Chapter 78
Ecosystems as Agent Societies, Landscapes as Multi-Societal Agent Systems

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ABSTRACT

Landscape ecology concerns the analysis, modeling and management of landscapes and their component ecosystems, mostly in view of the effects of the anthropic actions that they may suffer. As such, landscape ecology is well amenable to be supported by agent-based computational tools. In this chapter, we introduce the concept of "multi-societal agent system", a formal architectural model for distributed multi-agent systems, and we interpret it in ecological terms, to serve as an agent-based theoretical foundation for computer-aided landscape ecology. More specifically, we introduce the "ecosystems as agent societies" and "landscapes as multi-societal agent systems" approaches to ecosystems and landscapes, together with the core elements of the agent-based architectural models that support such approaches. The elements of those architectural models are then used to formally capture the main organizational and functional aspects of ecosystems and landscapes.

INTRODUCTION

This work concerns the use of agent-oriented concepts in the formal ontological account of environmental systems. In particular, it concerns the use of the concept of agent society for the formal account of the main organizational and functional aspects of ecosystems, and the concepts of import-export agent society and multi-societal agent system for the formal account of the main organizational and functional aspects of landscapes.

The concept of agent society is used here in the sense in which it has been used in our previous works, e.g., (Costa, 2014). The concept of multi-societal agent system, and its component concept of import-export agent society, are being introduced in the present work, for the first time.

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The environmental concepts were taken from (Pidwirny, 2009), complemented with (Wu, 2012). For the most part, however, they were not taken in the literal form they appear in those publications, but in a form adapted to the agent-based modeling point of view. This was a necessary step, to make them fit the conceptual framework of the agent societies.

STRUCTURE OF THE CHAPTER

The basic ecological concepts, in their revised form, are summarized in Section 3. The main organizational and functional features of ecosystems and landscapes (as evinced by the revised form of such concepts) are presented in Sections 4 and 5, respectively.

The concepts of agent society and multi-societal agent systems are given in Section 6. The way ecosystems and landscapes can be modeled in terms of agent societies and inter-societal systems is formally shown in Section 7 and 8, respectively. Section 8 also considers how to account for biomes and the biosphere as multi-societal agent systems.

Section 9 briefly deals with the issue of anthropic action on landscapes, sketching a general way to integrate multi-societal models of landscapes and human societies into models for landscapes that are subject to anthropic action.

Section 10 is the Conclusion.

THE BASIC ECOLOGICAL CONCEPTS

We characterize ecosystems, their components and related concepts, in terms of four dimensions[1], taking as primitive the concept of individual (i.e., a particular individual organism).

- The *populational* dimension, encompassing the set of individuals and types of individuals that constitute the ecosystem;
- The *organizational* dimension, encompassing the ways individuals and sets of individuals relate to each other, in terms of their interactions;
- The *functional* dimension, encompassing the functions that individuals and sets of individuals perform for each other, and the ways the interactions among organisms and sets of organisms coordinate with each other;
- The *geographical* dimension, encompassing the geographical areas occupied by the ecosystems, and the ways the ecosystems constitute themselves on those areas.

We use the four dimensions to define a series of concepts that leads to the concepts of *ecosystem*, *landscape*, *biome* and *biosphere*. We also characterize the concepts of *habitat* and *niche* [2].

- **Species**
  - **Populational Dimension:** Is a *group* of individuals characterized by the fact that individuals of a given species do not ordinarily breed with members of other species;
  - **Organizational and Functional Dimensions:** Species have no particular organizational or functional requirements;

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