Generic tissues in the US: developing a systematic classification based on endurance.

Professor Brenda Case Scheer[1]

[1] Emeritus Professor, College of Architecture and Planning, University of Utah, United States.

Abstract

This paper develops a tissue classification method that is applied to modern city form. The identification and classification of urban tissues in the United States, even if not definitive, is a useful exercise to undertake. It has potentially many applications, so that a particular tissue type or a variety of types, can be correlated with other actions in research and practice. For example, tissues types in a specific place could be correlated with air pollution, with crime, and with water usage. Providing a framework for identifying tissues, and inviting further expansion of the data set, is the ultimate goal of this paper. The author has already analysed several pieces of this puzzle through research and documentation on the morphology of suburbs, of gridded city centres, of edge cities, of historic fabrics, and of suburban commercial territories at different periods in US history. This paper will create a visual matrix as a starting point for a "tissue" catalogue. The matrix is organized by endurance of tissues (origin of the initial foundation fabric), as well as the concepts of "static, elastic, and campus" tissue.

Keyword*: urban tissues, endurance, campus, elastic, static*

Introduction

Developing plans into the future requires an understanding of not only what is present but also the past development of an area and also the potential change in the future. In this paper we will use the identification of American tissue patterns as a case study to address theoretically how tissue patterns should be identified, and to help specify the indexes that quantify the distinctions between one pattern and another. The primary lens through which the tissue types will be distinguished is the urban morphological concept of diachronic **change.**

Setting out to determine the *useful* categories of tissue types, this study uses a framework that prioritizes the relative endurance of tissues in the urban landscape. Based on the framework in Scheer's (2001) study, this tissue categorization amplifies and clarifies the three general tissue types of *static, elastic,* and *campus* identified there.

Epistemologically, urban morphology's greatest contributions to urban knowledge and urban planning are to 1) identify various urban elements and their patterns, 2) develop indexes that point to the quantification of those forms and patterns, for example indexes of connectivity, 3) to compare patterns and indexes to demonstrate how they change over time (diachronic) and 4) to identify how patterns and indexes compare across space (synchronic).

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The field of urban morphology has struggled to reconcile various methods and theories, has struggled to identify even the elements to study, (although it is narrowing down), and has struggled to develop indexes and patterns that can be used in multiple cultures comparatively both synchronically and diachronically. Fleishmann, et al, (2020) in a meta-study of quantitative-based urban morphology studies found 72 studies, using 361 unique indexes. The concept of an *index* is very useful, as it proposes that certain elements (a plot, say) are subjected to an operation that measures dimensions, its properties (like shape) and its relationship to other elements of its kind or to elements of another level or resolution.

Among the findings of this study, which looked only at papers that used numerical measurements (vs human pattern recognition capability) only 5% that were comparative were oriented to diachronic indexes. Most studies look at urban areas in a particular point of time and compare that form to other areas. (Fleishmann, et.al. 2020, p. 4)

And yet a diachronic morphological analysis, one that acknowledges or measures change over time, offers a set of information that is that is crucial for planning and urban design practice.

Background

Urban morphology is the study of urban form, isolated from other conditions that are critical forces in urban growth and development, particularly social and economic forces. This allows the isolated elements of form (physical objects, plots and street paths, and land) to be related systematically to those conditions. Urban morphology uses comparisons (diachronic and synchronic) to identify patterns or indexes as an essential methodology (Scheer, 2016).

One pattern that is consistently looked at is the *urban tissue* (Caniggia and Maffei, 2001), sometimes also identified as a *plan unit* (Whitehand, 2009). The urban tissue is a combination of several elements of urban structure to form a consistent and recognizable pattern. Understanding the location, character and extent of these patterns is one of the first analytical exercises that urban designers should do to begin the process of understanding a neighbourhood or town. The tissue is also a medium scale or *resolution* in comparison to other urban patterns, which range from the materials of a building to the region. (Kropf, 2017).

A common example of a tissue in the US is the ubiquitous curving suburb, which has streets, building plots (the American term is *lots*), and houses that fit together to form a recognizable district distinguished from other nearby districts. Other urban tissues are not so readily identifiable.

One way of classification of tissue, done by Wheeler (2015), looks at a variety of factors, but not systematically, relying mostly on the ability to distinguish different tissues by the way they appear on aerial photos (scale and arrangement), their location in the city, and an estimation of land use. This is a traditional methodology, and it has the advantage of being reproducible in practice (if not systematically applicable) if a bit of a black box in terms methodologically. In his extensive study, Wheeler identifies 27 unique tissue types in a worldwide survey of 24 cities.

