The Anatomy of Sprawl

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Imagine a physician who has never studied human anatomy. He knows the common medicines all the doctors use, the usual tests everyone orders. Like an actor on ER, he yells "CBC! Chem 7! Bag him!" but he does not know how to interpret the test results and cannot understand why the patient recovers or dies.

We know more about the complex systems of the universe than we do about the formal growth and change of our own cities. Planners and designers offer medicine: "New waterfront! Streetscape! Design guidelines! STAT!" but may have only an informal understanding of how these interventions actually operate.

Unlike human bodies, cities are greatly varied in their physical form. In order to study them comparatively, we have to establish a system of analysis that breaks the physical city down into fundamental elements that can be found in all cities, regardless of their location, history and culture. The study of the physical form of cities is called urban morphology.

This case study examines the anatomy of suburban growth patterns that occurred during the last fifty years. The hypothesis is that suburban growth develops in patterns that are strongly conditioned by the pre-urban fabric, such as farm roads and fields. These patterns can generate extremely scattered and disordered suburban environments, which are difficult to plan or change because they are structurally flawed.

The area selected for study is Hudson, Ohio, which is an independent city–township situated between Cleveland and Akron. Although Hudson has a historic village center that is almost 200 years old, recent growth there has far overshadowed that which occurred during the first 150 years of its existence.

Analysis of Form

What are the important physical components of the city? Urban planners generally treat the city as a functional object, classifying areas and corridors by use. The most common breakdown is land use, which categorizes areas by the activities that take place there. This is complemented by transportation analysis, which describes how people move between different areas.

These tools, while important, are not very informative about the physical character of a place. Areas marked "residential" on a land-use map could consist of bungalows, mansions or apartments. "Commercial" areas could include corner stores, malls or gas stations.

Although there is a relationship between the form of a building and the activities that occur there, the form of something cannot be presumed from its function. One need only consider the many instances in which houses are re-used for offices or restaurants to recognize that the house form is not married to the act of dwelling.

On the urban scale, it is sometimes useful to set aside the consideration of the function of buildings in order to discover more fundamental physical patterns. The physical nature of different residential neighborhoods may be quite distinct, because of differing street patterns, building types and scales. These differences may indicate that the neighborhoods were built at different times or that they house different economic groups.

The basic components analyzed by all urban morphologists are land subdivision (plots or lots), buildings and other structures, and streets. These are combined in various ways to form larger components such as blocks, districts or tissues, and regions.

Urban morphologists usually conceive of the basic spatial and physical systems of the city as a hierarchy defined by physical scale; that is, a building is smaller than a lot, which is smaller than a block, and so on.[1] Especially in the model developed by Caniggia and Maffei, there is the concept of a nested hierarchy: the larger parts are composed of aggregations of the smaller parts.[2] This model places an emphasis on the building type, especially the dwelling unit, as the defining element of urban form. Developed especially to explain traditional European cities, it presupposes a strong relationship between the basic building types and lots, blocks and streets.

In many recently built suburbs, though, the urban form usually depends much less on individual building types because the building-lot-street relationship is much weaker (particularly in commercial areas). Lots may be much larger than the standard types, giving substantial flexibility to the site plan (think of the standard "big-box" type, floating indefinitely in its parking lot). Lots are not necessarily arranged in geometrically defined blocks. Street and block patterns are not related to the building type.

A Spatiotemporal Model of Urban Form

To better understand the relationships among these basic urban components, I have turned to a model that ecological scientists use to study complex ecosystems. In this model, the various components are organized by the rate at which they change:

For example, individual tree leaves respond rapidly to momentary changes in light intensity, CO_2 concentration and the like. The growth of the tree responds more slowly and integrates these short term changes. Change in the species composition of the forest occurs even more slowly, requiring decades or even centuries.[3]

