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## SPECIAL ISSUE: NATIONAL SCIENCE FOUNDATION WORKSHOP

ARCHITECTURE AND ENGINEERING OF SUSTAINABLE BUILDINGS

# 01.
# CONSTITUTIONAL ECOLOGY:
## *The Case for Aligning Science and the Law in Urban Design*

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ABSTRACT

This paper discusses current trends in research related to the design of cities, primarily focused on the relationship between regulations that are put in place to control development and the outcomes resulting from the regulations. Unlike other arenas of urban research, where the desired outcome is the health, safety and welfare of the general public, research into the impact of regulations on a population is almost nonexistent. There are few protocols for tying the performance of regulations to outcomes and little testing of the regulations to ensure the outcomes align with their intentions. This paper makes the case that regulations have a significant impact on health, safety and welfare, and that their implementation and adoption should be tied to basic research and testing, and further, that there should be legal and scientific mechanisms in place to monitor the efficacy of the adopted regulations and to modify the regulations based on alignment with stated intentions.

KEYWORDS: research in cities, development regulations, health, safety, welfare, zoning, public health

## 1.0 INTRODUCTION

Cities are critical to the efficient operation of society. Beyond just issues of quality of life, they are large consumers of natural resources. They consume energy, both through the end use (electricity and gas) and through automobile and mass transit, as well as water, coal, building materials, and myriad of other natural and fabricated resources. In addition, there is a growing concern that the form of cities may have a profound effect on public health: chronic diseases related to obesity, heart disease, and asthma, among many others. But cities are making decisions about their development in the absence of critical data and analysis that provides direction for these actions. There is a clear need to establish research that provides a scientific basis for rationalizing city planning and urban design.

We have, for the past eighty years or so, used a pseudo-scientific set of criteria to direct and regulate the design and construction of our cities, towns and suburbs. From the very beginning, social-scientific measures formed the foundation of the professional planning movement. In this process, however, the rigors of basic research and scientific methods have been remarkably absent in reflection on the efficacy of planning's impact on the built environment. Abstract planning principles are translated into operational regulations without a basic protocol for testing, evaluating, and modifying assumptions based on the results of evidence. The reticence of the profession to test and evaluate is further complicated by the fact that planning is ultimately implemented through a series of legal documents – regulations. Once adopted, regulations are notoriously difficult to change, both due to the precedential nature of the legal system itself and the seemingly inherent credibility bestowed upon regulation by virtue of its own adoption.

At its core, the planning profession is charged with creating rules and guidelines for the development of urban places through constitutional policy powers: to provide for the health, safety and welfare of the general public. Ultimately, effectiveness of planning means, such as zoning, can and should be measured. For example, Justice George Sutherland states that plans and their regulations must "expand or contract to meet the new and different conditions which are constantly coming within the field of their operation" in the seminal Supreme Court case, *Village of Euclid, Ohio v. Ambler Realty Co.* (Village of Euclid, Ohio v. Ambler Realty CO, 1926). He went on to say that, "in a changing world it is

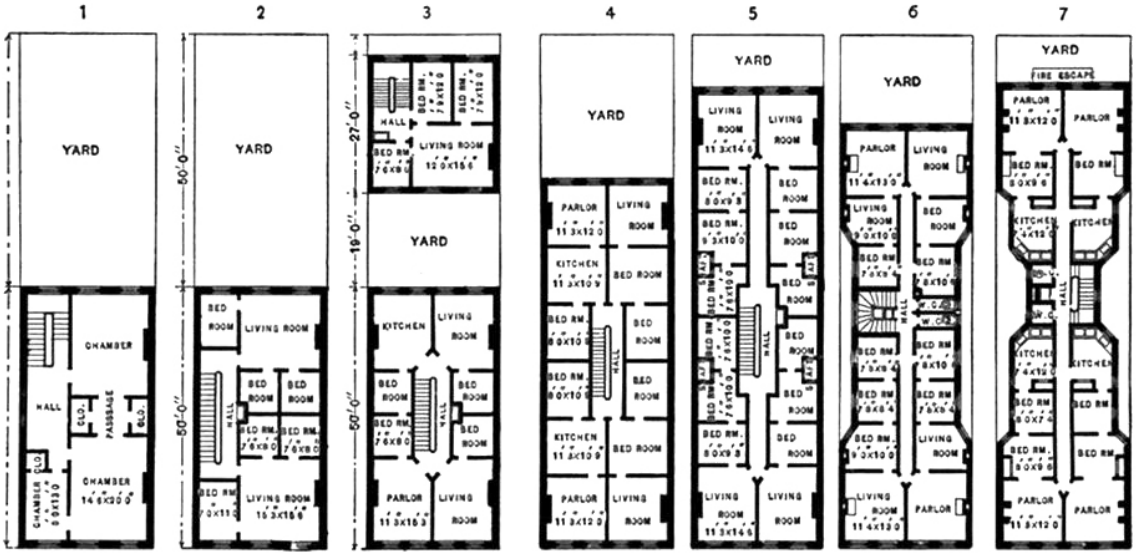
impossible that it should be otherwise."[1] What Sutherland knew as a fact, and the planning profession seems unwilling to address, is that planning is only as good as its ability to positively affect the health, safety and welfare of the people in places it impacts. And, if our impacts are not positive, we are obligated by the law to improve our regulations[1].

