

THE “NATURAL” TOWN
METHODOLOGY HYPOTHESIS FOR DEFRAGMENTATION OF THE URBAN ORGANISM

Giulio Tamburini

DAU-Università dell’Aquila - Monteluco di Roio – 67100 L’AQUILA
Tel. +39- 0862- 434134 - Fax +39-0862 -434143 – E-mail: tamburini@dau.ing.univaq.it

Pierluigi Properzi

DAU-Università dell’Aquila - Monteluco di Roio – 67100 L’AQUILA
Tel. +39- 0862- 434111 - Fax +39-0862 -434143 – E-mail: properzi@tin.it

Bernardino Romano

DAU-Università dell’Aquila - Monteluco di Roio – 67100 L’AQUILA
Tel. +39- 0862- 434113 - Fax +39-0862 -434143 – E-mail: romano@dau.ing.univaq.it

Donato Di Ludovico

DAU-Università dell’Aquila - Monteluco di Roio – 67100 L’AQUILA
Tel. +39- 0862- 434113 - Fax +39-0862 -434143 – E-mail: ddilud@tin.it

The urban linear areas represent the main environmental barriers in the territory, with respect to potential biological movements.

The ecological connectivity isn’t a traditional argument of the urban planning, but the planning at municipal level has several possibilities to insert this theme in its program.

For example, the elements that can be considered in the formal study of the plan are the urban and infrastructural fragmentation indicators.

In general the recover or the mitigation of the environmental fragmentation due to urbanisation is very complex, because it involves private interests and areas with high density of builds.

For this motivation the urban plans have to avoid the provisions of urban spaces with linear geometric forms, along the main roads, that have a high occlusion levels, in particular when this situation is present in the valley bottom.

It seems interesting the evaluation of the environmental fragmentation indicators that can be associated to the previsional aspects of the plans.

The dimension and the geometric forms of the spaces for new urban areas, the build typologies, the collocation of the infrastructural networks and their spatial relationships, the kinds of present use of territory that the plan indicate as sites of new urbanisation, are all parametric elements that can give the measure of the “fragmentation effects” of the plan.

It is clear that there is a possibility to find a relationship among the fragmentation characteristics of the plan defined through geometries, topologies and typologies of the involved areas, and the groups of species that could utilize the dispersion lines existent on the territory before the plan action.

Key words: Environmental continuity, urban fragmentation, environmental planning

Introduction and points of reference

Urban planning has started considering environmental compactness in the ecological reorganisation of the territory as well as the need for continuity between semi-natural and natural areas. The latter allows for the normal phenomena of ecological dynamics which are at the base of biodiversity.

The increasing number of opportunities for exchange between the representatives of the varying sectors of planning and ecology has highlighted a lack of biological data on the territory which could shed light on the prevailing natural organisation of the environment.

Although ecological data is available for limited areas and is often quite detailed, there is very little data on vast areas, that is to say on inter-regional and national levels.

Experience in this field is undoubtedly further ahead in Europe; an in-depth bio geographical study in Holland for example has allowed, over the last ten years, the implementation of extremely sophisticated environmental repair projects managed by public bodies created explicitly for this purpose (Harms, 1998).

Projects on a national level have been implemented by local administrations such as the provinces of Milan, Pavia (Malcevski, 1999), Rome (Battisti, 1999) and Vercelli (Conte et alii, 1999). They are however, on a limited scale and concern restricted, residual, environmental structures.

Projects of a territorial dimension worthy of note include that of Siena's which proposes analysis and forecast phases based on the concepts of ecosystem networks (Siena's provincial administration, 1997). Umbria's territorial plan takes into consideration environmental insularisation phenomena and includes a map (no.6) entitled '*Ecological islands, critical adjacent zones between islands, zones of ecological discontinuity, zones of particular faunistic interest*'. The territorial landscape plan for the Valle d'Aosta Region, adopted by the Regional Council in November 1996, makes numerous references to fragmentation and the consequent fragility of ecosystems and areas are described using homogenous structural units, functional ecosystemic units and macro-ecosystems (Castelnuovi, 1997).

