8 Evaluating WikiPLACE: A prototype decision support tool for urban design

Chapter Summary

This chapter describes the new WikiPLACE urban design decision support tool that was developed as an outgrowth of this research. It applies the prototype to "back-cast" the GHG emissions of a range of known examples of urban systems. It compares the resulting predictions with known measurements to provide an initial evaluation of the efficacy of the tool.

Portions of this chapter are drawn from the peer-reviewed paper "Wiki as Pattern Language" (Mehaffy and Cunningham, 2013) which is also included in full in the Appendix. Additional portions are specific to this dissertation.

A key part of this research has been to develop a prototype design decision-support tool that embodies the findings, strategies and methodologies developed during this research. While it must be noted that this research is not a software development project per se, nonetheless the software tool that was developed does represent a key implementation of a new *class* of technology that has been advanced herein. It is therefore important to present the tool as an instance of the technology, and to evaluate its performance as part of the overall evaluation and validation of the research herein.

The tool, developed in close collaboration with the software engineer Ward Cunningham, is called WikiPLACE – an acronym for "Wiki-based Pattern Language Adaptive Calculator of Externalities." Before presenting the structure of the tool, it may be helpful to explain the significance of the terms in this acronym.

The aim of the tool is to identify the predicted magnitude of **externalities**, that is, factors that are not normally calculated within economic transactions. In this research project, the externality of interest is greenhouse gas emissions from urban sources; however, as mentioned previously, other kinds of externalities could also be readily calculated by such a tool (e.g. resource depletion, future tax burdens, etc).

The tool functions as a predictive **calculator** based upon the previous research on how the factors being measured are most likely to generate externalities, following the modelling methodologies described previously.

The tool is **adaptive** in two ways: it is able to modify and adapt its calculations in response to variations in the chosen design scenarios; and it is able to modify and adapt its own structure through open source development, peer review, sharing, modification and evolution over time.

Lastly, the tool uses the structure of design patterns and **pattern languages**, which as we have seen have proven efficacious in the design of software, where robust but flexible design alternatives can be explored and assembled into larger proposed designs with reasonable reliability. In the context of the

Wiki, each Wiki page functions as a pattern, which as Cunningham describes it, is "a structured essay" that makes a falsifiable, revisable prediction about the relationship between design elements and the outcome they produce.

WikiPLACE is thus well-suited to function as a pilot example of the scenario-modelling tool discussed in this research, with specific application to the findings on greenhouse gas emissions and urban design decision support. A great advantage is that it can be tested on actual urban designs to evaluate how well it performs relative to known GHG emissions measurements. The last section of this chapter reports on three such test cases, and makes an assessment.

§ 8.1 The structure of WikiPLACE

The core of WikiPLACE is a collection of design patterns that, together, constitute an urban design scenario. For example, one pattern might establish the residential density, another the mix of uses, another the modal mix of transportation, and so on. (Indeed, these and other patterns are included in the initial "Alpha Test" version, as we will discuss in more detail below.)

Again it is important to emphasise that the deign patterns are, by their nature, not individual variables in abstraction, but whole-systems representations of particular kinds of urban pattern, forming contextual elements of a larger design scenario. This is key to the methodology, discussed previously, to model contextual scenarios rather than fragmentary variables in isolation – and thereby, to get a more robust prediction. Nonetheless, portions of each pattern are in fact defined by precise metrics which can be narrowly varied within alternate scenarios to assess their potential impact (for example, variations of residential density).

These design patterns together form the design scenario, in the form of the "project pattern language" - in other words, an integrated network of design elements and their relationships.

Each pattern applies a "predictive delta" to the metric or metrics of interest – that is, a prediction of how the metric(s) will change in practice, if that design pattern is applied in that way. This predictive delta is a mathematical formula or function (in other words, a mathematical model) that corresponds to the previous findings of peer-reviewed research. (Importantly, this research can be viewed through hyperlinks.) For example, if research shows a pattern of decreasing GHG emissions per capita from vehicle travel in relation to increasing residential density, then a function that describes that pattern will be applied to the metric of GHG emissions per capita, to produce a delta that corresponds to the research findings.

As discussed, it is relatively easy to examine the source of data, and, if desired, to make revisions. (For example, if changes or "calibrations" are believed warranted as a result of local testing and refinement.) The federated structure allows revisions on a local copy of WikiPLACE which, if found to be more reliable, could be used to replace other local copies, or – if the original author or curator agrees – the original from which it was derived.

Within each pattern, it is possible to vary an input metric (say, residential density) and explore changes in the prediction for outcome (say, GHG emissions per capita). It is technically possible to compare this to other "tradeoff" metrics – for example, changes to the average cost of each dwelling – although for this research that capability has not been developed.

Subsequent patterns repeat the cycle, applying the relevant predictive delta on the metric(s) of interest. These are selected from a series of hyperlink menus in each pattern that lead to subsequent pattern choices.

At some point, it is likely that two or more patterns will not just perform together in a linear way, but interact through a feedback process. For example, one pattern may produce, say, a 110% increase, and the second may produce a 110% increase, but the two together will not produce an increase of 121% (1.10x1.10) as might be expected; because of their interaction, they will produce, let us say, 121% x .95, a factor of their interaction.

This interaction factor must also be modelled within the system. There are two ways that WikiPLACE can do this. One is to build the interaction into the formulas that each pattern calculates, in such a way that the patterns will interact dynamically, reflecting the interaction between the factors being modelled. This method corresponds to the methodology of *system dynamics modelling* discussed in Chapter 6. In effect, the patterns form a network of stocks and flows which interact.

The other method is to apply a scaling factor to the result at a final step – a "network analyser" that adjusts the result in approximation of such a feedback dynamic. This is a "shortcut" method, but one that can be effective under the right circumstances. In fact, the circumstances correspond to the methodology also discussed in Chapter 6, an *improper linear model*. As such, it constitutes a pattern in its own right, and one whose function is to account for the interactive effects of other patterns.

Thus, by selectively choosing and defining patterns, WikiPLACE can quickly generate alternate scenarios. The user can model different scenarios by changing the value of individual patterns, or by employing different patterns altogether. These can be opened in different browser windows and placed side by side, if desired.

