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Mapping biodiversity patterns using digital imaging and GPS/GIS technologies

Final Report on NWACC project

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The major objectives of this project were to: (1) train students to collect biodiversity data (e.g., species diversity and relative abundance) and document their observations with digital images (video and still photography) along with geographic position data using a GPS, (2) teach students how to enter data and images into a GIS and conduct spatial analyses, (3) make the biodiversity maps and associated images available to a wide audience on the WWW, and (4) collaborate with local government and environmental groups to develop and prioritize restoration efforts. I believe that we have met these objectives, and our major accomplishments since the last report have been to refine the data collection procedures and produce a set of protocols for different habitats, implement the use of the technology into several more classes, partner with a variety of community groups on new projects, create many more digital imaging data sets to add to our website, and update the overall design of the website. We have a variety of projects in progress and others to add in the coming months, making this an ongoing and exciting endeavor for everyone involved. A recent UPS graduate, Erin Spear continued to work on the project until November, and then in February UPS senior Liz Fly took over as the student research technician. Both of them have done an excellent job on all aspects of the project and have contributed their individual creativity and ingenuity to the content. I outline our accomplishments below.

Protocols

Protocols have been written for photo point monitoring of terrestrial, freshwater, and marine habitats. For terrestrial habitats, this includes: Effectiveness of Restoration Projects, Biodiversity Surveys, and Invasive Species Monitoring. These protocols were based off of Hall (2002). The freshwater protocol focuses on Macroinvertebrate Stream Sampling. For marine habitats, the protocols include Intertidal Biodiversity Surveys and Subtidal Surveys.

Protocols have also been written for both the software and hardware used, including the Trimble GPS Unit and Mediamapper software, to allow for easy use by anyone accessing the website. These include:

- Calibrating your Digital Camera with your Trimble GPS Unit
- Creating a data dictionary for the GPS unit
- GPS Data Collection
- Transferring GPS-Linked Photographs to Mediamapper
- Transferring your map to HTML format

Projects conducted with different courses/collaborators

We have now completed eleven different projects (listed below) that have been uploaded to the website, and we have a variety of others that are planned or are still being processed. Collaboration with a number of classes and environmental groups has taken place to sample multiple habitats in the Puget Sound region.

Terrestrial projects

Tree tour of the University of Puget Sound campus: The Biology 112 class at UPS is required to learn about native and introduced plants in the local area, and many of these species occur on the UPS campus. Students typically learn about these species during a campus tour, and we decided to make this an online resource that they could use to find and identify the plants. We used a

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Trimble GeoXT GPS unit and digital cameras to collect georeferenced images of the plants on campus. All species were identified with the help of Ed Cole, the campus arborist, and Betsy Kirkpatrick, the plant biologist at UPS. The website is continuing to be used as a resource by different classes at UPS to identify native and introduced plant species. There are also links to more detailed information on the species that students can access to learn more about natural history and taxonomy. The tree tour website has also been useful to individuals visiting campus that are interested in native and introduced plants.

Point Defiance Park Geology: This project was done in association with the Geology department, and it provides a map that illustrates the geological formations found at Point Defiance Park. Dr. Mike Valentine, of the UPS Geology Department, provided the scientific information for this project. Images of geological formations are linked to their location on a map of the park. This resource is useful to students in Introductory Geology and Environmental Science that are required to learn about the geology of the local environment. The natural history of Point Defiance Park is also of interest to the general public, especially since this year is the 100th anniversary of the park.

Lichen biodiversity on trees: In General Ecology (Bio 211) we designed a lab where students examined the diversity of lichens found on trees in areas with differing levels of exhaust pollution by vehicles. Lichen diversity was examined in areas of high traffic flow vs low traffic flow, and digital images were taken of each quadrat and georeferenced to a map using Mediamapper. These images could then be reviewed at a later time for percent cover analysis and for comparisons with data collected using the dot sampling method. There was a distinct difference in the diversity of lichens among sampling locations, and two students are following up on this for their independent project in General Ecology. They will add the results of their study to the NWACC website when they are done.

Forest Habitat surveys: The class Forest Policy in the Pacific Northwest (SCXT 325F) is assessing pieces of forest that are at risk of development for their natural and economic profits. GPS-linked photographs were taken of two of these sites, Federation Forest and Crescent Valley. The georeferenced images and maps that were produced have helped the group make informed decisions on the threat and value of these lands. They will present their findings to their class as well as community members such as Cascade Land Conservancy, who will incorporate the student research into their own efforts to protect parcels of land.

Freshwater projects

Stream sampling: We finished a protocol for our Diversity of Life classes (Bio 112) where students conduct stream invertebrate biodiversity surveys to monitor stream health. This spring students took digital photographs of the locations where they collect their stream invertebrates to document habitat characteristics. The students were given some basic training on using digital cameras and GPS units, and then they learned how to collect the two types of information simultaneously so that their photographs could be georeferenced and then incorporated into a map. The laboratory of Diversity of Life sampled stream quality of three local creeks: Hylebos, Swan, and Mason Creek. This spring, GPS-linked photographs were taken at four sites at these three creeks. The water quality was analyzed by the students and has been incorporated into the

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maps. These georeferenced images and their associated maps will allow the students a visual of the environmental and man-made factors contributing to stream quality.