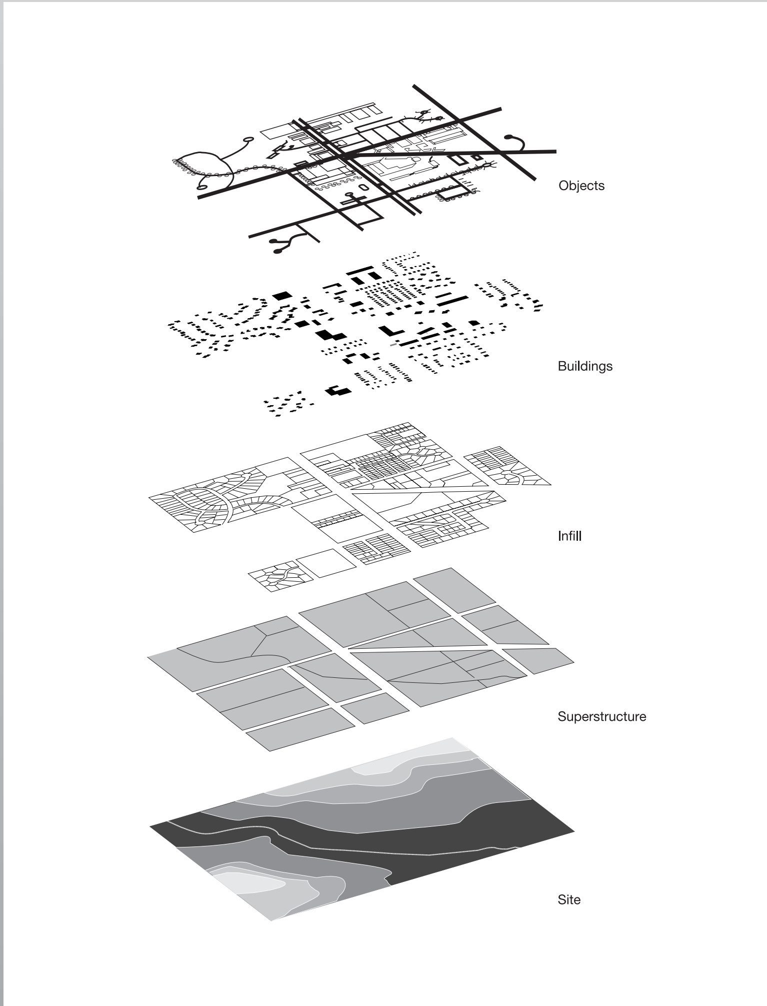
As the city grows and changes, its physical components also grow and change at different rates. The site of the city—its landform and bodies of water—changes on a geologic time scale. Streets and public ways are very persistent; in cities like Florence and Cologne, two-thousand-year-old Roman street plans peek out from behind a curtain of accumulated medieval and Renaissance buildings. By contrast, most buildings last only 100 to 300 years, and during their lifetime are repeatedly added to or altered by their inhabitants and owners. Objects like street trees and road signs normally have a much shorter endurance.

Moreover, each physical component can be comprised of a bundle of characteristics that have different rates of change. When considering streets, for example, the paving may change frequently while the right-of-way (path) may persist for a very long time.

Two broad groups of spatial ordering components—paths and plots—can be thought of as the checkerboard upon which the physical elements of the city are composed and built. The path of the street is the most persistent of human spatial demarcations, and its ability to endure for millennia places it in a different temporal order from the physical structures of the city.

Researchers also recognize the plot as a key spatial element of the city.[4] The plot is the division of the land into discrete units of ownership or control. Although it is not a physical object, it is often marked by more ephemeral objects like fences or walls, just as the path is made obvious by its paving. On any given plot of land, buildings may be adapted or rebuilt over and over while the outlines of the plot endure.

These components—site, paths, plots,



The spatio-temporal hierarchy introduces the element of time into urban morphological analysis.

buildings and objects—not only have different rates of change but also they appear at different moments in the construction of a city. It is useful to divide the paths and plots into two classes, the superstructure, which occurs on a large scale and pre-dates most urban development, and the infill, which represents the filling out of the urbanized growth, usually at a finer-grained scale.

These urban form components, shown as different layers of the same place, are shown in an accompanying illustration. The progression of the layers represents a hierarchy of expected rates of change from the most slow (site) to the most ephemeral (objects). These layers are:

Site. This includes landform, bodies of water and vegetation.

Superstructure. This includes paths and land boundaries that exist prior to urban settlement or are created to substantially restructure an urban settlement (such as urban renewal areas or new highways).

Infill. This includes finer-grained patterns of paths and plots that nestle within the superstructure, and are the basic framework for the construction of all built forms.

