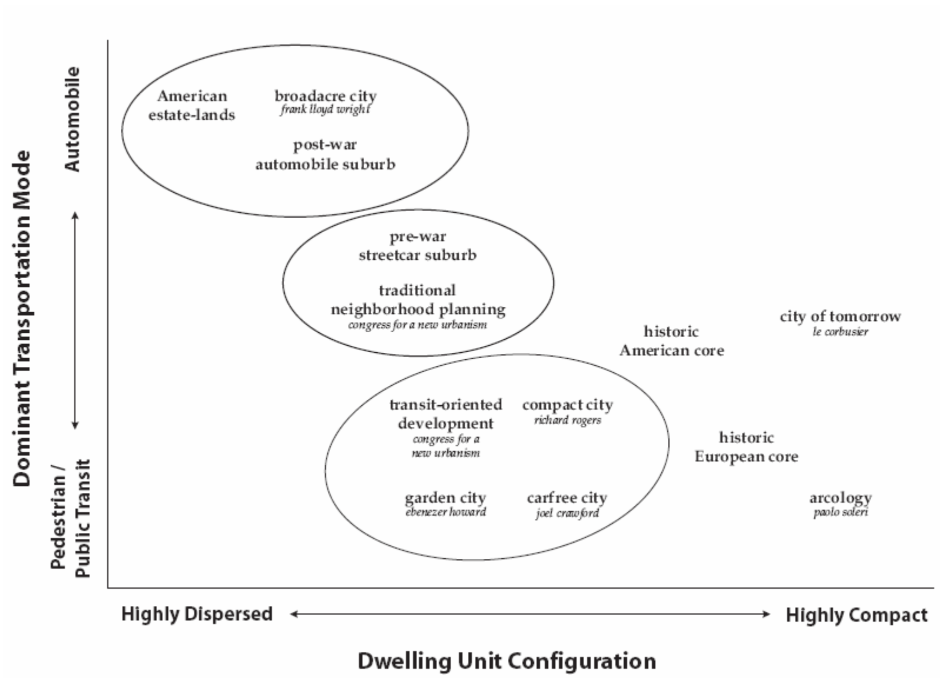

FIGURE 1: Relationship of Dwelling Unit Configuration and Transportation Mode

Much current research is focused on the role of sprawl in a number of ecological and public health issues. If the automobile is an integral component of sprawl, and sprawl is in turn indicted in so many social issues, then schemes that mitigate the effects of automobile space should be highly desirable. If we intend to reduce our ecological footprint by designing for density, then a method that describes this reduction, in quantitative and qualitative terms, will be important. On the morphological spectrum between lower-density *sprawl development* and higher density *compact development*, a study that evaluates urban sustainability performance in terms of lowering our ecological footprint will of course reflect a bias towards higher-density. An automobile suburb will score poorly, by definition, in measures of ‘sprawl’.

A single comparison, therefore, risks appearing tautological, as if to verify only that a denser environment will be more sustainable when sustainability is being measured against density-dependent variables. To counter this, it is important to recognize that the study seeks not to show simply which of two schemes is more sustainable, but that, given certain sustainability criteria, how much performance can be achieved and what spatial practices will produce that performance. Too much emphasis on a single comparison should be avoided; additional comparisons will generate a more complete field of urban practice, in turn allowing for more refined interpretation.

3.1 Existing Case: Wallingford

This study chooses for its built example the Wallingford neighborhood of Seattle, an urban area that reflects a better-case scenario for a district comprised primarily of single-family detached housing. Wallingford contains substantial urban amenities such as large park areas and some important neighborhood commercial areas in addition to a vibrant commercial strip. It is fully accessible by automobile (i.e. there are no pedestrian-only streets), but by virtue of relatively small blocks and significant traffic calming, it is considered pedestrian-friendly.

Wallingford is an excellent example of a *fin-de-siecle* streetcar suburb. Founded in 1883 and annexed to Seattle in 1891, Wallingford has retained much of its neighborhood commercial and architectural character. Today it is one of the most popular neighborhoods in Seattle, with high average home values, owing in part to a number of amenities, including views, and the aforementioned parks and pedestrian-friendly reputation. On the residential streets, substantial traffic calming is generated through narrow double-parked streets (allowing only one way traffic on two-way streets) and traffic circles with infrequent stop-signs – slowing cars down almost to dead slow at intersections. Wallingford appears much closer to a sustainable neighborhood than the lower-density post-war automobile suburbs. In fact, it is very similar in density, if not in outright form, to the traditional neighborhood development concept espoused by the Congress for a New Urbanism.[7]

Another advantage of Wallingford as a test case is its strong boundaries. For spatial analyses, the definition of a neighborhood or district boundary can be somewhat arbitrary, as the urban environment is a continuous system that defies rigid demarcation. *Regional effects* – variations in the measurement of a phenomena that derive from changes to a study area – are an important consideration. The regional effects of any given study area boundary present two problems: 1) just on the other side of the boundary are additional spatial entities that are not considered, and 2) any area-based calculations (e.g. gross housing units per acre, per capita park space, etc.) will be sensitive to changes in this base area as a denominator. Wallingford is bounded by Lake Union to the south, a large public park to the north-west, and high-speed roads to the west (State Highway 99 / Aurora Ave) and to the east (Interstate 5). The traffic intensity along the street boundaries discourage pedestrian crossings while the park areas make destinations beyond the far side quite distant for walkers. Lastly, there is no ferry or water taxi service from the Wallingford waterfront.

3.2 Design Case: The Carfree Reference District

Any scheme that successfully reduces or eliminates automobile dependency would potentially be an important contribution to sustainable design. This is precisely why the selected scheme for the proposed urban environment is free of automobiles. Another way to frame this study might be: how does a carfree scheme compare, in orientation and

[7] As described in the Charter for a New Urbanism and in numerous other works by CNU members.

performance, to an automobile dominated system. There are many schemes, at various scales, that mitigate the automobile's influence, usually with respect to speed (e.g. the Dutch *woonerf*), but sometimes also those which relegate the auto to a secondary, separated right of way from pedestrians (e.g. the Radburn plan).[8] When taken to it's logical extreme, full mitigation of the private automobile means simply eliminating them.[9] In his Life Between Buildings, Jan Gehl extols the superiority of the carfree Venetian model, in which "life and traffic [non-vehicular] exist side by side in the same space… [and] presents no security problems, no exhaust fumes, noise, and dirt, and therefore is has never been necessary to separate work, rest, meals, play, entertainment, and transit."[10]

As will be discussed shortly, a methodical evaluation of an urban design scheme can only occur if sufficient information is available about specific urban characteristics. One scheme that presents a wealth of information related to a well-conceived urban composition is the Carfree City, an urban design scheme authored by Joel Crawford.[11] The Carfree City is an ambitious sustainable urban design. It is presents a multi-scale approach that integrates holistic neighborhood design-based planning on the street, square, block, and district levels. These in turn form part of a high-speed transit typology that boasts average travel time between two furthest points in 37 minutes or less, with most trips being more frequent still – no small feat for a city of 1 million. Appendix B provides a synopsis of the Carfree City design. While these claims may invite the designation 'utopian', sufficient detail exists to evaluate the plausibility of the scheme. In fact, the plausibility of a design scheme is critical

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[8] Gehl, p113

[9] In response to the most common criticism of carfree urbanism, the Carfree City design accommodates motor vehicle access for emergencies, construction, maintenance, certain deliveries, etc. Private use automobiles are displaced altogether, though parking at the periphery of the district could be provided.

[10] Gehl, p111

to this analysis, for if it were implausible, the comparison itself would be moot. The next section is dedicated to the details of design scheme plausibility.

Just as Wallingford does not occur in isolation, neither does the proposed Carfree Reference District (CRD). The delineated boundary area of the CRD is not arbitrary but derived from its position as a node in a larger transit topology. The shape of the CRD's land area, i.e. its specific boundary delineation, is derived from its adjacency to other nodes as described in Appendix B. More detail on the CRD boundary are given in the next section.

3.3 Spatial Comparability

The selected cases have unequal populations and occupy significantly different land areas. How, then, are meaningful comparisons to be derived? This study makes use of two types of comparison: *allocational* and *distributive*. Spatial *allocations* describe the amount of some phenomenon per person. For example, the total amount of land as park space divided by the total population will yield an amount of park space per person. This represents the simple spatial allocation of park space per person. As will be described later, park space is generally accessible by everyone, so there is a uniform distribution in the allocation. For some spatial types, such as the size of one's yard, there is significant variance from very large yards to no yard at all. In these cases, the spatial allocation represents an *average*. Averages have the tendency to obfuscate the underlying distributions, so care must be taken in these cases to unmask the meaning behind the entire spectrum of allocations. The allocation *in aggregate*, be it simple or average, is used for comparison at the district level.[12] Spatial *distributions* represent an amount of something within a give area. For example, a given number of households within a specified walking distance – represented as an area in plan – describes the distribution of 'walkable households'.

[12] For this study, district and neighborhood are considered functionally equivalent geographic terms.

To maintain comparability, the overall spatial allocation for the Reference District is made equal to Wallingford on a per person basis. Appendix A identifies the composition of specific land uses as % of overall land use and as a per person allocation of land area. For Wallingford, the total land area (53,395,528 sf) divided by the population (17,481) yields a 3,044 sf per person share of land.[13] Thus, under idealized conditions, we would say that the resident of the Carfree District should have the same allowance of space, to be disposed with according to an alternative spatial practice. In reality, such greenfield development may not be practical. But for the purpose of comparison, such a normalization is imperative for results to be meaningful.[14]

As mentioned before, the effects of study area size and demarcation are important factors in urban analysis. The quantification of one's share of any environment will change with variation in the study area, so these study areas need to be articulated clearly: Wallingford's *urban area* is defined as the City of Seattle Wallingford neighborhood planning area boundary. It is measured to the centerlines of all streets that form its urban borders. The shoreline of Lake Union forms its southern border and is represented in the data by the city's hydrology layer.[15] Wallingford's urban area is comprised of all land use types aggregated within the bounded study area.

The *urban area* of the Reference District is a circle 760m (2,493 ft) in diameter; it is surrounded by a *greenbelt area* that is made equal to the calculated population of the

[13] Land area from GIS takeoffs, minus substantial area dedicated to the portion of the I-5 corridor that runs along the eastern edge of Wallingford (why?). Population from Bureau of Census data (2000), as calculated at the block group level.

[14] It should not be assumed that greenfield implementation is impractical or not preferable to urban redevelopment. To the first point, we need only look to the explosion of urbanization in China for many examples of new cities. To the latter point, there is considerable disagreement about whether we should use even more virgin land for the attainment of sustainability or if such land should be preserved as (more) natural in favor of the reconfiguration of existing cities. The author believes that comparative analysis such as set forth in this study can shed much light on the debate.

[15] City of Seattle GIS via WAGDA: http://wagda.lib.washington.edu/data/

reference design multiplied by the overall spatial allocation for Wallingford, less the urban area. This means that all gains from efficiency of land use through design-based planning will be given over to the greenbelt open space areas. In this way, the greenbelt area is not arbitrary, but rather is normalized to the overall 'fair share' allocation of space Wallingford residents enjoy. Crawford makes clear that such greenbelt areas might be given over to a whole host of uses, including recreation, urban forestry, local agriculture, or nature preserves. Of course, the less intense the human use, the greater the value of the ecosystem services provided by this greenbelt land.[16]

3.4 Urban Modeling

In order to apply the methods of spatial analysis, a sufficiently detailed model of the design scheme must be assembled or created. If existing spatial models exist, they may be taken together to create an overall model. If no models exist, they need to be drawn in CAD software from drawings (sketches or paper plans) or converted from raster data (i.e. vectorized scans). The dataset must include an accurate representation of the proposed built environment, for it will act as a virtual proxy in the comparisons. For this study, a detailed model of the Reference District was created from a set of specifications provided and clarified by the author.[17]

There are many meanings given to the word 'model' in academic literature. Unless abstracted to dilution, the term *model* connotes several concepts. For this study, two distinct meanings are intended: an *empirical urban model* that describes quantitative relationships and a *virtual urban model* that provides an experience of a physical place by proxy.

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[16] Per Costanza's work as described in "The Value of the World's Ecosystem Services and Natural Capital," *Nature*, Vol. 387, 1997.
[17] The author of this study spent 2 months working closely with Joel Crawford. This time provided ample opportunity to ask detailed questions related to the design and implementation of a carfree scheme.

Empirical modeling has steadily grown in sophistication and now includes such techniques as econometric modeling, input-output modeling, gravity modeling, cellular automata, and agent-base microsimulation.[18] These models all deal with the implications of spatially explicit cause-effect relationships, based upon positivistically derived functions.

The virtual urban model is most readily comprehended as a three-dimensional visualization, though in its electronic storage format it is nothing more than a serialized or relational database of representative ‘objects’ in a spatially explicit database. The urban environment being visualized might be existing or conceptual. A virtual model is similar in its representational qualities to the physical model an architect might present to a client or a site planner may use to explore the massing of a project relative to its context. While sacrificing tangibility, virtual models offer significant advantages over traditional wood, plastic, or foam; they have the ability to link objects with spatially explicit attributes, are viewable instantaneously from any perspective, and can be manipulated in real time. Thus, a virtual model does double duty as a visualization method and as a means of databasing morphological attributes. Virtual models can contain variable representations, such as greater levels of visual detail when viewed at close range. They may also be combined with other visualization techniques, such as shadow casting and realistic material properties such as reflectivity, transparency, and texture.

This study makes use primarily of empirical models, though a virtual model plays an important role in the evaluation of place as described in section 4.7, *Acceptable Experience of Place*. It should be noted that the field of virtual urban modeling is just now emerging as a discipline. In the author’s opinion, significant contributions to the theory and practice of urban design and planning will emerge from the use of virtual models.

[18] From Marina Alberti, UrbDP422: Geospatial Analysis, Lecture 13, May 11 2004

3.5 Required Data and Tools

The methods described in this study make use of substantial datasets and of sophisticated software to manipulate and analyze these datasets. The explosion of computational power of personal computers creates the opportunity to deal with the large datasets characteristic of the built environment. Most large U.S. cities now have comprehensive GIS databases relating to land use, land ownership, and the city's physical infrastructure. The combination of good data, computing power, and thoughtfully designed software provide new opportunities in comparative urbanism, where datasets – parcels, structures, and other physical entities – easily number into the hundreds of thousands. The City of Seattle parcel layer alone contains over 220,000 records, each with 20 mostly unique attributes, totaling almost 4.5 million spatially specific data points. Manual calculation of entities above the block level becomes tedious and prone to error, if not impossible outright. Clearly, software forms an integral component of this study.

The following software applications were used: Microsoft Excel for all tabulations, empirical modeling, and for data operations on spatial attribute tables; Autodesk AutoCAD for creating spatially explicit 2-dimensional models of the cases; ESRI ArcGIS to visualize and analyze geospatial data.; @Last SketchUp to create and visualize spatially explicit 3-dimensional models; and Adobe Illustrator to produce illustrative graphics.

The software applications listed above provide powerful means of collecting, storing, managing, retrieving, converting, analyzing, modeling, and displaying geospatial data. Therefore, the availability and quality of data is very important. Fortunately, the Wallingford area is covered by a robust GIS dataset obtained from the City of Seattle as provided through WAGDA, the Washington State Geospatial Data Archive.[19] A second GIS dataset for Wallingford was provided by the University of Washington Urban Form Lab.

[19] http://wagda.lib.washington.edu/data/

This data was originally used as part of a Walkable and Bikeable Communities Project under a grant from the Centers for Disease Control and Prevention, which have recently funded significant research into the links between urban form and public health. A third source of data is the built environment itself. Through direct observation in the field, data quality may be calibrated and refined.

GIS data does not represent the built environment perfectly. Usually, street edges and building outlines are drawn by hand on top of rectified digital orthophotos. The resolution of the photos used for this process in the Seattle dataset was 1 pixel = 1 square foot on the ground. When combined with some degree of incorrect interpretation of the base image and simple drawing errors, there will be more variance in this spatial data than in property lines and rights-of-way which are generated from legal platting records with a much higher degree of accuracy. Fortunately, a high degree of accuracy at this scale is not required to make the general order-of-magnitude comparisons between two urban schemes at a much larger scale. Moreover, the type of systematic error inherent to tracing on top of digital orthophotos is likely to be largely self-cancelling.

The availability of such a rich dataset is problematic for design schemes. Data for the Carfree Reference District comes from vector-based (.ai) data as originally drawn by the author of the design, Joel Crawford. Attribute information comes from the written description of the proposed environment as published in Carfree Cities. Design schemes frequently suffer from a lack of dimensionality – focusing on a small number of variables at the expense of a holistic systems view. Other designs suffer from a lack of meaningful specifications. We must be able to distinguish viable idea from fantasy. The remainder of this section makes the case that sufficient information about the carfree design exists to make this comparison meaningful.

4. Plausibility of Design Case

The plausibility of the design scheme specifically extends beyond those quantitative characteristics measured in this analysis. Evaluation of plausibility must be approached holistically and rigorously in recognition of the complex nature of the urban environment. If the design scheme is not plausible, then comparison to the built environment is frivolous. The physical plausibility of a design scheme is determined from both empirical and virtual models and describes the proposed urban environment as if it were actually built and operational. For a scheme to be considered plausible, it must either replicate or substitute for existing urban services. Urban services should be interpreted broadly; e.g. open park space provides amenity as a service just as roads provide automobility as a service. There are a number of factors of physical plausibility explored in evaluating the Carfree Reference District. The absence of plausibility for any of the following should cast doubt on the merits of the scheme. The evaluative categories are:

1. Building typology
2. Transportation network topology
3. Accommodation of space use
4. Distribution of space
5. Technological feasibility
6. Acceptable experience of place
7. Design flexibility

4.1 Building Typology

It is important to recognize the key determinants of building form. For example, dwelling units can neither be too small (unusable) nor too large (impractical or uneconomical). Residential building depths are limited by the amount of light that penetrates a living space. Office floorplates have minimum, maximum and optimum sizes for specific uses. Floor-to-floor heights vary by function, structural costs, and zoning limits. Most variables are also shaped by market trends that fluctuate over time – again, subject to a historical milieu.

The essential determination is whether the proposed scheme presents a set of building types that permit the utilization of space according to the needs of its users. It needn't exactly replicate current practice, but it must at least provide a defensible alternative. Typologically, the Reference District meets residential requirements primarily through a composition of perimeter blocks that support single-family attached townhouses (or rowhouses), multi-story walkups (or flats), and infrequent low-rise elevator buildings of 4 to 6 stories at the center. Retail and service spaces are provided in a mixed-use scheme that incorporates significant neighborhood commercial into the bases of many residential buildings, especially in the convivial public squares. The perimeter block also supports the development of single-purpose commercial spaces (office, etc.) at the prominent street intersections, which are realized compositionally as urban squares. A designated commercial strip supports building typologies that could include vertical big-box retail, warehouse, light to medium industrial, office, institutional, or civic space. Each of these building typologies exists in current American practice to some degree, and to a much larger extent in European practice. The building types programmed in the Carfree Reference District are deemed to be adequate for the accommodation of the comparable uses.

4.2 Transportation Network Topology

To provide the requisite freedom of mobility and economic dynamism associated with the (post)modern lifestyle, efficient means of moving both people and goods throughout the urban area is of primary importance. Such an evaluation is especially important to overcome the bias that Americans 'won't give up their automobiles'. This point is so fundamental, it bears additional explanation and should be stated outright: carfree design intends to displace the dominance of the private automobile in the activities of daily life where it is implemented. It neither suggests that carfree urbanism is appropriate for all contexts (e.g. rural living) nor that existing areas, developed to an automobile standard, should suddenly become bereft of automobility.

While the dominant mode of transportation within the district is pedestrianism, it is assumed that the district is connected to other districts and meaningful regional destinations (such as industrial centers, airport, commercial and cultural facilities, recreation, etc.) via effective public transportation. Crawford's scheme is very flexible, capable of utilizing inexpensive bus rapid transit, or more comfortable light- or heavy rail. Using the detailed descriptions of travel distances, headway times, time on station, service frequency, and capacity, we may reasonably accept that the Reference District's network topology is not only sufficient to meet transportation needs, but in fact represents a best-practice configuration for public urban transportation overall. Furthermore, the Carfree design recognizes that some automobility can be maintained for trips to locations not serviced (or serviceable) by public transportation, such as an excursion to a favorite hiking trail in the mountains. People who live in a carfree district might own their own private automobiles, keeping them parked in a garage structure except when used outside the district. Due to the rising costs of automobility and the increasing popularity of car-sharing programs like FlexCar and Zipcar, more individuals may choose to forgo automobile ownership altogether.