Many morphologists today, taking advantage of computational advances, use algorithms to develop classifications. For example, Bobkova, et.al (2019) used an unsupervised, iterative K-cluster analysis of five European cities to determine patterns of plots. The team succeeded in identifying seven different tissue types based primarily on the plot and indexes calculated from the geometry and configuration of the *plot* (plot density, plot shape, plot frontage, and plot accessibility to other plots). Although the analysis did not examine the element of *buildings*, it nevertheless was able to identify and quantify specific, distinct and meaningful tissue patterns in the cities studied. (Fig 2 is from Bobkova, et.al. 2019.) This method has the advantage of being able to identify patterns that may not be visibly apparent, although in the case of this study, there are no surprises. The seven tissues that emerged from the analysis are very similar to ones that emerge in traditional studies, which is somewhat reassuring.

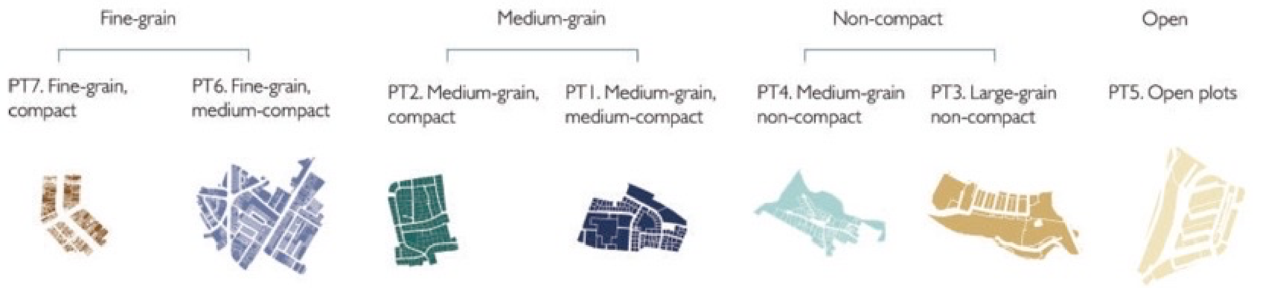

Figure 2: A quantitative profile of seven types of plot tissues that emerged from a cluster analysis by Bobkova, et.al. 2019

Both of these methods, the traditional and the algorithmic, are primarily used to identify patterns across space in a limited time period. In this paper we are looking for classifications of tissue types that, in some way, are cognizant of their **durability**.

Methodology

The goal of this paper is to identify and name a common set of generic tissue types that can be used by planners, engineers, designers and researchers, especially when projecting the future of a place. The criteria for the categories include:

- Tissues must be inclusive of nearly every urban form found in the US, including historic forms. To test this, the definitions were applied to random 500 -meter diameter aerial views of 10 cities and towns, and to five examples of historic development, and adjusted accordingly.

- Tissue types and patches, which are often identified with human pattern recognition, should also emerge from a series of calculations, including dimensions, indexes, and age/endurance.
- Tissue types are defined physically, not through a combination of land use and form. (Although some tissue types are very closely associated with a particular use).
- Tissue types are categorized by their *endurance*, that is, how long can we expect this form to last in the city – is it easy or difficult to change? This measure ensures that planners can work closely with those places that have the most potential to change relatively quickly.

The configuration of the plot series is the first classification. We know that plots are much more durable structure than buildings or other smaller built forms. By starting with plot series, we can separate out three distinct categories with little difficulty. These are plots that are in a regular series, where the plots are similar sizes (*static*), plots that are heterogenous compared to others surrounding them (*elastic*) or plots that are far larger than others in the urban fabric (*campus*).

Previous theory has postulated that these three distinguishing tissue types that have wide variability in their endurance. (Scheer, 2001). *Static* tissues are durable because the configuration is patterned similarly with every element. We know that buildings are more ephemeral than other forms, and that they change frequently, but the form of the plot and the streets which area built to "match" the scale and regularity of the building make it difficult (but not impossible) to replace one building with one of a greatly different shape or size. In the United States, strong local controls reinforce this quite natural endurance character and additionally, control the placement of the building on the lot with specifications of setbacks (required yards). The name "static tissue" is meant to invoke this resistance to change after the initial creation of the tissue. When paths, plots and built form are not congruent, there is not a natural resistance to change at the plot level.