Buildings. This includes habitable structures including houses and institutional and commercial buildings; also the enduring and highly visible structures (such as bridges) that inhabit the space of the paths. These structures are built within the areas defined by the plots or paths of the infill and endure for decades or centuries.

Objects. This includes cultivated vegetation (hedges, trees and lawns), man-made objects (fences, towers, signs, monuments, wires), underground infrastructure and surfaces (parking lots, driveways, sidewalk and street paving). These objects are also constructed within the plots and paths of the infill but have a shorter endurance.

It is possible to interpret the layers of the city as a rich collage of interaction between the way the city was and the way it is today. The relatively static layers represent, in a tangible, physical way, the city's history and an intense relationship with the land. More ephemeral layers reflect more immediate activities and ideas.

As in the ecological model, the more slowly a layer changes, the more it conditions changes in layers that change more quickly. For example, the relative permanence of the site, its resistance even to minor changes, makes it an enormous constraint on the location and distribution of paths while providing for a certain continuity in the urban pattern. The superstructure conditions the infill, the infill conditions buildings, and these in turn condition objects. Disturbances or discontinuities in older, more slowly changing layers can be very powerful. For example, dramatically widening an old road can affect every plot, building and object nearby.

Conversely, the faster-changing layers can only affect change in the slower layers through an aggregation of multiple changes that occur to many similar elements. The deterioration of a single building would not affect the layout of a block. However, the deterioration and destruction of multiple commercial buildings in an older downtown may eventually lead to the joining of small lots into larger ones.

The everyday changes of the city occur at the level of objects and buildings. Individuals alter objects every day: switching a sign or putting up a fence. Buildings, too, are relatively easy to change, perhaps by adding a room or filling in a porch. Buildings and objects are routinely destroyed and replaced, often replaced by quite different structures that are bigger, or a different type altogether. During the same time period, however, the spatial matrix of the paths and plots, especially the superstructure, usually remains constant. This layer is resistant to change because it requires tremendous social, economic and political power to change it—and when change occurs, it often signals an important historic event.

Hudson's Urban Morphology

Using this model, the following analysis describes Hudson's site, superstructure, infill patterns and buildings.

Hudson Township was originally part of the Western Reserve of Connecticut. The Western Reserve was divided into townships that are five miles square, or 25 square miles. The owners of Hudson Township surveyed the Township into 100 equal squares measuring 1/2 mile by 1/2 mile. These are called quarter-sections, because four of them make up a square mile (a section). This survey took place in 1799 and within one or two years settlers began to arrive.[5]

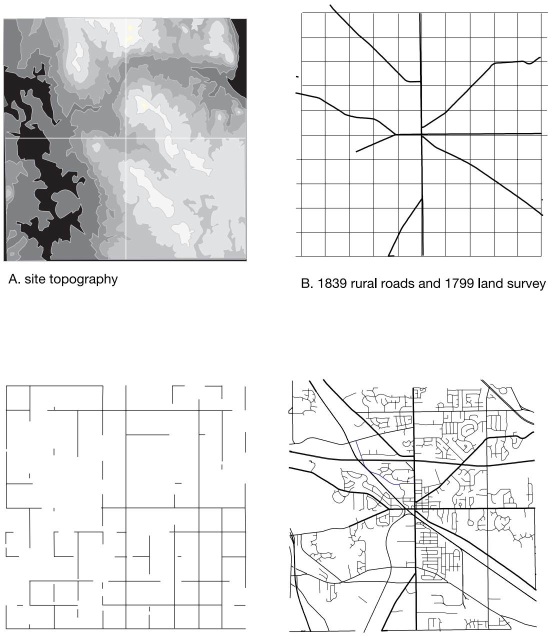
The original plan for the township called for a crossroads *cardo* and *decumanus*, typical in the Western Reserve. But the topography and presence of water was not considered when the township was originally divided; as it turned out, the western third of the township was (and is) covered in swamp, and the plan was not completed. Nevertheless, the earliest roads were in place by 1839, only 20 years after the surveying of the township, and the superstructure was essentially complete by 1901.

In 1950, Hudson was a small village on the verge of rapid expansion. One factor set it apart from its neighbors: an intense awareness of its history and its New England village qualities. At the turn of the century, in an attempt to rescue their little town from stagnation, citizens became obsessed with preservation, at a time when the U.S. preservation movement was in its infancy.