§ 8.2 Using WikiPLACE in practice

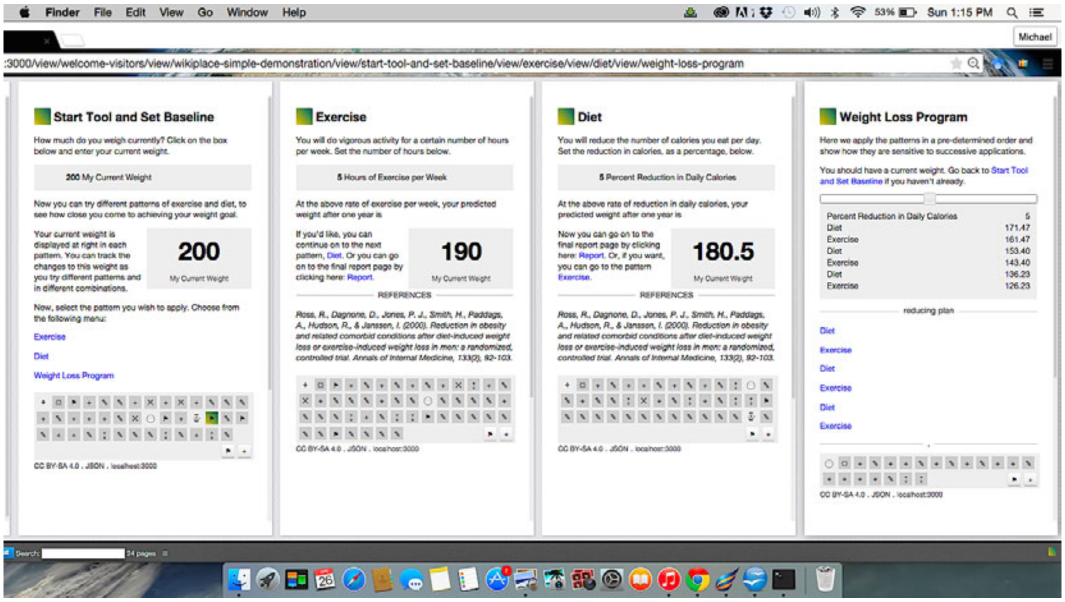


FIGURE 8.1 A simple example of how WikiPLACE works, using patterns for losing weight. This is the desktop view with the four pages open. Left to right: "Start Tool and Set Baseline" allows the user to enter their current ("baseline") weight; here the user has first selected "exercise" and entered 5 hours per week, with the resulting weight displayed after one year; next the user has selected "Diet" and entered a 5% reduction in calories, with the resulting weight displayed after (the same) one year; and finally, a page allowing the user to experiment with different combinations of patterns and "loading orders."

The simplified example above will conceptually illustrate how the underlying software actually works (Figure 8.1). In this example, we will be interested in the metric of personal body weight, and how we might achieve a weight-loss goal (analogous to lowering GHG emissions per capita). In this extremely simplified example, there are just two patterns – exercise, and dietary restrictions.

The first step in using the WikiPLACE tool is to set the baseline values for the design in question. The user does this by calling up the "Start Tool – Set Baseline" pattern from within the browser window. (This first pattern is accessed from a welcome page that appears on startup of the tool.)

Over a series of subsequent steps, the user will identify a series of design patterns to apply to the design, each of which will generate a predicted delta on the metric(s) in question – in this case, weight loss. The predictive deltas will be derived from research findings, which point to a relationship between the value of the design element and the outcome of the metric in question (in this demonstration they are fictional).

The user will then select the value or values of the design parameters – in this case, how many hours of exercise per week or how much reduction in consumption of calories per day – and the predictive delta for each patterns is applied to the metric and the result is updated.

Then the user selects the next pattern and repeats the process, with the results displayed as before. In this case, with only two patterns, the user can only proceed in one of four ways: Pattern A alone, Pattern B alone, Pattern A then B, or Pattern B then A. But in practice, with many more patterns, a user could quickly and easily try different patterns, back up, or even start again. All this could be done on one browser page, while another browser page is displaying a very different scenario (which could also be perhaps constructed by another user within a group). In this way, quick and user-friendly scenario-modelling is possible.

The final page shown here is an example of how the scenario can be revised and further analysed. On this page the user can combine a number of different sequences of diet and exercise, applying them in different sequences or "loading orders," and quickly view the result. The slider element at the top allows the user to experiment quickly with input values across a range of possible values.

This is only one of a number of methodologies that the Federated Wiki software provides to create a final step of analysis within the modelling system. As we will see with the WikiPLACE model, the important goal is to display the predicted value along with a summary of the method by which it was produced.

§ 8.3 The WikiPLACE prototype patterns

This prototype or "alpha test" version of WikiPLACE contains just four patterns, capturing four key conclusions of the research (documented through references to peer-reviewed research in each pattern). I have chosen four patterns in part because that is a sufficient number to see how collections of patterns behave within a modelling scenario. It also allows a minimally complete system on which to evaluate initial performance of the decision support tool, which we report in the conclusion of this chapter. However, it is theoretically possible to include any number of patterns, or have access to repositories of much greater numbers. (In the field of software design, this is currently how design patterns are accessed and shared.)

The four design patterns in this alpha test are derived from the research reported in previous chapters, and summarized below. The logic of their structure is a core outgrowth of the methodology described earlier, reflecting Bayesian, heuristic and iterative methods. As discussed, their structure also reflects a "systems approach" to urban design, rather than an attempt to model narrow variables in isolation. As we have seen, that approach is overly sensitive to initial conditions, and prone to produce "garbage in, garbage out" results. Instead the methodology here reflects the earlier discussions of "improper linear models," "Bayesian belief networks" and related advances in identifying usefully approximate knowledge.

Each pattern is a description of a design configuration, stated as a proposed solution to a design requirement. This structure follows from the logic of design patterns and pattern languages (Buschmann, Henney and Schimdt, 2007). The design requirement is not simply a narrow goal in isolation, such as "reduce greenhouse gas emissions." After all, the most direct response to such a narrowly defined goal might well be to cease all activity! Instead the goal of reducing greenhouse gas emissions is placed in the context of a larger urban design goal, as stated in the problem-statement of the pattern.

In the same way, WikiPLACE could model other quantitative externalities of interest to urban designers, such as the cost of development to the public, or the value of ecosystem services. Again, it could do so within a broader scenario of design, rather than as an isolated set of variables.

