Abstract

Ecomorphodynamics (or biogeomorphology) is a relatively recent branch of geomorphology. It studies the co-adjustment of landforms and living organisms across different scales, translating into continuous abiotic-biotic feedback. Although abiotic-biotic systems are widespread at almost every latitude, this work focuses on riparian corridors and coastal foredunes. Part 1 of this Thesis studies the interaction between riparian vegetation and rivers, while Part 2 concerns the foredune development in relation to dune-building grasses. These two landscapes might appear very diverse, yet they have some common traits. For instance, their evolution is mainly influenced by the feedback between plants, water, and loose sediment. Moreover, both coastal and riparian vegetation shows a dichotomic behavior in response to external stochastic disturbance (i.e., growth and decay when the disturbance is lower or higher than a critical threshold).

Practical solutions to issues concerning environmental management require an all-encompassing and interdisciplinary viewpoint. The adoption of an ecomorphodynamic approach to address these issues is increasing, drawing the scientific community's attention. Nevertheless, due to natural landscapes' complexity, advances in ecomorphodynamics demand cross-fertilization and shared methods from geomorphology, fluid mechanics, hydrology, biology, ecology, and other sciences. From this perspective, we hypothesized that monitoring through remote sensing might answer the modeler's need for quantitative information. The literature cannot confirm our hypothesis, as very few works have attempted to inform models with remote sensing techniques so far. Thus, the present work contributes to building a bridge between these two disciplines and developing tools for biomorphological investigation.

First, we outlined a novel methodology that integrates miscellaneous data and consolidated techniques with new tools and models. This integrated approach

allows us to model the morphological and ecological dynamics occurring in natural systems, supporting our understanding of the underlying feedback and the response to external forces. We defined and applied our methodology to riparian corridors in fluvial contexts while we set the stage to adapt it to coastal dune investigation.

Successively, we developed specific tools to provide quantitative information on vegetation based on remote sensing data. In this Thesis, we describe vegetation geometry and biomass extraction from georeferenced point clouds, such as Light Detection and Ranging (LiDAR) data. A literature review revealed a gap between forestry and river sciences leading to few attempts to characterize riparian vegetation. In light of this gap, we defined new algorithms for individual tree detection and shrub cluster segmentation in riparian corridors and embedded them into a unique procedure called *extensive biomass estimation*. In addition, we worked on satellite image analysis to retrieve topographical and ecological information in coastal areas by leveraging the functions and datasets from Google Earth Engine (GEE).

Finally, we focused on analytical stochastic modeling. Our riparian research relies upon one of the existing literature models for vegetation dynamics and focuses on model calibration based on real data, a task still highly investigated in the literature. We instead defined a new ecological model for coastal vegetation dynamics because of the paucity of similar works in the literature. Indeed, the existing models notably differ from each other and generally disregard the stochastic behavior of coastal forces. We remark that this part of our research is in its infancy, and future work will address model calibration based on satellite imagery within the frame of the presented *integrated approach*.