Outside the village boundaries, in the rural parts of the township, preservation was not an issue. Beginning in the 1950s, the township grew in response to the rapid growth of the adjacent urban areas, which were reached easily by the new interstate highway system. Since then, substantial amounts of farmland have been converted to housing subdivisions, and there is now very little undeveloped land.

Top: The superstructure of Hudson, Ohio: site conditions, pre-urban roads, and early land subdivision

Bottom: Hudson's growth

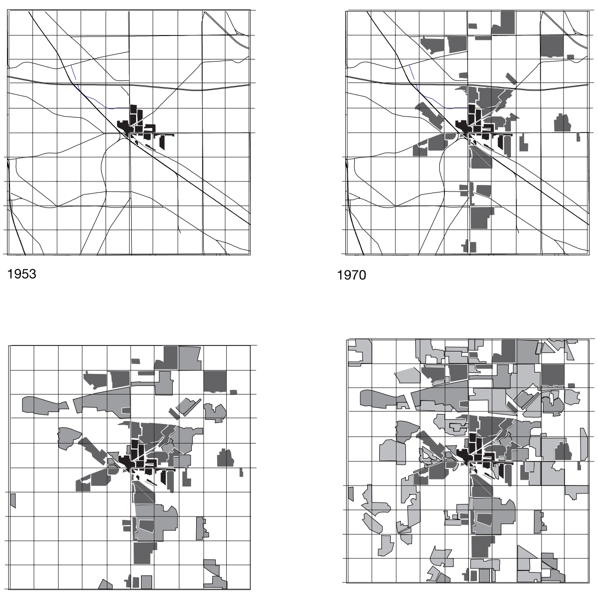


A. site topography

B. 1839 rural roads and 1799 land survey

C. surviving portions of land survey, 1995

D. 1953 street superstructure (dark) with infill streets as of 1995



1953

1970

1984

1995

Although the township's population and land coverage began to grow tremendously, the underlying superstructure did not change. Except for the interstate highway (which has no exit within Hudson), the primary road network did not change at all from 1953 to 1995, and the roads that existed in 1839 have evolved into major roads today. Numerous internal subdivision streets have been added to the street network, but none of them provide connections outside the borders of the subdivisions they serve.

Infill subdivisions seem arbitrarily shaped and capriciously related to the street network. But their boundaries trace the spatial structure described by the original grid lines, pre-urban streets and pre-urban ownership patterns, mostly former wheat fields. In fact, about half of the quarter-section boundaries that existed in 1799 are preserved as paths or as lot lines.

The conclusion is unmistakable: the overall suburban form is directly conditioned by the size and shape of the pre-urban superstructure. No amount of subsequent planning or zoning has had close to the impact on patterns of suburban development that the original land survey and the division of the land into farms and fields have had.

Three Suburban Tissues

Even so, the infill areas in Hudson have not all developed in the same manner, either in regard to street-lot-building relationships or to their ability to adapt over time. Indeed, it is possible to find within Hudson's suburban infill development at least three distinct patterns of block, lot and building aggregations, or what I call urban tissue, which differ in terms of their form and relative endurance.