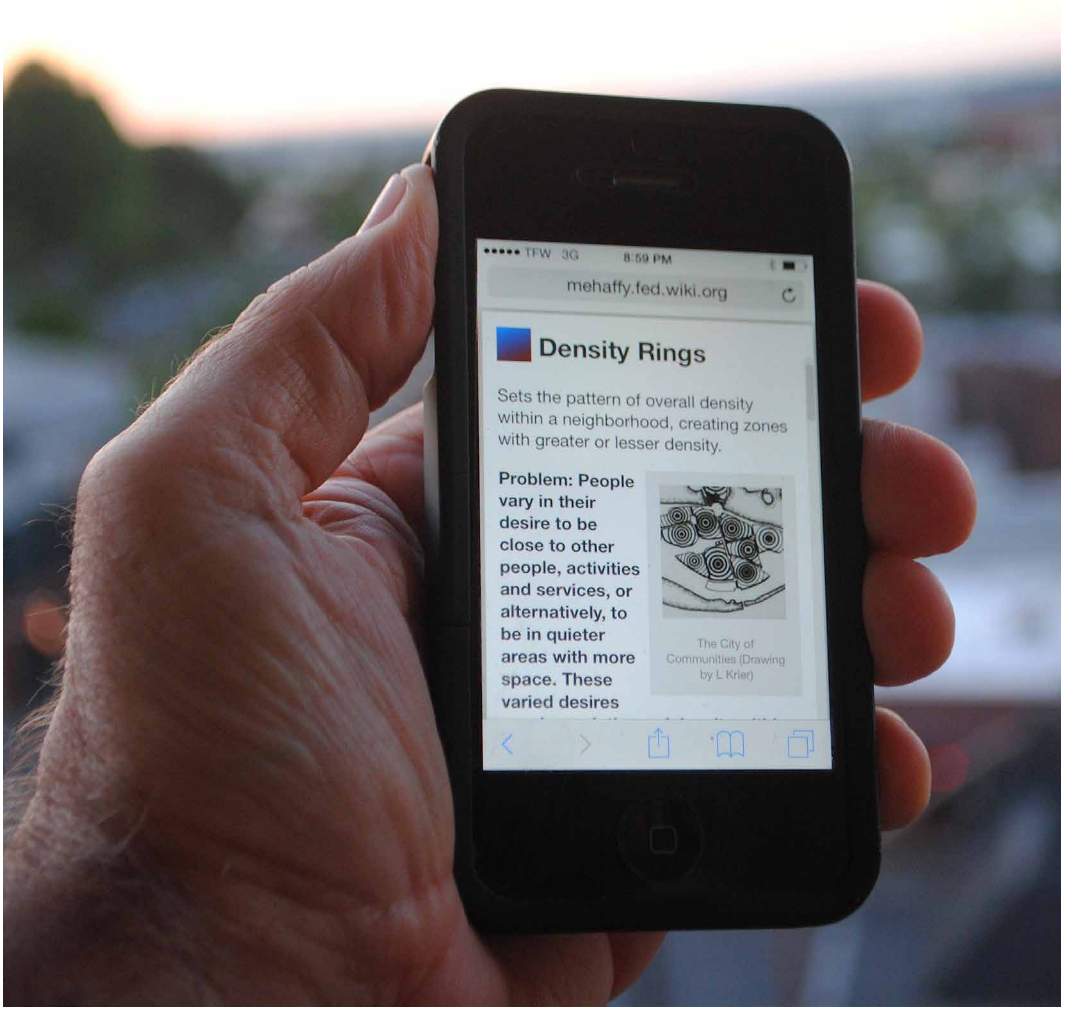


FIGURE 8.2 The WikiPLACE system is designed to be user-friendly. Here a pattern is visible on an iPhone that could be used at a field site. In this format it is possible to simply scroll between the patterns within a model for quick and easy use. It is also possible to select new patterns from a menu, and thereby to quickly construct a new model. As with any wiki system, it is also possible to edit the patterns, or even to write wholly new ones that are shared over a "federated" network.

For this prototype, my software development colleague Ward Cunningham and I have borrowed the pattern format, and even specific pattern names, from the classic 1977 book, *A Pattern Language*. There are three reasons for this. First, the book is extremely well known and studied, with over 3,700 citations on Google Scholar (2015). Second, the book's user-friendly format is evidenced by its perennial bestseller status across a wide audience; according to the US website Amazon.com, the book remains, in 2015, the number one bestselling book in the architecture category, some 38 years after its publication (Amazon.com, 2015). Third, the format is a familiar benchmark that has been successfully adapted to other fields, notably software (Buschmann, Henney and Schimdt, 2007).

However, we have varied the detailed structure of the patterns to fit the specific needs of WikiPLACE – an evolution that is perfectly appropriate to the deeper logic of pattern languages, as software users and researchers have demonstrated (Mehaffy and Cunningham, 2013). In this case the patterns have been written to capture the findings of the research, as we have discussed previously. Following are the four patterns together with their detailed structure.

PATTERN 1

IDENTIFIABLE NEIGHBOURHOOD NETWORK

This pattern captures the factors described in Chapter 3 as neighbourhood network – that is, a measure of the density of inter-connectedness of neighbourhood infrastructure, both within systems (e.g. street patterns) and between systems (e.g. waste-to-energy). It then asks users to score the degree to which their scenario conforms with that model. If there is a match, then a corresponding prediction of emissions reduction is applied to the metric. If there is no match, or a lesser match, then a prediction of a proportionally lesser reduction (or no reduction) is made. This is not to say that reductions might not be made with other urban forms, or indeed with a variety of other measures – but that the model is simply not reflecting those probabilities.