Kennedy Creek Salmon trail: A major chum spawning stream in South Puget Sound is Kennedy Creek, and South Puget Sound Salmon Enhancement Group (SPSSEG) has created an interpretive trail at the site where visitors can observe salmon spawning and gain appreciation for the biodiversity in the forest that is essential to the survival of salmon. We are working with SPSSEG to create a virtual tour of the Kennedy Creek site that showcases the biodiversity of the area and documents the fauna and flora that can be observed in the forest. We plan to do similar surveys of other local salmon streams.

Marine projects

Eelgrass beds and bacterial mats in Commencement Bay: Local environmental groups (e.g., Puget Creek Restoration Society) and government agencies (e.g., Washington Department of Natural Resources) are interested in obtaining scientific data on the distribution of eelgrass in Commencement Bay so that they can design future eelgrass restoration projects in the area. Pierce Conservation District provided funding to hire Erin as a technician on this project, and we conducted subtidal surveys of eelgrass beds and bacterial mats in Commencement Bay using underwater videography with the VMS-300. Intertidal surveys were also conducted using a Trimble GeoXT GPS unit and digital cameras and video cameras. Some of the videos and data from this project have been uploaded to the website to demonstrate how video/GPS/GIS technologies can be used to provide information that is important to evaluate environmental problems. Future Marine Biology classes will continue collecting data on this project and their results will be incorporated into the website. This study will provide information on whether eelgrass and bacterial mats are increasing or decreasing over time in Commencement Bay.

North Puget Sound Field Trip: This dataset was collected as part of a field trip to the San Juan Islands in Marine Biology (Bio 477) in the fall of 2005. Students were provided with cameras so that they could take photographs of the local flora and fauna on the trip. A Trimble GeoXT GPS unit was collecting the spatial location of the boat and all of the photographs could be georeferenced once we returned from the trip. The highlight of the trip was an encounter with the local resident pods of killer whales, and students attempted to take photographs of the whales that could be used to identify individuals. One individual was very apparent, J1, the oldest male in the pods that has a large dorsal fin with a notch in it. Students could also use their photographs to identify other whales according to the white patch on their sides and dorsal fin shape.

South Puget Sound Subtidal Biodiversity: In Marine Biology we conducted a variety of subtidal surveys of different habitats using a remote operated vehicle (ROV). Students were required to identify the organisms observed in each habitat and compare their relative abundances. We have added ROV video data from four different habitats observed during the labs. Also, one student did a study of the fish diversity and abundance at Sunrise State Park, a marine protected area, and compared it to an area that is not protected, near Point Defiance Park (ASARCO site). We

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used the ROV to collect the data from each site, and the geographic coordinates for the start and end of the survey were recorded.

Intertidal Biodiversity at Manchester State Park: Each year in Marine Biology we do biodiversity surveys of the intertidal organisms at Manchester State Park. This is one of the few natural rocky intertidal areas in central Puget Sound, and the biodiversity of macrofauna in this habitat is greater than in the more common soft bottom habitats. This year we collected data for the intertidal and documented what was observed using digital cameras. A GPS unit was used to collect spatial data and images were georeferenced using Mediamapper. The data show clear trends in the diversity of organisms with tidal height, size of rock, and the top/bottom of rocks. We plan to compare the diversity observed with other rocky intertidal sites in Puget Sound.

Point Defiance Park Beach Organisms: When collecting data on the geology of Point Defiance Park, we also collected images of the organisms observed in the intertidal. These images were georeferenced using Mediamapper and incorporated in a small webpage. We plan to have future students in Bio 112 expand this list of species during future intertidal field trips to Point Defiance.

Future projects

Future projects are planned with Dr. Travis Horton and Jeff Tepper (Department of Geology and Environmental Studies) to utilize the laboratory exercises for the invertebrate stream sampling and tree sampling in their ENVR-105 Environmental Science classes. In geology they also plan to use Mediamapper for documenting rock formations on their geology field trips, similar to the project that was done down at Point Defiance. This will be especially useful in the Field Geology class where they take field trips at different locations on the west coast to describe major geological formations.

We will also continue to use the protocols and labs created for Diversity of Life (Bio 112), General Ecology (Bio 211), and Marine Biology (Bio 477) courses. Students conducting independent research will also make use of the protocols, equipment and software for documenting their studies of biodiversity. In the future we plan to apply for funds to purchase ROV tracking hardware and software so that we will know in real time where the ROV is in the underwater environment. At this point we only know exactly where we put it into the water and where it comes up. Having an accurate record of the location of where the video footage is collected would be especially useful for the subtidal data, and it would make the information much more useful.

We plan to work with a variety of environmental groups to continue to collect data on biodiversity patterns in the Puget Sound region. At present we will be doing eelgrass surveys in the San Juan Islands and will be doing habitat surveys at a variety of salmon streams. We will also train some 3-5th grade students on using the technology in a marine science camp this summer that is being held in collaboration with Metro Parks, South Puget Sound Salmon Enhancement Group, and the University of Puget Sound. The results of these projects will be added to the NWACC website.