4.3 Comparable Spatial Accommodation

Comparable spatial accommodation indicates that there is a reasonable equivalent of per person space in design case vis-à-vis the built case. Once these allocations are expressed for the built case, they must be accommodated for in the design scheme or else substituted for in some reasonable fashion if the cases are to be considered comparable. Any discrepancies between these shares require convincing explanation.

The average unit dwelling unit area in the Reference District is set at 400 net square feet per household, only 76% of the 524 nsf average for a Wallingford resident, in aggregate. In short, the predominant Reference District building typology prefers smaller units and derives design benefits from this reduction. Furthermore, as can be seen in Tables 1 and 2, the Reference District's 400nsf is greater than or roughly similar to almost 45% of the housing stock in Wallingford.

Table 1 : Average Dwelling Areas by Person and Household in Wallingford

Type of Unit	# Units	% of Total	Total NSF	Average sf per Person	Average sf per Household
Wallingford Aggregated	7,824	100%	9,232,927	524	1,180
Single Family Detached (SF-D)	*4,391*	*56.1%*	*6,414,149*	*649*	*1,461*
Single Family Attached (SF-A)	*1,204*	*15.4%*	*1,149,750*	*424*	*955*
Multi-Family (MF)	*2,229*	*28.5%*	*1,669,028*	*333*	*749*

Source: City of Seattle GIS Data

Table 2 : Average Dwelling Areas by Person and Household in Reference District

Type of Unit	# Units	% of Total	Total NSF	Average sf per Person	Average sf per Household
Reference District Aggregated	5,111	100%	4,599,900	400	900

Source: Reference District Model

The Reference District allocational sufficiency was determined by assessing the required comparable space use in Wallingford and then fitting this to the availability of space as calculated through CAD drawings of the CRD. It was determined that 100% of residential space for a population of 11,500 residents, when discounted by the typological reduction explained above, and 93% of non-residential uses could be accommodated.[20] Thus the Reference District represents a plausible – if not exactly duplicate – allocation of space. Though the allocations may be similar, the distribution of uses is quite different, as explained next.

4.4 Comparable Spatial Distribution

The allocated space must also meet distributional requirements, that is, it must not only fit *somewhere*, but somewhere *specific*. This needn't be a precise location at the household address level, but must be consistent with a class of space use. For example, there exists a *de facto* requirement that retail uses be on the ground floor for optimal visibility, customer ingress, and efficient logistical access. Therefore, there must be sufficient ground-floor space available for retail to be considered accommodated according to distribution. This is determined in part by building typology and in part by functional requirements.

[20] This number is 500 fewer than Crawford's call for 12,000 in order to accommodate larger unit sizes desired by U.S. consumers. This is an example of the design flexibility described in section 4.8.

Thus distribution must be evaluated for any analysis sensitive to it. Walkability, in particular, is determined by distribution of services. When we weigh the importance of some trips over others according to survey data, explicit zones of walkability are generated. This is explained in greater detail in the walkability analysis. In the case of the Reference District, the composition of residential and commercial spaces is purposefully given a relatively uniform distribution. Unlike the small neighborhood commercial areas of Wallingford, the Reference District street design intentionally supports mixed-use along main streets, in the frequent squares, and along the central commercial spine. Designated service destinations are considered to be placed at random throughout the spaces available for that type of use, here generalized to retail. Therefore, the study does not require the creation of a randomized spatial distribution dataset for a more detailed analysis in GIS software. A variety of retail space is provided for, with smaller stores and shops clustered in squares and medium and even vertical big-box retail possible near the center.

Due to the principal of designing for a 5-minute maximum walk from periphery to center, even if all retail were relegated to the central commercial strip, walking times for all residents would remain very low. The design of the Carfree Reference District allows for an appropriate spatial distribution of urban uses.

4.5 Technological Feasibility

For a design scheme to be technologically feasible, it must not rely upon unproven technologies. And while it should seem obvious, it must not rely upon technology not yet invented, as in the structural system or atomic elevators of Frank Lloyd Wright’s Mile-High Skyscraper. The Carfree design is not predicated upon any construction or transportation technology not already in widespread use globally. The proposed building scale is modest by contemporary standards; large multi-national companies are accustomed to building enormous multifamily complexes, institutional buildings, and commercial high-rises. The passenger transit topology supports great flexibility in mode: heavy rail metro, light rail, trolley (tram) and bus rapid transit. Freight mobility is primarily rail-based, designed for standard shipping containers, and connected to the multi-modal global logistics network. The Reference District poses no unusual infrastructural demands; if anything, it substantially reduces these demands.[21] There appear to be no technological barriers to the implementation of Crawford's design.

4.6 Financial, Political, and Regulatory Feasibility

Infeasibility based upon finance, politics, or regulatory obstacles are frequently invoked as barriers to change. It is not only normal, but appropriate, for an innovative design scheme to depart from currently defined norms of finance or policy. Should these then be considered handicaps or outright proscriptions? For purposes of immediate implementation, this may be so. But for long-range planning, recognition must be given to the fact that market forces, political will, and legal structures evolve in response to changes in the human realm. As ecological pressures mount and resources dwindle, the underlying cultural values will shift. Whether responding to a 'shallow' or a 'deep' ecological perspective, it is foolish and self-defeating to presume change will never come. When underlying pressures inform changes to human behavior, the rules of financial, political, and regulatory feasibility evolve to permit new development types. Indeed, the dynamic partnership of environmentalists and the real estate development community represented by the Urban Land Institute signifies that such transformations are already underway.

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[21] Beyond, paved surfaces, infrastructure is not measured as part of this study. Nevertheless, the impervious surface calculations can be considered for infrastructural reduction.

This study compares the sustainable performance of urban environments; it does not attempt to assess the feasibility under the current regime of production. This should not be read as an attempt to demean the importance of these factors, but simply as a recognition that feasibility ought to be addressed in a separate context, a context that is mutable. Indeed, part of Lefebvre's revolutionary call is to use positions of technical authority and power to shift the political climate toward an implementation of a more just regime.

4.7 Acceptable Experience of Place

Much planning and design literature addresses the concept of place. In short, place is an understanding of a particular space that is informed through experience. This is a complex phenomenon, as ideas of place are informed both by the physical reality of the situation and by the idiosyncratic and culturally-biased perceptions of the individual experience of that space.

An explicit phenomenal comparison was not conducted. However, detailed virtual models of a number of urban elements were created for proving the phenomenal plausibility of the Carfree Reference District. These models clearly demonstrate that the spaces created within the composition achieve many desirable place-making qualities such as framed vistas, a sense of enclosure, unique streets, and imageable boundaries. As the Carfree concept draws much design inspiration and guidance from the built forms of historic urban areas of Europe, photographic documentation can attest to the vibrancy and integrative nature of such morphology. In a more substantive analysis, the claim to acceptability of place should be evaluated through interactive participation with others, perhaps in the form of a visual preference survey or other qualitative instrument. Failure to convince an audience of this acceptability doesn't preclude a design from ultimately creating a sense of place. Nor does agreement guarantee its realization. But as visualization techniques and technologies steadily improve, such interactivity will surely become more commonplace as a means of (at least tentatively) validating a design scheme.

4.8 Design Flexibility

As has been pointed out by Spiro Kostof and others, an idealized design scheme is rarely, if ever, executed perfectly according to plan.[22] The complexity of implementation and changing conditions on the ground force compromises upon the scheme. Recognizing the inevitability of such divergence, we must assess if a design scheme embodies a sufficient flexibility to accommodate unexpected ‘changes in plan’ without compromising the scheme’s plausibility.

The Carfree Reference District is a prototype of urban development. Crawford makes clear that the reference district design, like the reference topology that contains it, is meant to communicate feasibility and categorical best practice, not the desirability of its particular composition over a thoughtful local implementation. Furthermore, Crawford carefully explains the design variables that might change. He describes flexibility of block composition, façade composition, district topology (grid, radial, ‘organic’), development density, and even provision for some private-use automobiles. Each alternative involves tradeoffs; for example, lowering density would either 1) lower the overall population, 2) increase the land area consumed, or 3) increase walking times. The first two decrease ecological footprint performance; the latter decreases attractiveness as a pedestrian environment – but all are feasible. The Carfree City in general, and especially district level design, appear to embody sufficient flexibility to be implemented with minimal compromise to the design intent.

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[22] Kostof, *City Shaped*, p162

4.9 Determination of Plausibility

Once the design scheme is evaluated according to these plausibility criteria (or others, should better tests be devised), it may be determined plausible for the purposes of furthering the comparison. The Reference District meets these requirements for plausibility, as verified through spatial measurement of the proposed morphology and through analogy to the experiential qualities of existing spaces. Therefore, the analysis may proceed to the empirical measurement of spatial categories related to the sustainability performance criteria.

5. Comparative Analysis

The built environment is exceedingly complex, presenting myriad phenomena for consideration. One means of communicating such complexity is through a simplified metric that quantifies progress towards (or away from) a stated goal. The phenomena studied herein are represented by sustainability indicators, a method receiving substantial attention in recent literature. According to Virginia Maclaren, sustainability indicators serve as a means of evaluating how well policies and practices are affecting change toward stated goals.[23] This 'urban sustainability reporting' communicates meaningful information about urban conditions by including the relevant context of the empirical measures. For example, Sustainable Seattle, an NGO which reports annually on Seattle's sustainability, describes how well the city is meeting its goals and obligations under both local commitments and in relationship to state environmental frameworks such as the State Environmental Protection Act (SEPA), Shoreline Management Act (SMA), and the Growth Management Act (GMA). In Taking Sustainable Cities Seriously, Kent Portney defends the development and use of comprehensive indicators as an integral strategy for achieving sustainable goals.[24]

5.1 Use of Sustainability Indicators

This study uses sustainability indicators in a slightly different way. They are 'snapshots' of time, one built, one hypothetical. Such a technique adds a new dimension to the above scenarios; now we can compare what we will likely have in a 'no action' future versus an 'alternative action' future. With more case-studies, it would seek to position existing built environments relative to one another and to other design proposals, producing a sort of menu of spatial orientations that could be calibrated with social and environmental

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[23] Maclaren, JAPA 1996
[24] Portney, p 247

goals. This study suggests that indicators can be used not only to evaluate the trends within a given built environment, but can be used to explore the upper limits of spatial practice that could bring about substantial gains in sustainability. In the near term, it may be impractical to implement the ideas of carfree urbanism in the existing context of an American city, but it will be very important to know how much more sustainable we could become if there were the economic motivation or political will to make major changes to our production of space. Thus, each comparative indicator doesn't tell us which way we are trending, but rather how any given built environment stacks up to thoughtful sustainable design. It simultaneously serves to evaluate the design itself, for if it requires sacrifices or compromises and yet doesn't deliver, in an empirical sense, a better environment as measured by the indicators, then it has failed in its goal of advancing sustainability.

For each analysis, a sustainability *Indicator* is created. Appendix A presents a diagram explaining the conventions used in these indicator graphics. Each indicator expressed first in plan graphics of equal scale for visual comparison. The plan graphics represent not only accurate areas of the phenomena but also the spatial relationships tied to the configuration of these areas. Following the plans are indicator bars showing the measured allocations or distributions for comparative purposes. Wallingford data is shown in orange, the Reference District in green. For each pair of measurements, a *comparative multiplier* is given. This number is a simple ratio of the larger value to the smaller, indicating a multiplying factor of one to the other. These multipliers provide a sense of scale or magnitude to the issue at hand. If there are 4.29x more households in the Reference District that are within walking distance of important utilitarian destinations, it is easy to see how this is an improvement through design. But higher numbers are not always better. If we seek to reduce impervious surfaces by design, that a lower number would be better. Either way, a higher ratio is considered better than a lower one, but the numerator and denominator positions are switched for more-is-better versus less-is-better calculations. The comparative indicator is a simple up or down arrow. When it points upward, the Reference District condition is considered better than Wallingford. When it points down, the Reference District fares worse in the comparison. By looking at the whole constellation of indicators together, and in light of the spatial issues at hand, a more comprehensive view of spatial practice may emerge. This can be done with Figure 19 in the conclusion. These multipliers and indicators are discussed in detail in the comparative analyses.

5.2 Selection of Indicators

Because the carfree scheme uses higher development density to achieve particular environmental performance measures, it is useful to select indicators related to the urban design goals espoused through the design itself. The Carfree City lists 43 design goals. Appendix D presents a complete, annotated list.

An indicator may perform more than one function. For example, Crawford cites the reduction of impervious surfaces as a means of reducing infrastructure cost, whereas this study approaches the question of impervious surfaces with respect to urban runoff issues. Hence, some indicators may be useful more generally than the purpose set forth in a given analysis.

This section provides an analysis of three important aspects of sustainability planning: impervious surface coverage, amount and accessibility of green space, and walkability. Each of these is tied to the others through land use decisions that both reflect and enact an orientation toward the production of space. These indicators are not exhaustive, nor are they perfect. They are demonstrations of how indicators in general might be useful in comparing urban schemes. Many other indicators could have been chosen and should be evaluated in subsequent studies. The analytical methods used for the three categories of indicators could be extended to more inclusive or detailed datasets or supplemented by additional methods. Moreover, every selected criterion should be continually refined with better information coming from other empirical and qualitative studies of the phenomena in question.

5.3 Comparison of Impervious Surfaces

Impervious Surfaces Introduction

As mentioned earlier, the essence of urban sprawl is the combination of the dominant role of the automobile as a means of transportation and the low density, single-family dwelling units situated within that system. Both conditions need to be present for sprawl to exist. Consider the automobile infrastructure of a dense urban core: though the network itself consumes a large amount of land, building out to property lines and up multiple stories ultimately gives rise to compact development. And clearly a low-density suburb without significant automobile infrastructure is untenable.

With respect to intensity of use, a single lane of pavement on an interstate clearly provides utility to many more people per unit area than the same amount of pavement on a quiet neighborhood street. In simple terms, we might take this same amount of space – on the highway and on the residential street – and divide it by the total number of users. This is a simple example of ecological footprinting – a story about how much paved surface exists per person for a given use. Interstate users would account for a far smaller amount of space owing to the substantially larger denominator. In actuality, the downtown dweller and the residential dweller both use the interstate. So in this simplified example one's share of pavement would be the amount at home plus the amount on the interstate. Given that they both have the interstate in common, it would be a difference in pavement per person at home. How is this useful? It demonstrates, in a straightforward manner, one's contribution to spatial practice. This footprinting method can be extended as a multiplier to other metrics as well, such as each person's share in cost per area of road maintenance or amount of surface contributing to urban runoff, as is detailed next.

Why, then, should we measure impervious surface coverage? This study looks at impervious surface coverage in two ways – as a contributing factor to sprawl through lower density development and as a contributing factor to urban runoff. The first point should already be clear, though additional details will support this claim momentarily. The latter point is important from an ecosystem point of view because of the occurrence of damaging combined sewer overflow events.

Seattle's wastewater system was constructed as single network serving both sewage and rainfall catchment. Today, under normal circumstances, this combined sewer channels all effluent to wastewater treatment facilities. During periods of heavy rainfall, the capacity of the system is often overwhelmed. The excess effluent exits the system through a combined sewer outfall – directly into a natural water ecosystem. The effluent has significant adverse impacts on the ecosystem because it contains both pathogenic human and animal waste as well as a host of other anthropogenic pollutants and toxins. Because of the nature of a sewer system, these harmful agents are concentrated at the outfall and delivered directly into the creeks, streams, lakes and bays that surround Seattle. They imperil the health of humans and other species alike. Urban runoff is clearly an ethical concern, for reasons of public health and ecosystem vitality. But it also presents a pressing legal challenge for King County under obligation to the federal Endangered Species Act which demands mitigation of its contribution to the destruction of spawning habitat for anadromous salmonid fish.[25] This presents itself as an economic issue as well, for an important local marine industry surrounds the catch, processing, and distribution of salmon.[26]

Because it is very costly to retrofit a sewer system for an entire city, this is generally not considered as a feasible option. There are two contributing factors to combined sewer

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[25] Anadromous salmonid species are born in freshwater streams, rivers, and lakes, moving to salt-water to live out the majority of their lifespan, until returning to their native waters to spawn and ultimately die.
[26] Maclaren, JAPA 1996, from Sustainable Development Reader, p206

overflow that may be mitigated – the amount of impervious surface causing the runoff and the production of waste products that are collected in wastewater. The automobile contributes negatively to water quality issues in both ways: 1) through runoff from the impervious paved surfaces used for automotive transportation, and 2) through the production of waste products from automotive use. These waste products include oil and gasoline that is deposited directly onto the surfaces as well as atmospheric pollutants that eventually make their way to paved surfaces as they precipitate out of the air. According to a report from the University of Wisconsin, "the primary source of many [toxic heavy] metals in urban runoff is vehicle traffic", as "concentrations of zinc, cadmium, chromium and lead appear to be directly correlated with the volume of traffic in streets."[27] Thus, a reduction in automobile dominance would reduce both the need for so much paved surface even as the amount of pollutants tied to automobiles is reduced. But paved surfaces are not solely dedicated to automobiles. An analysis of the GIS data shows that sidewalks comprise a substantial amount of paved surface as well.

Another important category of impervious surface exists: the roofs of buildings. The rain protection afforded by the roof of a structure must shed that water somewhere. If it drains to the sewer system, it potentially contributes to combined sewer overflow events. There is much interest lately in mitigating these surfaces though 'green' roofs and water catchment systems that delay release of rainwater until sufficient sewer capacity is regained. These green roof systems are still being tested, but show some promise not only for the delay of rainwater outflow, but also some water absorption and filtration of pollutants. It could be decades before such systems are widely implemented, however.

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[27] From the report "Polluted Urban Runoff: A Source of Concern" , Environmental Resources Center, University of Wisconsin

Of course, not all water from roofs and impervious surfaces enters the sewer system, as some is allowed to absorb through the surrounding vegetation. This study does not purport to measure these factors accurately. Instead, the point is to evaluate the comparability of impervious metrics in general. Greater specificity can be added through subsequent analysis.

Impervious Surfaces Methods

What constitutes an impervious surface? In Wallingford, the following surfaces are included in calculations: paved vehicular surfaces – streets, sidewalks, driveways – and the roofs of buildings. Building roof areas are represented by building outlines in the GIS data. These building outlines are generally referred to as building footprints, though technically this is incorrect, as they are drawn from the rooflines as represented in digital orthophotos.[28] The overhang of most roofs is fairly slight when compared to the total surface area, so for the purpose of this study they are considered to be roughly equal. Tables 3 and 4 below details the amounts of each type of impervious surfaces as a percentage of total impervious surfaces and the data source used to calculate them.

Table 3 : Impervious Surface Coverage by Type in Wallingford

Coverage Type	% of Total	sf/ person	Data Source
Building Footprints	47.5	584	Seattle GIS: *building outline* shapefile
Vehicular Streets	37.5	461	Seattle GIS: *pavement edge* Shapefile
Sidewalks	8	98	Field calibrated estimate
Residential Garages	3	36	Seattle GIS: *building outline* shapefile, *GAR* attribute
Driveways	2	24	Field calibrated estimate
Parking Lots	1	14	Seattle GIS: *building outline* shapefile, *PKG* attribute
Residential Patios	1	13	Seattle GIS: *building outline* shapefile, *PAT* attribute
OVERALL TOTAL	**100**	**1,229**	

Source: City of Seattle GIS Data

[28] ‘Roofprint’ is an awkward concept.

Table 4 : Impervious Surface Coverage by Type in the Reference District

Coverage Type	% of Total	sf/ person	Data Source
Building Footprints		159	CAD model
Pedestrian Streets		127	CAD model
Sidewalks		--	n/a
Residential Garages		--	n/a
Driveways		--	n/a
Residential Patios		13	Normalized to Wallingford allocation
Parking Lots		--	n/a
OVERALL TOTAL	**100**	**299**	

Source: Reference District CAD model

Sidewalks are not drawn in the City of Seattle GIS data, so they must be estimated. This is accomplished by drawing a detailed sidewalk system for a representative block in Wallingford in AutoCAD using a digital orthophoto as an underlay and calibrated to field measurements. Then the total sidewalk area is divided by the linear length of the street centerlines surrounding the block, as this data is included in the GIS dataset. This provides an estimated sidewalk area per linear measurement of street. As virtually all streets in Wallingford have sidewalks on both sides, we may extrapolate the amount of paved sidewalk area by multiplying this per-linear-distance amount by the total length of all street centerlines.