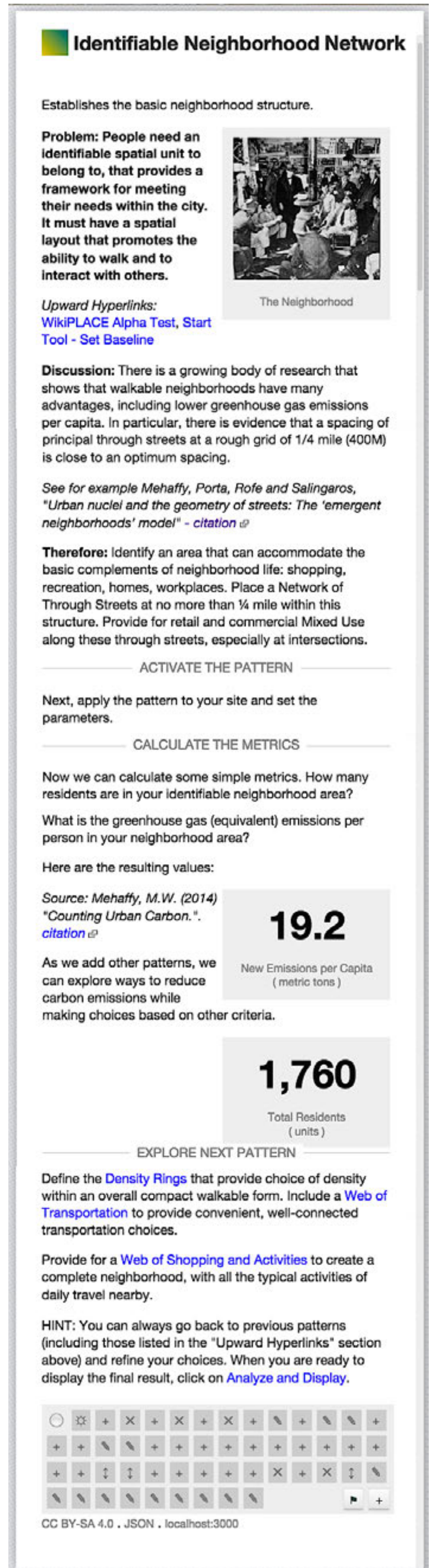


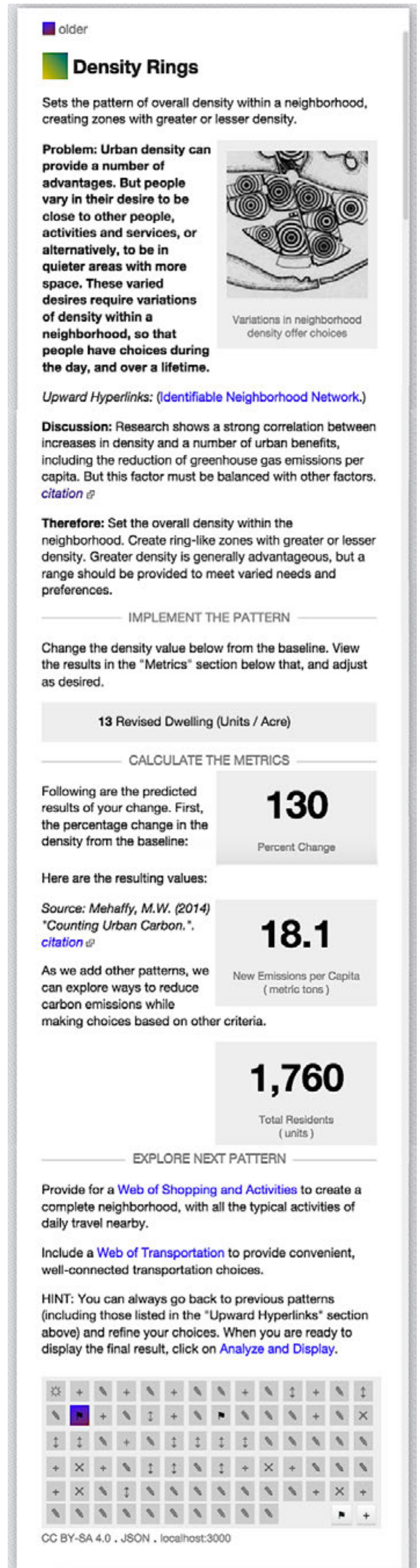
FIGURE 8.3 The pattern Identifiable Neighbourhood Network as it appears on the web browser screen of a desktop computer. Normally only part of the full height of the pattern is visible, and the user scrolls down to view the lower part.

PATTERN 2

DENSITY RINGS

As we saw in Chapter 2, one of the most significant findings regarding greenhouse gas emissions and urban morphology is that the variable of residential density is strongly correlated, inversely, with emissions, particularly (but not exclusively) from transportation sources. However, as we have also seen, it is not density as a variable in isolation that is causative – a dense residential area separated from offices and other needs by a long commute would not perform well – but rather, we are concerned with density in relation to urban pattern. Thus, the pattern defines an overall density while encouraging variations of density across gradations, or "density rings."

FIGURE 8.4 The pattern Density Rings as it appears on the web browser screen.



PATTERN 3

WEB OF SHOPPING AND ACTIVITIES

The Web of Shopping and Activities is also based on the research findings described in Chapter 3, and a factor referred to as the web of destinations – that is, the structural distribution of uses and destinations. Again the pattern describes an optimum condition described in the research, and again it asks users to calibrate the degree to which the design scenario achieves this pattern. A high calibration corresponds to a fine-grained mix of elements, while a low score corresponds to a baseline of segregated urban form.

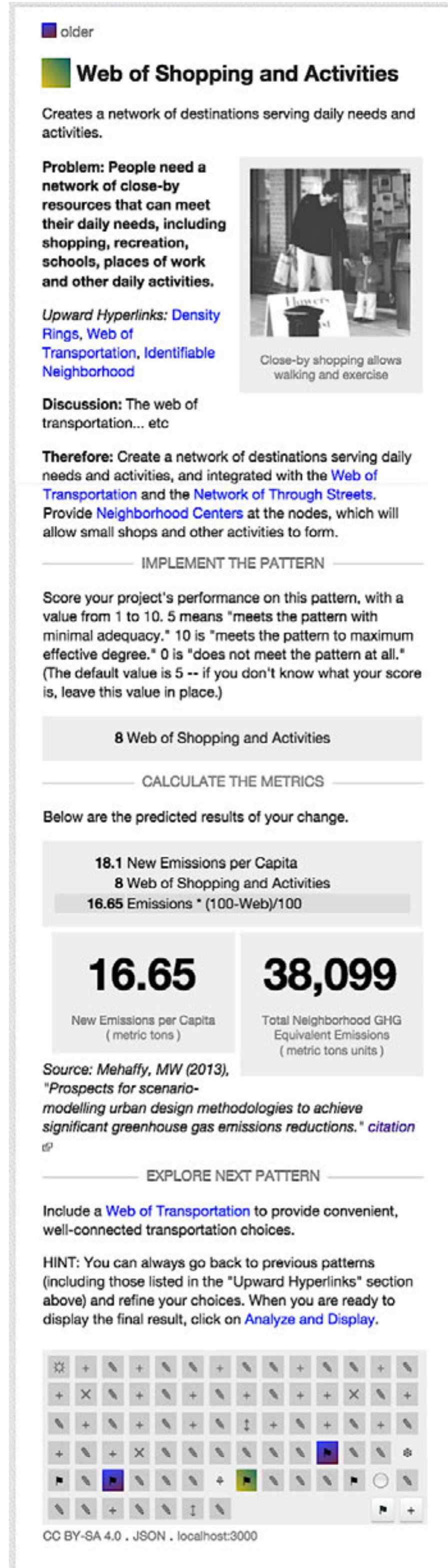


FIGURE 8.5 The pattern Web of Shopping and Activities as it appears on the web page.

PATTERN 4
WEB OF TRANSPORTATION

As we also saw in Chapter 3, the network of multi-modal transportation, or what was termed the "web of transportation," is also an identifiable factor in GHG emissions per capita. The term defines the provision of an integrated network of viable pedestrian-based multi-modal pathways. The pattern describes the best-performing condition that is identified in peer-reviewed research, and then it asks the users to calibrate the degree to which the design scenario achieves this condition, or alternatively, a baseline of more conventional, more fragmented, auto-dominated transportation system.