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Impact

This project has provided a novel set of tools for our students to collect and display their data. In addition, it has introduced them to technological applications that are integral to their understanding of spatial relationships in their fields of study. Students played a central role in the collection and development of the data used in this project, and they acquired the necessary skills to utilize digital imaging equipment, GPS units, and then incorporate the data into a GIS and webpage using Mediamapper. We expect to see a variety of professors integrate this technology into their courses, and students use the technology in their independent research projects. Thus, the implementation of this technology will have an ongoing impact on the teaching and research activities at UPS.

Innovation

The combination of digital imaging, GPS and GIS technologies are revolutionizing the way that we view the world. Products like Google Earth are being utilized by the general public to view fine scale spatial data for the planet, and it will soon be very easy for everyone to collect and upload spatial data to the internet. This project has provided students with an exciting opportunity to utilize the technologies that will be needed to become part of this digital imaging and spatial analysis revolution. By incorporating their research findings into an online database where others can view their accomplishments, students have taken ownership of their research project and become responsible for making sure the content is of high quality. Students in future classes will build on information that is collected from previous years, and can use the data to analyze their own questions (e.g., have forested sites changed over time in terms of introduced species or development; are eelgrass densities increasing or decreasing in the intertidal/subtidal).

Feasibility

This project has been very successful because once the appropriate protocols are followed, it is highly feasible to collect a large number of images and then georeference them using Mediamapper. We plan to use the technology on all of the field trips that we take so that we have a record of the major events that occur and the data that we collect. I think it would be feasible for all courses that conduct field trips to utilize this technology if it was more readily available. I gave a lecture on our project to other faculty and they were excited about the possibilities of using it on their field trips in a variety of disciplines.

Technology transfer and outreach

The website for this project will provide a readily accessible resource for the dissemination of data, protocols, and training exercises in conducting biodiversity surveys. This information should be easily transferred to individuals at other institutions who are interested. We have also been conducting outreach activities with local environmental groups and a local high school to incorporate this technology into some of their research projects.

Leverage

The University of Puget Sound has provided technical support from the Office of Information Systems for the computer hardware and software, and they have provided a lab set up with 20 computers with ArcGIS software. The Trimble corporation has provided GPS hardware and software. The digital cameras and video cameras, Remote Operated Vehicle, boat, and field sampling equipment have been supplied by the UPS Biology Department. Pierce Conservation

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District also supplied financial support for Erin Spear to conduct the underwater video surveys for eelgrass in Commencement Bay.

Collaboration

A variety of faculty, government agencies, and environmental organizations have become involved in this project. We partnered with the Puget Creek Restoration Society and Pierce Conservation District to conduct the eelgrass surveys in Commencement Bay. This information will complement the information collected by the Washington Department of Natural Resources, and their scientists have worked with us on protocols and evaluating our data. We will be working with the City of Tacoma and Metro Parks to examine the results of our eelgrass study since there are implications for the future restoration of their property. Our habitat surveys of local freshwater systems are of interest to a variety of environmental groups. We have partnered with South Puget Sound Salmon Enhancement Group to assess the Kennedy Creek watershed, and the information of the Hylebos, Swan Creek, and Puget Creek sites are of interest to the Pierce Conservation district Stream Team and local stream stewards at each site. Our Terrestrial projects were conducted in collaboration with the landowners and Cascade Land Conservancy, a group that is interested in purchasing and becoming stewards of these forested areas.

Outcomes Assessment

The students and collaborators mentioned above have provided us with feedback on the project and we have solicited feedback from users of the website. In our courses, we have tested students on the understanding of spatial patterns in biodiversity and the use of GPS/GIS technologies to collect data. Also, the ability of students to use these technologies are evaluated as part of their research project grade, which is based on the quality of the data collected and the level of analysis.

Project Budget

The majority of the funds requested in this proposal were used to purchase the VMS-300 complete system bundle that includes one copy of MediaMapper and a variety of accessories (\$4,100), and a laptop computer to work with the VMS-300 (\$1,400). In February 2006 I requested that the funds proposed for the purchase of a second copy of Mediamapper (\$2000) be used for additional student support on the project. We did not find a strong need to have a second copy of the software because the computer that Mediamapper is on is readily accessible to people wanting to use the software and hardware (VMS-300). The addition of senior student Liz Fly allowed the project to continue in earnest and she has been able to put in many hours toward completing the objectives of the study. Thus, the remaining funds have been used to support her work on the project.

	Amount
VMS-300 Complete system bundle	\$ 4,100.00
Dell laptop computer	\$ 1,400.00
Hardware/software for laptop	158.00
Wages for Erin Spear	\$ 1863.30
Wages for Liz Fly	\$2474.00
Total	\$ 9,995

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The University of Puget Sound and Pierce Conservation District have provided further support for the purchase of additional equipment, software, and wages for Erin Spear to conduct the eelgrass survey study component of the project.

Thank you for your support of our project. We have all enjoyed working on it and look forward to utilizing this technology in our future teaching and research endeavors.

Sincerely,

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