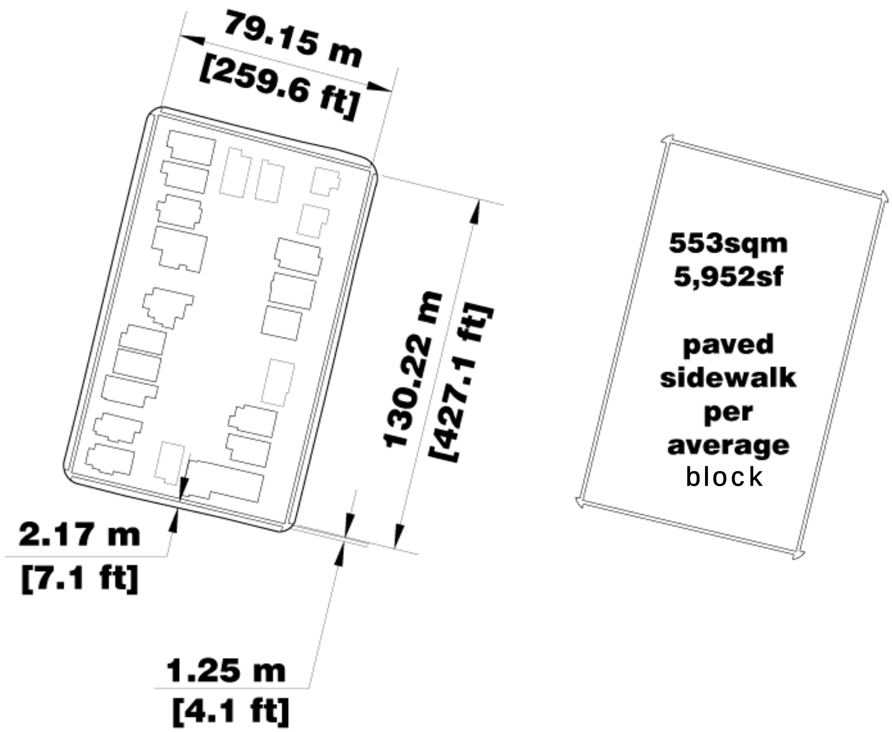


Figure 2 : Field Measurements for Typical Block in Wallingford

In the Carfree Reference District, impervious surfaces are comprised of building outlines and pedestrian streets as calculated in AutoCAD. This vector data is derived from original drawings and is calibrated to the author's specifications for average street widths and building depths.

Impervious Surfaces Analysis

From this breakdown we see that roughly half of the impervious surfaces are dedicated to transportation use and half to building footprints. Interestingly, this is true for both Wallingford and the Reference District.[29] Clearly, however, the per person share of impervious surfaces is substantially decreased in the Reference scheme. The carfree design

[29] It would be interesting to explore whether this is correlated or coincidental.

achieves this reduction in ecological footprint through two means: 1) the displacement of auto-dominated transportation by pedestrianism, and 2) a higher development density.

That the density of the Reference District design is higher should be obvious from the fact that, relative to Wallingford, substantially less *urbanized* area is consumed while the *overall* population density is equal.[30] Because of this normalization, overall housing density is equal as well. The net housing density of Wallingford is 6.34 dwelling units per acre (du/a). To be meaningful, we consider the housing density of the *urbanized* area of the Reference District in isolation from the greenbelt is undeveloped. This figure is 45.59 dwelling units net per acre – substantially higher, but consistent with figures provided by Chapin/Kaiser and Lynch/Hack as listed in Appendix D.[31] The Reference District density is achieved in three ways: 1) narrower streets, owing to their pedestrian orientation; 2) taller buildings – at an average of four stories, this is certainly denser than suburban development but much less dense than mid- or high-rise residential developments; and 3) through a predominantly row-house building typology with shared walls and a perimeter-around-courtyard configuration. This thoughtful scheme forms the traditional urban fabric of some of the most well-loved cities of Europe, such as Amsterdam, Köln, and Barcelona. Radically different schemes could have been chosen to create similar efficiencies. Take, for example, the Modernist vision of the tower-in-the-park championed by Le Corbusier where there could be even more green space as people are pushed upward in high-rise pencil-towers. As the neo-traditionalists are eager to point out, these interventions – a deliberate break from the historical pattern of urban development – tend to discourage street life and impose a mechanistic scale to the landscape. Indeed, there are ample examples of such projects having

[30] As mentioned earlier, the Reference District's greenbelt area is normalized to the same population density as Wallingford, at 14.26 persons per acre.

[31] This is further evidence of the acceptability of place in the Reference District design.

fared quite poorly.[32] Indicator [1] shows the comparative breakdown of impervious surfaces between pavement and building footprints. The metrics tell the story clearly and can be read in terms of either scheme. That is, we might say either that the ecological footprint of paved surfaces for the average individual in Wallingford is 4.36 times greater than the Reference District, or that the opposite is true, that the resident of the CRD is responsible for 4.36 times less pavement. Either way, the reduction of our impact – in terms of space consumed and the energy consumption and pollution connected to the automobile – clearly the Reference District is more efficient. For consistency with the other comparisons, a better/worse indication is given in terms of the design case. Thus, for this impervious surface analysis, the Reference District is considered 4.36 times *better*.

While it might be easy to overlook, the total surface area covered by sidewalks in Wallingford is 1.8 million square feet (> 40 acres), comprising nearly 8% of land covered by impervious surfaces.[33] Again, just as the footprint of automobile pavement may be measured against intensity of use, so can sidewalks. A person's share of sidewalk space in Wallingford is 98sf. The Reference District has no sidewalks but pedestrian streets. At 127sf, the RD resident is responsible for more impervious walking surface per person, but this is offset by the fact that automobile-only spaces have been fully mitigated, giving the aforementioned overall reduction of paved surfaces per person of 4.36 (or 436%).

As Lefebvre's method suggests, there is more to the story of spatial production than just how space is assigned categorically. We must look to the underlying system that produces space, in this case the dominant means of transportation. It should be noted that while the Wallingford neighborhood was platted before the invention of the internal-combustion engine, it's compatibility with the automobile is not coincidental. Steam-

[32] Especially U.S. urban renewal projects of the 60's and 70's – notorious for having failed the poor.
[33] Wallingford sidewalks represent 3.14% of total land area, 7.99% of impervious surfaces, and 16.11% of paved surfaces.

powered carriages were already in widespread use in England by the 1880's and it was anticipated that streets would carry traffic according to increasingly mechanized modes, though widespread pavement of streets in Wallingford did not begin until 1925.[34]

Indicator 2 looks specifically at paved surfaces as a subset of impervious surfaces. This adds to the story of spatial dominance by the automobile over the pedestrian. This multiplier provides the ratio of paved surfaces as streets for automobiles versus sidewalks for pedestrians.[35] The percentage of area dedicated to automobiles over pedestrians depicts spatial practice clearly. By designing wide streets for mechanized automobility in a low density housing configuration, the vast majority of paved surfaces are dedicated to this mode. This is not to imply that an unnecessarily large amount of pavement for pedestrians would be an improvement by default. These ratios must be considered in light of the per-person share as well, as the efficiency of the pedestrian streets of the carfree scheme come through density as well as the displacement of the automobile. The allocations are given below in **Tables 5 and 6**:

Table 5 : Paved Surface Coverage by Type in Wallingford

Coverage Type	Amount (sf)	% of Total	sf/ person
Vehicular Streets	8,054,444	75.6	461
Sidewalks	1,716,172	16.1	98
Driveways	425,000	4.0	24
Parking Lots	236,832	1.1	14
Residential Patios	222,998	1.0	13
OVERALL TOTAL	**10,655,446**	**100.0**	**610**

Source: City of Seattle GIS Data

[34] http://www.historylink.org/essays/output.cfm?file_id=3461
[35] For the Reference District, there are no sidewalks *per se*, only pedestrian streets, in the traditional vernacular of old-world cities.

Table 6 : Paved Surface Coverage by Type in the Reference District

Coverage Type	**Amount (sf)**	**% of Total**	**sf/ person**
Pedestrian Streets	1,464,124	90.9	127
Sidewalks	0	-	-
Driveways	0	-	-
Parking Lots	0	-	-
Residential Patios	146,701	4.3	13
OVERALL TOTAL	**1,610,825**	**100.0**	**140**

Source: Reference District CAD model

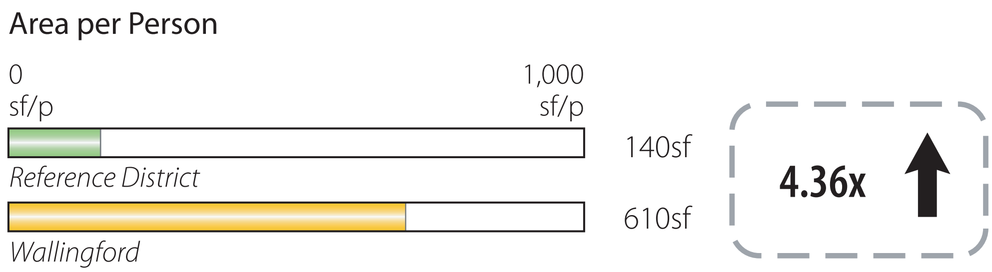
Read another way, the CRD is 4.36 times more efficient at allocating paved surfaces as pedestrian-dominated space even while using substantially less pavement as is demonstrated in Indicator 1.[36] It is reasonable to conclude that the Carfree Reference District makes a substantive contribution to the reduction of our ecological footprint through the use of traditional urban design principles. The remaining indicators tell a similar story, demonstrating empirically the efficiencies gained through an alternative approach to spatial production.

[36] 610sf divided by 140sf = 4.36 multiplier.

Figure 3

Indicator 1 | Impervious Surfaces by Coverage Type

Indicator 1a | Allocation of Impervious Paved Surfaces



Indicator 1b | Allocation of Impervious Building Footprints

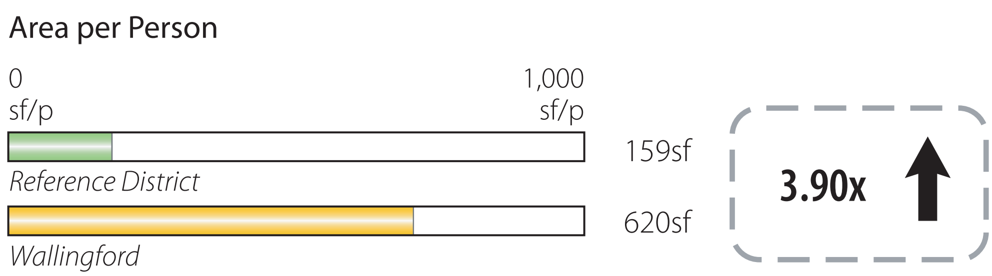


Figure 4: Metrics for Indicator 1

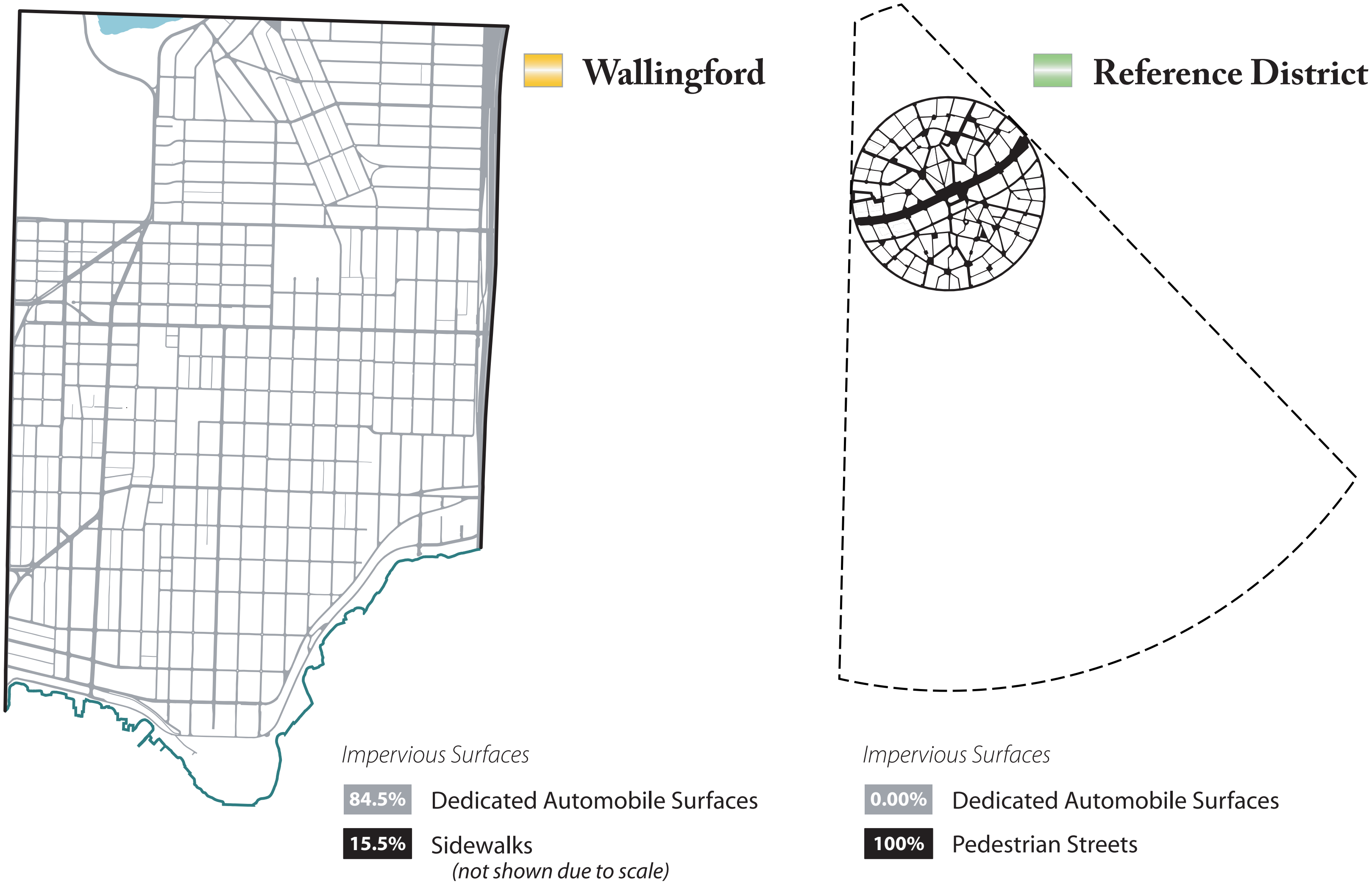


Figure 5

Indicator 2 | Impervious Paved Surfaces by Transportation Mode

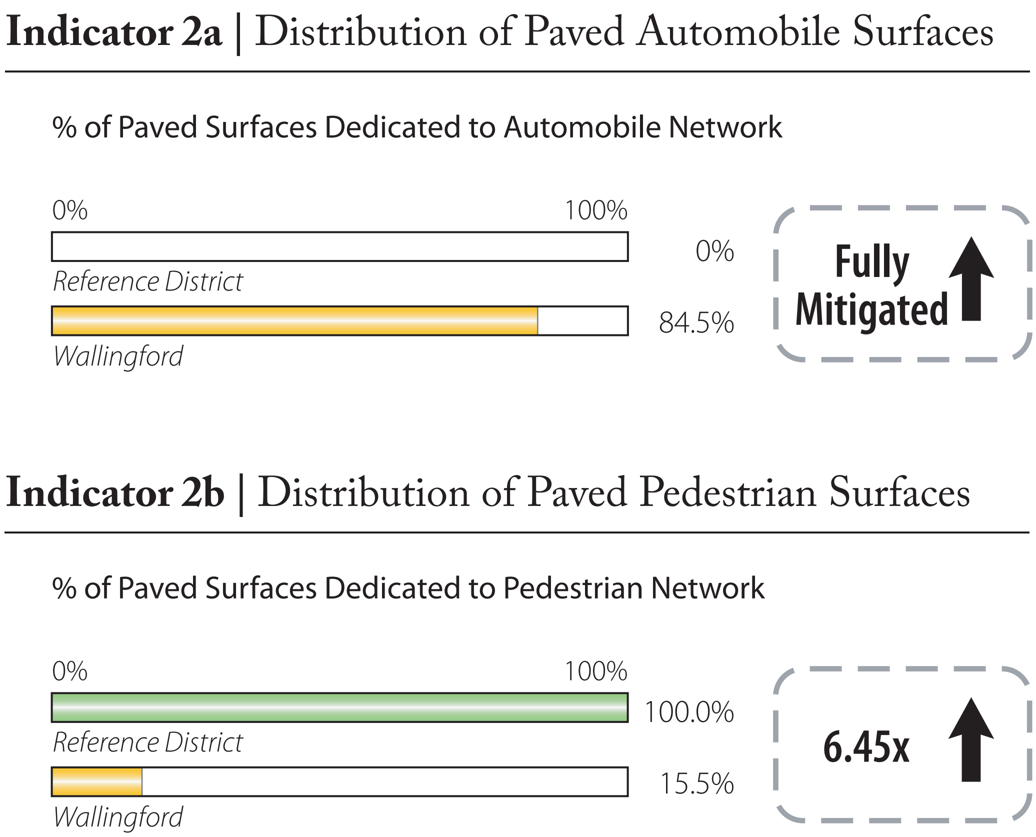


Figure 6: Metrics for Indicator 2

5.4 Comparison of Open Space and Green Space

Green Space Introduction

Whether it be access to open sky and sunlight, views, or a feeling of connectedness to nature, open green spaces provide urban dwellers with substantial psychological and physical benefits. Open green space cannot be thought the same as open space in general. There are many types of 'open' space, and they require some thoughtful attention to categorization. On one end of the spectrum is a loose definition equal to all land area not covered by a building footprint. Such a definition lacks the ability to discern the quality of a space as offering an positive amenity. As such, open space would include all spaces that are inaccessible (fenced-off parcels), residual (e.g. utility easements), or otherwise undesirable for passing time (e.g. parking lots). A definition that demands a certain level of spatial quality would be more meaningful. In this analysis green space is taken to be open spaces of a naturalistic quality that at minimum provide a grassy area or playfields for recreation. Green spaces might also be landscaped or wooded. Some are traversed by trails or possess a character that more closely resemble a native ecosystem. There are several examples of such parks in Seattle, though none are found in the Wallingford neighborhood.[37]

A second dimension to the analysis of green space is accessibility. Common green spaces, such as parks and the greenbelt surrounding the Reference District, are available to each and every resident, owing to their public status. On the other hand, private green spaces, namely the yards surrounding single family residences, are the exclusive domain of the individual household. Generally this is the land-owner, but a single-family renter also enjoys this exclusivity.

[37] Some examples include Pipers Creek at Carkeek Park, the ravine at Ravenna Park, the wooded hilly area of Magnuson Park, or the arboretum at Washington Park.

There is a powerful bias in American culture toward the production and maintenance of private space. But quasi-private green spaces exist as well, such as the yards surrounding duplex/triplex configurations where access is shared between two or three households. Another form of quasi-private space surrounds a multi-family development. This green area is usually exclusively landscaping that doesn't provide the functional equivalent of a private yard, but still provides an important natural amenity nonetheless. The provision of private green space is offset by the reduction of common green space, as will be shown in the subsequent analysis.

Green Space Methods

The analysis of open and green spaces is very straightforward. GIS data for parcels was sorted by type of land use. Next, parcel areas were calculated, tabulated, and categorized into subtypes of land use. Any space not built upon or paved for transportation purposes was considered 'open'. However, meaningful analysis proceeds only after identifying the appropriate subtypes of open space should be compared. Tables 7 and 8 list the types of open and specifically green spaces found within the study areas, along with total areas, allocation per person, and as a percentage of total land use.