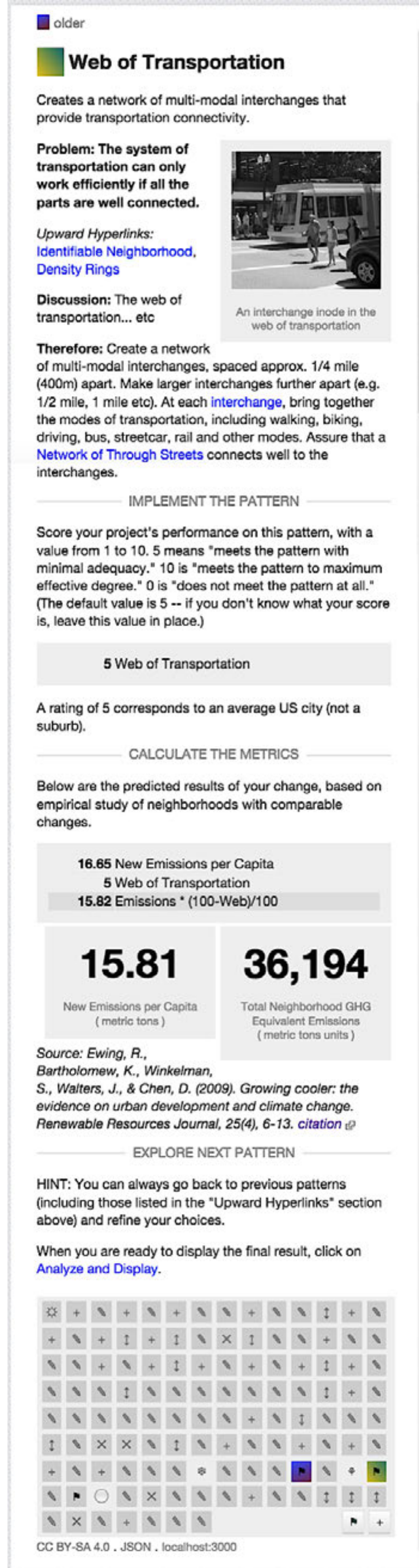


FIGURE 8.6 The pattern Web of Transportation as it appears on the web browser screen.

SUMMARY DISPLAY PAGE WITH (OPTIONAL) ADDED ANALYSIS OF RESULTS

The last display page provides a summary of the results (see last panel to the right in Figure 8.7). An alternate experimental version of the software has featured an opportunity to calculate interactive network effects between the patterns. Because the interactions are relatively simple in the case of this WikiPLACE Alpha Test version, and the order is fixed, the interactive adjustments are not significant at this stage and we have eliminated them from this preliminary model. A more complex version we have begun to develop will allow the patterns to interact dynamically, forming a dynamic structural model. Further development of this capability is one goal of postdoctoral research.
However, it should be remembered from the discussion of "improper linear models" in Chapter 6 that greater precision is not always the same as greater accuracy, and that approximate models can sometimes be better decision-making guides (Dawes, 1979). With that in mind, it is useful to see how the WikiPLACE model performs against actual data.

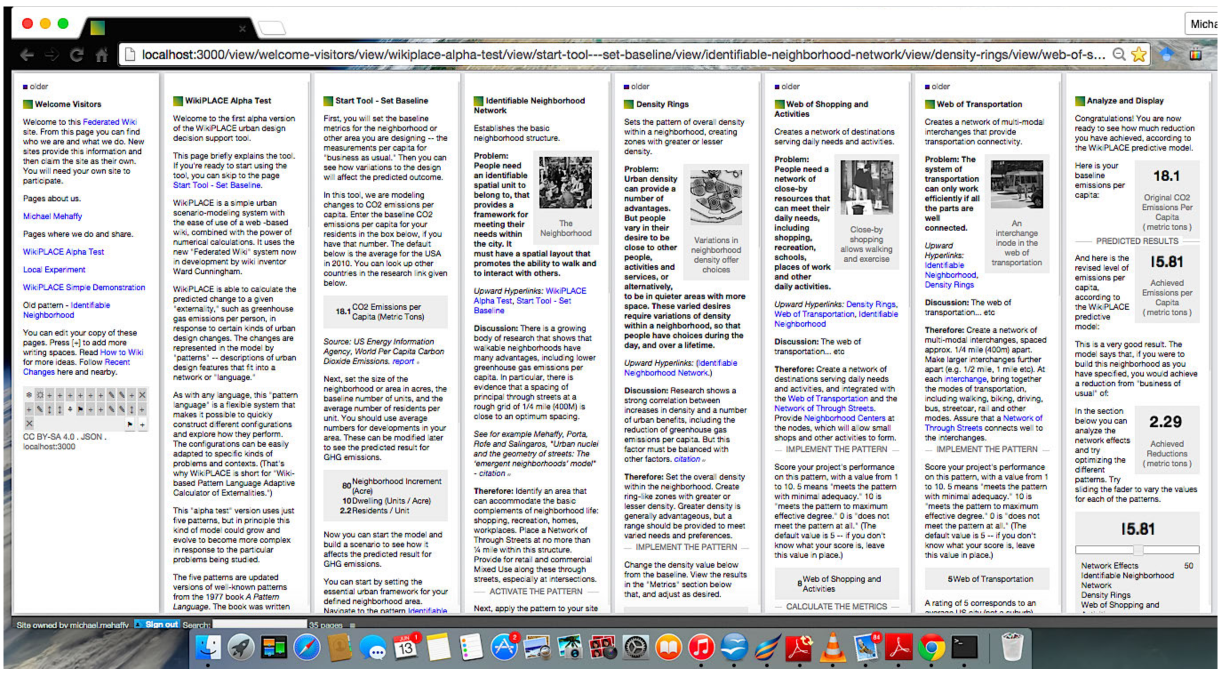


FIGURE 8.7 The complete structure of WikiPLACE as it appears in maximum zoom out on a desktop, showing all the patterns in the alpha test version. From left to right, the introduction and startup page, the Start Tool – Set Baseline page, the four patterns, and the final display page. Users can adjust the values of the patterns, or change the order or number of patterns. Following the protocol of a wiki, users can also edit the patterns as they desire, or even write new ones on their own local copy (which can be shared with others, if desired, throught the federated network).

§ 8.4 Preliminary evaluation of the WikiPLACE tool

As an initial evaluation of the tool and its modelling methodology, I conducted a "reverse forecasting" test – that is, a test of forecasting accuracy by comparison with known examples. By comparing a range of known examples, we can get an approximate gauge of the predictive performance of the tool relative to real-world inventory results.

Here, however, we encounter an important problem in this analysis: the previously discussed problem of inconsistent inventory methodology, and "apples to oranges" comparisons (see Chapter 2). In this research I have carefully chosen to define emissions as measured per capita, generated by consumption activities of people living in neighbourhoods. This is distinct from in-boundary and aggregate emissions. As discussed, this is an important boundary definition because it enables us to examine how people, living and working in neighbourhoods of different morphologies, might consistently vary their emissions based upon those morphological differences – as indeed the evidence herein has shown.

However, consumption-based, per-capita inventories at the neighbourhood scale are uncommon. Where they exist, they cannot be easily correlated with other comparable neighbourhoods within the same or other cities, or with their average country emissions. This is, in fact, an important need that I intend to develop further in post-doctoral research.

