Elucidating the successional trajectories of Louisiana barrier island vegetation communities through data mining

Rationale

Barrier islands are important coastal landforms that provide numerous ecological services, with their provision of terrestrial habitat for fauna and amelioration of wave and wind energy considered particularly valuable (Barbier et al. 2011). However, barrier islands that form as a component of river delta cycles, such as those in the eastern portion of Louisiana, are highly dynamic and ephemeral features that naturally degrade into subaqueous shoals (Penland et al. 1988). In Louisiana, where the delta cycle has been interrupted and coastal land loss is occurring at an accelerated rate, recurrent restoration activities must be undertaken to maintain these highly beneficial systems in the coastal landscape (Khalil et al. 2013). The State of Louisiana has an extensive and successful history of initiating and managing barrier island restoration projects (Khalil et al. 2013), with all barrier shorelines within the state now having experienced some degree of rehabilitation. However, despite this successful history of initiating barrier island restoration projects, data gaps exist regarding the development of vegetation communities on restored barrier islands over time (i.e., successional trajectories), particularly in regard to their modulation by exogenous events. Resolving such knowledge gaps would be beneficial as the vegetation community composition is highly relevant to the provision of habitat for fauna as well overall barrier island resilience in the face of high energy storm events. Further, identification of major secondary species in successional trajectories would enable follow up plantings on an appropriate timeline to improve project outcomes and benefits. The research proposed herein seeks to address these data gaps by mining the extensive monitoring data collected from State of Louisiana restoration projects relevant to barrier islands (over 34,000 individual vegetation species cover measurements across 33 projects) to develop successional trajectories. Additionally, relevant meteorological and environmental setting data (i.e., exogenous factors) will be derived from various sources and integrated into analyses to examine the possible roles of these factors in structuring barrier island vegetation communities. Through these analyses understanding of an area of particular interest to CPRA (barrier island plant succession) will be advanced, thereby enabling informed refinement of future CPRA Master Plans.

Statistical Analysis Approach

Vegetation and spatial location data will be downloaded from the Louisiana Coastal Protection and Restoration Authority's Coastal Information Management System (CIMS) for all projects relevant to barrier island habitats (e.g., dunes, swales, back-barrier marshes, etc.). Data will be manipulated into formats appropriate for multivariate exploration and the integrity of the data verified. Although the exact analytical workflow will be adaptive to ensure optimal results, based on preliminary investigations the below analytical process is anticipated. Non-metric multidimensional scaling analysis will be performed in a habitat-specific manner on those data sets with multiple collection years to investigate gradients in vegetation community composition over time. When temporal gradients in species composition over time are detected, a combination of Similarity Percentage (SIMPER) and non-parametric (e.g., Spearman) correlation analyses will be performed to identify those species most responsible for driving these gradients. The role of exogenous factors in modulating species composition will also be evaluated through non-parametric correlations and visualized through vector overlays. Significant differences in species composition between sampling years within projects and habitat types will be assessed using perMANOVA to determine distinct successional stages. All project datasets exhibiting temporal gradients and distinct assemblages in species composition will be combined into a series of habitat-specific datasets, which will then be investigated in a decision tree framework to assess predictability of successional stages. Data will be randomly allocated (70:30) into training and test data sets for validation, and resulting decision tree will be post-pruned based on the complexity parameter.

G.I.S. Approach

The temporal (average of ten years between the first and last monitoring dates) and spatial spread across the coast will enable the use of ArcGIS Pro software to detect changes in habitat composition over time and space. The habitat data will be paired with geospatial data such as LIDAR and high-resolution satellite imagery to track landscape changes and determine land stability with habitat type. Further, hurricane track and windspeed data will be incorporated when possible to quantify the impact of disturbances on successional trajectories of habitat composition. Spatial analyses such as forest-based classification and regression, geographically-weighted regression, and time-space cubes will complement traditional statistical analysis to reveal any spatial patterns in the data. Data from a current project focused on coastal ridge terrestrial and emergent vegetation communities for the RESTORE Act grant will be leveraged where possible to complement the CIMS data. Specifically, the RESTORE project includes three saline sites in Barataria-Terrebonne that can be included to increase pertinent data points for the predictive models on several habitat assemblages.

Deliverables

Both a Master's Thesis and a peer-reviewed publication will occur as an outcome of this project. In addition to the student's thesis, a brief technical summary, analytical workflow diagram, conceptual model, and decision tree graphic will be prepared for dissemination to practitioners.

References

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Penland, S., Boyd, R., and Suter, J.R. 1988. Transgressive depositional systems of the Mississippi Delta plain; a model for barrier shoreline and shelf sand development. Journal of Sedimentary Research 58: 932–949.