CS486C – Senior Capstone Design in Computer Science

Project Description

Project Title: ***Mobile app for exploring local ecosystem services of animals***	
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Project Overview:

Loss of habitat, human hunting, pollution, and climate change have placed tremendous stress on many ecosystems worldwide, causing many local animal populations to face depletion and extinction. In fact, ecosystems are complex webs of connected interdependencies between local species, such that the collapse of one species may have wide-ranging effects on the entire local ecosystem. Modern ecological science uses the concept of *ecosystem services* to characterize these ecosystem interconnections; each animal species provides certain "services" to the ecosystem...that one or more other species may, in turn, depend on to survive and prosper. As one might expect, depletion of a particular species generally has a negative implications for the ecosystem services they provide.

There has been much work about the impacts of faunal extinctions on ecosystem services such as nutrient distribution. For example, extinctions and hunting pressures have decreased nutrient movement by large animals to less than 10% of its former value (Figure 1 left) leading to significant hypothesized decreases in nutrient concentrations at the continental scale (Figure 1 right).

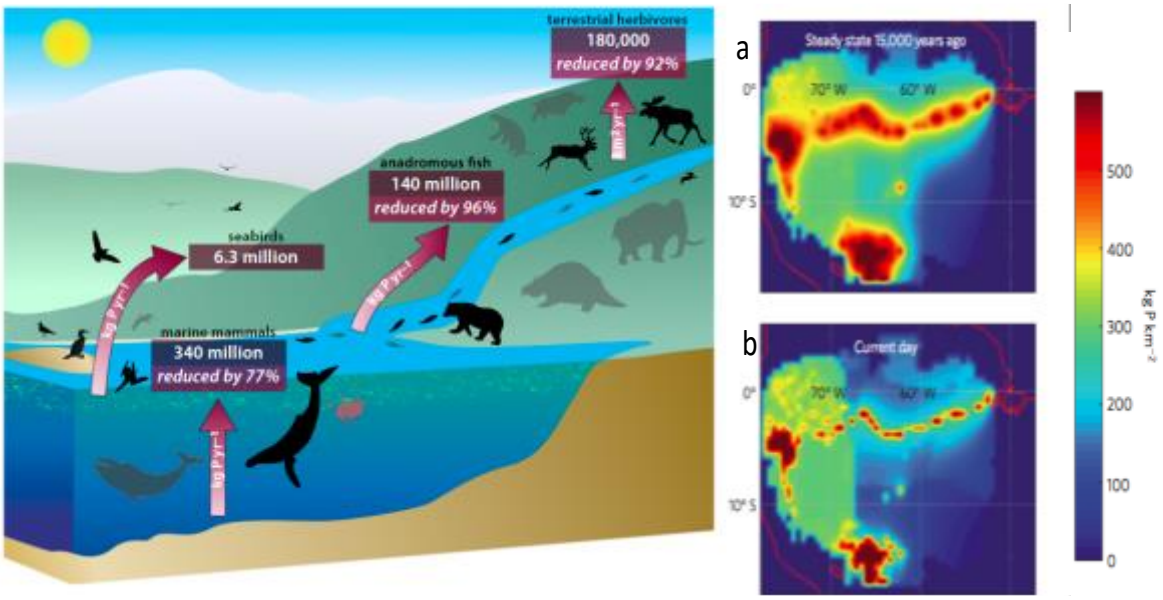

Figure 1. (left) Potential interlinked system of phosphorus recycling. The diagram shows a potential route of nutrient transport from marine to terrestrial systems in the past. Red arrows show the estimated fluxes or diffusion capacity of nutrients. Grey animals represent extinct or reduced population densities of large vertebrates. (right) Estimated movement of phosphorus concentrations in the Amazon Basin (a) with no large animal extinctions and (b) with large animal extinctions.

The fundamental problem motivating this project is that, while many average citizens express some concern about species depletion and extinction, there is really very little understanding of the potential implications, simply because the interdependencies between species are complex and not obviously visible. In particular, it would be useful for an average citizen to be able to explore the predicted *local effects* of ecosystem degradation, customized specifically to where he or she lives. This personalized educational tool would bring the potential consequences of *specific local ecosystem degradation* home to citizens and policy-makers, allowing them to make more informed decisions on proposed policy initiatives.