Therefore, the approach I have taken in this initial evaluation is to use three different types of reverse forecasting comparisons, and assess the performance of the model as an average across these comparisons. That is, I will start with the known parameters of one entity, and then use the model to predict the emissions of the second entity based on its morphological differences.

It is essential that as many other emissions-influencing factors as possible, beyond urban morphology, be excluded, so that the results are not skewed by these outside factors. Thus, as much as possible, the comparisons should hold steady for climate, economic prosperity, demographics, governmental systems, mix of fuels and zero-emissions sources, and so on.

The three comparisons generally do hold these factors steady, and any variations are further averaged out over the three different kinds of analysis. (As we discussed in Chapter 6, aggregation is always helpful in improving predictive power.)

The three comparisons are:

1. **Countries compared to cities within them.**
2. **Different cities compared within the same country.**
3. **Different neighbourhoods compared within the same city.**

For each model run, I used a consistent weighting of the patterns, but I varied the score of each pattern based upon the change of morphology. I used a ranking from 1 to 9, where 5 is the midpoint of no change, 9 is the highest score representing a full implementation of the pattern, and 1 is the lowest score, representing a complete lack of presence of the pattern.

In later iterations of the model, specific attributes could be measured and calculated more precisely as desired. For example, density could be measured as number of persons per hectare, or a similar metric. For this initial proof-of-concept, I have used a rough approximation of the variations based upon the findings of the research reported earlier.

I also calibrated the "deltas" of the patterns – the magnitude of possible GHG reductions from the full implementation of each of the patterns – from the findings of the research. Though this is a very rough estimate at this stage, it should be remembered that the purpose of the wiki-based system is to allow further refinement and evolution of the model and its accuracy. (Its purpose is also to encourage more development and comparison of consumption-based inventories at smaller scales.)

§ 8.4.1 Countries compared to cities

The country-city pairs were selected because they have greenhouse gas emissions inventories that have been developed through standard UNFCC inventory methods and data (as reported in Dodman, 2009). To do the evaluation, I set the baseline per capita emissions according to national per capita inventory data for each of five countries. I then ran the model to calculate predicted per-capita emissions for each of five cities within those countries, whose parameters of urban form were then assessed according to the four patterns within the model. I then compared the results to the actual greenhouse gas inventories for those cities, as an initial assessment of the degree to which the tool does accurately predict per-capita reductions.

It is important to note here an important issue regarding in-boundary versus consumption-based inventories. The UNFCC methodology relies on in-boundary inventories. While they typically show similar results to consumption-based inventories in cities where production and consumption are roughly balanced, in-boundary inventories provide misleadingly high results for those cities that do large volumes of manufacturing and exporting of goods that are consumed (and demanded, through purchasing behaviours) in other parts of the world. Examples are cities in China, which for that reason have not been considered for use in this reverse forecasting test.

For cities that do not have an unusual concentration of export manufacturing – or equally unhelpful for our purposes, an unusual scarcity of it – there is a relatively close correlation between in-boundary and consumption-based numbers. For example, in the US state of Oregon, which has done comparative analyses of both, in-boundary emissions are 15.8 metric tons per capita per year, while consumption-based emissions are 18.8 metric tons per year – meaning that 3.0 metric tons per year of emissions generated by Oregonians occur in other parts of the world, such as goods manufactured in China. This represents an increase of 18.9% over in-boundary emissions. (McConnaha et al., 2010.)

Although most inventories are in-boundary, not consumption-based, if an in-boundary national inventory is compared to an in-boundary city inventory, both of which are typical for intensity of manufacturing and balanced import/export, the result will at least be “apples to apples” and should give a useful approximation of the magnitude of consumption-based emissions reduction, or “delta,” to provide an indication of the performance of the model.

Another limitation is that the comparison of the model results here is to cities, not to neighbourhoods. We know from research on the dynamics of cities that their efficiencies derive partly from the interactive behaviour of the city as a whole, and individual neighbourhoods cannot easily be separated from the characteristics of the overall city. Put differently, this should indicate to us that a model applied to a neighbourhood in isolation should not predict a magnitude of reduction that is equivalent to that of a city as a whole.

For purposes of this experiment, then, we should expect this model to get a lower magnitude of emissions reduction for the given cities than we see in the full-scale cities in question.

The cities and countries were chosen with the following goals in mind:

1 ***Each city is reasonably typical for its country*** in climate, economy, demographics, political and legal system, and mix of fuels (including zero-emissions sources) as well as other GHG sources, so that those factors are generally equivalent in the comparisons.

2 ***Each city is typical of its country's mix of manufacturing and import/export,*** so that the in-boundary measurements are not artificially skewed by demand occurring in other locales. (For this reason, Chinese cities have been excluded.)
3 ***The city-country pairs are relatively diverse,*** representing different continents, parts of the world, country sizes, climates, etc.

The five city-country pairs are:

1 **London, and the UK *(Europe).***
2 **New York City, and the US *(North America).***
3 **Barcelona, and Spain *(Europe).***
4 **Tokyo, and Japan *(Asia).***
5 **Rio de Janeiro, and Brazil *(South America).***

I scored the cities on the degree to which they met each of the four patterns, so that the delta to be applied by that pattern could be calculated. In scoring each pattern, I evaluated the approximate degree to which each city's morphology varies from the average city or town in that country. For example, London, while a very dense city that meets the patterns very well, is more like the average U.K. City or town than, say, New York City is like the average American city or town. Thus it does not score as high in the evaluation for that pattern.

The following table shows the scoring I gave to each city relative to its national baseline:

Pattern Scoring - Country to City Comparison

Country (City)	***Neighborh. Network***	***Score 1-9***	***Density Rings***	***Score 1-9***	***Web of Activities***	***Score 1-9***	***Web of Transport.***
UK (London)	Low	6	High	8	Moderate	7	Low
Spain (Barcelona)	Low	8	Very High	9	High	8	Low
US (New York)	High	9	Very High	9	High	9	Moderate
Japan (Tokyo)	Moderate	7	Very High	9	Moderate	7	Moderate
Brazil (Rio de Janiero)	High	8	Very High	9	High	9	High

TABLE 8.1 Scoring for the country to city comparison.

I then ran the WikiPLACE model, applying the maximum delta for each pattern to the score for each pattern. For example, the maximum delta for Pattern 1 is 20%, but London scores 6 on the 1-9 scale, so the actual delta applied is 5%.

The output of each pattern then supplied the input for the next pattern, and so on through the sequence of four patterns.

The last output forms the final predictive value for emissions, which is then compared to the actual inventory value. The deviation value and percentage are also shown.