A nationally supported system of testing and evaluation protocols, both for proposed regulations and adopted regulations, is still absent from planning and urban design processes. Jurisdictions continue to rely on theory and precedents alone when adopting new regulations. Because of the significant impact that the built environment has on the health, safety and well-being of the general population, it seems logical that the profession would adopt scientific research protocols. To avoid doing this would be analogous to the pharmaceutical industry, in the absence of the Food and Drug Administration, releasing new drugs to the public without trials and then turning a blind eye to potentially negative outcomes.

This paper will examine several specific cases that articulate the issues outlined above and provide suggested methodologies for beginning to frame a scientific method for planning and urban design at a consistent, national level. It also makes the case that institutions, such as the National Science Foundation, should establish foundations for research in these areas. The answers to the questions posed above, if they are to be solved, must be considered scientifically and comprehensively.

## 2.0 THE BIRTH OF REGULATIONS

The impetus for regulating the built environment came from conditions that we can hardly imagine today. In the second half of the nineteenth century, people were living in conditions that were extremely unhealthy. For example, extreme population density grew in the Tenth Ward of lower Manhattan without infrastructural support – population densities were as high as 1000+ people per acre, or roughly 50 times the density of Manhattan today[2]. Most of this population lived in tenement houses with little natural light, open pit latrines and no




1. Old Knickerbocker dwelling.
2. The same made over into a tenement.
3. The rear tenement caves.
4. Packing-box tenement built for revenue only.
5. The limit; the air shaft — first concession to tenant.
6. The double-decker, where the civic conscience began to stir in 1879.
7. Evolution of double-decker up to date.

Figure 1: The evolution of the Knickerbocker tenement house type leading up to the 1901 Act and subsequent to the Act. The transformation from 5 to 6 demonstrates the direct, positive effect the Act had on the living conditions of the residents; in this case, the diagram illustrates shafts for natural light and air included on sidewalls between the buildings, which were lined up in rows. (Source: *The Battle with the Slum,* by Jacob A. Riis, New York, NY: The Macmillan Company, 1902).

air circulation. With the publication of books such as Jacob Riis's *How the Other Half Lives,* the public began demanding reform through regulation and local jurisdictions responded[2]. One of the most important steps forward was New York State's adoption of the 1901 Tenement House Act. Figure 1 illustrates the impact of regulations as demonstrated by the evolution of houses themselves. The Tenement House Act served to open living quarters to light and air, and set the conditions for healthier living environments.

While the 1901 Tenement House Act is representative of the changes that were affecting individual building form and execution, it was with the adoption of the 1916 Building Zone Resolution of the City of New York that the role of regulations addressed what is commonly understood as zoning. The catalyst for this action was the completion of the Equitable Building in the financial district of the city. The building was reputed to cast a seven-acre shadow across the district at certain times of the day and year, with significant detrimental effect upon those other buildings in the affected area, and upon the general health and welfare of residents and office workers in the district. As a response, the city of New York adopted the resolution. The resolution provided for a number of requirements, including the zoning of the city into areas for residential, commercial and unrestricted uses, the requirements of yards for light and air, and restrictions on the height and form of buildings to ensure natural light and air for the district in general, not solely for the individuals occupying the buildings. The regulation had a significant impact on the quality of the city as demonstrated in Figure 2, the height and setback requirements for buildings permitted under the new resolution. Further, the regulations were easily tested and evaluated to determine the efficacy of their providing more light and air into the city streets and parks[3].