Table 7 : Open Space (Exclusive of Paved Surfaces) in Wallingford

Coverage Type	Amount (sf)	% of Total	sf/ person
Greenbelt (Exclusive of Parks)	-	-	-
Courtyards	-	-	-
Private Yards – SFD	12,696,608	39.8	726
Soft ROW	7,128,001	22.3	408
Public Parks	5,968,485	18.7	341
Non-Residential 'Open' Space	2,847,691	8.9	163
Private Yards – SFA	1,827,419	5.7	105
Multi-Family 'Amenity' Space	1,016,193	3.2	58
Private Decks	229,928	0.7	13
Private Patios	222,998	0.7	13
OVERALL TOTAL	**31,937,323**	**100**	**1,827**

Source: Seattle GIS Data

Table 8 : Open Space (Exclusive of Paved Surfaces) in the Reference District

Coverage Type	Amount (sf)	% of Total	sf/ person
Greenbelt (Exclusive of Parks)	25,871,955	81.3	2,250
Courtyards	1,518,903	4.3	132
Private Yards – SFD			-
Soft ROW			-
Public Parks[38]	4,446,495	12.7	387
Non-Residential 'Open' Space			-
Private Yards – SFA			-
Multi-Family 'Amenity' Space			-
Private Decks			-
Private Patios			-
OVERALL TOTAL	**31,837,353**	**100**	**2,768**

Source: Seattle GIS Data

Some subtypes pertain only to one or the other case; e.g. Wallingford does not include any greenbelt space. Similarly, the Reference District does not contain any strictly private yards or 'soft' right-of-way. Public park areas are calculated from GIS data. Courtyards in the Reference District are taken from design-based specifications as drawn and calculated in AutoCAD.[39] Private yards are defined as parcel areas with building footprints subtracted. Patios and private decks are areas contained within the building footprint database and have been separated out for more refined exploration of land use. Multifamily residential 'amenity' space refers to the open space surrounding a multifamily development that could include landscaping, patios, or small private yards for some residents. This simplified approach doesn't account for amenity areas such as balconies, raised plazas, or rooftop gardens. However, the total area potentially devoted to these uses is very small.

[38] Public parks in the Reference District are specifically urban 'pocket parks', and therefore represent a very small amount of total open space. It would be likely that a substantial amount of the greenbelt areas would be dedicated to public parks as well.

[39] Reference District designs in AutoCAD are all in metric units (meters), so small conversion factor errors will occur, but are insignificant with respect to the magnitude of the numbers themselves.

The grass ‘amenity strip’ between the curb of the street and the sidewalk is termed ‘soft’ right-of-way and included as open space. Therefore, ‘hard’ ROW is the total of sidewalks and paved rolling surfaces for automobiles.

Sidewalk areas present a challenge to classification. In this analysis, they are tabulated as part of the transportation network owing to its strong functional affinity for that category. But they might also be considered open space. Here qualitative judgment of spatial character is essential to the task of understanding sidewalk space. First, consider the total amount of area dedicated to sidewalks and ‘soft’ ROW. Of the total land area, sidewalks represent 3% and ‘soft’ ROW more than 13%. The grassy areas provide some runoff diversion and certainly ameliorate the otherwise hardscape surfaces. When seen in this light, they are positive enhancements. But if we look at this as a spatial practice, it becomes clear that the sidewalk and grass strip are not particularly high-quality spaces. They are long and narrow, monotonously repetitive, rigidly oriented, and largely appearing to lead only to other single-family houses. Without a doubt a grass strip is more appealing than a concrete strip, but it’s not a place you’d set up a barbecue or arrange to meet friends. Therefore, sidewalks are considered ‘open’ spaces, but not ‘green’ spaces, though they are indeed generally covered with grass.

The aesthetic of sidewalk space is not being called into question, as the architectural charm of Wallingford’s Craftsman bungalows and handsome landscaping make the walking experience quite enjoyable. Rather, it is the distances created by the density of detached single-family homes that detracts from pedestrianism. Even on the fairly modest lots of Wallingford, walking origins and destinations are further from one another, thus less traversable by foot. In the walkability analysis that follows, the distinction between types of walking will further clarify the nature of pedestrian-dominated space.

Green Space Analysis

As can be seen in Tables 9 and 10, The Reference District provides more total green space per person (2.20x), and substantially more park space per person (7.73x) than does Wallingford.[40]

Table 9 : Allocation of Open Space in Wallingford

Space Type	Measurement	Units
Allocation of Total Green Space	1,256	sf/p
Allocation of Green Space as Parks	341	sf/p
Allocation of (Quasi-) Private Green Space	915	sf/p
Total Green Space	21,961,631	sf
Average Individually Accessible Green Space	5,969,400	sf
Accessible Space as % of Total Green Space	27.18%	

Source: Seattle GIS Data

Table 10 : Allocation of Open Space in the Reference District

Space Type	Measurement	Units
Allocation of Total Green Space	2,768	sf/p
Allocation of Green Space as Parks	2,636	sf/p
Allocation of (Quasi-) Private Green Space	132	sf/p
Total Green Space	31,837,353	sf
Average Individually Accessible Green Space	30,318,582	sf
Accessible Space as % of Total Green Space	95.23%	

Source: Reference District CAD Model

Since we presume a general preference for individual control of land over collectively owned land, this is the only indicator where Wallingford bests the Reference District, devoting a significant 6.93x to private ownership. In Wallingford, a resident's share of private open space is 915 sf. This is a simple average of the total privately owned open space divided by population. A more detailed approach breaks down private open space per dwelling unit type in an attempt to unmask the underlying spatial practice in greater

[40] Per Figure 8, it is assumed that all of the greenbelt area could be given over to public parks. However, should the land be used for another purpose, that other purpose should be evaluated as well.

resolution. Table 11 shows the breakdown of (quasi-)private space associated with the different housing types.

Table 11 : Distribution of (Quasi-) Private Green Space in Wallingford by Units per Parcel

# Households per Parcel	Total Area by Type	Total # Households	% of Total Households	Average Green Area	% of Total Area
1	11,491,324 sf	4,439	53.9%	2,589	84.5%
2-4	1,368,36 sf	1,477	18.0%	926	10.1%
5+	734,606 sf	2,312	28.1%	322	5.5%

Source: Seattle GIS Data

Here we see that the average private yard for a detached single-family home is almost 2,600sf. Whereas for more compact multifamily units, only 322sf of open space exist per household. Stated another way, 53% of the dwelling units command 84.5% of the privately owned open space, whereas some 28% of units collectively command less than 6% of privately owned open space. And much of that is merely landscaped area that provides no opportunity for gathering. At 322 sf per household, the bottom 28% average 143 sf per person – barely more than the per person allocation in the Reference District. So even given the preference for private ownership, a change to a carfree system would have very little impact, in terms of personal green space, for nearly 1/3 of the population.

One’s personal ‘share’ of green space is only an indicator of how much green space is provided overall. In terms of total green space, the Reference District provides nearly three times (2.77) area per person. Because the vast majority of open space surrounding the Reference District is essentially a greenbelt, and whereas most of the open space in Wallingford is dedicated to private single-family yards (for 50% of the residents), the Reference District provides almost eight times (7.72x) as much open space as parks.

There is a more compelling inquiry, one that is able to capture the nature of private ownership versus commonwealth: how much green space is accessible by any given individual? Only a tiny fraction of the total land area given over to private yards is available to any given resident (roughly 6 hundredths of a percent), namely that area in *one's own* yard. In the Reference District, this amount is similar, but what is gained is critical. As the whole population trades off private space in exchange for common space, the cumulative effect is tremendous. This amount of individually accessible green space is evident graphically on Indicator 6 (Figure 11).

Because of its compact form, the carfree scheme intends to preserve the open space that would otherwise be engulfed by sprawl development as open space. How this open space would be used is flexible: greenbelt nature preserve, localized agriculture, landscaped park lands, etc. The key point being that the land is not developed as an urbanized area. Of course, local conditions – i.e. adjacency to natural and other urban boundaries – would ultimately limit the possible greenbelt extent. For comparative purposes, the assumption is made that if each person in Wallingford has a total local land footprint of some 3,000sf at a given density, then the residents of a carfree city should be entitled to the same land area to be disposed of differently – through an alternative approach to spatial practice. This is one example of a tradeoff between private and social orientation of spatial practice that needs to be made more explicit in the context of density decision-making. And the results confirm the cost-benefit relationship: Total green space in Wallingford is 544 acres, of which 141 acres (25.9%) are available to any given individual (on average). This individually accessible green space is the total of all parks plus one's share of private open space. In the Reference District, the average individually accessible green space is 765 of 799 acres (95.7%), or nearly all of the land use. Truly this reflects a social orientation toward space, where the vast majority of land is held in commonwealth to everyone's mutual benefit. This isn't meant to disparage the primacy of private property in the United States, only to offer alternatives, at least conceptually, so that individuals have a more thorough understanding of the impact of maintaining an unquestioned status quo.

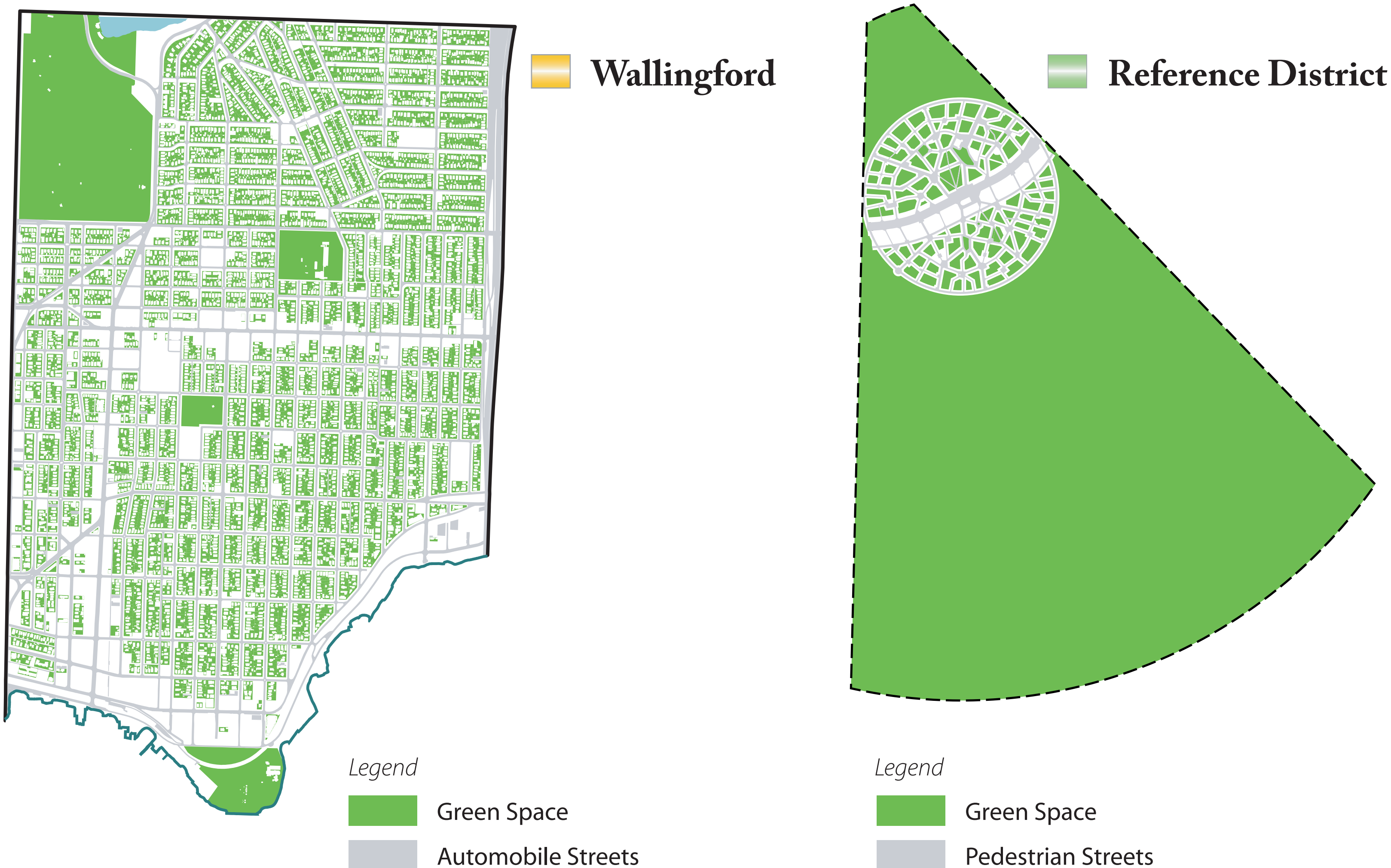


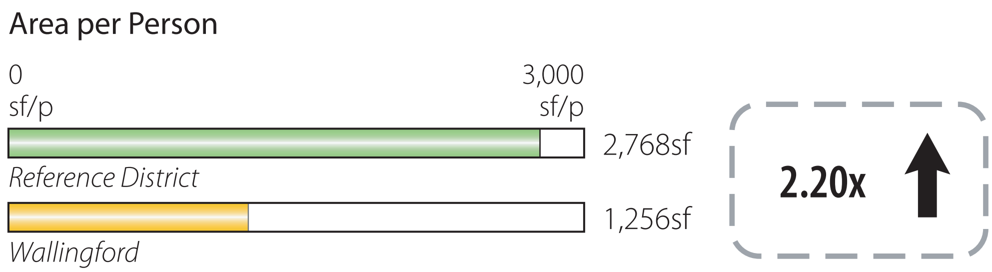
Figure 7

Indicator 3 | Allocation of Open Green Space

Figure 8

Indicator 4 | Allocation of Green Space as Parks

Indicator 3 | Allocation of Open Green Space



Indicator 4 | Allocation of Green Space as Parks

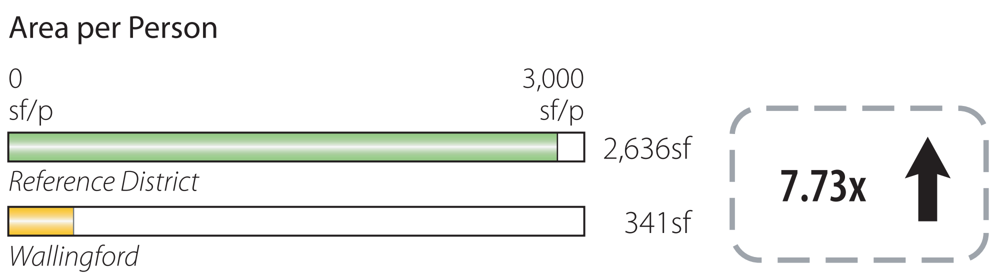


Figure 9: Metrics for Indicators 3 and 4

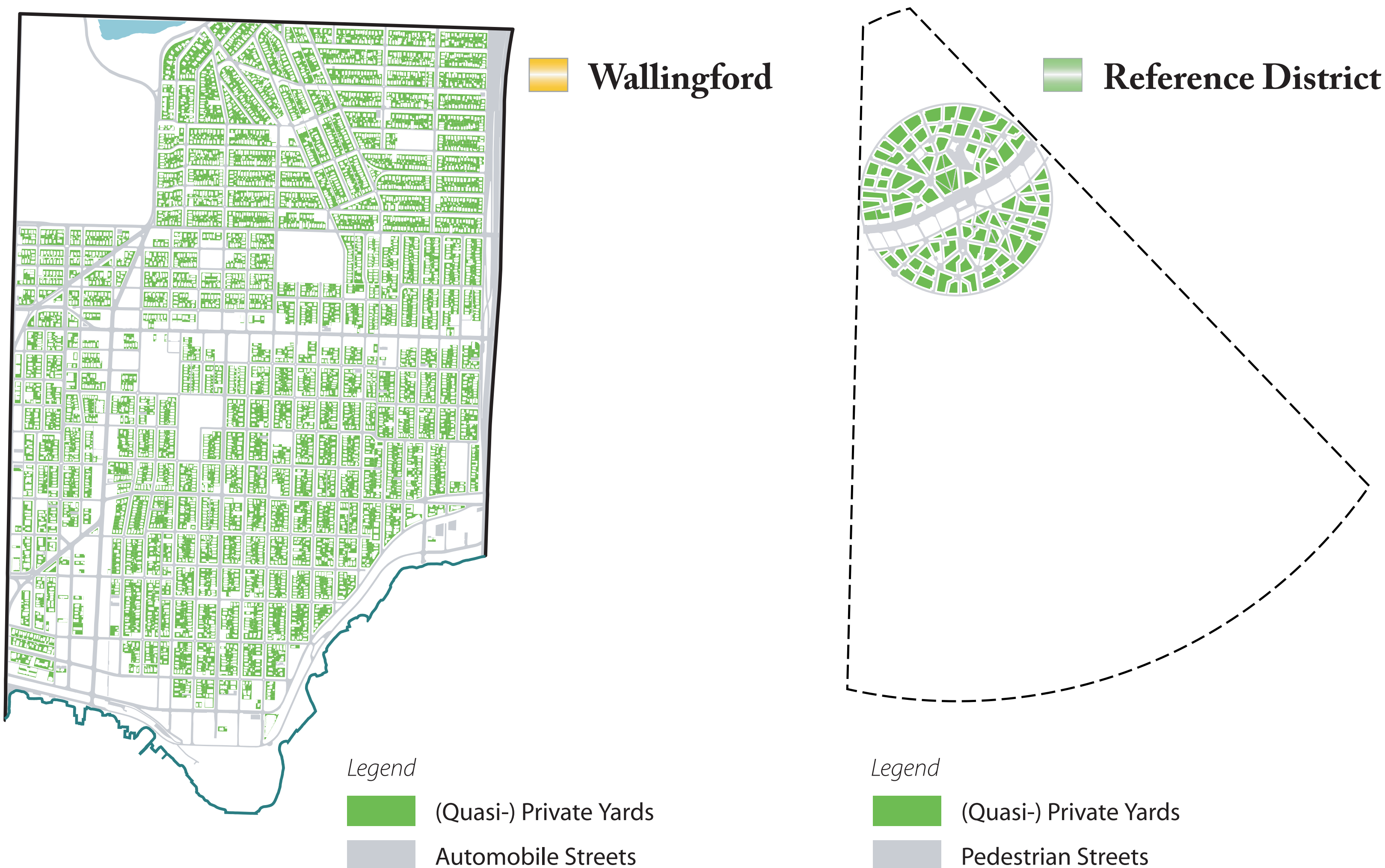


Figure 10

Indicator 5 | Allocation of (Quasi-) Private Private Yards

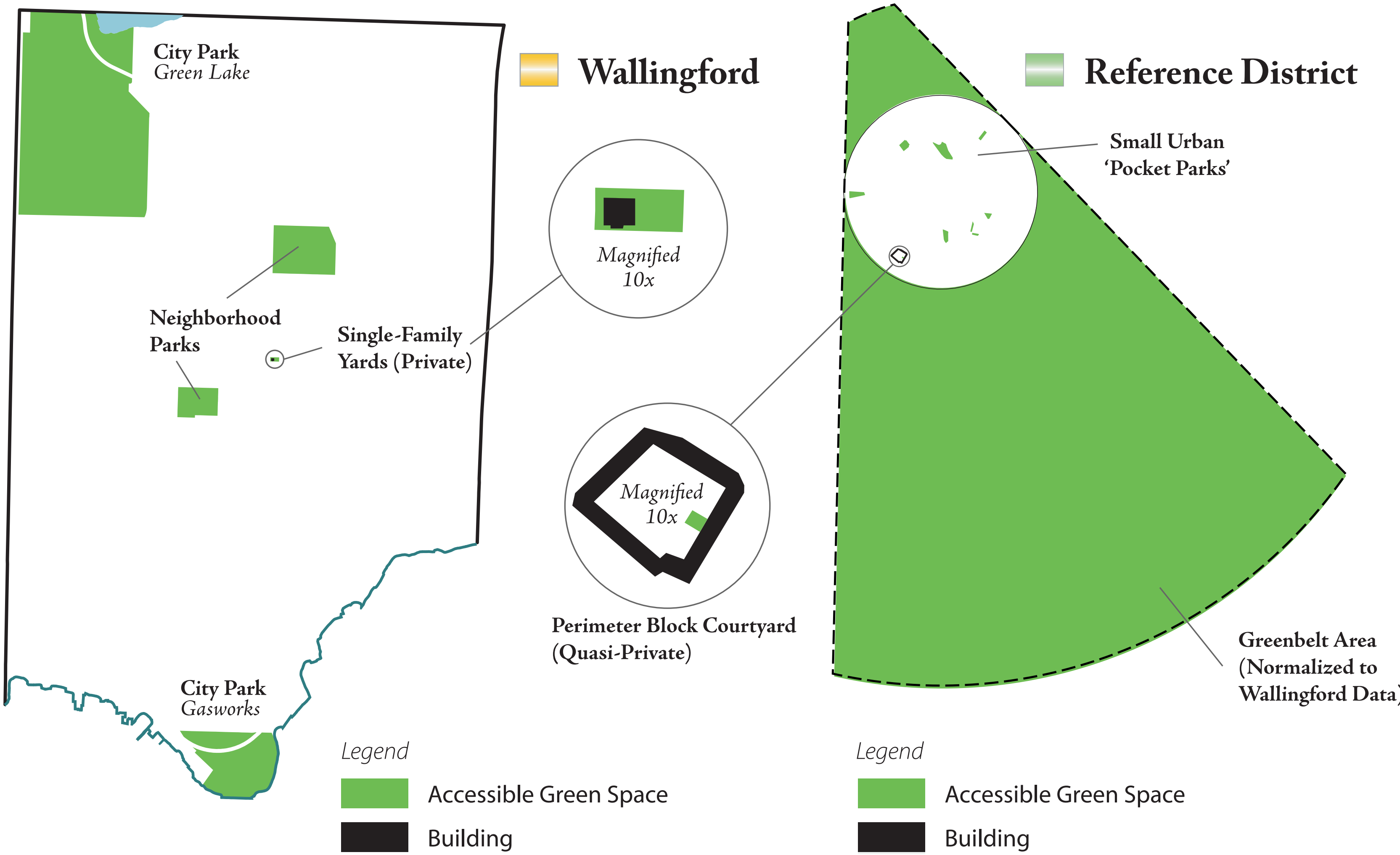
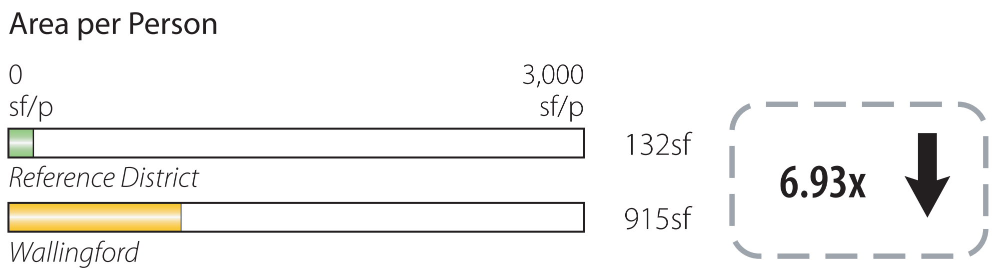