A growing technical and political sensitivity to environmental continuity has resulted in changes in regional legislation. The Abruzzo Region offers an important example: in the first Regional Reference Framework (RRF) adopted by the Regional Council in November 1995, no reference was made to ecological connectivity apart from a green network between natural basins in a chapter concerning the area's tourist potential. However following the issuing of 'Norms for safeguarding the contiguous areas of Regional and National Parks' in which a

matrix for environmental repair between the region's protected areas using the contiguous areas introduced by law 394/91 was geographically produced in 1998, a new RRF is being prepared which acknowledges the need for ecological corridors whilst also highlighting the lack of norms to cover this area.

Other regional urban legislation that is sensitive to the question of environmental continuity include that of Molise, Basilicata, Emilia Romagna and the Abruzzo although the latter's legislation is still in draft form. As potential lines of ecological connectivity can only be visualized on a large territorial scale, inter-regional and regional planning have a far more important role in controlling environmental fragmentation than planning on a local level.

Hence the concept of environmental continuity has become an important preliminary reference point for planning sensitive to the ecological potential of the environment both on a widespread (national and interregional) and local (inter-city and city) level.

Environmental continuity on a territorial scale.

Biopermeability

The concept of biopermeability (Romano, 1996, 2000) has been defined through various national research programmes as the geography of non-urbanised spaces or spaces that are not used for intensive settlements or farming.

There are limits to the application of the concept of biopermeability: it is useful in representing the natural physiognomy of medium to large dimensions but it has no meaning in a local context. On a local level, data concerning relationships deriving from analyses of fauna, vegetation, local morphology, climatology and landscape ecology have an essential role in the description of the ecological functionality of the territory.

The configuration of biopermeability cannot offer an efficient operative system when the area under study is an ecosystem of limited dimensions. Hence a study of the conditions of territorial biopermeability and the consequent conditions of environmental continuity only has significance in applications that require a reading to the scale of 1:100,000 and less. This means that the concept of biopermeability can be used to assist forms of planning and correlated decisions on a regional and provincial scale.

Territorial requisites must also be taken into account when studying the applicability of the concept of biopermeability. In fact its application, studied in the Appennines, is relevant to those environmental contexts of significant spacial variability in which the ecomosaic is very distinct (Forman, 1995).

Other studies have highlighted the presence of conditions of biopermeability that can be classified in at least two categories: an isotropic biopermeability that characterizes the environment of 'internal' areas made up of vast natural and semi-natural spaces with areal dimensions; and a directional biopermeability, in some cases canalised, typical of hilly areas in which connectivity can be achieved using river environments and abandoned farmland.

The varying typologies of environmental connection as well as the barriers (urbanisation and infrastructures) present in any given territory represent an interesting field of study.

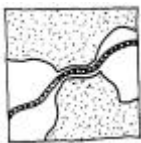
The classification adopted by an Abruzzese study for a national programme of monitoring of ANPA ecological networks (L'Aquila University 1999) is as follows:



A. Vast areas of environmental continuity characterized by a high degree of naturality and no significant infrastructural barriers.



B. Vast areas of environmental continuity made up of semi-natural territory with no significant infrastructural barriers, disturbances arising from farming and rural activities.



C. Vast areas of environmental continuity characterized by a high degree of naturality with infrastructural barriers of medium entity and disturbance from traffic..



D. Vast areas of environmental continuity made up of semi-natural territory, infrastructural barriers of medium entity and disturbance arising from traffic and farming and rural activities.



E. Linear tracts of environmental continuity (usually waterways) with disturbances arising from pollution, adjacent human activity and barriers of medium entity (longitudinal viability along river belts, structures blocking water flow)



F. Vast areas of environmental continuity characterized by a high degree of naturality with major infrastructural and urban barriers .



G. Vast areas of environmental continuity made up of semi-natural territory with major infrastructural and urban barriers.