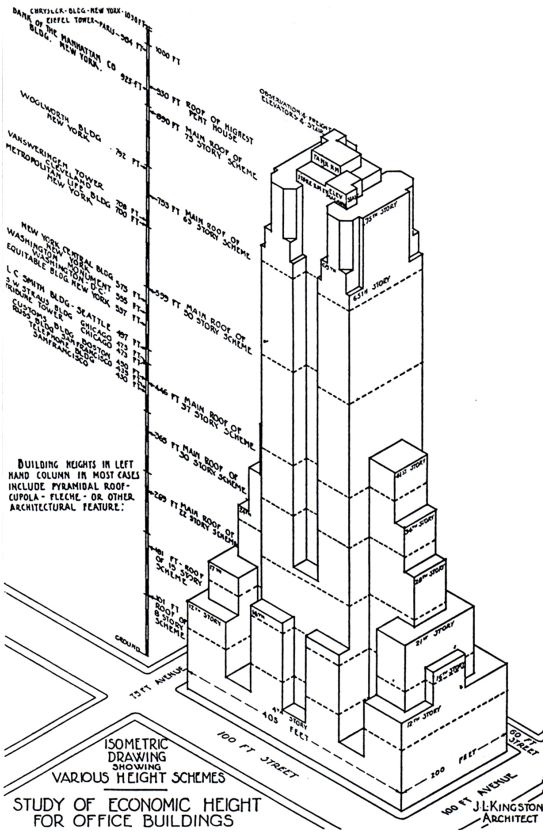



Figure 2: Diagram from the 1916 Building Zone Resolution describing the setback requirements for new buildings (Source: Building Zone Resolution, 1916).

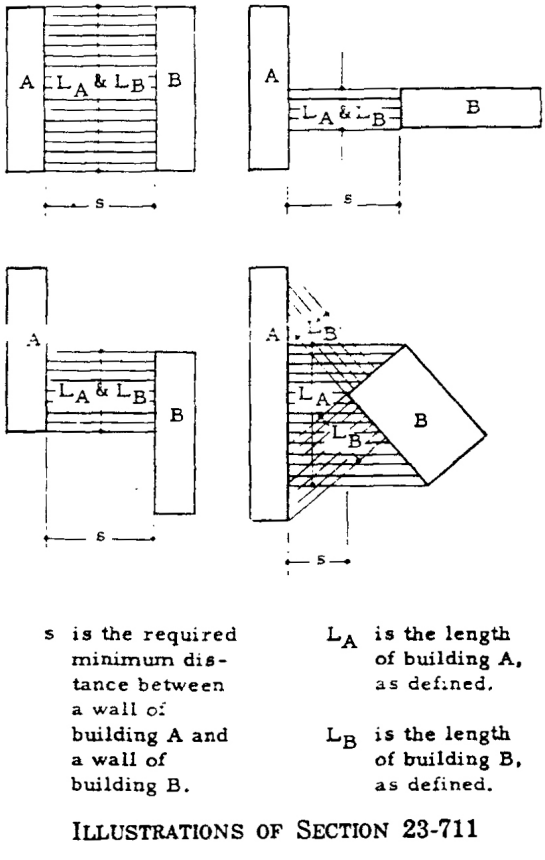



Figure 3: Diagram from the 1961 Zoning Resolution describing the calculations for meeting building spacing requirements (Source: 1961 Zoning Resolution, 1961).

This original ordinance was updated and modified many times over the course of 45 years until the 1961 Zoning Resolution superseded it. The adoption of this ordinance signalled the acceptance of a radically transformed understanding of the way regulations operated. Instead of relying on simple, straightforward guidelines that were easily tested, the newly adopted regulations were much more reliant on formula-driven criteria for development. This transformation created a scenario in which it was almost impossible to project the physical outcome resulting from the regulations because each project was easily manipulated based on local and site-specific conditions. This is demonstrated in Figure 3, a seemingly simple calculation to determine building massing and spacing that opened the process to infinite possible results, most of which led to unintended consequences. In addition, there was almost no incremental testing of the proposal to ensure that it would garner the desired results and that those results would meet the constitutional guarantees of health, safety and welfare. While the specifics of the 1961 Resolution were not copied verbatim into other ordinances across the country, the logic of regulating the development of cities and towns and suburbs was predicated on this resolution almost universally. The following two sections demonstrate two very specific regulations that were adopted, generally, throughout the country without testing and evaluation, and the impact they have had and continue to have on the built environment[4].

