



Adrienne Grêt-Regamey was recently appointed to the chair of spatial planning at the ETH, and is currently building up her research group Planning of Landscape and Urban Systems (PLUS). PLUS concentrates on integrating the goals of sustainable development, economic viability, and good governance in spatial planning. Specific aspects of her research include: inverse model methods in landscape and environmental planning, integration of environmental concerns in spatial planning processes (e.g. the value of ecosystem services), risk-based decision-making for landscape and urban development, and participatory approaches in landscape and environmental planning (including visualization tools).

gret@nsl.ethz.ch
www.irl.ethz.ch/plus

New approaches to understanding complexity

Science of Cities = Big Science

The world is facing a doubling of the urban population within the next fifty years, leading to a world where three out of five people live in cities. Today, one in six people live in shanty towns or slums and suffer from disease, unemployment, and poverty. Despite these huge challenges for humanity, the science of cities has not been recognized as a 'big science', unlike for example biological science or physics. However, just as biological science underpins human health, the science of cities underpins the overall well-being of humanity.

The complexity of a city can be grasped by applying four levels of analysis that form a framework for all aspects of urban research: system articulation, theory development, methods, and application in management and planning³. System articulation encompasses the identification of the entities, the spatial representations, and the scales of resolution of urban information. Once these system features have been identified, patterns can be determined and represented as a theory. This theory can then be operationalized using a range of methods and tools. Finally, theory and methods must be validated, and the insights applied to management and planning.

System articulation begins with identifying entities. Cities are made up of infrastructures that are both the product and carrier of the activity of humans, households, and organizations. These physical and social entities can be analyzed by either function or spatial ranges or by both dimensions together. For each defined entity, the maximum level of resolution, both in space and time, is set by the available data. The third step of system articulation is to determine the spatial representation of the entity, for example as a continuous gradient or flow, or as discontinuous nodes, networks, or points. The system articulation responds to a specific research question. For example, housing quality can be analyzed either from the social dimension using networks, or from the ecological dimension in the form of a point pattern. It must be kept in mind that this articulated system is only a selection out of the bigger framework of the whole city system, and will not give an answer to the entire system. Certain phenomena will only be revealed at certain system levels and not at others.

From the system articulation, patterns can be identified and represented in a theory. Once a pattern is identified, its marginal rate of change can be determined, and built into a theory. The theory should be able to model the pattern and predict the change in the pattern over time. A range of tools and methods with different levels of complexity and data requirements can then be used to operationalize the theory. Methods can either describe the system or analyze it statistically in order to produce a mathematical model. Once the system model or description has been developed, it must be validated, so that the results can be integrated into policy (i.e. defining desired goals) and design (i.e. the planning process).

³ Wilson, Alan G. (2000) *Complex Spatial Systems: The Modeling Foundations of Urban and Regional Analysis*. Prentice Hall, New Jersey.

A number of approaches that attempt to develop new forms of system articulation, theory development, and methods in other disciplines can be applied to the analysis of cities. An example of a new system articulation is the net view of agglomeration economies in Switzerland, in which a spatially intelligent development of economic activities reduces transport costs and brings benefits to the networked centres⁴. A new approach to theory is the index for urban permeation developed by Jaeger et al.⁵, which classifies how much of a landscape is interspersed with urban settlement areas. One example of a new method is the use of agent modeling to analyze landscapes⁶, for example modeling the behavior of hikers in a landscape according to their reactions to landscape parameters. This approach can also be applied, for example, to model human reactions to safety measures.

Adrienne Grêt-Regamey is using integrative approaches to system articulation, theory development, and methods in the PLUS approach. The PLUS system articulation integrates ecosystem services, such as nutrient cycling, into planning. For example, the inclusion of avalanche protection, soil infiltration, and biodiversity value into the planning of settlement expansion of a Swiss alpine village resulted in a redefinition of the desired building zones around the village⁷. The PLUS approach also uses inverse modeling techniques taken from atmospheric physics. Scenarios of possible desired futures of cities offer starting points for inverse modeling, with the goal of defining the actual boundary conditions that are necessary to reach these future states.

One obstacle for modeling a complex system such as a city is the continuous integration of new information. Oceanographers have developed data assimilation techniques to continually integrate new information into current models. PLUS is investigating if similar techniques can also be applied to the science of cities.

As an emerging science, the science of cities is faced with numerous research challenges. Methods and approaches currently used in other disciplines offer promising tools to try to understand the complexity of city systems.

⁴ Oswald, F. & Baccini, P. (2003) *Netzstadt: Einführung in das Stadtentwerfen*. Birkhäuser – Verlag für Architektur, Basel.

⁵ Jaeger, J., Schwick, C., Bertiller, R., Kienast, F. (2008) *Landschaftszersiedelung Schweiz – Quantitative Analyse 1935 bis 2002 und Folgerungen für die Raumplanung*. Wissenschaftlicher Abschlussbericht. Schweizerischer Nationalfonds, Nationales Forschungsprogramm NFP 54 “Nachhaltige Siedlungs- und Infrastrukturentwicklung”. Zurich, 344 pp.

⁶ Cavens, D., Lange, E., Schmid, W. (2003) *Virtual Alpine Landscapes and Autonomous Agents*. In: Buhmann, E. and Ervin, S. (eds.) *Trends in Landscape Modelling*. Wichmann Verlag, Heidelberg.

⁷ Gret-Regamey, A., Bebi, P., Bishop, I.D. & Schmid, W. (2008) *Linking GIS-based models to value ecosystem services in an Alpine region*. *Journal of Environmental Management* 89: 197-208.