

Development and Assessment of Bioinformatics Tools for Species Conservation and Habitat Management

Melanie A. Sutton^{†‡}, Lori Deneke[†], John Eme[†], Wayne Bennett[†], and Frank Wray[†]
University of West Florida, Departments of Biology[†] and Computer Science[‡]
Corresponding author: msutton@uwf.edu

Abstract

This project represents an interdisciplinary approach to integrating computational methods into the knowledge-discovery process associated with understanding biological systems impacted by the loss or destruction of sensitive habitats. We specifically developed bioinformatics tools for the study of (1) beach mouse communities and (2) marginal fish habitats. Data mining was used in these projects to intelligently query databases and to elucidate broad patterns that facilitate overall data interpretation. Visualization techniques that were developed present mined data in ways where context, perceptual cues, and spatial reasoning skills can be applied to uncover significant trends in behavioral patterns, habitat use, species diversity, and community composition.

1. Introduction

Beach mice are small, nocturnal burrowing rodents that have a very specific habitat preference (see Fig. 1). They live only in primary and secondary sand dunes that populate barrier islands along the Gulf coast of Alabama and Florida, and on the Atlantic coast of Florida [1-3]. Fifty years ago, these habitats consisted of uninterrupted stretches of coastal dunes. Today, however, coastal exploitation has left suitable beach mouse habitat only in pockets of protected areas separated by miles of development. Similar situations have driven one subspecies of beach mice from Florida to extinction and others have been designated as endangered or threatened.

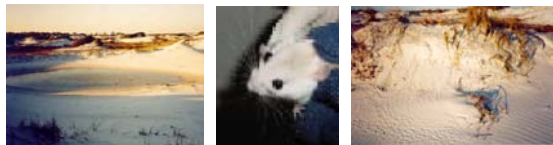


Figure 1. Santa Rosa Beach Mouse dune habitats

The marginal fish habitats of the Wakatobi Marine National Park in Sulawesi, Indonesia face similar threats of encroachment (see Fig. 2). Certain species of fishes found in these habitats complete their life cycle without

entering the adjacent coral reef communities, whereas other species use the reef as a nursery for their young or as a foraging area [4]. Due to their proximity to shore and abundance of sea life, these sensitive areas are often the first to be disturbed by human activity, sometimes before the biodiversity and ecological relationships have been adequately surveyed [5-6].



Figure 2. Reef-associated marginal fish habitats

Our goals in developing Internet-searchable databases and innovative multi-media-based visualization strategies for these two projects involve two objectives: (1) to streamline data analysis for these biological systems and (2) to provide virtual access as well as educational opportunities to these habitats for laypersons and students who might not otherwise be able to explore these areas. Tools developed for tracking the population dynamics of the Santa Rosa Beach Mouse will be used to study how habitat fragmentation impacts population dynamics, with the goal of facilitating the development of better management practices for related subspecies. Similarly, the implementation of a database for assessment studies of species diversity and community composition of sensitive marginal habitats is necessary for the establishment of practices to ensure diverse and productive reef and reef-associated systems.

2. Materials and Methods

Researchers at UWF have tracked movement patterns of the Santa Rosa Beach Mouse monthly since July 2002 in the Gulf Islands National Seashore area of Santa Rosa Island in Florida. Mice are caught using live-traps that are baited with rolled oats. Upon capture, the animal's mass, gender, relative age (adult or juvenile), and reproductive status are assessed. Mice are then released, with select animals marked using numerical ear tags.

Similarly, UWF researchers traveled to Indonesia in 2002 to gather preliminary taxonomic information for several habitats. An upcoming 2003 tour will augment this, with data derived from three replicate 30x20 meter collection plots sampled at each of three marginal habitats. Fish population sizes, population density for each species (fish/m²), Shannon-Weaver diversity, species richness, evenness, and dominance indices will then be calculated for each of the targeted habitats.

3. Results

3.1. Development platform

Prototype databases for both projects were initially implemented using Perl's database management (DBM) facilities, with HTML-based query forms processed using CGI scripts running on a UNIX platform. For both projects, database files were also provided on-line in raw format, for researchers investigating trends beyond those implemented with the current toolset. For the fish biodiversity project, specific Species Entry Forms and Museum Archive Forms were also designed to streamline on-line data entry.

3.2. Visualization tools

Preliminary visualization tools focused on clickable image maps and associated CGI-script-based queries providing mined data along multiple directions, keying on factors such as microhabitat, site-specific species information, and species prevalence across habitats. For example, for the beach mouse project, a color-based representation of the trapping grid located in sand dune/scrub habitat was used. Clicking on trap sites resulted in database queries to display all mice trapped at the indicated locations. Alternatively, selecting mouse identification numbers was used to examine how movement varied by gender and reproductive status, allowing users to discern trends such as whether males or females travel furthest in a given time period or whether pregnant females stay closer to home.

3.3. Assessment and inter-institutional educational objectives

Preliminary assessment and testing of on-line resources was conducted by students taking a bioinformatics course at UWF. This resulted in a number of suggestions for techniques to enhance display tools emphasizing habitat use and behavioral patterns. To increase awareness of conservation efforts, we have also produced introductory pages to provide virtual access to image archives for the international scientific and lay

communities. Formal on-line assessment associated with the development of educational modules linked to curricula objectives of pre-college students is also currently underway.

4. Summary and Future Directions

Conservation of species and habitats has taken on new urgency in the face of the collapse of major fisheries and destruction of sensitive habitats worldwide. Biodiversity assessments are thus essential to properly catalogue and conserve sensitive areas. In addition to the on-going implementation of educational modules discussed above, we are also in the process of porting our projects to a relational database model to support upward scalability of both projects.

5. Acknowledgements

We wish to thank researchers of Operation Wallacea for their support. Source code and material examples are available at <http://uwf.edu/msutton/bioinformatics>.

6. References

- [1] Gore, J.A., and Schaefer, T.L., "Santa Rosa Beach Mouse survey", *Florida Game and Fresh Water Fish Commission Nongame Wildlife Program*, 1993.
- [2] Oli, M.K., Holler, N.R., and Wooten, M.C., "Viability analysis of endangered Gulf Coast beach mice (*Peromyscus polionotus*) populations", *Biological Conservation*, 97, 2001, pp. 107-118.
- [3] Wooten, M.C., "Estimation of genetic variation and systematic status of populations of the beach mouse, *Peromyscus polionotus*, with considerations for their management", *Florida Game and Fresh Water Fish Commission Nongame Wildlife Program*, Tallahassee, FL, 1994, 33 pp.
- [4] Pollard, D.A., "A review of ecological studies on seagrass-fish communities, with particular reference to recent studies in Australia", *Aquatic Botany*, 18, 1984, pp. 3-42.
- [5] Kimani, E.N., Mwatha, G.K., Wakwabi, E.O., Ntiba, J.M., and Okoth, B.K., "Fishes of a shallow tropical mangrove estuary, Gazi, Kenya", *Marine and Freshwater Research*, 47(7), 1996, pp. 857-868.
- [6] Ley, J.A., McIvor, C.C., and Montague, C.L., "Fishes in mangrove prop-root habitats of northeastern Florida Bay: Distinct assemblages across an estuarine gradient", *Estuarine, Coastal, and Shelf Science*, 48(6), 1999, pp. 701-723.