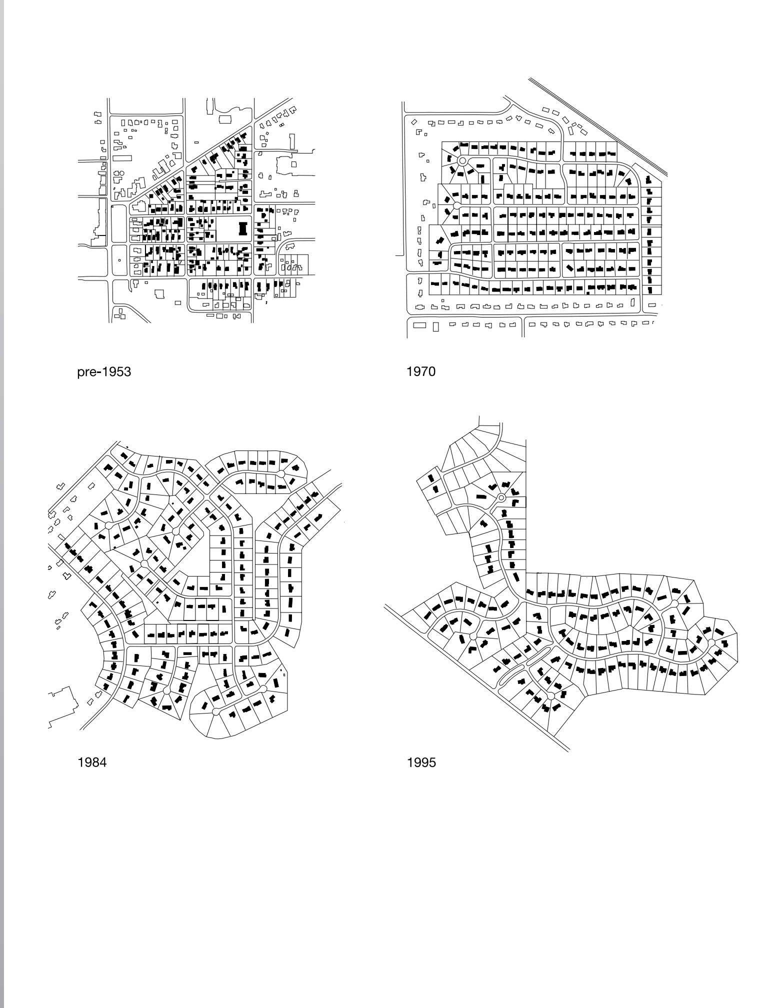
The vast majority of the area has been developed as what I call "static" tissues, or planned subdivisions, in which lots and streets were developed and sold for the construction of single-family homes. A second pattern has been "campus tissues," or tracts of land that are developed with several buildings but not subdivided into distinct properties. Finally, in some places, especially along the pre-urban paths, land development proceeded as "elastic tissues," or a thickening of the existing settlement pattern, evolving from rural to urban almost imperceptibly as farmhouses were joined by other roadside structures.

Static tissues. The most extensive development in Hudson has been in the form of planned subdivisions. These have very distinct path-lot-building type patterns whose correspondence parallels that of tissues in traditional cities. The term "static" refers to the relative stability of these tissues, which have the following characteristics:

• *The lots and paths are planned together, surveyed at about the same time, and are originally built out within a short period (ten to twenty years).*
• *The subdivided lots are small compared to the pre-urban lots they occupy and are roughly consistent in size throughout each area of tissue.*
• *Each lot usually contains a primary structure, of a type that the tissue itself was specifically designed to accommodate or that has evolved from the original type without requiring either an aggregation or further subdivision of the lots.*

Over the course of Hudson's development, static tissues have come in several forms, consistent with the modern subdivision types identified by Michael Southworth and Peter Owens.[6] They evolved from the original small-scale blocks of the Village to the newer, curvilinear subdivisions of the outer town. The most recent of these static tissues cannot be subdivided easily into blocks or other smaller physical units.

Since 1970, for the most part, variations in the arrangement of paths and lots in static tissues have been a matter of style, not a consequence of changes in the typology of the houses intended to occupy the lots (although the most recent houses are larger). This trend reflects a growing self-absorption on the part of house owners, who want



Examples of static tissues in Hudson

to project an image of individuality, which is provided by the larger lots and curved streets that bring each home into separate focus as one travels through the area. In earlier tissues, by contrast, several houses are visible at the same time, creating a clear sense of the common public space of the street.

The "static" label reflects a presumption about the expected long-term endurance of tissues with the above characteristics. The relatively small size of the lots indicates a divided form of ownership and management that resists wholesale change through lot aggregations; these forms also tend to be protected through codes that prevent further subdivision. The rapid build-out of these tissues also tends to favor a consistent application of building types, which in turn tends to stabilize an area: redevelopment that is inconsistent with the existing fabric is discouraged because it can have a chilling effect on the value of nearby properties.

Over a long period of time, of course, this stability can be eroded by the many incremental changes that occur in the buildings or objects. Rooms are added, porches are removed, houses are re-sided, garages are replaced by rec rooms, lawns are paved; eventually, enough small changes accumulate so that the neighborhood's consistency is eroded and it is vulnerable to larger changes.