## 3.0 EXAMPLES OF REGULATIONS' EFFECT ON URBAN DEVELOPMENT

### 3.1 Example One: Local Streets

In the seminal zoning case, *Euclid v. Ambler*, the core issue before the court was the question of protection of single-family neighborhoods. The case was brought to the court in a time, the 1920s, when questions of appropriate uses in these neighborhoods was critical as it was not uncommon to find toxic uses, such as rendering plants, slaughterhouses and tanneries, among others, interspersed with people's dwellings. At the time of the case, there was a clear need to separate these extremely unhealthy operations from the districts where families lived[1]. Over the course of subsequent decades, however, the protection of single-family neighbourhoods expanded greatly. This can be demonstrated in a number of regulations adopted, especially through the 1950s, including minimum lot sizes for single-family homes, extremely restricted uses such as the restriction on corner groceries, neighborhood restaurants and other uses that had, historically, been a part of the rich mixture of a healthy neighborhood. While there are many examples of regulations that were adopted that have, and continue to have, negative impacts on the health, safety and welfare of the general public, there are some that stand out as clearly demonstrating the need for scientific study to determine the true impact they have. And further, they demonstrate the legal implication of the enactment of the regulations.

In 1957, a new subdivision ordinance was adopted in the City of Atlanta. It included, as did many other ordinances adopted throughout the country at the time, a seemingly simple, clear and intelligent requirement that cut-through traffic (traffic moving through a particular geographic area with no intention of stopping in that area) should be minimized, or if possible, eliminated from single-family developments. In the Atlanta Ordinance the statement, *"Local streets shall be so laid out that their use by through traffic will be discouraged,"* was a prominent element of the ordinance[5]. The requirement led, and continues to lead, to a very particular development pattern, as demonstrated in Figure 4. Individual suburbs are designed and developed in such a way that there is absolutely no connectivity between the subject development and other, contiguous or proximate developments (residential or commercial). This seemingly benign requirement has had enormous impact on the lives of the inhabitants of the communities developed under this requirement. The result is a community that disconnects neighbors from each other, where people are discouraged from walking and where the primary way to move through the system is in an automobile.

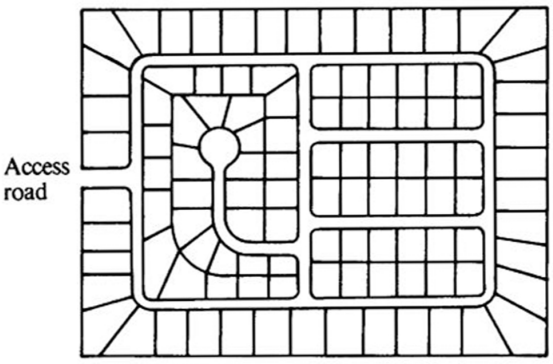



Figure 4: Typical land development pattern resulting from regulations prohibiting through traffic.

However, when this ordinance was originally adopted, it was not tested, evaluated and determined to operate effectively to actually provide a healthy and safe environment for its occupants. Further, in the face of mounting evidence that instead of being a healthy and safe development strategy, it is actually causing unhealthy and unsafe results for the inhabitants of the areas developed under the regulation. Certainly further investigation is warranted to expand and verify the initial research, but this expanded research is extremely slow in coming. And as with all regulations and laws, changing them is extremely difficult.

It is here, in the evaluation of regulations, that the benefit of following a scientifically dictated protocol for research would prove beneficial. If, for instance, basic research provided the data and interpretation of data to correlate the regulation with issues of Health Related Quality of Life (HRQOL), such as obesity, asthma, heart disease, pedestrian and vehicular deaths and injuries, crime rates, even long-term house values, an issue of welfare, the professionals charged with creating and adopting the regulations would have much greater certainty that they were adopting regulations that resulted in measurably healthier, safer and more economically vibrant developments, and they would be fulfilling their professional obligation to ensure the constitutional guarantees upon which Justice Sutherland based the ruling that made the regulations constitutional in the first place. Further, from a legal standpoint, it would be much easier to modify existing regulations if there was compelling scientific research to back up the proposed modifications.

## 3.2 Example Two: Walking

Current research suggests that walking provides health benefits; that areas of cities with more pedestrians are safer; and that areas of cities, particularly commercial, with more pedestrian traffic are more economically robust. As with most current information regarding cities, towns and suburbs, and the efficiency of their operation, more research is needed to understand correlations between walking and urban planning. As evidence-based research supports the premise that more people walking in cities promotes the health, safety and welfare of the general population, current regulations can be evaluated based on their efficiency in producing developments that are conducive to pedestrian activity.