Figure 11

Indicator 6 | Individually Accessible Green Space

Indicator 5 | Allocation of (Quasi-) Private Yards



Indicator 6 | Individually Accessible Green Space

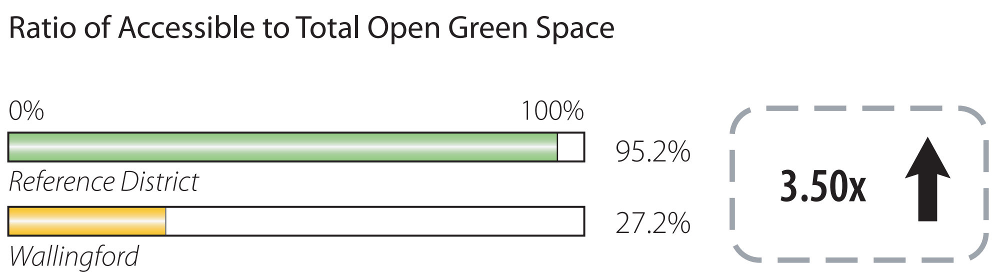


Figure 12: Metrics for Indicators 5 and 6

5.5 Comparison of Walkability

Walkability Introduction

With the growing indictment of sprawl as a supporting cause of a host of public health, environmental and social issues, many urban designers are calling for mitigation of the causes of sprawl. Because of the pivotal role of the automobile in the production of sprawl, schemes that address the mitigation of the spatial effects of automobile-dominated space should be of particular interest. The primary attraction of the private automobile is self-described: mobility. Mobility is a relationship to spatial movement that provides maximum flexibility of access with maximum freedom of use.[41] If an urban design scheme that seeks to supplant the automobile is to be taken seriously, it must make provision for replacing the reduction or loss of automobility. That is, if private automobile space is not allocated, it must be substituted with a functional equivalent. This alternative means could include other mechanized means such as personal rapid transit (PRT) systems or a utility-car system. [42] In the Carfree City, as in Venice, the dominant mode is walking.

Walkability was an integral component of all urbanism until the beginning of transportation mechanization around the 1890's. By default, urban patterns reflected a pedestrian-dominated production of space. With the development of auto-dominated suburbs in the 1950's, utilitarian walkability ceased to be practical altogether. Density and pedestrianism are mutually constitutive and form an inverse relationship to density and automobility. Pedestrianism both supports and is encouraged by higher dwelling unit density.

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[41] A general theme throughout "Mobility: A Room With A View"

[42] Personalized Rapid Transit is explained in some detail on p124 in "Future Transport in Cities"; the Utility-Car concept is, in the author's opinion, a naïve concept promoted by architect Moshe Safdie in "The City After the Automobile"

Pedestrianism suffers when automobility dominates spatial production, pushing meaningful destinations further apart as density is lowered.

The average distance a pedestrian is willing to walk has been frequently set at 5 or 10 minutes according to several sources.[43] These numbers appear somewhat arbitrary, possibly reflecting a psychological disposition toward common increments of time measurement. Moreover, a number of factors affect the distance someone is willing to walk, including fitness, experience of the route, weather, etc. A peculiar problem arises when interpreting data related to the willingness of pedestrians to walk *x* minutes (or *x* distance) for *y* purpose. Any function relating these will provide a description of the current behavior, but cannot anticipate how one's attitude toward the experience of walking might change if the environment itself or the walker were different.

Jan Gehl describes the conviviality of 'life between buildings' as a positive feedback loop. It seems reasonable that behaviors toward walking might modulate between tolerance and pleasure, and thus walkability distances might also be altered. A further issue with current walkability scores is that it only recognizes the current state of public health, currently dominated by inactive lifestyles. If a pedestrian environment encouraged walking, improvements to muscular and cardio-vascular health could either enable faster walking speeds or greater endurance translated into greater distances. Improved experience of place along the route from origin to destination and back would likely exert a positive influence on walking. Walkability should be considered a hallmark characteristic of sustainable urbanism for three reasons: 1) pedestrianism produces a substantially smaller ecological footprint in terms of land and energy consumption, 2) a pedestrian-oriented environment produces a much improved social environment, and 3) substantial health benefits (mental and physical)

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[43] Sometimes this is expressed as the near-equivalents: ¼ and ½ mile. For example, 5 min @ 250 ft/min = 1,250' whereas ¼ mile = 1,320 ft.

accrue to walkers that are otherwise lost to automobility. The rationale for walkability metrics is simple: if important walkable destinations do not exist within a reasonable distance from one's home, then such a household must choose to drive, utilize a public transportation option (if available), or forgo the trip altogether. While public transportation may be available to some, it cannot be thought equal to flexibility of self-determination of route that either automobility or walking possesses. This study looks at walkability to utilitarian destinations for the realization of important daily or weekly needs, and to the common green spaces described in the previous section.

Walkability to Top 5 Utilitarian Destinations

This utilitarian walkability study originated in a paper co-authored with Jennifer Kipp, a fellow student in the Urban Planning program.[44] Walking may be described by three categories of purpose: utilitarian, pleasure, and exercise. The destination-dependent nature of utilitarian walking makes it the most sensitive to spatial distribution. Walking for pleasure and exercise may have a route, but this route is generally flexible. Furthermore, these categories are not mutually exclusive. For example, utilitarian walking might be a pleasurable activity and it certainly should be considered exercise. Walking for pleasure to someplace specific, such as a favorite park, reintroduces a spatial destination, yet this wouldn't normally be considered a utilitarian destination. Therefore, utilitarian walkability is the most useful measure of sustainable density.

The selection of the destinations to measure is taken from the Walkable and Bikeable Communities survey conducted by the Urban Form Lab at the University of

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[44] "Wallingford v. the Carfree District: A Comparison of Walkability and Land Use as Indicators of Urban Sustainability" written for UrbDP422, Geospatial Analysis (Instructor: Marina Alberti)

Washington.[45] Two datasets were assembled, one for an age group from 18 to 65, and another for those older than sixty five. Both are presented below in Tables 12 and 13 The walkability analysis used in this study uses the data for the 18-65 group, but a more comprehensive view would be useful. We would expect to see different areas of walkability for the 65+ age group for two reasons: 1) walking speeds and distances would likely be lower, and 2) as is evident in the tables, choice of utilitarian destinations is somewhat different. The top five destinations were chosen as a meaningful but not overly demanding criterion:

Table 12: Top 5 Utilitarian Destinations for Respondents Aged 18-65 in Wallingford

Destination	# of Respondents (n = 505)	% of Total	Total # of Desitinations
Grocery Store	250	50	1
Non-Fast Food Restaurant	126	25	46
Drug Store	94	19	3
Convenience Store	93	18	10
Cafe or Coffee Shop	84	17	17

Source: Walkable and Bikeable Communities Study, Urban Form Lab, UW

Table 13: Top 5 Utilitarian Destinations for Respondents Aged 65+ in Wallingford

Destination	# of Respondents (n = 103)	% of Total	Total # of Desitinations
Grocery Store	29	28	1
Drug Store	23	22	3
Bank*	16	16	2
Post Office*	14	14	1
Non-Fast Food Restaurant	14	14	46

Source: Walkable and Bikeable Communities Study, Urban Form Lab, UW
** Post Offices and Banks not field verified*

The graphics in Figure 13 show a 5-minute and 10-minute boundary of walkability and the parcels (Wallingford) or building plats (Reference District) contained within each. These are

[45] Complete WBC data available in Appendix E.

then used to calculate the total number of 'walkable households' according the method described below.

Walkability to Utilitarian Destinations Methods

A '5-minute walkable household' is defined as one that is located within a 5 minute walk of *at least one of each* of the top five destinations. Similarly, a '10-minute walkable' household is one that achieves the same performance in a 10 minute walk. A number of steps are required to perform this analysis for Wallingford using the parcel-based WBC dataset. A distinct advantage of the WBC data over the standard City of Seattle database (upon which it is built) is its inclusion of detailed destination designations that conform to the WBC survey instrument. To evaluate the accuracy of the land use data, all relevant commercial uses were identified on a field survey map. All identified use-locations were then field verified. Some uses were found to no longer exist and were deleted and several non-identified use-locations were added. This resulted in a spatially accurate distribution of important walking destinations. The attribute table containing the specific parcel information was updated and used in the subsequent geospatial queries.

Next, the number of households that are able to access these destinations within a certain number of minutes' walk was determined. It is possible to compute these trips from either direction, from origin to destination or the reverse, destination to origin, as the required walking time is identical. To maintain clarity, testing each origin produces a *household walking range* while testing destinations produces a *service area*.[46] The service area method was used because it requires substantially less computation. A walking buffer is first created for each discrete destination parcel according to its use. For parcels containing multiple uses, multiple buffers were created. Instead of using simple airline buffers, each use

[46] This 'service area' is sometimes referred to as a 'walking-shed'.

location was calculated using a network buffer that takes the true transportation network into account. An average walking speed of 250ft/min is used.[47] This translates to a 5-minute buffer of 1250' and a 10-minute buffer of 2500', roughly ¼ mile and ½ mile respectively.[48] All buffers for a given use are then dissolved into a single service area demarcating a 5- or 10-minute walk. The total walkable area to the top 5 destinations is logically represented by the intersection of all five service areas, i.e. the maximum overlapping area that supports walkability to at least one each of the top 5. Clearly, a small number of instances of a commercial use can have a large impact on this analysis. For example, the Wallingford study area contains only one full-service grocery store (a Quality Foods Center – QFC, in the historic Food Giant location). One noticeably vacant grocery store (a former Safeway on Stone Way) may have changed the analysis significantly had it been operational.

Finally, residential parcels in the total walkable area are located by a spatial query of all parcels that have a centroid within the walkable area. Then the total number of residential units, as contained in the 'resunits' field, are tabulated from this subset of all residential parcels.

Utilitarian Walkability Analysis

The historical platting for substantial private yards along occasional streetcar lines in Wallingford produces a relatively low urban density (6.6 du/a), which in turn produces low walkability scores. As shown in Table 14, only 230 households (3% of the total) are within a five-minute walk of the top 5 destinations. For a ten-minute walk, the number climbs to 1,812 households (23%). Of course, a post-1950's automobile suburb would fare even worse, owing to even lower densities and single-family zoning which purposefully excludes

[47] Many sources: Perry's and Stein's Neighborhood Units; Godschalk, Chapin, Kaiser; more recently, Calthorpe; even from the standard highway design manual from AASHTO.
[48] ¼ mile = 1320'; ½ mile = 2640'

commercial development. In such places, many environments would have no households within a 10-minute walk of any top 5 destination. It should be noted that during periods of heavier traffic or along well-traveled routes, including the 45th Street corridor that is the focus of the walkable area, substantial increases in time can ensue while a pedestrian waits at a stoplight for a 'walk' signal. These events would decrease the listed households even more. Furthermore, the average walking speed ignores the variability of walking speeds that especially disfavors those pedestrians over 65 years of age and those with physical challenges. These factors would affect a proposed scheme as well, however if designed for pedestrianism outright, the variability of walking speed will have relatively less impact on the overall score.

Table 14: Walkable Households to Top 5 Utilitarian Destinations (18-65) in Wallingford

Walkability Area	# of Households	% of Total
5 Minutes	230	3.0
10 Minutes	1,812	23.3

Source: Field Verified Seattle GIS Data

By contrast, the Reference District begins with walkability as a paramount physical planning principle. The district can be traversed end-to-end in 10 minutes by design, so it is not difficult to understand its 100% 10-minute walkability score. Due to the lack of distributional specificity of commercial uses, the 5-minute walkability score can be calculated two ways: either as a worst-case minimum, represented by a location at the periphery, or by the mathematically average location within the district. Both are considered in this analysis, but the worst-case example is shown graphically on Indicator [7]. The approach used to calculate walkability demarcations is the opposite of the one used for Wallingford. That is, the calculation is based on accessibility from the average household walking range. This assumes both a fairly uniform distribution of both destinations and household density. Both premises are supported by the mixed-use building types and composition as articulated in the design scheme. When calculated as a minimum walkability, the score is 1,942 households (38%). When calculated from a mathematically average position (which is quite accurate owing to the circular nature of the design), it is 3,016 households (59%). Of course, the two cases have different populations so the household numbers cannot be compared directly. The percentages, representing the ratio of walkable households to total households, can be compared directly and are shown in Table 15.

Table 15: Distribution of Walkable Households in the Reference District

Walkability Area	# of Households	% of Total
5 Minutes – From Worst-Case Location	1,942	38.0
5 Minutes – From Average Location	3,016	59.0
10 Minutes	5,111	100.0

Source: Reference District CAD Model

Walkability to Public Parks

As mentioned in the previous section, common green space (generally understood as public parks in Wallingford) serve an important role in urban areas. They form a functional role in providing open space and a place to congregate, but they are closely tied to important psychological benefits of 'connection to nature' or 'getting away from the bustle of urban life'. (source, justification) The total amount of park space, or even the individually accessible park space from the prior analysis, doesn't describe how far one must walk (or drive) to access the park. There are many sources pointing to how much park space ought to be located within some distance one's household. For example, Christopher Alexander prescribes 3-minutes as the maximum distance.[49] Kaiser, Godschalk, and Chapin put this desired figure at <1/4 mile, or 5.28 minutes (rounded to 5 minutes in this analysis).[50] Such numbers could be refined using additional survey data based upon local conditions. A 10-minutes' walk to a park is included as well to maintain consistency with the utilitarian walkability scores.

Walkability to Common Green Space Methods

This analysis measures service areas for common green space using the more simplified method of airline distance buffering. An 'x-minute walk' means that from a walkable household a pedestrian could access the open space of a park in x minutes. Any minutes beyond can be enjoyed in the open space. Because park space covers a broad area, the greater precision of network analysis is deemed unnecessary. However, whatever method is chosen, it must be used consistently in all cases in order to ensure comparability of measurements.

For Wallingford, 3-, 5-, and 10-minute buffers were created from each parcel identified as a public park. These were then dissolved into areas of walkability. Every parcel with a centroid within this dissolved buffer was included in a subset of x-minute walkable parcels. The number of households was then calculated using the 'resunits' field of this subset.

For the Reference District, two types of park space exist: urban 'pocket parks' consistent with the type of amenity provided in larger cities and an allocation of park land around the perimeter of each district that would contain garden plots and a continuous network of paths throughout the entire city topology. Thus, offsets were created in AutoCAD

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[49] Alexander, A Pattern Language, p308

[50] From Kaiser, Godschalk, and Chapin (1995) as presented in Land Use Planning Made Plain, p96

from the urban park geometry as well as from the perimeter. [51] By design, and as confirmed by the explicit area analysis, every square foot of building footprint was located within a 3-minute walkable area. Again, owing to complete coverage, a spatially explicit location of households was not required for analysis. The graphics showing these areas are shown as Indicator 8 (Figure 15).

Walkability to Common Green Space Analysis

Walkability to parks in Wallingford is much better than to utilitarian destinations. Nearly one-quarter of Wallingford households (23.7%) are within a 3-minute walk to open park space. Somewhat less than half are within 5 minutes (44.2%). And nearly all (93.2%) are within a 10-minute walk. This performance, though laudable, is still overshadowed by the fact that every household in the Reference District is within a 3-minute walk of park space – satisfying even Alexander's stringent recommendation. Again, this is no accident, but an intentional outcome of the design process. One obvious conclusion should be stated nevertheless: higher density development is capable of putting amenities such as common green space within a much closer walking distance than lower-density development.

[51] As a technical note, the 'offset' command in AutoCAD does not produce exactly the same geometry as the 'buffer' routine in ArcGIS. This affects the radii of intersecting corners and must be corrected for. Parallel edges are unaffected.

