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THE SALMON RESOURCE AND SENSITIVE AREA MAPPING PROJECT: INTEGRATING A NATURAL RESOURCE GIS WITH FIELD OPERATIONS VIA HANDHELD COMPUTER APPLICATIONS

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Abstract: The Salmon Resource and Sensitive Area Mapping (SRSAM) project was a unique effort undertaken by the Oregon Department of Transportation (ODOT) to develop a Geographic Information System (GIS) of sensitive natural resource sites integrated with high-resolution digital color infrared imagery for the entire Oregon state highway system (approximately 9,000 miles). SRSAM data allow ODOT to plan maintenance and roadway/bridge project activities with up-to-date environmental resource data by providing maintenance workers, biologists, and transportation planners with access to a current, updateable database of sensitive environmental features.

Taking full advantage of the SRSAM GIS for ODOT's transportation planning uses required development of an effective system for delivering information to individual users in the field. To this end, ODOT contracted with Mason, Bruce & Girard, Inc. (MB&G) to develop two handheld computer applications that integrate spatially referenced data, including SRSAM's sensitive resource data, with field data collection forms, thereby allowing users to view, manipulate, and enter data in the field. Use of these applications requires no specialized knowledge of GIS software, empowers users by providing access to an extensive database of environmental information, and through the use of standardized ArcPad forms for routine tasks improves the efficiency of field data collection and management.

The first application addresses ODOT's requirements for Mitigation Site Assessment, and enables biologists to spatially identify areas where maintenance or remediation is necessary. This allows a more rapid and efficient response when regulatory performance standards are not being met. The second application focuses on Environmental Scoping, the process by which ODOT identifies environmental issues likely to be associated with proposed projects. This coarse-level assessment requires numerous sources of environmental information. ODOT's Environmental Scoping Application allows users to view over 20 reference data layers, including project-site imagery, while in the field. Other data layers within the Environmental Scoping application are dynamic, allowing users to update and correct spatially referenced environmental information based on their observations. The computer-based forms for both applications obviate the need to transcribe field data collected on paper, thus eliminating a time-consuming and error-prone procedure.

Overall, SRSAM has provided a mechanism for ODOT to deliver sensitive natural resource data to maintenance crews, biologists, and transportation planners making field decisions that could impact sensitive resources. ODOT's commitment to completing the SRSAM project state-wide was a key reason that ODOT's routine road maintenance activities received a programmatic exemption under the Federal Endangered Species Act (ESA). The cost to ODOT of not obtaining the programmatic permit for maintenance activities has not been calculated, but surely would have been substantial (millions of dollars). Furthermore, the handheld computer applications, as well as the SRSAM GIS, offer a solution to a difficult ODOT challenge by standardizing data collection and storage techniques throughout the state, thereby streamlining ODOT's efforts to protect sensitive resources. In sum, the SRSAM project represents an innovative, multifaceted solution to ODOT's challenge of environmental compliance and stewardship.

The SRSAM Project

During the late 1990s the Oregon Department of Transportation (ODOT) recognized that it could play a central stewardship role in protecting and enhancing Oregon's natural resources. ODOT also realized that attention to natural resource issues as a routine procedure during transportation-related development or maintenance activities could reduce the incidence of unnecessary negative impacts to those resources and the associated costs of mitigation or special permitting. To this end, ODOT began an effort to integrate natural resource management with its transportation system maintenance and development activities. ODOT identified two primary components that would be instrumental to its efforts: 1) a comprehensive inventory of sensitive natural resources along ODOT's transportation network, and 2) capability to produce maps, primarily to be used during maintenance activities, to indicate the locations of sensitive resources and associated restrictions.

ODOT contracted with Mason, Bruce & Girard, Inc. (MB&G), a natural resources consulting firm, to collect the desired natural resource information along ODOT's transportation corridors and develop the associated Geographic Information System (GIS) for storing and updating the statewide inventory. ODOT referred to this effort as the Salmon Resources and Sensitive Area Mapping (SRSAM) project.

To build the GIS, MB&G acquired high resolution color infrared imagery of the entire highway system across the state of Oregon. These imagery data were coupled with existing and field- verified sensitive resource data to form the basis of the SRSAM GIS (Carson et al. 2001, Carson et al. 2003). By the end of the SRSAM project development phase in 2005, MB&G had built a GIS inventory of sensitive natural resource data along all state-maintained highways in Oregon, covering approximately 9,000 roadway miles.

