UNDERSTANDING FLOWS OF ECOSYSTEM SERVICES: THE INTERCONNECTEDNESS OF TERRESTRIAL, COASTAL, AND MARINE SYSTEMS

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Abstract

ARIES is a new methodology and web application meant to assess ecosystem services and illuminate their values to humans in order to make environmental decisions easier and more effective. In this contribution, we discuss the use of ARIES to understand how marine, coastal, and terrestrial ecosystems are linked in the provision of ecosystem services. We illustrate perspectives for integration of such thinking into coastal management and decision-making.

Keywords: Coastal Processes, Ecosystem services, Coastal Management

The benefits that our societies receive from ecosystems in the form of services such as water purification have a dynamic nature in that they are carried from source of origin to areas where they are used. Matter, energy or information serves as carriers that transmit the benefits through space and promote its transfer to humans. For example CO_2 is the vehicle for carbon sequestration and storage, floodwater for disturbance regulation, and scenic views for aesthetic value. Tracking the spatial flow of benefits can be help highlight the interconnectedness between terrestrial, coastal, and marine ecosystems, providing decision-makers and managers a way to assess the propagation of potential impacts and the opportunity of protecting or enhancing existing functions. ARIES (ARtificial Intelligence for Ecosystem Services) is a new methodology and web application (Villa et al., 2009) meant to assess ecosystem services (ES) and illuminate their values to humans in order to make environmental decisions easier and more effective. By creating ad-hoc, probabilistic models of provision, use and flows of ecosystem services in a region of interest, ARIES helps discover, understand, and quantify environmental assets, their likely beneficiaries, and what factors influence their value according to specified needs and priorities. Thanks to a grant from UNEP, the coverage of ARIES is being extended to include coastal and marine systems, which are the focus of this contribution. Ecosystem services dynamics can be seen as a generalized source-sink problem, where ecosystems are the source of benefits that meet the needs of specific human beneficiaries. Modeling ES in a given spatial and temporal context requires: (1) determining the currencies of these benefits, such as water, CO2 etc; (2) determining likely surfaces of both provision and usage relative to the area and time of interest; (3) quantifying the rates of flow of the correspondent benefits. It is the rate of flow (current or potential) that can be directly related to the value of the ES, both in abstract and in economic terms. Most of the many difficulties of modelling ES depend on the high heterogeneity of behavior exhibited by the benefits they produce. Among these: 1. Provision and usage happen at entirely independent scales in space and time. Therefore, a scale-explicit approach needs to be taken, and theoretical instruments that can tackle multi-scale systems are lacking. Recognizing the spatial and temporal decoupling between source and use, between benefits and their carriers has important implications for management, mitigation efforts, and policy actions. 2. The "currency" of benefit provision is rarely an easily modelled biophysical quantity. Easier cases include, e.g., CO2: quantification of its exchange from vegetation to atmosphere may be all that's needed to assess benefits of carbon sequestration. Things are much more complex with currencies like sense of identity or avoided risk of flooding. 3. Little clarity exists in the literature about quantifiable definition of ES, their benefits, and the modalities of their propagation from ecosystem to human beneficiary. The ARIES methodology is based on explicit conceptualizations that lay out first of all a novel vision of ES, based on the breakdown into individual benefits, each of which is modeled independently, then linked to the others. Domain ontologies in ARIES result from a large-scale expert consensus. Artificial intelligence techniques (machine reasoning, pattern recognition) examine source data and extract from the ontologies models that best represent the situation at hand. ARIES builds ad-hoc, probabilistic Bayesian Network models that inform the users of the full probability distribution of the outcomes of their decisions (Villa, 2009). The result of an ARIES user session is a set of GIS maps that describes in depth the spatial distribution of benefits produced the area, their potential and realized values, and the causal relationships that link the values to each other, to their likely beneficiaries, and to actual or potential policies. Users can enter a scenario explorer module to explore the likely changes in ecosystem service provision and usage engendered by changed environmental conditions, consequent to either natural change or their own actions. We will discuss the ARIES methodology and demonstrate the software toolkit to highlight its potential in informing ES-centric decision-making in coastal and marine decision-making.

References

1 - Villa F., Ceroni M., Bagstad K., Johnson G., Krivov S., 2009. ARIES (ARtificial Intelligence for Ecosystem Services): a new tool for ecosystem services assessment, planning, and valuation. Proceedings of the BioEcon conference, Venice September 20-23.

2 - Villa, F., 2009. Semantically-driven meta-modelling: automating model construction in an environmental decision support system for the assessment of ecosystem services flow. In: *Information Technology in Environmental Engineering*, I.N. Athanasiadis, et al., Editors. Springer: New York, NY. p. 23-36.