Throughout the United States, the single most difficult element to incorporate into new developments, redevelopments and other forms of modifying a jurisdiction's form is the creation of new streets. This difficulty stems from several issues: maintenance costs borne by the jurisdiction, a pre-conceived notion that more streets are less environmentally beneficial, and, as demonstrated in previous section, a general belief that more streets lead to more traffic. Each of these issues demands additional research, but it is extremely difficult to replicate the highly connected street systems of cities and towns constructed in the pre-regulatory era. In this specific case, we are focusing on expanding pedestrian activity, and the effect the street system and the regulations that drive street locations have on the efficacy of providing pedestrian activity.

As a basis for researching this issue, the correlation between street layout and pedestrian activity, the first step is to identify areas that seem to promote pedestrian activity and those that seem to suppress it. An example of the former is New York, arguably one of the most highly pedestrian cities in the world. In New York, specifically Manhattan, the streets are highly connected, with resulting block sizes of 200 feet in the north-south direction, and block sizes generally between 500 and 800 feet in the east-west direction. In this system, there appears to be a correlation between the size of the block face and the level of comfort in walking similar distances. As demonstrated in Figure 5, a walk in the north-south direction of 10 blocks is perceptually different from a walk in the east-west direction of the same distance. This begins to identify the possibility that the physical distribution of streets has a direct effect on the pedestrian's comfort, and further on the efficacy of the system to produce the desired result, more pedestrian activity. It is generally perceived to be easier to walk the half-mile uptown than the same half-mile crosstown.

The research on block dimensions and its correlation to a supportive system for pedestrian activity is not the end, however. It is an analytical method to help cities create more energy-efficient and healthier overall systems. The increased number of people who walk, due to myriad factors, will have a direct impact, we hypothesize, on the reduced use of fossil fuels for automobiles. It should also create a more efficient overall system for distribution of utilities and a more resilient infrastructure layout, which minimizes rebuilding when single buildings are reconstructed or newly constructed. In addition, increased walking should correlate, again, we assume, to decrease numbers of health problems such as chronic disease and asthma. However, the basic research to prove or disprove these hypotheses is currently almost nonexistent. Cities are, in aggregate, among the largest users of energy, and home to the greatest number of people, yet the national planning community,