Current Uses of SRSAM Data

The SRSAM data corridor extends at least 500 feet from the centerline along each side of the roadway. This corridor approach accurately captured the data needed to produce the maps ODOT originally desired for use during maintenance and project planning activities. ODOT uses the SRSAM GIS to produce two types of maps that depict: 1) Resource Areas (i.e., "RES" maps), and 2) Restricted Activity Zones (i.e., "RAZ" maps).

Resource Area Maps

RES maps are used by ODOT biologists and project planners to identify the locations of sensitive resources (e.g., streams, wetlands, known rare plant populations, potential threatened or endangered species habitat) along the transportation corridor. These maps indicate the types of sensitive resources present along the highway in 0.01-mile increments, providing an accurate on-site resource tool that can be used when making decisions on resource management. For example, under a separate environmental resource management program, ODOT has established Special Management Areas (SMAs) designed to protect specific native plant species and their habitats in specific locations along roadways. These SMAs are included in the RES maps taken to the field by ODOT biologists and can be updated as new sensitive native vegetation and habitats are located and recorded in the field or as new management activities are implemented at already established sites.

Restricted Activity Zone Maps

ODOT maintenance crews use the RAZ maps to identify sensitive resource sites so that their activities (e.g., mowing, pesticide applications, snow/ice removal, ditch/drainage maintenance) do not harm these resources. The color-coded RAZ maps clearly indicate zones along the roadway where specific maintenance activities are to be completed with caution or avoided entirely due to the presence of a sensitive resource. The maps are designed to require no biological training for interpretation. Through the use of the SRSAM-derived RAZ maps, ODOT actively promotes conservation of sensitive resources and habitats by providing direct knowledge of their locations to roadway maintenance crews so impacts can be avoided.

Handheld Computer Applications

The RAZ and RES maps represent significant improvement over the previous level of natural resource data accessible to ODOT staff. However, prior to the end of the original SRSAM project, ODOT recognized a need to provide even more accurate and up-to-date natural resource data for field actions. The printed RES maps were falling short of this goal since, by necessity, they only depicted data layers chosen before the field visit was made. Important data needed in the field could therefore be inadvertently left off the maps and thus not available during the field visit. In addition, ODOT observed that the SRSAM GIS itself needs to be regularly updated to reflect changes in natural resource locations and conditions as observed in the field; otherwise the data would eventually become archaic. To address these needs, ODOT funded a pilot project and asked MB&G to develop two handheld computer applications designed to deliver information from the SRSAM GIS and other sources to individual users in the field.

To meet the needs of field data delivery, ODOT asked MB&G to focus the application development efforts on two common tasks where SRSAM data had already proven to be useful: 1) post-construction wetland and biological mitigation site monitoring, and 2) environmental scoping for transportation projects.

The hardware platform chosen by ODOT for both handheld computer applications was the Trimble GeoXT, a relatively powerful and field-rugged handheld computer with integrated global positioning system (GPS) capability (sub-meter accuracy). ODOT chose ESRI ArcPad software because of its GIS/GPS capability and its customizable data entry interface.

The handheld applications deliver GIS data and imagery to the user in the field. The user then populates ODOT-standard electronic data forms presented by the application following a standardized field survey protocol. Both applications also enable the user to collect new spatially referenced (GPS) data while in the field. The electronic forms embedded in the applications, coupled with standardized field data collection methods required by users of the applications, promote consistency and efficiency while reducing errors due to data transcription.

Mitigation Site Assessment Application

Transportation projects in Oregon, such as bridge replacements or roadway widening efforts, often result in impacts to regulated biological or wetland resources (e.g., fish species protected by the Federal Endangered Species Act or wetlands protected by the Clean Water Act). ODOT must meet mitigation conditions included in any project-related permits they receive from regulatory agencies during the environmental permitting process. These permits frequently require ODOT to offset the expected impacts to regulated resources by constructing and maintaining mitigation sites such as created wetlands or fish habitat improvements. These mitigation efforts must be monitored over a period of time, often 5 years, to satisfy defined success criteria for providing legitimate replacement of the resource functions lost by building the project. ODOT desired a handheld computer application that would enable staff to collect the monitoring data associated with ODOT mitigation sites throughout the state.

MB&G delivered Version 1 of the Mitigation Site Assessment Application to ODOT in December, 2005. During 2006 ODOT contracted with MB&G to monitor 14 biological and wetland mitigation sites using the Mitigation Application. Overall, the application proved to be an effective tool for monitoring mitigation sites. Data collected with the Mitigation Application were used by ODOT to produce monitoring reports for submittal to the regulatory agencies involved in permitting and monitoring each project (e.g., see MB&G 2006). MB&G is currently updating and refining the Mitigation Application for state-wide use by ODOT and contractor biologists performing mitigation monitoring.