WikiPLACE Output – Country to City

Country (City)	*Init. Value (Baseline)*	*Pattern 1 Score 1-9*	*Pattern 1 Max. Delta %*	*Output Value*
UK (London)	11.19	6	20	10.63
Spain (Barcelona)	10.3	8	20	8.76
US (New York)	23.92	9	20	19.14
Japan (Tokyo)	10.59	7	20	9.53
Brazil (Rio de Janiero)	8.2	8	20	6.97

Country (City)	*Input Value*	*Pattern 2 Score 1-9*	*Pattern 2 Max. Delta %*	*Output Value*
UK (London)	10.63	8	30	8.24
Spain (Barcelona)	8.76	9	30	6.13
US (New York)	19.14	9	30	13.40
Japan (Tokyo)	9.53	9	30	6.67
Brazil (Rio de Janiero)	6.97	9	30	4.88

Country (City)	*Input Value*	*Pattern 3 Score 1-9*	*Pattern 3 Max. Delta %*	*Output Value*
UK (London)	8.24	7	20	7.41
Spain (Barcelona)	6.13	8	20	5.21
US (New York)	13.40	9	20	10.72
Japan (Tokyo)	6.67	7	20	6.00
Brazil (Rio de Janiero)	4.88	9	20	3.90

Country (City)	*Input Value*	*Pattern 4 Score 1-9*	*Pattern 4 Max. Delta %*	*Output Value*
UK (London)	7.41	7	20	6.67
Spain (Barcelona)	5.21	8	20	4.43
US (New York)	10.72	9	20	8.57
Japan (Tokyo)	6.00	7	20	5.40
Brazil (Rio de Janiero)	3.90	9	20	3.12

Country (City)	*Final Predicted Value*	*Actual Inventory Value*	*Deviation*	*% Deviat.*
UK (London)	6.67	6.20	0.47	7.09%
Spain (Barcelona)	4.43	3.40	1.03	23.21%
US (New York)	8.57	7.10	1.47	17.18%
Japan (Tokyo)	5.40	4.80	0.60	11.18%
Brazil (Rio de Janiero)	3.12	2.30	0.82	26.34%
Average Deviation =				**17.00%**

TABLE 8.2 The results of the WikiPLACE reverse forecasting experiment for five city-country pairs. WikiPLACE was able to predict the reduction within an average deviation of 17.0%.

The results are reasonably accurate, with an average deviation across the five city-country pairs of 17.0 percent.

§ 8.4.2 Cities compared to cities

The next comparison is to city pairs that differ in the parameters of urban form, particularly density. The baseline is taken from an analysis of energy use in cities that, working from the results, developed a life-cycle analysis model of four cities in the USA: Orlando, Phoenix, Austin, and Seattle (Nichols and Kockelman, 2015). It is important to note that Nichols and Kockelman looked at energy, not emissions, and therefore did not consider fuel sources or emissions (including zero-emissions sources). However, the analysis does provide a reasonably good "apples-to-apples" comparison of these cities. This is because their mix of fuel sources and zero-emissions sources is comparable, and other factors are comparable.

Nichols and Kockelman's model shows the following percentage change in energy use for the four cities:

1. **Orlando 0% *(Baseline)***
2. **Phoenix -11.8%**
3. **Austin -16.0%**
4. **Seattle -16.8%**

Taking these values as reasonable approximations of GHG emissions deltas, we can generate a table of four per capita GHG emissions measurements for these four cities. Using the USA baseline of 23.92 for Orlando, we derive:

1. **Orlando: 23.92**
2. **Phoenix: x -11.8% = 21.10**
3. **Austin: x -16.0% = 20.09**
4. **Seattle: x 16.8% = 19.9**

I then scored the deviation from the Orlando baseline standard for the four cities. They generally have comparable urban form (a relatively dense mixed-use core surrounded by auto-dependent sprawl) but they vary in density, as Nichols and Kockelman noted. Thus I scored changes to the density pattern, but not to the other three patterns (with the sole exception of Seattle, which I scored higher on its web of transportation).

Pattern Scoring – City to City Comparison

City	Neighborh. Network	Score 1-9	Density Rings*	Score 1-9	Web of Activities	Score 1-9	Web of Transport.	Score 1-9
Orlando	Baseline	5	8.2	5	Baseline	5	Baseline	5
Phoenix	Comparable	5	10.7	6	Comparable	5	Comparable	5
Austin	Comparable	5	11.3	6	Comparable	5	Mod. Higher	6
Seattle	Comparable	5	16.8	7	Comparable	5	Mod. Higher	6

** Persons per acre*

TABLE 8.3 Scoring for the four cities based on Nichols and Kockelman data. Orlando is the baseline for the comparison of the other three.

Taking these values as inputs to the WikiPLACE model, I generated the following results:

WikiPLACE Output – City to City Comparison

City	*Init. Value (Baseline)**	*Pattern 1 Score 1-9*	*Pattern 1 Max. Delta %*	*Output Value*
Orlando	23.92	(Baseline)		23.92
Phoenix	23.92	5	20	23.92
Austin	23.92	5	20	23.92
Seattle	23.92	5	20	23.92

* *Orlando baseline*

City	*Input Value*	*Pattern 2 Score 1-9*	*Pattern 2 Max. Delta %*	*Output Value*
Orlando	23.92	(Baseline)		23.92
Phoenix	23.92	6	30	22.13
Austin	23.92	6	30	22.13
Seattle	23.92	7	30	20.33

City	*Input Value*	*Pattern 3 Score 1-9*	*Pattern 3 Max. Delta %*	*Output Value*
Orlando	23.92	(Baseline)		23.92
Phoenix	22.13	5	20	22.13
Austin	22.13	5	20	22.13
Seattle	20.33	5	20	20.33

City	*Input Value*	*Pattern 4 Score 1-9*	*Pattern 4 Max. Delta %*	*Output Value*
Orlando	23.92	(Baseline)		23.92
Phoenix	22.13	5	20	22.13
Austin	22.13	5	20	22.13
Seattle	20.33	5	20	20.33

City	*Final Predicted Value*	*Actual Inventory Value*	*Deviation*	*% Deviat.*
Orlando	23.92	(Baseline)		0.00%
Phoenix	22.13	21.10	1.03	4.64%
Austin	22.13	20.09	2.04	9.20%
Seattle	20.33	19.90	0.43	2.12%
Average Deviation =				**5.32%**

TABLE 8.4 The results of the WikiPLACE reverse forecasting experiment for four cities compared. WikiPLACE was able to predict the actual results within an average deviation of 5.32%.

§ 8.4.3 Neighbourhoods compared to neighbourhoods in the same city

The third reverse forecasting experiment also uses data from Nichols and Kockelman (2015). They gathered data for five different neighbourhoods in Austin, Texas, with notably divergent characteristics of urban form. Other typical factors were generally comparable – namely, climate, economics, political and legal system, and mix of fuels and zero-emissions sources.