In *elastic* tissue, the plots appear in an irregular pattern, with lots and buildings highly varied in size and frontage. This tissue is usually the result of an accumulated, piecemeal, or accreted form of urban development or one that has degenerated from a static tissue over time. The basic elements are not planned with any congruency, and may have been developed before urban settlement, for example, the streets and plots may be unchanged from farm roads and field boundaries.

Elastic tissues undergo change at the building level with some frequency, when, for example, a small McDonalds is replaced by a new larger one. Our research has also found that elastic tissues are more likely to be aggregated to create a single large site for redevelopment, especially in a growing city.

The *campus* tissue is the final category. This is simply a very large plot with a single dominant building (e.g., airport, mall), many buildings (e.g., college campus, amusement park) or no buildings at all (e.g., parks, gravel pits, railyards, junkyards). These areas can undergo rapid change or can be quite stable. Very large buildings are often very specialized and therefor can become obsolete and need replacement, despite their size. Very large buildings and campus buildings in general can also be quite resistant to change, a situation that includes monuments.

The categorization of tissues has two steps, working through two unique elements of urban form: the plots and the buildings. Methodologically, the first step is to identify an index of **heterogeneity** of plot size and frontage, which would include a comparison or clustering of the size of plots, their frontage dimensions, and a factor of plot accessibility (Bobkova, et. al, 2019). The data set could then be divided into clusters with highly similar, highly dissimilar and significantly larger lots.

Once the basic categorization is made, the second cut identifies the patterns of buildings and their associated open space configurations within the plot itself. Unique classifications are: 1) Primary single building on the plot, 2) Multiple similar/repetitious buildings on one plot, 3) Multiple dissimilar buildings on the plot, and 4) No significant buildings on the plot. Thus, the "campus geometric tissue" for example is characterized as a large single lot (campus) with multiple repetitious buildings. Again, the index here is very straightforward. (Table 1.)

In some cases where the tissue identification was ambiguous, the plot map (cadastre or assessor map) was consulted. Thus, the method used was a traditional one of identifying the unique tissues through visual, non-numerical, pattern recognition, means. Although in this study, we used the traditional method of human pattern recognition, numerical indexes to distinguish and count these tissues are well within the capability of modern computation.

BUILDING PATTERN on each plot / **PLOT PATTERN relative to surrounding plots**	**Single building**	**Open space, not vacant**	**Multiple Similar size buildings**	**Multiple, accreted buildings**
STATIC: Homogeneous, multiple plots	S			
CAMPUS: Single large plot	M	R	G	A
ELASTIC: Heterogeneous plots				

Table 1. Exploring the potential of tissue classification using two factors: building patterns and plot patterns. Dark circles correspond to the seven tissue classifications identified, but this table suggests other possibilities. Key: S: static; M: major building, R: revered, A: accreted.

Results and Discussions

The following descriptions and the chart (Figure 3) describe the generic tissues. In all classifications, “vacant” lots may also occur.

Static tissue

1. *Static*. Within a range, of geometric consistency geometrically ordered, similar size plots with similar arrangement of buildings on them. Paths are primarily arranged to provide access to the plots. Usually have high density of paths, and high connectivity. Plots are similar size, constrained by the *plot series* configuration. Building types (one or two per plot) are similar if not identical types. Building type variation may signal a new tissue. Tissues may include open spaces and public buildings, integrated within the distinct tissue. Many varieties, many scales, many densities/intensities. Usually residential, but can also be mixed use.

Campus tissue, in order of their expected endurance from long to short:

3a. Campus geometric. One lot with multiple ordered, similar, repetitious buildings. Paths and open space, and parking are internal to the plot, all complementary to the buildings. Usually multi-family residential, can be high rise. A variation is commercial: office park, warehouses, storage units.

3b. *Campus revered*. Parks, cemeteries, preserves. Often very stable, independent (not integrated in a tissue patch).

3c. *Campus major building.* One very large plot with one large building and associated open space (including parking). Often a large investment, but specialized, so likelihood of obsolescence is greater, unless it is a monument. Examples: arena, convention centre, isolated public building, church, stadium, airport, shopping mall.