Elastic tissues. The least stable of the three types of infill is the elastic tissue. In Hudson, elastic tissues developed as a thickening of the rural development patterns, mostly along the pre-urban paths. Their characteristics include the following:

- *The tissue is not pre-planned; it evolves over time and has a rapid change rate compared to static tissues.*
- *Lots tend to be highly varied in size, though they are generally larger than lots in static tissues, and generally contain a single major structure.*
- *Elastic tissues tend to produce very few paths, relying on pre-urban paths for access. Paths within the tissue are built individually rather than as logical networks.*

Areas of elastic tissue are primarily composed of retail, commercial and industrial uses, such as strip shopping centers, fast food emporiums and gas stations (although residential buildings are sometimes mixed in).

Elastic tissues form the breathing spaces of a rapidly developing suburb. They lack the congruence of building types, lots and streets that characterize traditional cities or static tissues. Change in these areas occurs at a faster rate than elsewhere in the city, and is characterized by rapid turnover in businesses; obsolescence, major remodeling and destruction of buildings; and the aggregation and subdivision of land to create new development opportunities. The tremendous pressure to develop and redevelop these areas is not inhibited by consistent fabric or small-scale ownership patterns, as it is in static areas; in effect, the elastic tissues are the only place that significant change can happen in a short period of time.

Campus tissues. Significant areas of the developed suburb are composed of larger tracts of land owned by single entities and developed with multiple buildings. The characteristics of campus tissues are:

- *The pre-urban lot is not subdivided and contains more than one significant structure.*
- *Internal paths are organized as private streets; as such, they do not form boundaries between lots.*

Examples of campus tissues are universities, shopping complexes, airports, apartment complexes, medical centers, corporate campuses, industrial complexes, civic centers, recreation areas and government centers.

It is difficult to generalize about the change characteristics of campus tissues. Most of the time, internal changes take place relative to changing functional requirements, without the usual inhibitions of lot boundaries or surrounding paths or structures. In this regard, campuses are quite flexible. There is also a marked tendency for campuses to expand into other tissues nearby, or (less commonly) to contract if the current use no longer warrants the land area. More recently, campus tissues have been carved from left over space between subdivisions, or established without reference to the surrounding development.

Suburban Tissues and the Spatio-temporal Model

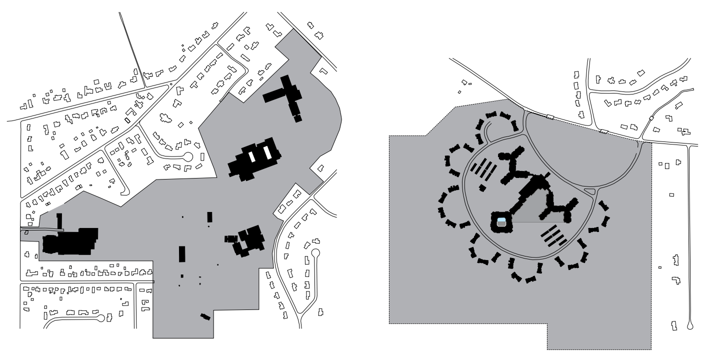
The spatio-temporal model suggests that the longer the natural lifespan of a system, the more influence it has on the slower layers in the hierarchy. Using this model to understand the suburban form of Hudson, we see that the most enduring layers—the site and superstructure—limit the location and expansion of the infill, while the infill may have little or no effect on the superstructure.

The static tissues and campus tissues respond neatly to this model, fitting comfortably within the superstructure. In static tissues, the lots and paths form a semi-rigid matrix within which certain changes can easily take place and others are constrained; breaking the bounds of this matrix is difficult and unusual. Campus tissues are likewise structured by paths and plots, but in a less rigid manner that allows a far greater range of changes to occur.

Elastic tissues, on the other hand, cling tightly to the superstructure. They do not generate a structure of infill streets; thus, there is no semi-rigid matrix that limits further change. In most instances, building types are not particularly conditioned by the lots, since the lots are not planned to accommodate a specific building type. Instead, lots have been aggregated from smaller lots and any particular building may be planned to maximize the use of a randomly sized lot. Another common change is to subdivide a large lot along its road frontage, leaving a larger parcel in the back with road access, and smaller lots in the front. All this leads to a tissue where the buildings are extremely varied in size, type and orientation.