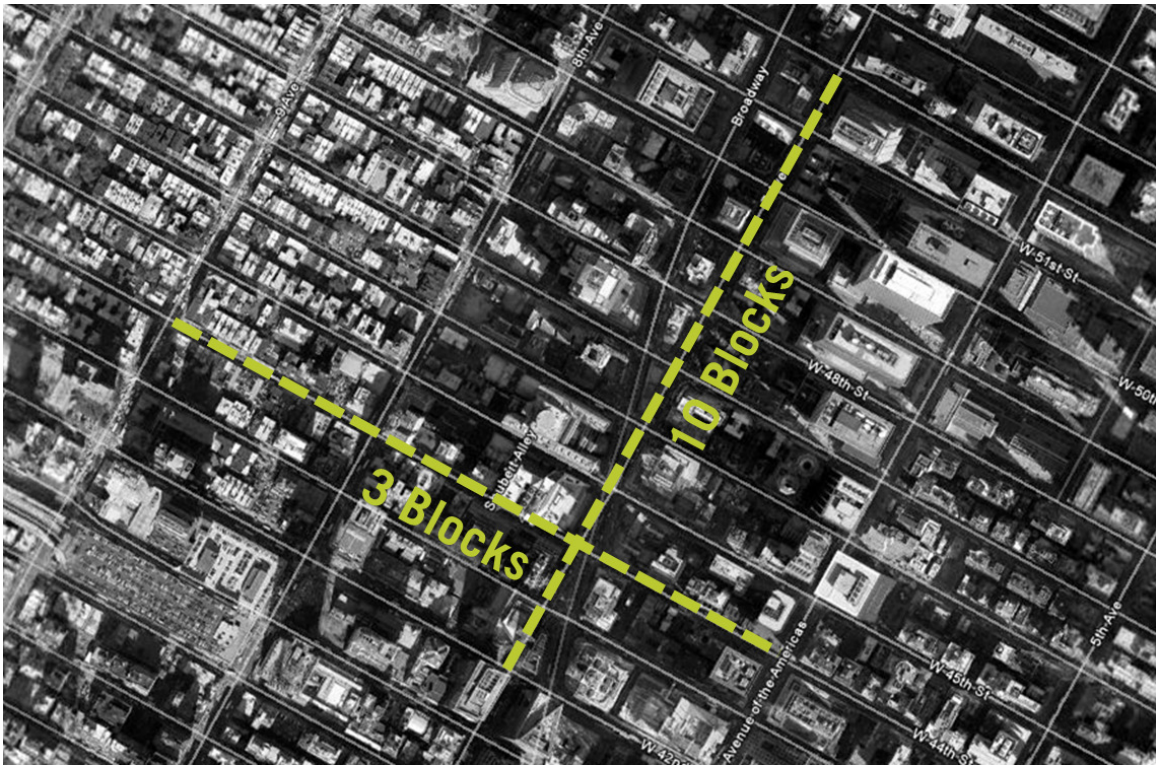



Figure 5: Demonstration of the physical difference in pedestrian experience; uptown versus crosstown.

and the funded research within which it is engaged, is minimal. There is a clear need for an increase in research in these areas, and to increase the connection between current health-related research and the planning profession.

The physical layout and the efficiency of the pedestrian system in this case is tied directly to the original regulation that dictated where and how streets would be laid out as Manhattan developed. In this case, it was the Commissioners' Plan of 1811, a survey and plan that identified the location of streets as the city grew. The power of the regulation in this case was the certainty of the outcome, and in retrospect, the value of the plan for producing (or allowing) significant pedestrian activity[6].

Throughout the twentieth century, however, the methodology for the design of street patterns changed radically. As indicated in Example 1, connected streets were discouraged or prohibited[5]. Further, streets were no longer identified in a specific plan, guaranteeing short block faces and highly connected system, but were placed project-by-project based on capacities of individual projects and the demands those projects would place on the vehicular efficiency of the system. The resulting pattern of development is indicated in Figure 6. It clearly shows the physical implications of the regulations, including limited intervening public streets, expanded parking requirements, significant building setbacks, among other requirements that led to the disappearance of the connected system of all pre-regulatory cities. The outcome of these regulations is the production of development patterns that deter inhabitants from walking. There appear to be direct correlations between the sizes of blocks (or the frequency of streets) and the level of pedestrian activity. This is further indication of the need for a rigorous research platform for the investigation of these issues.


Figure 6: A typical development pattern resulting directly from the regulations governing the jurisdiction..

## 4.0 WAY FORWARD

There is research underway that attempts to align the planning and urban design professions more closely with scientific research. These efforts are framed around two distinct trajectories. The first is identifying, through research, the correlation between regulations and physical development patterns historically. The second is the creation of research tools that allow for the testing, projection, and evaluation of proposed policies and regulations, as well as provide for analysis of implemented regulations and recommendation for modifications based on data analysis.

### 4.1 Correlation Between Regulations And Development Patterns

The first trajectory is exemplified through a simple analysis of the relationship between regulations in place and block sizes. Assuming Example two above is accurate, then what was the correlation between regulations in place and the resulting block sizes, and by extension frequency of streets? Table 1 below indicates the results of a cursory investigation into the relationship between the existence of subdivision regulations and the size of blocks. In this statistically limited sampling, the data suggests that there is potentially a significant correlation between the mere presence of a regulation and the efficacy of creating small, consistent block sizes.

Observation 2: the standard deviation of average block size in the following selected cities has increased from .79 to 6.14 from pre-1928 subdivision to post -1928 subdivision.

| | Pre 1928 Block Size | | | | | Post 1928 Block Size | | |
|---|---|---|---|---|---|---|---|---|
| | | avg. | max | | | | avg | max |
| | | acres | acres | | | | acres | acres |
| 1 | Atlanta, GA | 3.70 | 8.26 | | 1 | Atlanta, GA | 22.87 | 44.49 |
| 2 | Boston, MA | 3.09 | 4.13 | | 2 | Boston, MA | 9.45 | 14.46 |
| 3 | Baltimore, Md | 3.29 | 5.78 | | 3 | Baltimore, Md | 14.93 | 22.72 |
| 4 | Charleston, S.C. | 4.12 | 6.07 | | 4 | Charleston, S.C. | 16.89 | 25.25 |
| 5 | Chicago, Illinois | 3.51 | 4.96 | | 5 | Chicago, Illinois | 14.74 | 19.10 |
| 6 | Los Angeles, CA | 4.41 | 7.89 | | 6 | Los Angeles, CA | 8.01 | 16.08 |
| 7 | New York, N.Y. (Manhattan) | 2.60 | 3.67 | | 7 | New York, N.Y. (Manhattan) | 7.72 | 13.31 |
| 8 | Omaha, Nebraska | 4.34 | 8.26 | | 8 | Omaha, Nebraska | 8.27 | 13.42 |
| 9 | Portland, Oregon | 1.92 | 3.72 | | 9 | Portland, Oregon | 2.69 | 4.24 |
| 10 | Philadelphia, Pennsylvania | 3.07 | 6.33 | | 10 | Philadelphia, Pennsylvania | 5.03 | 5.88 |
| | | | | | | | | |
| | Average | 3.41 | 5.91 | | | | 11.06 | 17.90 |
| | Median | 3.40 | 5.93 | | | | 8.86 | 15.27 |
| | Std. Dev | 0.79 | 1.80 | | | | 6.14 | 11.42 |