Environmental Scoping Application

Early in the project development process, the ODOT Regional Environmental Coordinator (REC) visits a proposed project site to identify the environmental issues likely to be associated with the proposed project. This initial site reconnaissance serves to provide a coarse-level assessment of the expected environmental permitting requirements for the project. The REC typically populates a standard ODOT form designed to capture this information, and then produces a report based on the data collected during the site visit. This coarse-level assessment requires the REC to access numerous (>20) sources of environmental information (i.e. Oregon Natural Heritage Information, Hazardous Materials Sites, etc.) from the Web and from ODOT's server prior to conducting the site reconnaissance.

ODOT recognized that having the data from these databases available to the REC during the site reconnaissance would greatly increase efficiency and effectiveness. A further advantage of having the data available in the field is that the REC can record inaccuracies or omissions in the database information detected during the routine visit, thereby improving the quality of the base data. ODOT asked MB&G to design a handheld application, the Environmental Scoping Application, to meet this need. The key functionality desired by ODOT was the delivery of key environmental base data layers, ability to populate standard site reconnaissance field forms, and the ability to capture and edit spatially-referenced (via GPS) data while in the field.

MB&G delivered Version 1 of the Environmental Scoping Application to ODOT in December 2005. Version 1 displays 21 distinct data layers of environmental information for access by the REC during the site reconnaissance. In addition, this application allows the user to populate standard site reconnaissance field forms and to capture new point, line, and polygon data that are geo-referenced and associated with attribute forms. This Environmental Scoping Application has yet to be systematically field tested by ODOT, but this may occur in 2007.

Conclusions

SRSAM has increased ODOT's efficiency with respect to environmental regulatory compliance and managing environmental resources by delivering sensitive natural resource data to personnel tasked with making decisions that could impact those resources: maintenance crews, biologists, and transportation planners. In addition, the handheld computer applications, as well as the SRSAM GIS, offer a solution to a difficult ODOT challenge by standardizing data collection and storage techniques throughout the state, thereby streamlining ODOT's efforts to protect and manage sensitive resources.

In summary, SRSAM has provided ODOT with the ability to deliver critical natural resource data to maintenance crews, biologists, and transportation planners making field decisions that could impact sensitive resources. The hand-held applications developed by ODOT and MB&G have enhanced and improved this ability, thus furthering the Agency's resource protection and stewardship goals.

Biographical Sketches: Bob Carson is a Principal with Mason, Bruce & Girard, Inc., and the manager of the Environmental Services Group. His 25 years of experience includes serving as environmental project manager or task leader on over 200 projects involving Endangered Species Act (ESA) and National Environmental Policy Act (NEPA) compliance and permitting, biological resource studies, and wetland delineation and mitigation. His technical expertise includes wildlife, forest, and wetland ecology and management. Bob is a Certified Wildlife Biologist and a certified Professional Wetland Scientist. He earned his Masters of Science in Wildlife Resources in 1984 from the University of Idaho, and Bachelor of Science in Forest Science in 1981 from The Pennsylvania State University.

Milt Hill is an Environmental GIS Program Manager with the Oregon Department of Transportation (ODOT). His 19 years of experience with Geographic Information Systems (GIS) in State Government encompass a broad range of activities including computer system administration, GIS analysis, GIS project management, program administration, and contract and consultant management. Prior to his employment with ODOT, Milt was the GIS Program Coordinator for the Oregon Department of Fish and Wildlife (ODFW). Milt is a certified GIS Professional (GISP) and has completed the Oregon Project Management Certification Program (OPMCP). He earned his Bachelor of Science in Geography from Portland State University in 1989.

Wendy Wente is an ecologist and project manager with Mason, Bruce & Girard, Inc. She has 13 years of experience in research design and implementation. Her professional expertise includes wildlife surveys, habitat assessments and field research designed to meet the needs of public sector clients. She specializes in federal permitting documentation primarily associated with the Endangered Species Act and the National Environmental Policy Act. Wendy earned a Bachelor of Science degree in Zoology in 1992 from Miami University in Oxford, Ohio. She completed her Ph.D. in Ecology, Evolution, and Animal Behavior at Indiana University in 2001. Prior to joining MB&G, Wendy worked as a post-doctoral researcher with the US Geological Survey, where she conducted research on problems of applied ecology including a multi-year study of regional amphibian decline and an experimental study of the effects of cattle grazing on wetland water quality.

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