Indicators of territorial environmental fragmentation

A understanding of how the presence of barriers interrupts the natural environmental continuity is fundamental for orientating planning instruments towards the operative methodologies and criteria aimed at solving or mitigating the disruption of the eco-mosaic active in Italy and Europe.

Research into the physical characterization of fragmentation has made use of indicators calibrated on the typology and dimension of barriers caused by infrastructures and urban settlements with a prevalently linear development (Romano 2000).

These indicators can be used to provide information concerning the state of fragmentation and to establish policies on an interregional level. The indicator for fragmentation caused by infrastructures is defined by the kilometres of road with respect to the territorial unit considered (protected areas, administrative environment, landscape unit). The index of fragmentation caused by linear urbanisation, on the other hand, is proportional to the maximum length of the settlement under study and the theoretical radius of its total surface which is taken to be circular.

Environmental fragmentation by infrastructures (IFI)

The IFI (Infrastructural Fragmentation Index), as the name itself indicates, concerns the fragmentation generated by roadways and is evaluated in relation to a unit of surveyed territory. The calculation of the IFI is based on the following elements:

P_i = the weights assigned to each category of infrastructure

A_n = surface calculated per n environmental units

$L_{k,n}$ = length k of infrastructures within the environmental unit n

$$LP_{k,n} = L_{k,n} \cdot P_i$$

$$SLP = \sum_{k=1}^j LP_{k,n}$$

$$IFIterr = \frac{SLP}{A_n}$$

The surface A_n corresponds to that of the Environmental Unit in which infrastructures are present.

Thus the value of the index of fragmentation due to infrastructures is obtained for each environmental unit. By dividing the IFI values into ranges it is possible to classify environmental units and obtain a configuration that allows us to identify which units are most fragmented by the presence of infrastructures.

Note that it is possible to assign varying weights to roadways allowing structures such as tunnels or rural roadways to be classified as completely permeable.

Environmental fragmentation by linear urbanisation

Fragmentation caused by concentrated or scattered linear urbanisation can be evaluated using the UFI (Urban Fragmentation Index).

In contrast to the IFI, the local UFI has to be calculated using the area inhabited and the territorial UFI using the environmental unit.

If two different urban area conformations, the first linear and the other concentrated are considered, approximating the two polygons with lines, then $L > L'$. Assuming that the surface S of the inhabited area is equal to the circumference and given that, minus factor p , S can be expressed as:

$$S = R^2 \cdot \pi \quad R = \sqrt{S / \pi}$$

the local UFI will be equal to:

$$\text{case 1} \rightarrow UFI_{loc} = L \cdot R$$

$$\text{case 2} \rightarrow UFI'_{loc} = L' \cdot R$$

$$\text{then: } UFI_{loc} > UFI'_{loc}$$

Consequently, linear urban structures cause more fragmentation than concentrated ones.

The UFI indices, calculated for each urban agglomerate, are then summarized in a further index on environmental units, the index of fragmentation caused by territorial urbanisation which shows how the local UFI affects the territory to which it refers.

The Index of Fragmentation due to territorial Urbanisation can be defined:

$$UFI_{terr(i)} = \frac{\sum_{j=1}^n UFI_{loc(j)}}{S_i}$$

where: i = environmental unit i -th

j = approximate line j -th

n = total number of lines within the environmental unit i -th

In practice, the terrUFI is obtained by first summing the values of the locUFIs for the agglomerates within the environmental unit and then normalising this value for the area of the unit itself. As with the IFI, each unit is associated to an index of fragmentation caused by urbanisation, consequently it is possible to classify them by dividing the indices into ranges.