Figure 7: Statistical analysis provided by Douglas Allen, Georgia Institute of Technology[7].

The conclusion derived from this preliminary investigation is that there is an inverse correlation between the degree to which regulations are implemented and the efficiency of creating consistency; the stated goal of the regulation. If this is verified through further research, it implies that the regulations adopted to provide for health, safety and welfare are resulting in development patterns that are inconsistent with the goals of the regulations.

This early work supports the proposal that there should be regional, and even national, systems in place to track these issues. The computing power, and much of the data already exists, but the planning profession is slow in taking up the move to identify critical data that would form the foundation for a more rigorous and directed national research agenda[7].

## 4.2 Human Spatial Comfort

The second trajectory is exemplified through the research of John Peponis at the Georgia Institute of Technology[8,9,10,11,12,13]. This effort is predicated on the notion that existing development is measurable, both in terms of its physical characteristics (e.g. the connectedness of streets, the alignment of streets), as well as its operational characteristics (e.g. the amount of pedestrian activity, the level of retail development). Both of these aspects measure the efficacy of the system. The correlation between the physical and operational characteristics and the system itself is built on analysis and evaluation of existing conditions. The results of these analyses are then used to construct a model that interprets projected systems to evaluate their effectiveness prior to implementation, in an objective manner based on data and analysis. These tools can be used to test and evaluate proposed regulations prior to adoption and continue to evaluate as the regulations are implemented, and provide recommendations for modification reflecting a potentially higher level of efficacy of the system.

In a recent paper, Peponis et al. propose a specific strategy for implementing measures of street connectivity that is determined based on standard GIS computational platforms[8]. The innovation in the proposal is the specifics of measurements and their correlation to

experienced outcomes, as well as the potential for more refined methods of projecting effects of regulations on urban development. The core objective of the research is to determine a method for measuring street connectivity and "setting the foundations for future research aimed at testing theoretical hypotheses."[8]

The metrics evolve from a specific desire to understand how much street length can be reached as one walks in a number of different directions. This is further framed, and limited, by utilizing specific distance thresholds to provide consistency and control in the research. The unit is defined as a *mean metric*, a method to measure potential pedestrian reach, as well as density of available streets. The system generally works as such:

> "[w]e have pursued the relationship between mean metric reach and other measures in two ways. First, we studied the relationship between block size and mean metric reach in theoretical infinite regular square grids… For such grids, the smaller the urban blocks, the higher the mean metric reach. Furthermore, the smaller the block size, the higher the rate at which the metric reach increases with an increase in threshold distance."[8]

Figure 8 below describes the general analytical process and outputs. The figure at the left indicates presence of retail land uses, which correlate to pedestrian activity, and the dispersal is further described on a larger scale in the middle figure. The figure on the right indicates the level of connectivity, based on the parameters input in the computational model. In this figure the intense red color indicates a higher level of connectivity, while the intense blue color indicates reduced connectivity. The statistical analysis below indicates the correlation between location of retail, pedestrian activity and the level of connectivity in the street pattern.