Over the last decade, advances in ecological science have made this sort of location-specific ecosystem modeling possible. We have created *ecosystem service maps* that characterize local and regional variations in ecosystem services; these are based on geographic range maps and mean body size for most animals (including terrestrial mammals, birds, fish, and marine mammals). There are also range maps and mean body size data for fauna that have gone extinct over the past 15,000 years (e.g. mastadons), but that co-evolved with our modern ecosystem before becoming extinct. With these spatial and body mass datasets, we used scaling theory (the use of animal size to predict behavior) to make predictions about how these animals impact their ecosystems and how these ecosystems once functioned. This work has resulted in detailed ecosystem services maps for three key ecosystem services provided by animals: nutrient distribution, seed distribution, and microbe distribution. Note that these maps are much more than static maps, they are the result of applying specific algorithms to species data at each specific locations on the map…meaning that they can be *re-computed* after changing local species densities, thereby allowing "what-if" visualizations that explore various species depletion scenarios on ecosystem services.

Clearly, this information would have enormous benefit to the public, decision makers, and managers of the globe's natural areas – if it could be made easily available! The goal of this project is to create a mobile application that (a) provides geo-located access to information on local species (both current and extinct); and (b) allows the user to vary the local population of various species to explore the effects on local ecosystem services. Specific functionalities of the software project will include:

Phase 0: Minimum viable product

- Mobile App will access a geo-indexed database of existing and extinct animals, based on the current location of the user.
- Mobile app will display detailed information on each animal species, including a picture and other key information. Might be automatically extracted in real-time from Wikipedia; or could be pre-extracted, formatted and stored in the database.
- Mobile app will provide some visualization of local ecosystem services (e.g. a color map with a legend, etc.) to allow user to view ecosystem services at specified location. or could be pre-extracted, if the information can be contained within an easy to use app.
- Database will be provided as web service installed on a cloud server, and will be accessible to the app via a data connection.
- Basic administrative interface for central database, allowing updating of contained data via secure web portal or other means.

Phase 1: A truly usable result

- App GUI will provide a way to alter the local densities of existing and extinct local species, and will display re-computed and updated ecosystem services maps resulting from the change.
- App GUI will provide advanced or multiple visualizations of local ecosystem services, e.g., clearly showing the *change* in services from some baseline as changes to species densities are made.
- Ability to explore areas other than where user currently is, e.g., drag "current location" pin to an arbitrary location on map to explore that local ecosystem.
- More advanced administrative interface for web-based database, to simplify additions and updates.

Phase 2: Really cool advanced features

- Knowing changes in the three basic ecosystem services is just the start. Users ultimately want to know how this will affect everyday life. Advanced features would provide a mechanism(s) for displaying tangible effects of ecosystem service changes, based on a model to be provided by the sponsor. For instance, you might see that degradation of "seed distribution" ecosystem service might result in local desertification, or changes from forest to grasslands, etc.
- Front page that advertises "popular ecosystems" to explore, plus way to "rate" or "bookmark" places. Idea is that really cool ecosystems (based on user reviews/view/etc) should be profiled.

Knowledge, skills, and expertise required for this project:

- Experience/Interest in mobile application programming. Exact platform (iOS, Android) will be negotiated between sponsor and team in the design phase.
- Design and deployment of basic web services, for centralized database.

Equipment Requirements:

- Ordinary development platform and software/tools freely available online.
- Client will provide access to appropriate mobile device(s) for product testing, if needed.

Software and other Deliverables:

- Mobile application, as outlined above. Installed, configured and demonstrated on a device of client's choice.
- Web-based database and administrative portal, as outlined above. Installed on a virtual machine (e.g. AWS) recommended by team and provided by sponsor.
- User manual written for non-technical (ecologist) users, covering installation, configuration, and updating of the core database. Also covers operation of the app, including installation and connection to database.
- A strong as-built report detailing the design and implementation of the product in a complete, clear and professional manner. This document should provide a strong basis for future development of the product.
- Complete professionally-documented codebase, delivered both as a repository in GitHub, BitBucket, or some other version control repository; and as a physical archive on a USB drive.