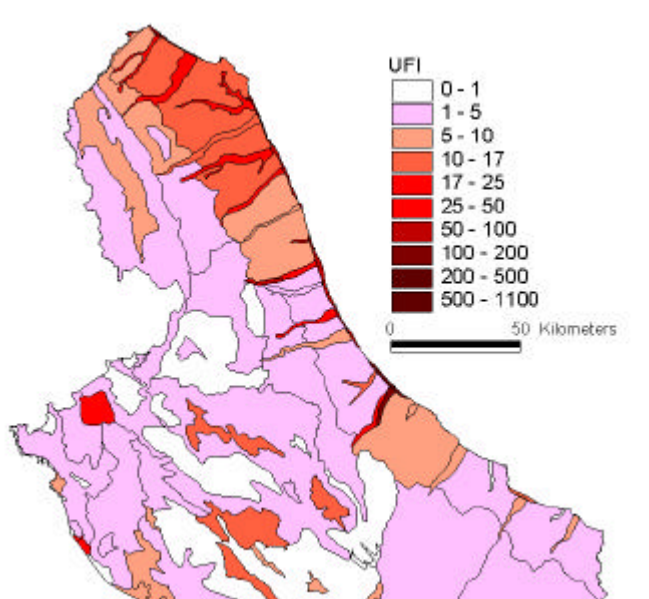


Figure 1 An example of territorial UFI distribution, calculated in order to main Environmental Units (lito-morpho – vegetational) of the Central Italy (Planeco, 1999).

The definition of the indices outlined above shows how they are valid on a territorial scale but how local features of fragmentation escape identification. Further indicators such as units of analysis, compactness, scattering of settlements, heterogeneity of the eco-mosaic can contribute to a better interpretation of real conditions.

The study of continuity and fragmentation of vast areas is progressing with the aims of graduating biopermeability and evaluating the tendencies of fragmentation itself. However to achieve improvements on an ecological level and in terms of the environment action needs to be taken on a local level.

Environmental continuity on a local level

One of the biggest problems in this field is that local council planning does not allow for the strategic development of environmental continuity. This brings up again the theme of relationships between different levels of planning. Action to stop habitat fragmentation can be

managed on a local level (contiguity between territorial green spaces, alternative solutions to the delimiting of extensive properties, re-naturation of area of land, infrastructural by-passes, local farming policies), however the strategic configurations of ecocontinuity are neither visible or noticeable. The strategic configurations of ecocontinuity are clear on a regional and national level but regional and national legislation are unable to influence action on a local level to assure continuity.

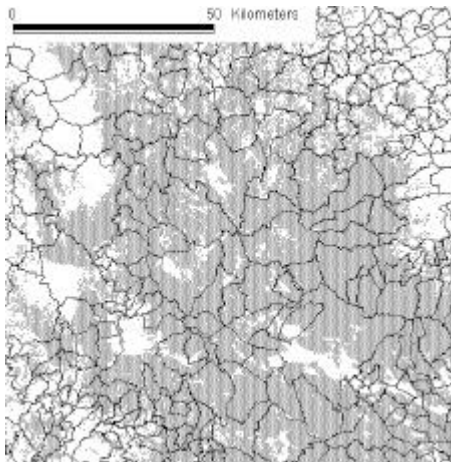


Figure 2 Comparison between middle dimension of the municipalities in Central Italy and the territorial geography of environmental continuity.

Undoubtedly one of the questions that current research should answer is how to integrate legislation on the environment on differing levels.

Once local planning recognises the need for eco-connectivity a whole new range of procedures are available to deal with the problem.

Urban planning, be it aimed at improving the city and surrounding area or developing and increasing territory settlements, can control fragmentation.

Recovery of environmental continuity is extremely complex to manage in the case of linear urban fragmentation: linear urban fragmentation being very difficult to remove or mitigate due to the involvement of private interests and the typology of operation.

Hence local planning instruments should try and avoid earmarking areas for expansion along roadways which is typical in Italy, especially in river valleys.

It would be interesting to prepare coefficients of environmental fragmentation which could be used to evaluate the state of fragmentation of the urban area, and as instruments for planning.

Measuring the fragmentation caused by planning

The dimensions of the spaces set aside for new settlements, their typology, their geometric form, the displacement of the new infrastructural networks and their spacial relationships (Fabietti, 1998), and their current use could all be considered variables that could be expressed parametrically and used to 'measure', by means of relational algorithms and models, the fragmentational effect of the plan on the environment concerned.