3c. Campus Accreted. One large plot developed in planned or accreted fashion: university, hospital, corporate campus, country clubs, high schools. Sports complexes. Often with large amount of green space and parking relative to buildings (in US). Internal change is highly likely in response to changing conditions. Somewhat common to expand boundaries. Less common to contract boundaries. Can be completely abandoned over time, causing a retarding condition in the urban fabric.

Figure 3. *The seven generic tissue patterns with estimates of their relative endurance (resistance to change over long periods of time.*

Elastic tissue

3a. *Elastic degenerate*: original geometrically ordered plot series, now with dissimilar arrangement of buildings, subdivision or joining of plots, resulting from redevelopment over a long time. Plot series is still constrained by surrounding paths/streets. These can have emergent (new) patterns, again due to generative conditions. They may also seem organic after a number of cycles of development. Over a longer period of time, however, especially in the context of limited external controls, the static tissue can break down in specific ways. In the US, this is primarily the combination of one or more plots to accommodate larger, more contemporary building types. But this degeneration of tissue has and can happen anywhere. One of the fascinations that we have in urban morphology is to examine historical records to find the "evolution" of form over time and this gradual deterioration of static tissue is a very common process. In these tissues the plot series (a block or a block face) may still be preserved, however, resulting in a different kind of order that may be durable. This also happens when the initial intentional built form is quickly obsolete and cannot be reconciled with the plots and paths, as happened frequently in the US in initial downtown grids.

3b. *Elastic accreted*. Plot series with great heterogeneity of size and shape, and resulting heterogeneity of buildings. Low average number of routes/paths to constrain change. A kind of emergent, loose pattern. Paths not originally developed to serve the plots, but to serve connections between attractive poles. Emergent order can develop, based on written and unwritten generative conditions. Depending on age, a very mature pattern (built out) may be termed organic, with less elasticity because it is tightly and densely developed. *Wheeler: commercial strip, country roads, incremental and mixed, organic, heavy industry.*

After these two classification cuts (plot and buildings) other attributes can be applied if greater sensitivity to tissue uniqueness is required. Scale and grain are two of the most important distinguishing features, especially for static tissues, as is the plot coverage. Three dimensional aspects may be important, as well.

When these tissues are subtracted from the urban map, what is left are the pathways, which, in a sense, may constitute their own tissue type. This is particularly important for paths that do not have a relationship with the surrounding tissues, such as limited access highways and rail lines. Other paths should probably be included within the boundaries of the tissue itself.

Conclusions

This paper has identified seven unique, generic US tissue types, using the theoretic construct of change over time. Several important caveats and areas for further research present themselves.

First, this study specifically examined only US examples, which exclude two important tissue formations which are inherently more complex than this analysis may be able to define. The first is informal settlements, which are extremely common in cities of the global south, but unknown in the US. These have very interesting, usually accreted forms that sometimes show clear signs of emergent order (Drummond, 1981). The second is very old and evolved historic urban form, where settlement form may be a complex combination of accreted or degenerate processes over several hundred years of settlement. The Italian School excels in this arena. In comparison, most US tissues can be said to be immature examples of urban form, with most barely registering more than one or two cycles of evolutionary change.

Third, this study also excludes very complex urban forms with multiple public and private vertical layers and ambiguous plots. These are becoming more important and are arising ubiquitously in China and other modern, dense cities.

The tissue types have been identified using traditional observations from maps, including examining changes over time. However, we recognize the ability and desire to use the inherent data provided by the geometry of city elements to more formally identify tissues. In any analysis, however, some notion of the theoretical basis for selecting certain element and characteristics of those elements is required. Thus, although this analysis uses a traditional method, it would be entirely possible to sort (cluster) the urban environment based on these criteria, which is why they were identified with possible indexes. This step is beyond the scope of this paper. It is also, at this point, beyond the capabilities of most planning agencies in the US.

Another level of analysis suggested by this study is characterized by the concept of a *patch*, a term from landscape ecology, which is a "relatively homogeneous area that differs from its surroundings." Tissues do have extent, therefore they also have size and area, so one can have large patches of a single tissue or small patches. Looking at the extent of these patches is an area for future research.

Urban morphological analysis is usually dependent on the nature of the inquiry itself, there being little or no standard set of maps, scales, or classifications. In that light, this study hopes to provide one set of standards for analysis in the US context. The author invites comments and especially suggestions or modification to this classification and would like to invite readers and practitioners to freely apply it.

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Brenda Case Scheer, University of Utah, 776 N Eastcapitol, Salt Lake City, UT, 84103, Scheer@arch.utah.edu