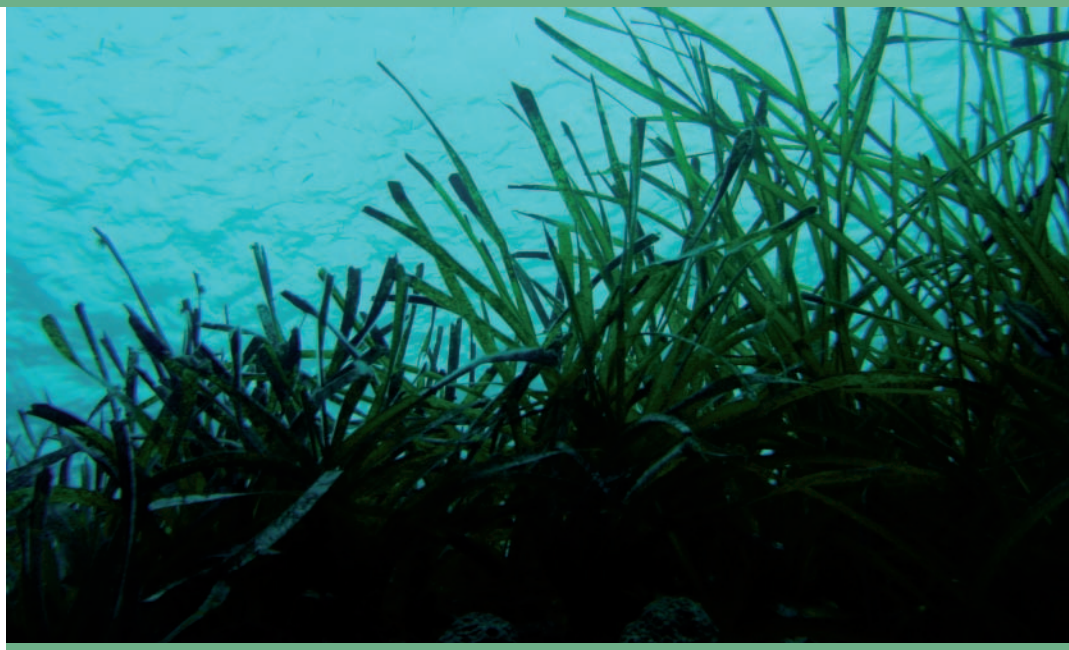
NEST
Pathfinder

DETERMINING COMMON PATTERNS IN COMPLEX NATURAL SYSTEMS

EDEN



Many properties of natural biological systems – from plants to microbes – are connected. EDEN is developing tools to determine patterns of connections in different natural systems, to see both how individual species differ and how different species have evolved from common ancestors. These networking methodologies will make it possible to identify which biological populations should be protected to maintain a species. A particular focus will be preserving biodiversity in the Mediterranean.

Biological systems are highly complex, with evolutionary relationships between species generally represented as phylogenies or evolutionary trees. However, many properties of natural systems are related to the way they are interconnected. Complex science projects are now attempting to apply modern network theory to natural or manmade systems to characterise such interactions and understand their development.

This new scientific paradigm is being applied in EDEN – not looking directly at how things are connected but rather at the global pattern of connections involved, and at developing suitable analytical tools. The project will work on methods to analyse the structure of biological populations and identify key points that influence the distribution of these populations.

Using large samples of genetic data, EDEN will apply highly innovative cross-disciplinary network methods to examine population structure, gene flow, evolution and biogeography. This will make it possible to replace the 'tree of life' concept with a much more flexible 'network of trees' to gain biological insight into the evolution of life.

Dual-prong approach

Two dimensions are involved: the ecological and the evolutionary. On the ecological side, EDEN is seeking to characterise interactions between different species and between different populations inside a species. This approach involves understanding how they interchange genes, how they meet each other and what kind of connections they maintain.

On the evolutionary side, the same kind of ideas can be applied on a larger scale using similar methods to analyse how some of the species studied have developed: when they differentiated from a common ancestor; which species descend from which other species; and what kind of relationships develop between species.

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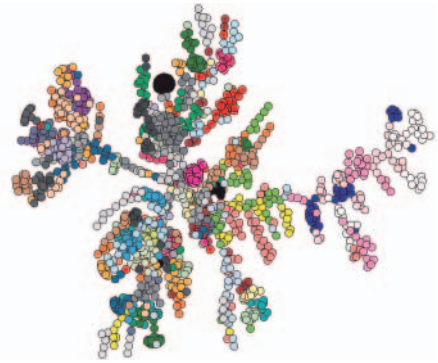

A multidisciplinary approach at European level, involving biologists, mathematicians and bioinformaticians, is essential to carry out this task. Despite the focus on biological populations, the approaches being developed come from other fields. The methodologies were first developed in the context of both physical and social systems requiring complex network analysis. The intention is to bring the methods developed in these other disciplines to bear on biological networks.

Europe's north and south join forces on EDEN. The project team hails from four different institutions, team members who have previously developed bilateral contacts in other contexts. For example, the Spanish coordinators from the University of the Balearic Islands have worked with members of Portugal's Center of Marine Sciences in projects on the biology of plants, as well as with personnel from the Helsinki University of Technology on communications networks. And there has been collaboration between the Finnish group and Germany's Leipzig University. These earlier experiences made it possible to assemble a team that combined good working relationships with relevant expertise in all the fields concerned.

Preserving biodiversity

Work has begun using a mass of genetic data already collected on many Mediterranean sea plants. During the development of the project, the intention is to expand the data to cover not only marine plants but also some marine animals. In practice, there is not a lot of difference genetically between plants and fish, for example. Much more important differences are expected to be found with bacteria and microbes. EDEN is particularly keen to study microbes as there is a strong difference in their genomes and in the way they reproduce. The intention is to find patterns of evolution and patterns of ecological relationships in all the areas covered.

A key goal is to ascertain which important biological populations should be protected to maintain a species. This activity will focus particularly on *Posidona oceanica*, a long-living clonal sea grass that provides an ecologically rich natural habitat that is crucial in maintaining biodiversity in coastal ecosystems in Southern Europe. Despite being protected under the Habitats Directive and the Convention for Biological Diversity, this sea grass is in drastic decline through the Mediterranean – a source of both ecological and economic concern, since local fisheries are also dependent on the marine plant.

Using network characterisation tools developed in EDEN, new diagnoses can be designed to evaluate global Mediterranean sea grass health, to estimate habitat extinction probabilities, and to design conservation and management strategies.

The approach being developed is, therefore, highly relevant to improving the understanding of population dynamics, evaluating the consequences of habitat fragmentation and local extinctions on the fate of species, as well as to improving the level of information on the spread of invasive species. Results will be shared with other groups involved in European complex systems research, particularly through NEST Pathfinder's GIACS action.

AT A GLANCE

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Ecological Diversity and Evolutionary Networks

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The marine plant Posidonia oceanica, one of the organisms for which EDEN will develop extensive network-based genetic analysis.

A Minimum Spanning Tree representing genetic diversity of samples of a marine seagrass (each of the circles) across the Mediterranean.