It might also be possible to establish the relationship between the fragmentation features of a plan expressed in terms of the geometry, topology and typology of the areas concerned, and the groups of species that could, in theory, continue to use the theoretic lines of dispersion present in the territory.

These relationships could be established with the appropriate ecological-spatial data. However this data is often not available for planning instruments or at best only in a form of checklist.

The measuring of fragmentation caused by planning is particularly important for those settlements that are not particularly large and in environments that have remained practically intact. The application of this methodology to large metropolitan areas where the spread of urbanisation to areas of a semi-natural or natural nature is more gradual is less relevant.

In fact the theories concerning planning instruments sensitive to first environmental and then ecological continuity outlined here in a preliminary form originate from studies on mountainous regions where in the space of a couple kilometres there are urbanized areas and areas of great naturality.

The difference in naturality, however it is measured (for example with indicators of biodiversity), can create difficulty in planning as the criteria used for determining the direction of expansion could damage the environmental quality of an area evaluated in merit of the conditions for continuity.

The problem of taking into consideration species other than man in urban planning, opens up an innovative field of study both for natural sciences and planning. The numerous variables, their possible interdependence and their importance in the planning procedure in fact require an interdisciplinary approach (between urbanistic science, the natural sciences and applied mathematics) at least as far as the theory of systems and decision support processes are concerned.

The effect of economical and ecological pressure on urban planning configuration.

When an urban plan allows new settlements of an extensive nature, even with restricted indices of density, the result will be a dispersion of urbanisation over the territory which is generally associated with high levels of environmental fragmentation.

Construction of buildings for residential purposes brings with it the erection of fences and hence the creation of impermeable spaces, nocturnal lighting, a flux of traffic and people, which all represent barriers with respect to local environmental continuity. Interstitial, restricted spaces remaining are generally of a semi-natural or natural character and destined for parks or agricultural use.

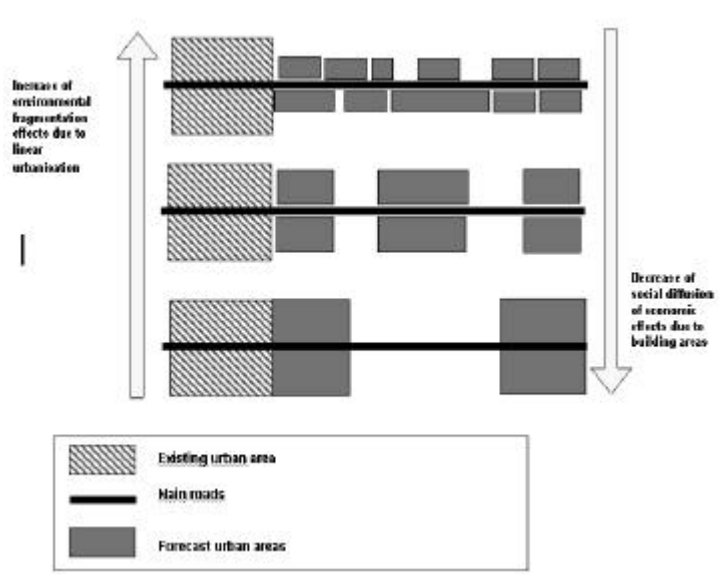


Figure 4 Typical models of distribution of new town parts with respect to main roads and social and economical effects of planning decision.

Economic pressure, which is at the basis of the extensive settlement model, is responsible for creating urban environments of high quality, of a residential nature that cover a large area of public and private space.

In theory a highly concentrated urban settlement in limited space, characterized by high building indices means less land is used than would be in the case of an extensive settlement. However the profits from housing investment in this model is limited to a small number of people.

The extensive model is therefore that which urban planning has favoured bringing about significant fragmentation even in small urban areas such as those found in the central Appennines.

Bringing a halt to extensive settlements is difficult if cannot be shown scientifically that this model of suburban development is responsible for environmental fragmentation and alterations in the ecological continuity of the territory.