Nichols and Kockelman completed an inventory of energy use per capita, combining both operational and embodied energy. Because zero-emissions sources are a negligible component of Austin energy, the level of energy consumption per capita is generally representative of GHG emissions per capita. Therefore on this basis we can impute a GHG value variation from a theoretical baseline, here taken from the USA average given previously. The actual number is not what is of interest to us here, but the relative comparison between the numbers as measured and the prediction of WikiPLACE

Austin Neighborhood Data from Nichols and Kockelman (2015)

Neighborhood	*Operational*	*Embodied*	*Combined*	*Delta from WL Baseline*	*Imputed GHG Value*
Westlake	101	23.99	124.99	0.00%	23.92
Anderson Mill	94.46	22.14	116.6	6.71%	22.31
Hyde Park	77.18	11.99	89.17	28.66%	17.06
Riverside	60.97	7.41	68.38	45.29%	13.09
Downtown	54.67	3.78	58.45	53.24%	11.19

TABLE 8.5 Operational and embodied energy in five neighbourhoods in Austin, Texas, and imputed greenhouse gas emissions for each.

I then scored the five neighbourhoods according to the four patterns, noting in particular the data on density, and the other factors:

Pattern Scoring – Neighborhood to Neighborhood

Neighborhood	*Neighborh. Network*	*Score 1-9*	*Density Rings*	*Score 1-9*	*Web of Activities*	*Score 1-9*	*Web of Transport.*	*Score 1-9*
Westlake	Baseline low	5	962	5	Baseline low	5	Baseline low	5
Anderson Mill	Low	5	6148	6	Low	5	Low	5
Hyde Park	High	7	5713	6	Moderate	6	Moderate	6
Riverside	Moderate	6	17249	9	Moderate	6	Moderate	6
Downtown	High	7	4857	6	High	8	High	8

TABLE 8.6 Scoring of the five neighbourhoods based on their attributes of urban form. Westlake is identified as the baseline for the other four.

Taking these values as inputs to the WikiPLACE model, I generated the following results:

WikiPLACE Output – Neighborhood to Neighborhood

Neighborhood	Init. Value (Baseline)	Pattern 1 Score 1-9	Pattern 1 Max. Delta %	Output Value
Westlake	23.92	(Baseline)		23.92
Anderson Mill	23.92	5	20	23.92
Hyde Park	23.92	7	20	21.53
Riverside	23.92	6	20	22.72
Downtown	23.92	7	20	21.53

Neighborhood	Input Value	Pattern 2 Score 1-9	Pattern 2 Max. Delta %	Output Value
Westlake	23.92	(Baseline)		23.92
Anderson Mill	23.92	6	30	22.13
Hyde Park	21.53	6	30	19.91
Riverside	22.72	9	30	15.91
Downtown	21.53	6	30	19.91

Neighborhood	Input Value	Pattern 3 Score 1-9	Pattern 3 Max. Delta %	Output Value
Westlake	23.92	(Baseline)		23.92
Anderson Mill	22.13	5	20	22.13
Hyde Park	19.91	6	20	18.92
Riverside	15.91	6	20	15.11
Downtown	19.91	8	20	16.93

Neighborhood	Input Value	Pattern 4 Score 1-9	Pattern 4 Max. Delta %	Output Value
Westlake	23.92	(Baseline)		23.92
Anderson Mill	22.13	5	20	22.13
Hyde Park	18.92	6	20	17.97
Riverside	15.11	6	20	14.36
Downtown	16.93	8	20	14.39

Neighborhood	Final Predicted Value	Actual Inventory Value	Deviation	% Deviat.
Westlake	23.92	(Baseline)		0.00%
Anderson Mill	22.13	22.31	-0.19	-0.85%
Hyde Park	17.97	17.06	0.91	5.05%
Riverside	14.36	13.09	1.27	8.84%
Downtown	14.39	11.19	3.20	22.25%
Average Deviation =				**7.06%**

TABLE 8.7 The results of the WikiPLACE reverse forecasting experiment for five neighbourhoods. WikiPLACE was able to predict the reduction within an average deviation of 7.06%.

As can be seen, the results of these reverse forecasting experiments are encouraging. The results for the city-country pairs, for example, are reasonably accurate, with an average deviation across the five city-country pairs of 17.0 percent. In that case it will be noted that each of the WikiPLACE predictions was not as great as the actual difference – that is, the WikiPLACE predictions were more conservative than the actual measurements. This is likely to be because of other benefits of cities that the model does not account for – or does not yet account for. The use of such tools may in fact serve as a useful research tool to uncover these other factors.

The run for city-to-city comparisons gives even more accurate results. That is in part because the variations are focused on changes in density, while other factors are not as varied. Density is also the variable that Nichols and Kockelman studied, so it is not surprising that WikiPLACE has given a very similar result. Nonetheless it is encouraging to see a satisfactory performance.

The result for the neighbourhood to neighbourhood comparison, an average deviation of 8.82%, is also encouraging. The largest deviation was for Downtown Austin, which is still relatively low in residential density. This may suggest that the other factors can be more significant when density is low. However, this question remains for investigation. Nonetheless it demonstrates how WikiPLACE can be an aid in uncovering interesting research questions.

§ 8.5 Conclusion

It must be stipulated that this is a very preliminary experiment with limited data. As I noted, this research has made clear to me the need for more data at the neighbourhood scale, with apples-to-apples comparisons of sources, boundaries and other parameters. More data would make it easier to verify the results of the WikiPLACE methodology with greater confidence. (As discussed, there are many other reasons why this would be beneficial.) At present, there are admittedly problems in the underlying data and its relevance to consumption-based, per-capita, neighbourhood-scale modelling – problems that weaken the reliability of these results.

Nonetheless, these preliminary results do tend to suggest that WikiPLACE can give quite good predictions of reductions based on urban form, in line with empirical research. This is in spite of its simplicity and its “improper linear” attributes, as discussed previously. That is indeed the goal of this approach – a more comprehensive model, more able to account for larger behaviours of the system in question, and thus, more useful as a guide to urban design decision-making.

Of course, the essence of wiki methodology is evolutionary improvement, and post-doctoral research will provide a continuing opportunity for improvement. The next key step is likely to be an application of WikiPLACE on one or more actual projects involving a constituency of users, who can evaluate the user-friendly aspects of the tool.

The other key need is to redress the shortage of consumption-based GHG emissions data at neighbourhood scale. I may be able to help to accomplish that goal in part by bringing together existing data sets and combining them to create more comprehensive and comparative inventories. In part it could also be accomplished with local studies that develop the inventories according to a unified protocol. As noted earlier, it is my hope that WikiPLACE would be a useful stimulus for this research, and as such, a research tool in its own right.

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