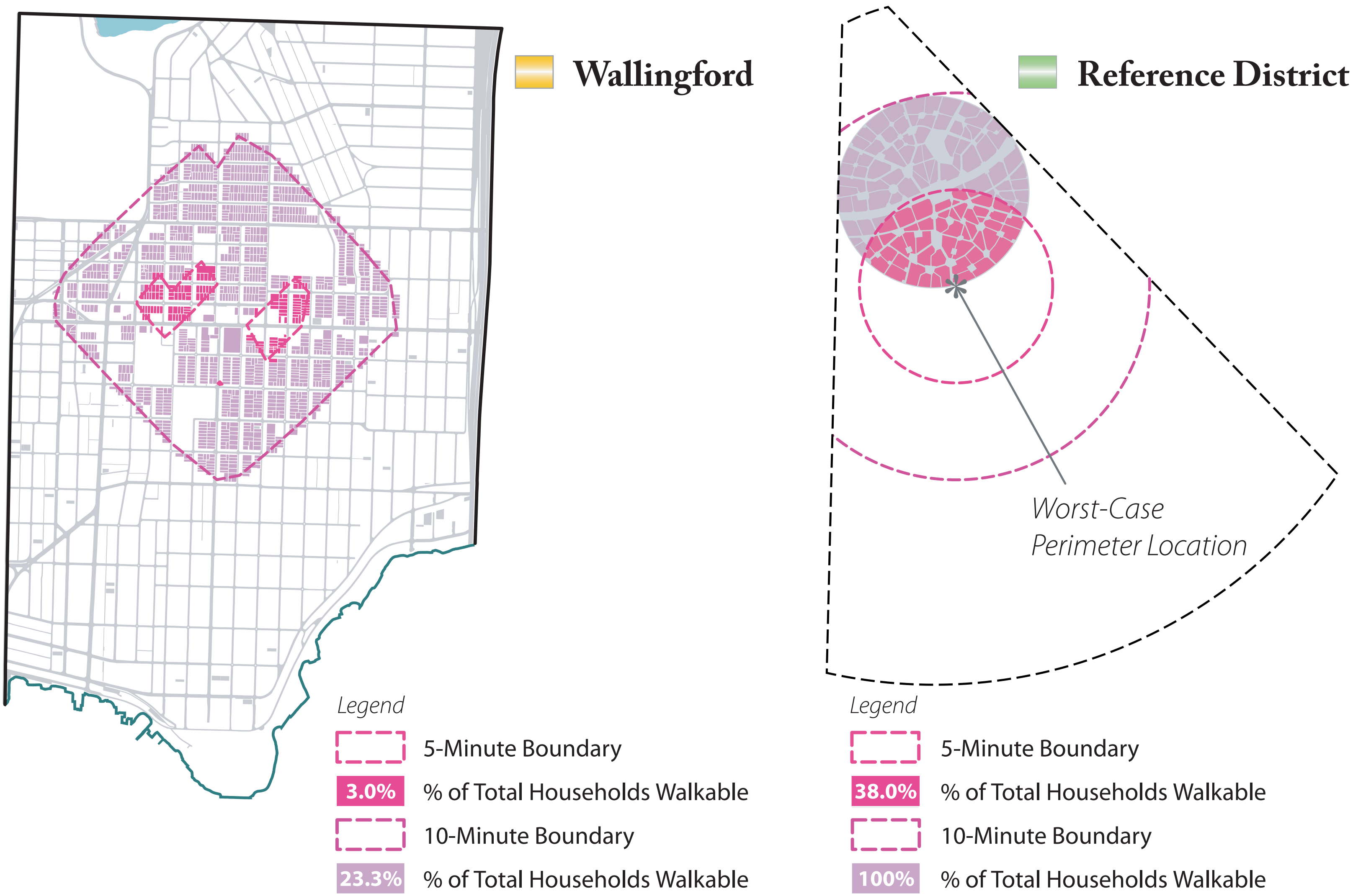
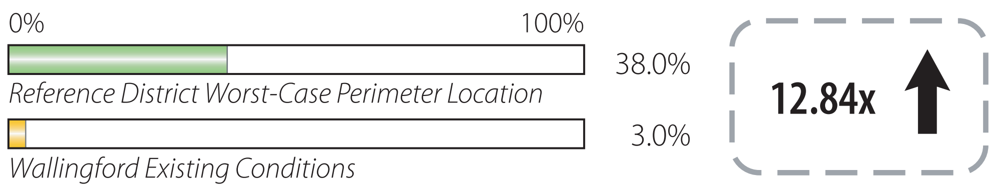


Figure 13

Indicator 7 | Walkability to Top 5 Utilitarian Destinations

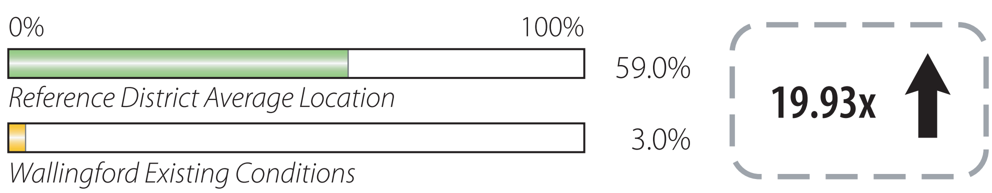
Indicator 7a | Walkability to Top 5 Utilitarian Destinations

% of Households Within 5 Minutes



Indicator 7b | Walkability to Top 5 Utilitarian Destinations

% of Households Within 5 Minutes



Indicator 7b | Walkability to Top 5 Utilitarian Destinations

% of Households Within 10 Minutes

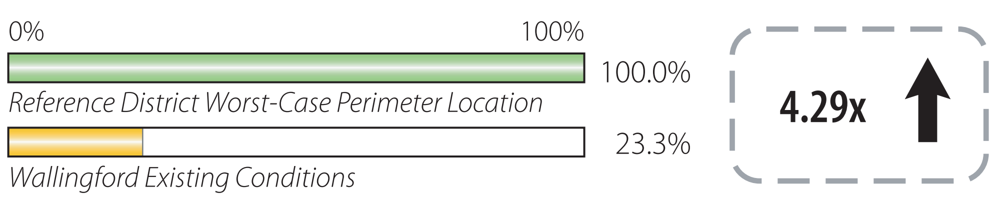
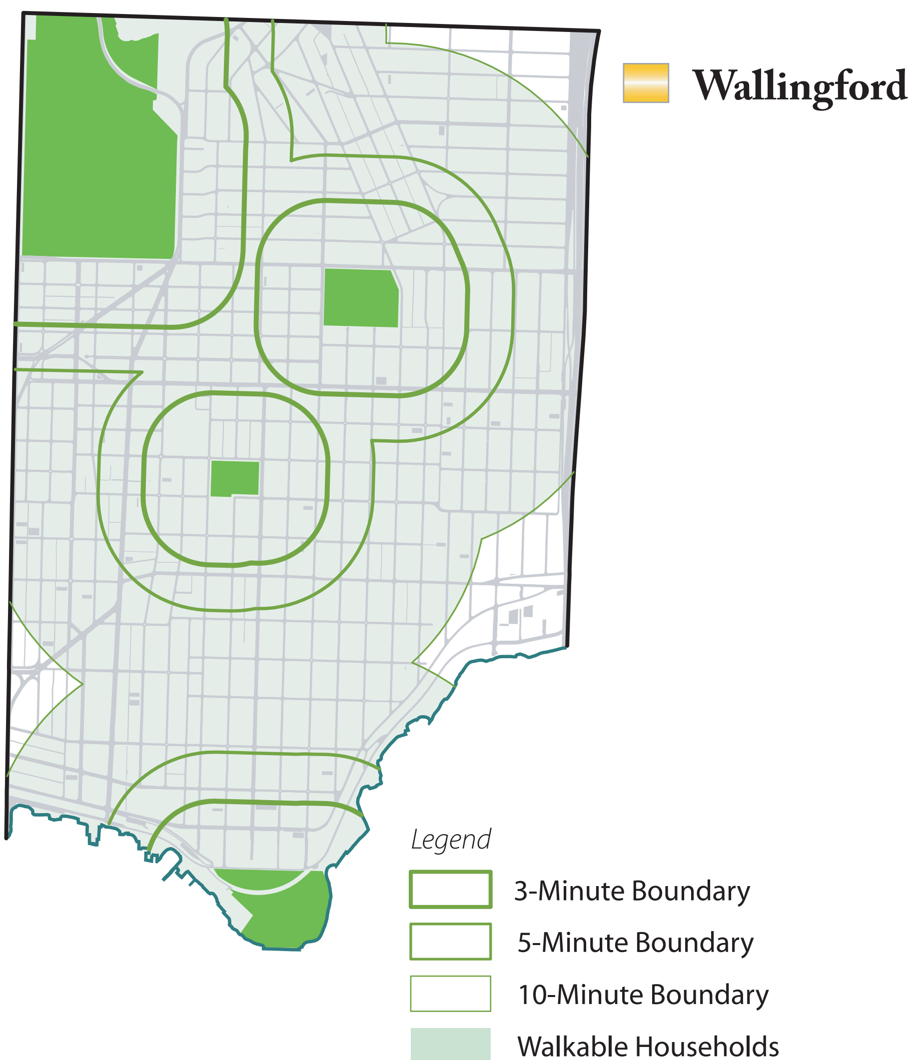


Figure 14: Metrics for Indicator 7



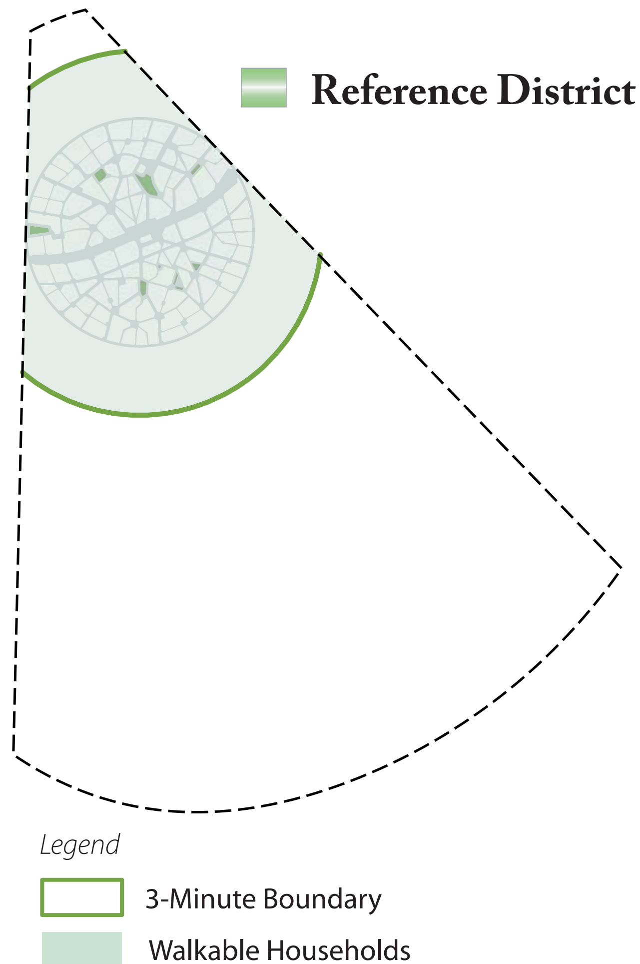
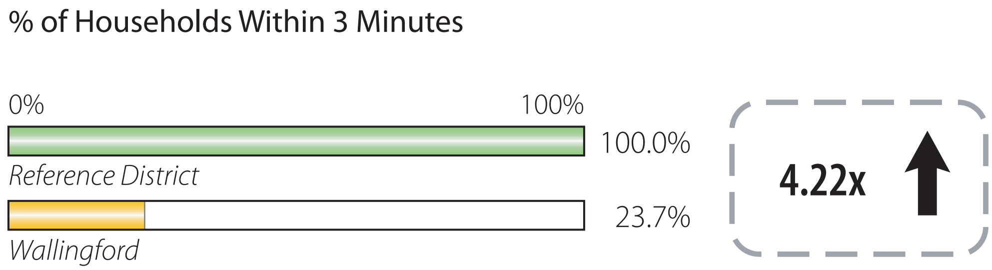


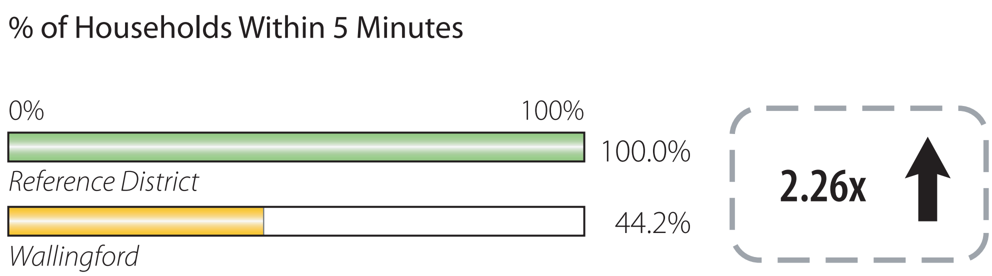
Figure 15

Indicator 8 | Walkability to Park Space

Indicator 8a | 3-Minute Walkability to Park Space



Indicator 8b | 5-Minute Walkability to Park Space



Indicator 8c | 10-Minute Walkability to Park Space

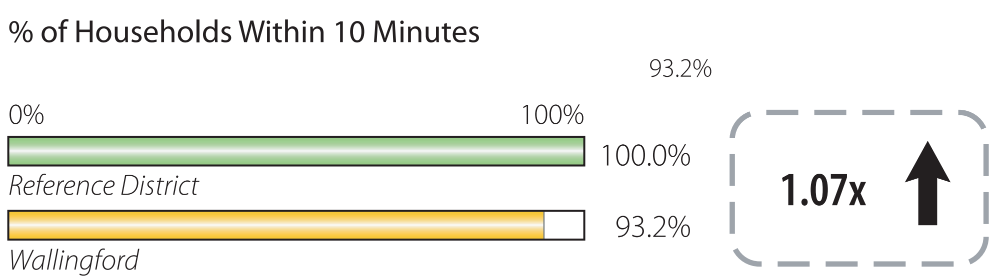


Figure 16: Metrics for Indicator 8

6. Conclusion: Attaining Greater Urban Sustainability Through Design

Scenarios for the Future

Robert Costanza, a leading ecological economist, provides a tidy four-square typology to guide our understanding of our possible futures, the eventual product of our contemporary spatial practice.[52] Like Blaise Pascal's Wager, which explores the cost-benefit relationships between *acting* as if God exists or not when considered against the ultimate *reality* of whether God exists or not, Costanza elevates the reality of societal/civilizational orientation to a personal understanding of the future. This, when combined with a Lefebvrian understanding of spatial relations, provides a powerful basis for urging personal responsibility for spatial practice and its outcome.

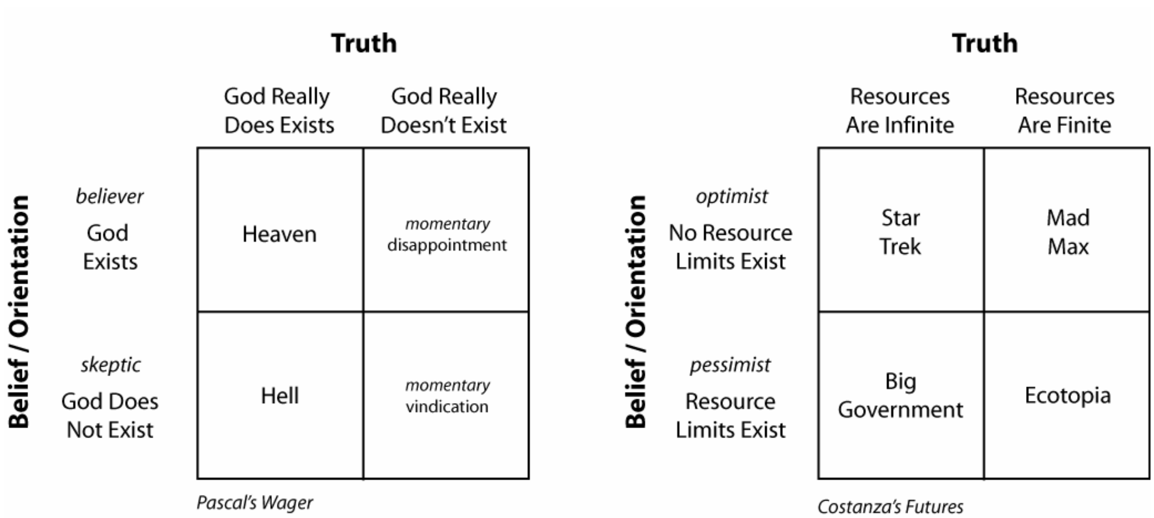


Figure 17 : Rational Scenarios: Pascal's *Wager* and Costanza's *Futures*

Costanza paints our *belief* in the finitude of natural resources as either optimistic or pessimistic. This compares then with the ultimate *reality* of whether this is indeed so. Rather than

[52] Much material in this section comes from "A Revolutionary Approach to Sustainability", written by the author for UrbDP498 – Qualitative Research Methods, and "A Normative Theory of Sustainable Design" for BE552 – Theories of the Built Environment, both led by Dr. Mugerauer.

Heaven and Hell, we find before us four distinctly different futures. Each is readily apprehended, and several studies have been done that utilize the scheme as a matrix of preferences, a menu of desirable outcomes. In short, if we orient our civilization as if no resource limits exist, then 1) if we are right, we will live in a world akin to Star Trek, where humans reach their fullest potential with unlimited clean energy, space travel and ultimate dominion over nature; or 2) if we are wrong, we will live in a world akin to Mad Max, a post-apocalyptic nightmare where our civilizational power is ultimately squandered and the human condition is characterized by suffering and remorse. If we orient our civilization as if resource limits do exist, then 1) if we are right, we will have a world akin to Ecotopia, living as bountifully as possible within our means, preventing Mad Max; or 2), if we are wrong, we will have an burdensome government unnecessarily hampering progress (especially economic) toward the ultimately attainable Star Trek scenario. Clearly, as is the point of Pascal's Wager, not all options carry equal weight when considered together. Costanza's contribution to sustainability is a profound one, for he combines simple logic with powerful visualization to illuminate the eventualities associated with societal and civilizational orientation, with the implicit message that our belief can change. Indeed, the aggregate societal orientation is not static, but changes as its members manifest current ideologies through their social practices. Put more directly, our orientation toward the optimistic is a choice (however manipulated) and not a predisposition.

Once we have a productive working definition of sustainability, we must turn our minds to the question of how to attain sustainability. With the knowledge that orientation is a choice and that our reality is shaped by our social context, an obvious conclusion is to generate revolution through alterations of key relations of power. There are two areas of emerging scholarship that speak directly to this facet of the sustainability issue. The first is the neo-Marxian critique of space, and the second, a new brand of utopian urbanism, both intended to restore our balance within nature. Clearly, sustainability is a very complex, high-level concept in application.

Another difficulty arises from the fact that the word sustainability refers to two modes of spatial production. In *spatial practice*, it represents a state of the biospheric condition that supports the *representational space* of human aspiration for distributive justice among groups and across generations. Therefore, sustainability is not an *object*, it is not obtained. Further, it is not a historical *bifurcation*, something that can be achieved or permanently arrived-at. Rather, it is an *attained state*, possibly attained in myriad ways, and certainly an attainment that can be lost again. It is not a milestone we're after, but a balancing of our interaction with the rest of the natural world and with each other that is ongoing, indefinite – *the attainment of an aspiration*.

Regardless of one's philosophical orientation – deep (nature as intrinsically valuable) vs. shallow (anthropocentric utilitarian value) or optimistic (no limits) vs. pessimistic (inherent limits) – we must admit the reality that each response will fare differently according to how successfully it deals with the reality on the ground, whatever that may be. It is simply irresponsible to deny the possibility that any given *status quo*, the product of a unique moment in the history of the production of space, will always be the superior one. From a historical perspective, such a claim is ludicrous, and for any philosophy that acknowledges some manifestation of a Hegelian dialectic, a powerful Marxian structure for contextualizing the *status quo* is at hand.

Will we continue to build the world according to the singular logic of capital accumulation, until such time as the earth's own capital is spent? Or will we bend the logic of development to a broader, more sustainable, social aim? I can only speculate on our ultimate course of action, but one thing seems certain: if, at some point in the future, our civilization is compelled to eschew the excesses of late industrial capitalism in favor of a more geocentric system of production, there will be a great clamoring for guidance on how to attain the greatest amount of sustainability at the least expense to our sensibilities as citizens of a post-modern world. The author hopes that by leveraging those abilities and technologies that have afforded us the capability to dominate nature so thoroughly, we will create innovative solutions to live longer with less.

The purpose of creating indicators is to tell a story – in this case, the story of urban sustainability. For an environment to be truly sustainable, it must not just reduce our human impact on the planet but provide a suitable place to live. From a pragmatic standpoint, making change ahead of catastrophe will be a tough sell unless the alternatives can provide lessened impact *and* improvement in urban living conditions *at the same time*. This is the test put to the Carfree design scheme. As David Harvey suggests, the 'insurgent architect' will be a major force for sustainability – using design to find solutions that lessen impact and improve urban spaces.[53] He talks of 'spaces of hope' where human ingenuity, when coupled with a critical approach that addresses challenges with an intellectual honesty, can propel appropriate change.

On the other hand, one can imagine the draconian implementation of ecological austerity measures as per Costanza's 'big government' or 'mad max' scenarios. Increasing degrees of austerity are acceptable when the alternative is sufficiently terrifying. It is common for environmentalists to talk of a major calamity that will awaken us to the need for change. But our world is currently dominated by a space of late industrial capitalism, as been explained by Felix Guattari, Harvey, and others.[54] This is a dual, complementary domination – of capitalism, with its attending epistemological system of the scientific validation of knowledge. The issues of environmental degradation are slow-burning, to use the parlance of news reporting. They fail to keep the attention of even the relatively well-informed public, being pushed out by the more stimulating fast-burn issues that take precedence owing to their immediacy and novelty. Even when ecological issues reach the level of calamity, as was

[53] Harvey, p223
[54] Guattari, p47, his term is Integrated World Capitalism

witnessed with the Hurricane Katrina disaster, debate over whether the tropical storm issued from human-influenced climate change or not sterilizes the inquiry. If we can't be sure, science tells us, then it isn't true with certainty. Without certainty it becomes very difficult to take definitive, timely action. This is why Maclaren argues that the story of sustainability has become so important as a means of reframing the way we look at environmental issues. With our current knowledge, planetary systems are too complex to be modeled deterministically. And quite possibly they are too complex to ever be modeled deterministically, if the systems themselves do not follow strictly deterministic laws, as many contemporary philosophers of science argue.[55] Thus we are left to interpret a meaningful understanding from what we can ascertain. The story of sustainability is about fitting this interpretation to an ethical framework that is meant to be commonly shared sensibility.[56]

Some argue that this interpretive act is too laden with ideology to be considered objective. But it is not objective knowledge that is sought after. That Wallingford has more impervious surface area per person than the Carfree Reference District cannot be denied. Nor can the apodicity of ratios comparing amount of impervious surfaces dedicated to automobile versus pedestrian space. It is the intersubjective agreement that produced a social aim such as 'reduce impervious surfaces to decrease the human threat to wild salmon' that provides the basis for comparative interpretation. Then we may say that the carfree scheme is the better of the two in terms of reducing the amount of impervious surface area to achieve sustainable performance.