A. roadside strip

B. village center

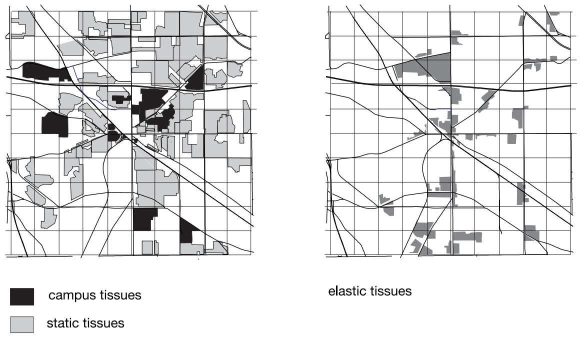


A. school complex

B. apartment compex

Examples of elastic tissues in Hudson

Examples of campus tissues in Hudson



Distribution of static, elastic and campus tissues

Urban Planning and the Spatiotemporal Model

Much planning for suburban areas is done with little understanding of the spatio-temporal processes that form these places. The model of physical growth presented here suggests that different planning and design interventions are appropriate for different layers of urban form and different kinds of development tissue.

In planning for undeveloped territory, for example, it would be wise to examine the physical arrangement of existing property boundaries and rural roads, as these are likely to be the checkerboard on which the real estate game is played. Once development begins, the road structure is more or less fixed, whether it is adequate or not. Intervention at the earliest stages of development of an American suburban region could most productively take the form of rethinking rural networks for new suburban growth.

This is especially important in the locations where elastic tissues are expected to grow, which are generally predictable. Areas of elastic tissue areas could become denser, more limited in their extent, easier to control and more attractive if an orderly pattern of streets and lots were established in advance, much as it is for housing subdivisions. The tissue pattern itself would help condition the form of the development, while a larger number of streets would improve access and relieve traffic congestion, thereby encouraging business activity.

Planning for the evolution of already developed suburban areas is extremely difficult because they are highly constrained by the superstructure and, in some cases, the infill layers. Widespread densificiation of sprawling static tissues is unlikely; if anything, planning tools are configured to promote stability, not change, in these places. Rapidly changing elastic tissue areas are structurally disordered at the level of lots and paths, and deeply conditioned by their relationship to the superstructure, but most cities focus on building design, signage and landscape controls rather than addressing these more fundamental structural issues. Campus tissues, which can evolve into large, inaccessible islands, are largely left unregulated.

The regulatory techniques that suburbs commonly rely upon are either insufficient for controlling suburban form or poorly used. Most significantly, no regulations or local agency control the formation, continuity or distribution of the superstructure. The sprawling infill layer, conditioned by low-density zoning and subdivision codes, is largely designed by private land developers, who pay little regard to any relationships outside their subdivision boundaries.

Suburban form is most strongly related to patterns and shapes that do not normally come to the attention of planners. Modern regulatory processes do not address some of the most influential and long-lasting layers of the city, tending instead to intervene in transitory conditions such as specific land use, building details, and built landscape. Such transitory conditions should be lightly regulated to provide more leeway for growth and change, while the urban framework should be more controlled than current practice allows.

Notes

1. Karl S. Kropf, *An Enquiry into the Definition of Built Form in Urban Morphology* (University of Birmingham Ph.D. Thesis, 1993); Anne Vernez-Moudon, *Built for Change* (Cambridge, Mass.: MIT Press, 1986).
2. Gianfranco Cannigia and Gian Luigi Maffei, *Architectural Composition and Building Typology: Interpreting Basic Building* (Florence: Alinea, 2001)
3. R. V. O'Neill, D. L. Angelis, J. B. Waide and T. F. H. Allen, *A Hierarchical Concept of Ecosystems* (Princeton, N.J.: Princeton University Press, 1986), 76.
4. Many researchers have commented on this, but the original, classic study is M. R. G. Conzen, Alnick, *Northumberland: a Study in Town-Plan Analysis* (London: Institute of British Geographers Publication 27, George Philip, 1960).
5. Rebecca Rogers, *Hudson, Ohio: An Architectural and Historical Study* (Hudson, Ohio: Village of Hudson, 1973), 18-20.
6. Michael Southworth and Peter M. Owens, "The Evolving Metropolis: Studies of Community, Neighborhood and Street Form at the Urban Edge," *Journal of the American Planning Association* 59:3 (Summer 1993), 271-287.

Acknowledgment

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