ABSTRACT

Wetlands are dispersed fractal aquatic habitats that play a key role in watershed eco-hydrology. Wetlands provide critical habitats for specialized fauna and flora, process nutrients, and store water. Wetlands are found in a wide range of landscapes and climates, including humid/tropical regions where surface water is abundant, and in semiarid/arid regions with surface-water deficits. Wetland morphology and hydrology are governed by geomorphology and climate. Wetlands are dynamic; they change in space and time in response to unsteady external conditions, and over longer term to internal process feedbacks. Together, wetlands form a mosaic of heterogeneous, dynamic, aquatic habitats in varying spatial organizations, networked by hydrological and ecological connections.

The overarching goal of the proposed research is to provide a robust theoretical framework to model the dynamics of multiple wetlands spread across watersheds (wetlandscape). In particular, the three main lens I used for identifying the spatiotemporal variability in wetlandscapes were: hydrology, morphology and ecology. Indeed, the hydrological modeling of wetlands is of key importance to determine which habitats are potentially able to host aquatic and semiaquatic species, as well as function as retention basin for storing considerable amount of water or for processing nutrients. Wetlands interaction with the landscape topography is essential to characterize the morphological attributes of these waterbodies. Different generating mechanisms have produced differences in wetland shapes and extent. However, even if wetlands are different among regions, and also within the same landscape, the set of function that they can support is similar. In the present research, I have also proposed that because water accumulates at low elevations, topography-based models helpful for the identification of wetlands in landscapes. These types of models are useful especially in those cases were wetlands data are sparse or not available. The proposed approaches could reproduce the abundance and distribution of active wetlands found in the NWI database, despite the differences in identification methods. In particular, I found that wetland size distributions in all the conterminous United States share the same Pareto pdf. Furthermore, the wetland shape is constrained into a narrow

range of 2D fractal dimension (1.33;1.5). Since this method can be carried out with only a DEM as input, the proposed framework can be applied to any DEM to extract the location and the extent of depressional wetlands.

Wetlands are among the most biologically diverse ecosystems, serving as habitats to a wide range of unique plants and animal life. In fact, wetlands and their surrounding terrestrial habitats are critical for the conservation and management of aquatic and semi-aquatic species. Understating the degree and dynamics of connectedness among individual wetlands is a challenge that unites the fields of ecology and hydrology. Connectivity among spatially distributed mosaic of wetlands, embedded in uplands, is critical for aquatic habitat integrity and to maintain metapopulation biodiversity. Land-use and climate change, among other factors, contribute to wetland habitat loss and fragmentation of dispersal networks. Here, I present an approach for modeling dynamic spatiotemporal changes, driven by stochastic hydroclimatic forcing, in topology of dispersal networks formed by connecting habitat zones within wetlands. I examined changes in topology of dispersal networks resulting from temporal fluctuations in hydroclimatic forcing, finding that optimal dispersal network are available only for limited time period, thus species need to constantly adapt to cope with adverse conditions.

Loss of wetlands leads to habitat fragmentation and decrease in landscape connectivity, which in turn hampers the dispersal and survival of wetland-dependent species. Ecosystem functions arise from interdependent processes and feedbacks operating concurrently at multiple scales. In this thesis, I integrated stochastic models for landscape hydrology to study the temporal variability in wetlands attributes (e.g., stage, surface area and storage volume, carrying capacity) with ecological network theory allows for characterization of the spatiotemporal dynamics of habitat distribution and connectivity that is essential to meta-communities. The proposed framework can be applied in diverse landscapes and hydro-climates, and could thus be used at larger scales. The proposed approach could also inform conservation and restoration efforts that target landscape functions linked to transport in wet ecological corridors. The interdisciplinarity that characterizes this work allows for a wide spectrum of potential applications. Despite the ultimate goal of the thesis consists in the eco-hydrologic modeling of wetlandscapes, the backbone of the proposed models could be extended to any kind of patchily habitat driven by stochastic forcing.