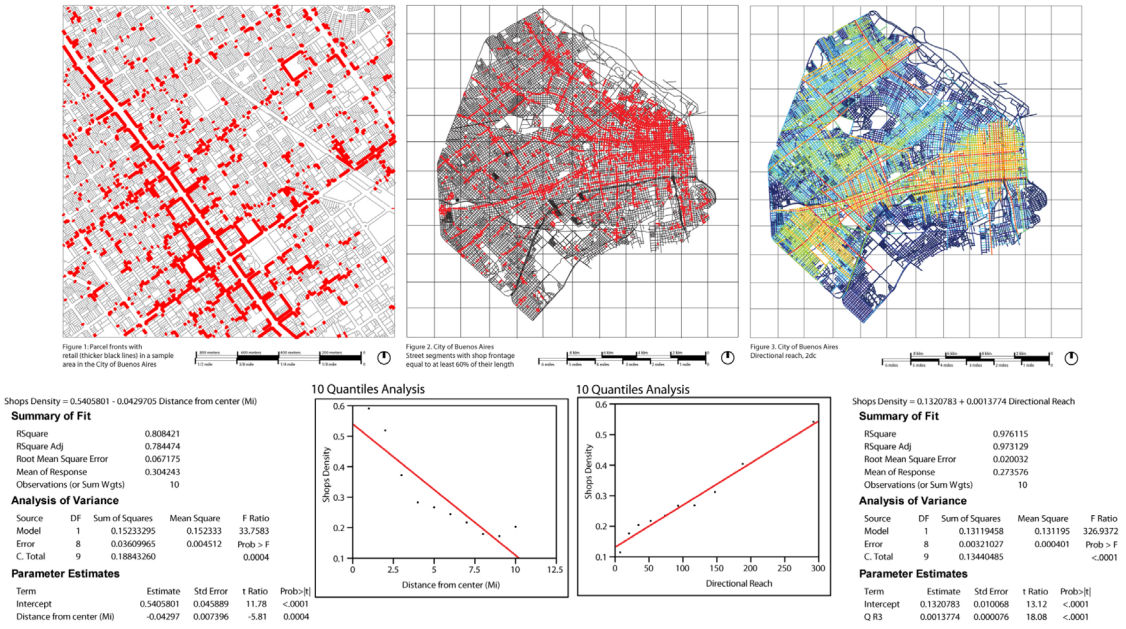



Figure 8: Modelling the effectiveness of certain elements of the city (Courtesy of John Peponis).

## 5.0 FUTURE RESEARCH PLAN

The future of research in the field of planning and urban design requires a directed strategy. In many instances policies are implemented that have little basis in analysis, and minimal correlation to other research that has bearing on planning policies. To implement this, these following aspects should be addressed and executed:

- Create a working organization that brings the various public health and planning organizations together to specifically focus on issues of planning and its relationship to city planning.
- Provide strong protocols for research and analysis in the planning process that are adopted by the profession.
- Revise statutory enabling legislation to require a higher level of objective analysis and research into policy and regulatory adoption processes.
- Support more inter-disciplinary funding for basic research into the issues of city planning and public health.
- Increase support from the Federal Government for basic research in these areas. This will require a concerted effort of those involved to change perceptions about the scientific nature of research in these areas.
- Provide funding for and a legal mechanism to track the efficacy of current and newly adopted regulations. This should be modeled on efficacy tracking protocols in the pharmaceutical industry.

These recommendations will require a cultural shift in the planning and urban design professions that foregrounds basic research as a model for planning. It will require the planning profession to objectively evaluate current planning practices and make modifications to ensure results, and to change when results are other than anticipated. It will also require a shift in the urban design field. Urban designers should allow reliable and objective research, and its results, to play a much larger role in the design process. Other fields that have significant levels of impact on public health already operate in this manner, relying on research to make decisions and implement policy. It is critical that the planning and urban design fields learn from these examples and adapt to these models.

## 6.0 CONCLUSION

This paper examined the current and future trends in research as it pertains to city planning and urban design. It is intended to demonstrate the need to reconsider the methodology used in planning cities, towns and suburbs. There is a significant lack of scientific rigor in the research protocols, and further a lack of research in general, in these arenas. The paper poses questions and identifies potential fundamental problems with the current system, and further identifies the need for support for these efforts.

Regulations drive the pattern of development almost to the exclusion of all other influences. They are legally binding and not easily susceptible to change. However, the method through which current and future regulations, and the environment in which they are created, can change is through the implementation of stringent protocols for basic research. The built environment affects our health, safety and welfare, and the rigor with which we investigate the effects on the public should be commensurate with those efforts.

Many of the questions that need to be addressed such as the relationship between urban form, pedestrian movement, and public health cannot be adequately addressed because we do not have a database of sufficient size and depth on the variables of urban configuration to adequately research the issues. Is there a relationship between energy consumption, public health, and the configuration of urban infrastructure? The same questions remain unanswered for energy consumption, and especially re-use of existing infrastructure in light of land use changes over time. What configurations offer the greatest accommodation of change? The aim of this paper is to propose that these efforts are in the best interests of the national citizenry, and that as we regulate the development of cities, we should align the laws that dictate our actions with scientific evidence.

## ACKNOLWEDGEMENT

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