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[55] For a thorough treatment, see Polkinghorne "Methodology for the Human Sciences" and Bernstein's "The Restructuring of Social and Political Theory"

[56] Per an unpublished paper by Robert Mugerauer, Sustaining Entire Mixed-Environments.

The Production of Space

When we decide there must be a change in the course of civilization, we are confronted with the full force of power resident within the inertia of the current hegemonic power. How then, are we to affect change? Lefebvre insists that the revolutionary project be based upon an understanding of the spaces that constitute our reality. Through critical understanding and compassion, we can transform human culture to bend it toward our collective benefit and desire, and away from our misery and demise. But to do so means altering the production of space toward that end. More to the point, Lefebvre illustrates an essential nexus between the revolutionary project and the production of space: "A social transformation, to be truly revolutionary in character, must manifest a creative capacity in its effects on daily life, on language and on space…"[57]

By understanding the relationships between social, conceptual and symbolic space, the revolutionary practitioner can influence the ongoing development of human civilization by modifying its orientation, both directly as a technocrat, but also indirectly through effective communication with the public. Several contemporary urban designers (including Crawford) are responding to Lefebvre's call by articulating schemes that nurture human social structures while altering the relations of industrial throughput. One major avenue for this work lies in the repair of social spaces for people by designing space that is human-oriented, not auto-oriented. Architecture may have squandered its power to affect positive social change, but it has not been lost altogether. Architects certainly do design social space even today, but only insofar as they refine the possibilities within an envelop of 'possible spaces' as defined by the mechanisms of dominant social practice. This is always the case, except perhaps in local, idiosyncratic projects. Planners too are rendered largely ineffectual, having accepted the primacy of incrementalist,

[57] Lefebvre, 1974, 54

rational planning. Socially-oriented urban designers are bound to neither, and so it comes as no surprise that their conceptual space is an avenue for real progress.

The dynamics of urban systems have been studied at great length, at least indirectly, by economists for centuries. But as is inherent to positivism, econometric methods are only adept at describing the interactions of stakeholders in the present state, in a relatively fixed context. That is to say, they describe *what is*, but cannot describe with much certainty *what will be* and certainly not *what should be*. Only a historical approach affords a sense of place for our cultural understanding of social orientation.

Mobility and the Production of **Autospace**

There is no doubt that mobility – the freedom to move through space at one's leisure and under one's own control – is a powerful force. The 'American Way' is steeped in the automobile, as is the global economy and therefore global power structures. One needs to look only cursorily at the politics of petroleum to see this clearly. Moreover, the automobile is crystallized into the urban exoskeleton, as Manuel DeLanda calls it, framing the core criteria for nearly all Western development since World War II.[58]

With respect to mobility, Lefebvre explains that "owners of private cars have a space at their disposition that costs them very little personally, although society collectively pays a very high price for its maintenance."[59] The problem of the automobile is twofold, for it is unsustainable in its current form as a material object, and it's production of space, *autospace,* is also unsustainable through its spatio-temporal externalities. The former is much better understood and certainly more intuitive – physical automobiles produce untold environmental degradation, health problems, economic dislocations, even death. But the distinction is important. For even if

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[58] DeLanda, 2000, 27
[59] Lefebvre, 1970, 359

the physical automobile can be made to be environmentally harmless materially (zero-pollution / zero-danger – a doubtful prospect), it would still persist to dominate urban *space* unnecessarily, and with this domination follows the whole host of related problems.

6.1 Spatial Dominance: Pedestrian Friendly vs. Pedestrian Oriented

I choose the phrase spatial dominance because one type of space is produced at the expense of the other. We cannot simultaneously produce, in one location, both automobile and pedestrian space. They are mutually exclusive because of their disparate spatio-temporal requirements, especially with respect to speed and amount of area required for efficient service.

The author rejects the notion that consumers (at least some – even in the United States) will never give up 'the American Dream' of a large, detached single-family home on a large lot serviced by the private auto – and the concomitant sprawl it generates. Preferences are constantly in flux and are in large part shaped by spatial practice. If we choose to alter our spatial practice, be it on ethical or even purely pragmatic terms, then our orientation toward sustainability is changed. Thus, it could be changed to achieve sustainability goals. Moreover, as the New Urbanists have argued, offering sustainable alternatives is not about prescribing how everyone ought to live, but rather an expansion of choices so that we might incrementally improve our urban performance as new developments are created or old districts are regenerated.

One form of spatial dominance illustrated through this study is that of movement. It is clear that Wallingford is dominated by autospace. What is less clear is what it means that so many consider Wallingford to be pedestrian friendly. Pedestrian friendliness masks the underlying dominance of the pedestrian by ameliorating its most obvious effects. But those spatial considerations that escape the casual eye or are otherwise imbedded in a small way in any given individual preference yet are magnified many-fold *en masse*, such as the provision of massive amounts of 'soft' right-of-way or large private yards that deplete commonwealth, are intrinsically tied to the ongoing production of autospace. For an urban environment to be considered truly pedestrian dominated, the production of space must respond to a substantially different spatio-temporal context – the realm of the pedestrian.

Gehl, in his *Life Between Buildings: Using Public Spaces*, explores the nature of the interstices of urban space, the space between buildings. His thesis is simple: “Life between buildings comprises the entire spectrum of activities, which combine to make communal spaces in cities and residential areas meaningful and attractive.”[60] He acknowledges that both necessary and optional activities have been examined thoroughly, but laments that the resulting social activities “and their interweaving to form a communal fabric have received considerably less attention.[61] His sharp criticism of autocentric functionalist planning denounces the effects of autospace and single-family development. “The spreading and thinning our of dwellings assured light and air but also caused an excessive thinning of people and events… Great distances between people, events and functions characterize the new city areas. Transportation systems, based on the automobile, further contribute to reducing outdoor activities.”[62] His empirical investigations of social space dovetail with those of Edward Hall, author of *The Hidden Dimension*, in that our experience of the phenomena of place are guided by our sensory envelope, which is itself defined by the unique characteristics of the human sensing systems – i.e. the distance receptors (eyes, ears, nose) and the immediate receptors (skin, membranes, muscles). To make the point especially clear, Gehl provides diagrams that convey in simple terms the potential barriers to the sensory basis of social interaction. They are reproduced in Figure XX below. Clearly, and in accordance with his thesis, spaces that generate socialization are those that bring humans into sufficiently close proximity. In the comparative analyses this is especially clear in the speed and distance categories.

[60] Gehl, 2000, p16
[61] Gehl, 2000, p16
[62] Gehl, 2001, p48

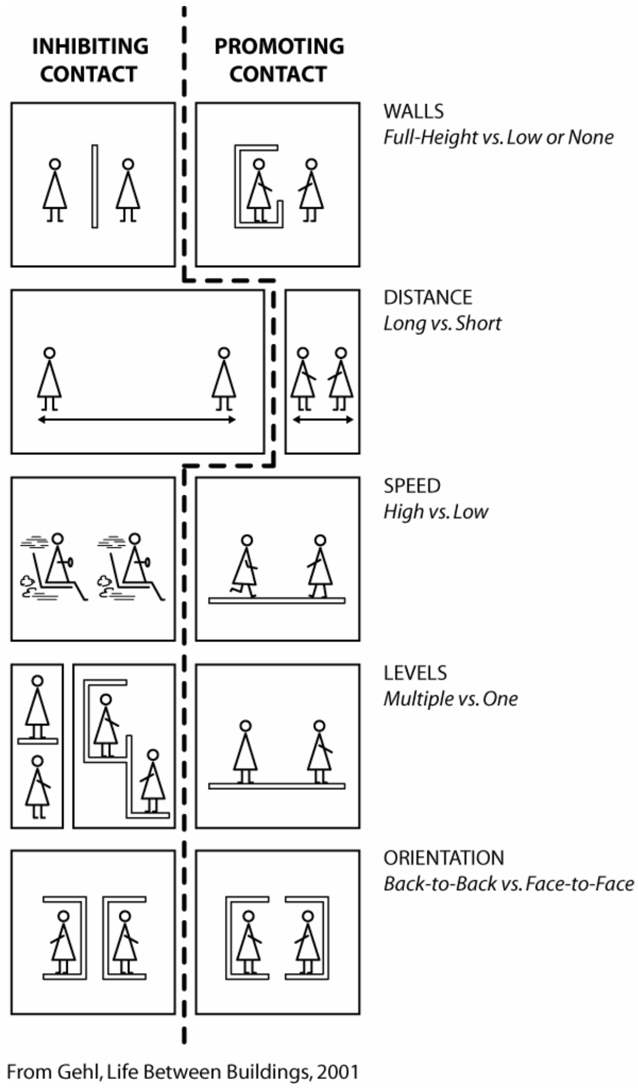


Figure 18 : Factors Affecting Sociability on Streets

The most pernicious effect of the reproduction of autospace on social space is the obliteration of socialization opportunities at the nodes of a transportation network. Node, drawing from topological analysis, may seem a bit sterile for a discussion of social space, so we can substitute the vernacular for clarity: street *intersection* (automobile node) and *square* (pedestrian node). If a street system designed for automobiles has dominated the development of urban space within a city, whether in the form of a grid or some other morphology (radial / monumental, 'organic' or some hybrid), then there simply is little place for pedestrians to meaningfully occupy.

The automobile has all but fully displaced casual social opportunities on most streets, a primary ingredient to development of community identity, thereby laying waste to the social fabric of American cities.

One solution to this problem has been to reclaim small sections of street as 'pedestrian only' in an attempt to revitalize an area, usually a concentration of retail establishments. Such attempts have met with mixed success, with many projects succeeding brilliantly (Fanuiel Hall, Boston; Pike Place Market, Seattle; River Walk, San Antonio), but many others have proved spectacular failures (Fourth Avenue Mall, Louisville; State Street Mall, Chicago). There are a host of factors that contribute to the viability of such a space, but chief among them is a relatively high concentration of people. Planners typically think of urban density in terms of physical structure – number of dwelling units per acre, floor-area-ratio, etc.) instead of number of people per area. This is an important distinction because in low-density single-family districts, not only are the buildings themselves far apart, but the decreasing average household size in most US cities means even lower population density. This effect diminishes population density geometrically as a function of housing density over a serviceable walking area.

Lower population densities make efficient and pleasant public transportation options impossible. It increases distance to important destinations of necessity and pleasure so as to 'require' driving. It banishes social spaces such as squares and even pure intersections where people 'rub shoulders' with other members of the proximal community. It produces an space that is dominated by the automobile in every way. The opportunity for mobility comes at a very high price indeed. The hegemonic quality of this domination is difficult to perceive for the ordinary person who is steeped in the normalcy of autospace nearly every waking minute. But with sufficient exposure to different sensory realities – a pleasant lunch in a square in Utrecht, a beautiful hike through an alpine wilderness – can awaken the consciousness to the subjugation of human-scaled urbanism for the individualistic desire for extreme mobility. Again, Gehl:

> That life between buildings is a self-reinforcing process also helps to explain why many new hosing developments seem so lifeless and empty. Many things go on, to be sure, but both people and events are so spread out in time and in space that the individual activities almost never get a chance to grow together to larger, more meaningful and inspiring sequences of events. The process becomes negative: *nothing happens because nothing happens*." (emphasis in original, Gehl, 2001, 78)

This recognition of a negative-feedback loop provides an inhibitory mechanism to the production of social space. But it certainly does not affect the production of space itself, for spatial production must occur at any rate. So if the space being produced is not social space, what is it? It is auto space. It may be argued that the auto is simply the conveyor of people, and therefore auto-dominated streets are still properly spaces for people-within-machines. This is certainly true from a utilitarian standpoint with respect to mobility, but without a doubt, there is an obvious diminishment of casual, but vital, social interaction to nearly nothing. And most of those few interactions are characterized by fear (near collision), frustration (traffic), or anger (‘road rage’).

As Figure 1 suggests, there is a broad spectrum of development density, from sprawling to compact. But how compact is too compact? By measuring open space as an important urban amenity, in terms of both area and access, urban breathing room is factored into the design of the built environment. Density can take many forms, and at some point densities likely become counter-productive, as can be seen in numerous world cities – especially in developing nations. Again, the ability to evaluate urban design qualitatively through visualization will have a profound impact on comparative analysis. For Crawford, following Gehl and other practitioners of design-based planning, there is a balance between density, access to light and air, walkability, mechanized mobility, and dwelling unit configuration.

6.2 A Social Orientation Toward the Production of Space

Spatial practice is set in motion for a given land are by the orientation of the spatial decision-making framework that initially dominates it. The Carfree City takes as its starting point a host of social and ecological performance criteria that inform the design process to arrive at a built form that is purposive in light of its achievement of performance goals. Wallingford takes as its starting point the subdivision of land into a grid pattern for the convenience of platting and the maximization of land values for the initial speculators. The single family dwelling on a modest sized private yard would be the predominant building type and roads to accommodate mechanized mobility would form its backbone.

When comparing an automobile environment to one that is carfree, some substantial differences are inevitable. To leave open the exploration of innovative design schemes that might improve our lives by virtue of enabling and encouraging *healthier lifestyles*, some provisions made in one scheme may not have a direct counterpart in the other. For example, while both schemes have open space as parks, the Reference District has a unique greenbelt area, whereas Wallingford provides for many families to have private yards that are unknown in the carfree scheme. Thus it is important to measure functional categories over nominal ones; i.e. sidewalks and streets are both *impervious* or *paved surfaces*. Yet, by the character of their functional role (slow, pedestrian vs. high-speed, mechanized) they create quite distinct experiences.[63] Similarly, the experience of an arterial *street* is different than one for local access, and both are altogether different than the *streets* of a carfree city such as Venice. Only by taking stock of the phenomenal, the experience of place, can inform the rationale for looking at metrics one way over another – whether to consider 'paved surfaces'

[63] In an interesting analogy, fast-food has come under increasing criticism for its impact on social well-being, and an alternative practice, traditional *slow*-food, is offered as an antidote.

versus ‘paved pedestrian and vehicular surfaces.’ The additional level of detail speaks volumes about our orientation toward the production of space.

This comparative study sheds light on the nature of space as produced in different spatial regimes. Such discoveries can act as a sort of compass, locating any given current practice within the context of other current models as well as predictive- or design-based schemes. An orientation toward the private open space at the expense of commonwealth, toward automobility to the detriment of pedestrianism, and toward an ethos of individualism over ‘person-in-the-community’.[64] It is hoped that by refining the methods introduced in this study, additional work can be done to reveal alternative approaches to urban design that once again favor a social orientation toward the production of space. Furthermore, this study has shown how Joel Crawford’s scheme fares empirically in comparative measures of sustainability, when measured by ecological footprint, as it proposes a scheme to manifest such a social orientation. It is also hoped that a compromise between knowledge that is neither strays too far toward an utterly relativistic ‘abdication of reason’ nor toward a deterministic objectivity devoid of human action might be found.[65]

Above all, the goal is not to determine a univocally *best* scheme, but to provide a means of evaluating the tradeoffs represented by a certain orientation relative to current practice – a knowledge of the life-world that transforms spatial practice. Accounting for the empirical properties of these schemes renders them tangible for comparative purposes. Accounting for the qualitative and functional properties of these schemes renders them accessible to hermeneutic interpretation. These comparative sustainability metrics are numbers which represent an orientation toward the production of space. This spatial practice, in turn, shapes our environment, our future, our civilization. In a democratic society faced

[64] Portney, p138
[65] Polkinghorne, p27

with critical questions of survival and quality of life, of justice and ethics, and carrying the burden of maintaining a massive ecological footprint, the direction of our current spatial practice must be laid bare.[66] Options, alternative utopias, must be presented for consideration. And decisions must be made – that is, we must choose either to attain sustainability or else we remain unsustainable. The future rests in our collective human action. Sufficiently compelling analyses of urban design and comparison to existing environments will assist in planning a future, like the indicators themselves, for better or for worse.

[66] National ecological footprints reveal much about the relationship between affluence and sustainability.

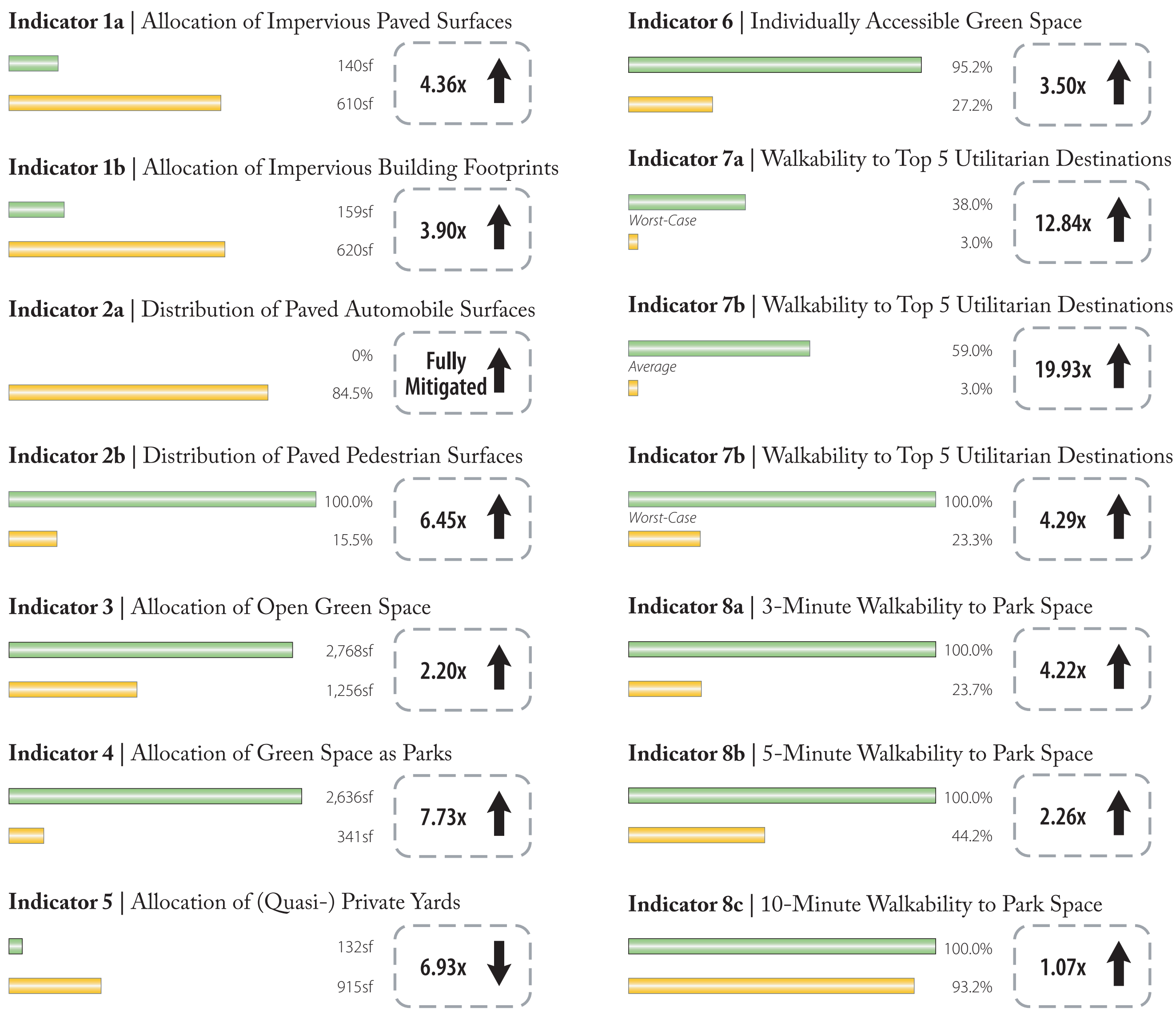


Figure 19: Comparison of All Indicators

BIBLIOGRAPHY

Alexander, Christopher. *A Pattern Language*. New York: Oxford University Press, 1977.

Barton, H. et. al. *Sustainable Settlements: A Guide for Planners, Designers, and Developers*. Bristol: U. of the West of England and Local Government Management Board, 1995.

Battle, G. and McCarthy, C. *Multi-source synthesis: the design of sustainable new towns,* in Architectural Design profile No. 111, *New Towns*. London: Academy Group, 1997.

Bernstein, Richard. *The Restructuring of Social and Political Theory*. Harcourt Brace Jovanovich, 1976.