The cognitive elements that must be included in the analyses that influence urban planning are those that concern the ecological make-up of the territory concerned. It is therefore essential to know the potential lines of dispersion of the varying groups of species, the levels of biodiversity and dynamics of the vegetation present, the ecological-landscape structures and the habitats and ecosystems of the area designated for development.

The preparation of a cognitive framework organised in this manner is not an easy task in terms of contents and time especially considering the times of research in the naturalistic field and the preparation of planning tools (if for the latter, years then for the former, tens of years for the acquisition of a significant database).

The natural sciences need to prepare instruments based on the susceptibility and potentiality that will provide support for territorial planning and limit environmental fragmentation.

These instruments could then be used to counterbalance expansion pressure resulting in calibrated action and the drawing up of a network of environmental connectivity, graduated therefore on relationships and not simple, spatial adjacencies (Baudry & Merriam, 1988, Franco, 2000). These reflections open up new lines of study for controlling territorial transformation involving comparison and an operative dialogue between city projects (made up of urban distribution geometry, volume, typologies and infrastructural patterns) and the ecological pattern (key sites, links, relationships and typologies).

References

- Amministrazione Provinciale di Siena (1997) *PTCP Piano territoriale Provinciale*, Assessorato alla Pianificazione Territoriale e al Servizio Informativo e Statistico, Siena.
- Battisti C. (1999) *Le connessioni tra aree naturali attorno alla città di Roma*, in: Dimaggio C., Ghiringhelli R., Atti del seminario "Reti ecologiche in aree urbanizzate", 5.2.99, ANPA, Provincia di Milano, F. Angeli Ed., Milano.
- Baudry J., Merriam H.G. (1988) *Connectivity and connectedness: functional versus structural pattern in Landscape*, in: *Connectivity in Landscape Ecology. Proceedings of the 2 International Seminar of IALE*, Munstershe Geographische Arbaiten.
- Conte G., Salvati A., Melucci A. (1999) *Gli indici di qualità dell'ambiente ripario per l'integrazione di reti ecologiche nei piani territoriali, il caso della provincia di Vercelli*, Atti del Workshop ANPA-ARPA Piemonte, Paesaggi rurali di domani, Torino.
- Castelnovi P. (1997) *Gli studi e le ricerche*, in: Regione Valle d'Aosta, Piano Territoriale Paesistico, Urbanistica Quaderni, n.14, INU, Roma.
- Fabiatti W. (1998) *Reti, città e territorio, infrastrutture e urbanistica*, Urbanistica Dossier, 10, INU, Roma.
- Forman R.T. (1995) *Land mosaics, the ecology of landscape and regions*. Cambridge, Univ. Press.
- Franco D. (2000) *Paesaggio, reti ecologiche ed agroforestazione*, Il Verde Editoriale, Milano.
- Harms W.B., Wolfert H.P. (1998) *Nature rehabilitation for the river Rhine, a scenario approach at different scales*, in: Nienhuis P.H., Leuven R.S.E.W., Ragas A.M.J., New concepts for sustainable management of river basins, Backhuys Publishers, Leiden, The Netherlands.
- Malcevschi S. (1999) *La rete ecologica della provincia di Milano*, Quaderni del piano per l'area metropolitana milanese, Angeli Ed.
- Properzi P. (1998) *Ecological networks in new italian regional laws*, Planeco Newsletter, 1, DAU, Università dell'Aquila.
- Regione Abruzzo Delibera di G.R. n. 3582/C del 30.12.98 "Norme di salvaguardia relative alle aree contigue dei Parchi Nazionali e Regionali".
- Romano B. (1996) *Oltre i parchi, la rete verde regionale*, Andromeda Ed., Teramo.
- Romano B. (2000) *Continuità Ambientale*, Andromeda Ed., Teramo.
- Scandurra E. (1987) *Tecniche Urbanistiche per la pianificazione del territorio*, CLUP, Milano.
- Università dell'Aquila, DAU (1999) *La continuità ambientale in Abruzzo*, ANPA, Rapporto finale, Agenzia Nazionale per la Protezione dell'Ambiente, Regione Abruzzo, L'Aquila.