Congress for a New Urbanism. *Charter of the New Urbanism.* New York: McGraw-Hill, 1999.

Costanza, Robert, *et.al.* "The Value of the World's Ecosystem Services and Natural Capital," *Nature*, Vol. 387, 1997.

Crawford, J.H. *Carfree Cities.* Utrecht: International Books, 2000.

Crawford, J.H. *Carfree Design Manual*. Unpublished draft.

De Landa, Manuel. *A Thousand Years of Nonlinear History*. New York: Swerve, 2000.

Fishman, Robert. *Bourgeois Utopias: The Rise and Fall of Suburbia*. New York: Basic Books, 1987.

Fishman, Robert. *Urban Utopias of the 20th Century*. Boston: MIT Press, 1982.

Frumkin, Howard, et. al. *Urban Sprawl and Public Health: Designing, Planning, and Building for Healthy Communities*. Washington, D.C.: Island Press, 2004.

Gauttari, Félix. *The Three Ecologies.* London: Athlone Press, 2000.

Gehl, Jan. *Life Between Buildings: Using Public Space.* Skive: Arkitektens Forlag / Danish Architectural Press, 2002.

Girardet, Herbert. *Creating Sustainable Cities*. Devon: Green Books, 1999.

Harvey, David. *Spaces of Hope.* Berkeley: UC Press, 2000.

Houben, Francine and Luisa Maria Calabrese, eds. *Mobility: A Room With a View.* Rotterdam: Netherlands Architectural Institute, 2003.

Kelbaugh, Douglas. *Common Place: Toward Neighborhood and Regional Design*. Seattle: University of Washington Press, 1997 (reprinted with corrections 1999).

Kostof, Spiro. *The City Assembled: Elements of Urban Form Through History*. Boston: Bulfinch Press, 1992.

Kostof, Spiro. *The City Shaped: Urban Patterns and Meanings Through History.* Boston: Bulfinch Press, 1999.

Krier, Léon. *Architecture: Choice or Fate*. Windsor: Papadakis, 1998.

Lefebvre, Henri. *The Production of Space.* Blackwell Publishing, 1974.

Lefebvre, Henri. *The Urban Revolution.* 1970. English translation, University of Minnesota Press, 2003.

Leung, Hok-Lin. *Land Use Planning Made Plain*. 2nd Ed. Toronto: U of Toronto Press, 2003.

Lynch, David. *Site Planning, 2nd Ed.* Boston: MIT Press, 1971.

Maclaren, Virginia. "Urban Sustainability Reporting." *Journal of the American Planning Association 62 (2)*, 1996, p184-202

Marshall, Stephen. *Streets & Patterns*. New York: Spon Press, 2005.

Merryfield, Andy. *Metromarxism: A Marxist Tale of the City.* New York: Routledge, 2002.

Panerai, Philippe, Castex J., DePaule J.C., and Samuels I. *Urban Forms: The Death and Life of the Urban Block.* Oxford: Architectural Press, 2004.

Polkinghorne, Donald. *Methodology for the Human Sciences.* State University of New York Press, 1983.

Portney, Kent. *Taking Sustainable Cities Seriously: Economic Development, the Environment, and Quality of Life in American Cities.* Boston: MIT Press, 2003.

Safdie, Moshe. *Arcology: The City After the Automobile.* Boulder: Westview Press, 1998.

Soleri, Paolo. *The City in the Image of Man.* Cambridge, MA: MIT Press, 1969.

Steuteville, Robert, and Langdon, Phillip, et. al. *New Urbanism: Comprehensive Report and Best Practices.* Ithaca: New Urban News, 2003.

Throgmorton, James and Barbara Eckstein, eds. *Story and Sustainability: Planning, Practice, and Possibility for American Cities*. Boston: MIT Press, 2003.

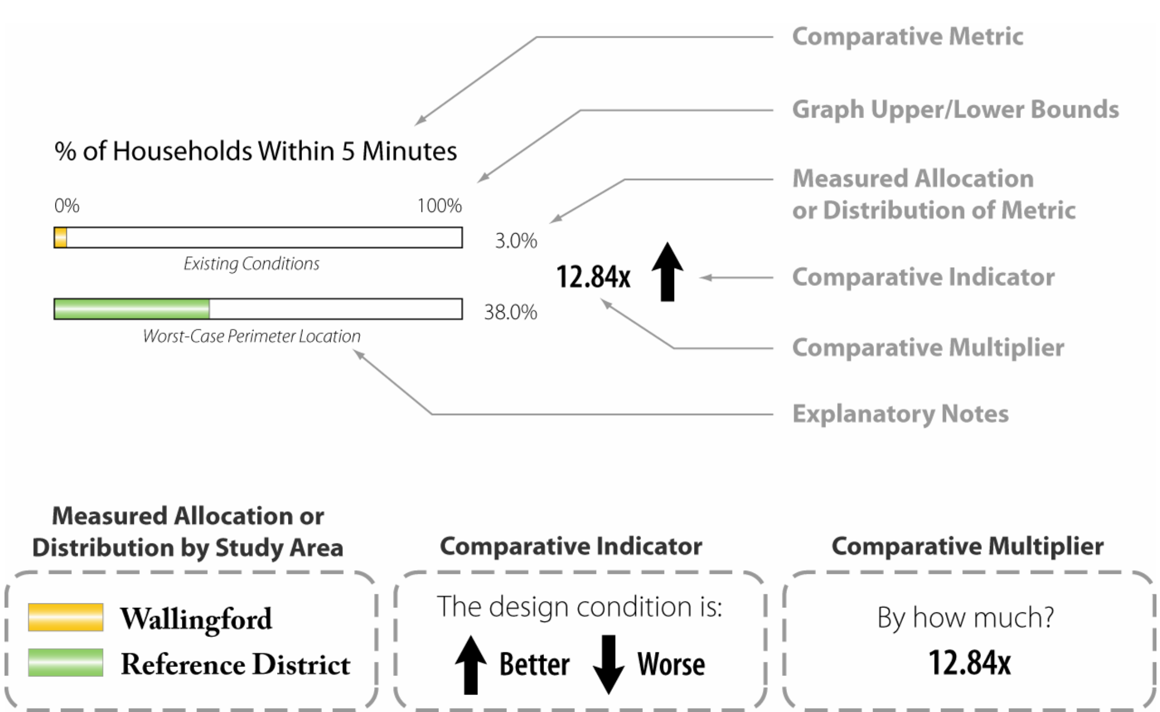
Wackernagel, Mathis and William Rees. *Our Ecological Footprint: Reducing Human Impact on the Earth.* Philadelphia: New Society Publishers, 1996.

Walters, David and Linda Luise Brown. *Design First: Design-Based Planning for Communities.* Oxford: Architectural Press, 2004.

Wheeler, Stephen and Timothy Beatley, eds. *The Sustainable Urban Development Reader*. New York: Routledge, 2004.

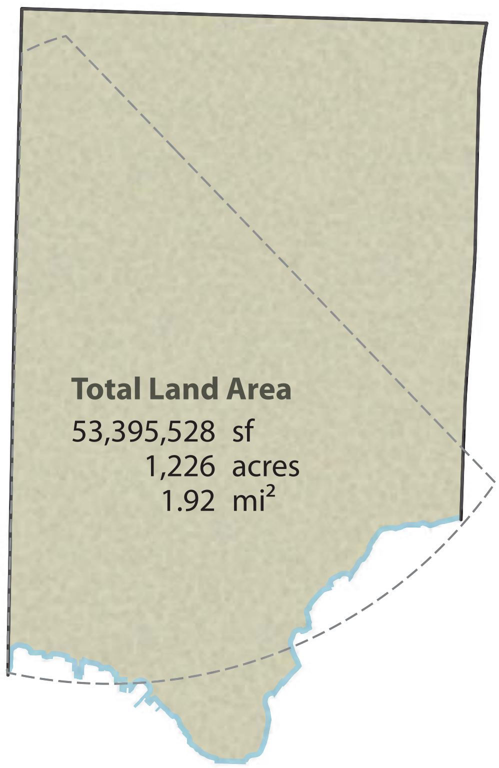
APPENDIX A

How to Read Comparative Indicator Diagrams



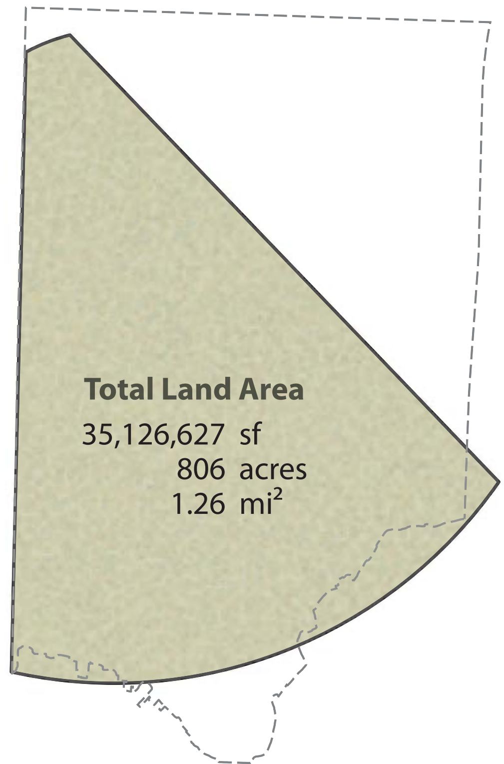
APPENDIX B
Study Area Definitions and Geographic Data

Wallingford



Residential Population	17,481 p
Population Density	14.26 p/ac
Number of Households	7,769 hh
Average HH Size	2.25 p/hh
Overall Housing Density	6.34 du/ac
Developed Area Housing Density	equivalent to overall density

Reference District



Residential Population	11,500 p
Population Density	14.26 p/ac
Number of Households	5,111 hh
Average HH Size	2.25 p/hh
Overall Housing Density	6.34 du/ac
Developed Area Housing Density	45.59 du/ac

APPENDIX C
Brief Synopsis of the Carfree City Design

The following text was taken from www.carfree.com.

Sundown, Parma

The Problem

The industrialized nations made a terrible mistake when they turned to the automobile as an instrument of improved urban mobility. The car brought with it major unanticipated consequences for urban life and has become a serious cause of environmental, social, and aesthetic problems in cities. The urban automobile:

- Kills street life
- Damages the social fabric of communities
- Isolates people
- Fosters suburban sprawl
- Endangers other street users
- Blots the city's beauty
- Disturbs people with its noise
- Causes air pollution
- Slaughters thousands every year
- Exacerbates global warming
- Wastes energy and natural resources
- Impoverishes nations

The challenge is to remove cars and trucks from cities while at the same time improving mobility and reducing its total costs.

The Solution

The urban automobile can only be supplanted if a better alternative is available. What would happen if we designed a city to work without any cars? Would anyone want to live in such a city? Does it make social, economic, and esthetic sense? Is it possible to be free of the automobile while keeping the rapid and convenient mobility it once offered?

Public transport is typically a disagreeable and slow substitute for the car. It needs to become a pleasant experience and should attain the average speed of a car in light city traffic. This can be achieved using proven technology, but densely-populated neighborhoods are a prerequisite for rapid mobility and economical public transport. Fortunately, dense cities can also offer a superior quality of life.

We should build more carfree cities. Venice, the largest existing example, is loved by almost everyone and is an oasis of peace despite being one of the densest urban areas on earth. We can also convert existing cities to the carfree model over a period of decades.

Piazza San Marco, Venice
One of the world's great public spaces

Design Goals

The design of cities is driven by three principal needs:

- High quality of life
- Efficient use of resources
- Fast transport of people and goods

Design Standards

The fulfillment of these needs in a carfree city gives rise to the following design standards:

Rapid Transport

Provide fast access to all parts of the city. In a city of one million it should be possible to get anywhere in considerably less than an hour. Passengers should never have to transfer more than once.

Nearby Stations

Both in consideration of time and of the limited mobility of small children, the elderly, and the infirm, nearby transport halts are required. The design standard is a five-minute walk.

Nearby Green Space

Green space should be available within a five-minute walk of virtually every front door.

Venice: a fine-grained city, four stories high

Four-Story Buildings

Buildings should generally be limited to a height of four stories because higher buildings appear to be harmful to the people who must live in them. (See *A Pattern Language* for a detailed discussion of this point.)

Economical Freight Transport

City economies depend on fast, economical freight transport. A city which intends to keep trucks off its streets must make workable provisions for freight transport.

Going Carfree

The carfree city can be built. Venice is proof enough.

The four billion inhabitants of the developing world seem eager to adopt Western patterns of car use. They should be advised of the costs and encouraged to think about better solutions. Can the planet carry the ecological burden? The developed nations cannot deny developing nations the use of technology and resources that are used in the developed nations. Since most of the world's cars are found in the developed nations, they must take the lead in designing and building carfree cities.

Carfree cities probably must become the norm by the end of the 21st Century, due to energy constraints. We should begin now to prepare for the change, which is an opportunity to build urban environments superior to any ever known.

APPENDIX D
Carfree City Urban Design Goals

Table D-1 lists the 43 design goal formally espoused within Joel Crawford's Carfree City scheme. Each goal is accompanied by notes indicating whether, in the author's opinion, the goal was achieved and how this conclusion was arrived at. Furthermore, those goals specifically measured are noted by Indicator number.

Table D-1 : Carfree City Design Goals

Goal	Achieved?	Notes
Diverse Economy		
Ample space for small business	yes	per spatial analysis
Workable sites for heavy industry	?	not studied
Broad range of infrastructure to support innovation	?	not studied
Practical delivery of standard shipping containers	?	not studied
Energy & Resource Efficiency		
Basic services located in every district	yes	per spatial analysis
Short runs for utilities	yes	compared with Wallingford
District heating	< >	not studied
Shared walls	yes	self-evident; reflected in design
Multiple stories	yes	self-evident; reflected in design
Efficient transport of people & goods	yes*	yes for people, per transportation analysis; goods not studied
Low Construction Costs		
Low-per capita paved surface area*	yes	per spatial analysis; *also an indicator related to surface runoff issues; ****Indicators 1 & 2: Impervious Surface Areas**
Short runs for pipes and cables	yes	compared with Wallingford
Short transport lines	yes	highly optimized system, reflected in design
Quality of Life		
Regular opportunities for informal social contact	yes	per spatial analysis, field studies, Jan Gehl, Krier, Alexander, Crawford, my photos, etc…
Safe, early independence for children	yes	per spatial analysis
Continued self-reliance for elderly	yes	per spatial analysis
Ease in meeting life's daily needs	yes*	reflected in design; *daily routines may be significantly different in character, so a period of transition from an old regime to a new one may be required – in the author's experience, such changes as walking to meet daily needs can be adopted easily in a couple of weeks and be assimilated fully in a month. seasonal familiarity will only come with years of experience, of course, what a pleasure. **the new system would solve some problems even as it generated new ones; on the balance, however, it appears as though the new inconveniences are far outweighed by the much more important new advantages
Routine destinations located within	yes	per spatial analysis;

the district		** **Indicator 7: Utilitarian Walkability**
Minimal externalized transport costs	< >	probable based upon cursory evaluation; not studied in depth
Mixed uses in every neighborhood	yes	self-evident; reflected in design
Low noise levels	yes	self-evident; reflected in design
Active street life	< >	probably based upon numerous studies; however, many criticisms of traditional urbanism focus on it being distinctly 'un-American' and therefore unlikely to be adopted even if built; so, in defference to the possible truth of such a claim, though I personally reject the logic behind such a claim, let us say only that the building blocks for active street life are abundant, have claim to a long tradition of urban excellence, backed by property value and market preferences, not to mention their exceptional utility and performance when measured relative to progressive policy goals
Rapid Access to Nature		**** Indicator 8: Walkability to Parks**
Small gardens behind most buildings	yes	self-evident; reflected in design
Open natural areas adjacent to every district	yes	self-evident; reflected in design; **Indicators 3-6 : Access to and Amount of Open Space**
Beauty		*of course, difficult to measure, but common sense oriented
Human scale	yes	self-evident; reflected in design; (*perhaps not to the lay-person)
Carfree streets	yes	self-evident; reflected in design; (*i.e. architecture and the urban experience are more beautiful than parked cars)
Richly-textured buildings	yes	flexible massing and façade systems reflected in design (building types)
Well-proportioned streets and squares	yes	in agreement with the European Traditional Urbanist School
Good Passenger Transit		
Maximun 5-minute walk to transport	yes	per spatial analysis
Frequent service	yes	design supports frequent service; not studied in depth
Minimal land occupation by transit	yes	per spatial analysis
Dense utilization of public transport	yes	per spatial analysis
Low capital & operating costs	?	not studied
Energy-efficient transport	yes	based on per-capita inputs
Minimal externalized costs	?	not studied
Car parking at the periphery	yes	self-evident; reflected in design
Efficient Transport		
Truck-free city streets	< >	in most designs, at least some surface trucks would be likely – however, they needn't be noisy or large and could be restricted to certain hours of operation, as commercial activity currently is when adjacent to residential areas…
Fast and economical freight delivery	?	not studied
Minimal land occupation by transport	yes	per spatial analysis
Efficient energy use	?	not studied
Intermodal exchange with global freight network	yes	self-evident; reflected in design

APPENDIX E
Top Utilitarian Walking Destinations by Age Group

Table E-1 : Utilitarian Waling Destinations for Younger Adults (18 to 65)

Rank	Destination	# of Respondents (n=505)	% of Total
1	Grocery Store	250	50%
2	Non-Fast Food Restaurant	126	25%
3	Drug Store	94	19%
4	Convenience Store	93	18%
5	Café or Coffee Shop	84	17%
6	Bank	80	16%
7	Post Office	64	13%
8	Video Store	51	10%
9	Other (Specify)	47	9%
10	Clothing Store	44	9%
11	Fast Food Restaurant	42	8%
12	Library	38	8%
13	Book Store	36	7%
14	Hardware Store	22	4%
15	Pub or Bar	22	4%
16	Doctor's or Dentist’s Office	20	4%
17	Dry Cleaners	19	4%
18	Theaters and Movie Theater	19	4%
19	Mall, Shopping Center or Plaza	17	3%
20	Religious Institution	14	3%
21	Farmers Market	13	3%
22	Office Supply Store	12	2%
23	Health Club	8	2%
24	Big Box Retail - e.g. Home Depot	7	1%
25	Art Gallery or Museum	7	1%
26	Community Center	6	1%

Source: Chanam Lee, University of Washington Urban Form Lab

Table E-2 : Utilitarian Waling Destinations for Older Adults (Over 65)

Rank	Destination	# of Respondents (n=103)	% of Total
1	Grocery Store	29	28%
2	Drug Store	23	22%
3	Bank	16	16%
4	Post Office	14	14%
5	Non-Fast Food Restaurant	14	14%
6	Clothing Store	9	9%
7	Book Store	8	8%
8	Religious Institution	8	8%
9	Café or Coffee Shop	7	7%
10	Library	7	7%
11	Convenience Store	6	6%
12	Hardware Store	6	6%
13	Mall, Shopping Center or Plaza	6	6%
14	Other (Specify)	6	6%
15	Theaters and Movie Theater	5	5%
16	Dry Cleaners	4	4%
17	Health Club	4	4%
18	Doctor's or Dentist's Office	3	3%
19	Fast Food Restaurant	3	3%
20	Farmers Market	2	2%
21	Office Supply Store	2	2%
22	Big Box Retail - e.g., Home Depot	2	2%
23	Art Gallery or Museum	2	2%
24	Community Center	1	1%

Source: Chanam Lee, University of Washington Urban Form Lab

APPENDIX F
Residential Density Standards

Table F-1: Residential Density Standards (Chapin & Kaiser)

Dwelling Unit Type	Net Density Dwelling Units per Acre
Single Detached	5-7
Semi-Detached	10-12
Row Houses	16-19
Multi-Family: 2 Story	25-30
Multi-Family: 3 Story	40-45
Multi-Family: 6 Story	65-75
Multi-Family: 9 Story	75-85
Multi-Family: 13 Story	85-95

Source: Chapin and Kaiser, 1979, p455

Table F-2: Residential Density Standards (Lynch & Hack)

Dwelling Unit Type	Net Density Dwelling Units per Acre
Single Detached	<8
Zero-Lot-Line Detached	8-10
Semi-Detached	10-12
Row Houses	16-24
Stacked Townhouses	25-40
Multi-Family: 3 Story Walkup	40-50
Multi-Family: 6 Story Elevator	65-75
Multi-Family: 13 Story Elevator	85-95

Source: Lynch and Hack, 1984, p466