Geospatial Technologies for Wildlife Enforcement in Protected Areas

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Abstract

Environment Canada establishes and manages a network of National Wildlife Areas, Migratory Bird Sanctuaries and Marine Wildlife Areas to protect important wildlife habitat and unique ecosystems. Many areas are remote or in northern locations, making it difficult and costly to monitor ecological integrity and compliance with relevant regulations using conventional means. Environment Canada and the Canadian Space Agency initiated the Space for Habitat project to evaluate a suite of earth observation technologies to facilitate monitoring of high priority habitats across Canada, and to support wildlife enforcement officers in the field. Officers across the country are being equipped with mobile field computers that integrate the powers of Global Positioning Systems, mobile mapping software and satellite imagery. These tools facilitate data collection to support enforcement duties such as inspections and investigations, and verify the accuracy of satellite interpretations. To promote optimal use of the tools and technology, Space for Habitat partnered with the Smithsonian Institute and Carleton University to design and deliver theoretical and hands-on training to enforcement officers. Results demonstrating the potential of earth observation data and other geospatial tools to significantly improve the effectiveness of enforcement and management activities in protected areas are highlighted.

Keywords: Geospatial Technology, Protected Areas, Wildlife Enforcement, Monitoring

1.0 Introduction

Environment Canada establishes and manages a network of National Wildlife Areas, Migratory Bird Sanctuaries and Marine Wildlife Areas to protect important wildlife habitat and unique ecosystems. Many of these protected areas are remote or in northern locations, making it difficult and costly to monitor ecological integrity and compliance with relevant regulations using conventional means. Environment Canada and the Canadian Space Agency initiated the Space for Habitat project to evaluate a suite of earth observation technologies to facilitate monitoring of high priority habitats across Canada, and to support wildlife enforcement officers in the field. In this context, the Space for Habitat project intends to:

(1) Develop and implement an earth observation based land cover monitoring plan, including data acquisition and analysis protocols for the network of National Wildlife Areas and Migratory Bird Sanctuaries (Seed and Duffe, 2008)

(2) Build effective capacity in the use of geospatial technologies within Environment Canada through training and equipping wildlife enforcement officers in the field with mobile GIS and GPS technology.

This paper focuses on the second objective of technology transfer and officer training and some of the challenges in developing and implementing appropriate field data collection protocols to selecting suitable field equipment. We describe how these efforts will lead to improving the effectiveness of enforcement and management activities in protected areas for both domestic and international commitments.

2.0 Applications of Geospatial Technology to Wildlife Enforcement

Geospatial technologies include the suite of hardware and software tools and data associated with Global Positioning Satellites (GPS), remote sensing and Geographic Information Systems (GIS). In recent years, the increased accessibility of these technologies has opened their application beyond the sole use by geomatics professionals and allowed dissemination into the field of wildlife management (O'Neil 2005; Leimgruber et.al., 2006; Sampson and Delgiudice, 2006). Specifically, the successful integration of geospatial technology in wildlife enforcement has been demonstrated with efforts to control deforestation in Brazil (Fearnside, 2003) and reduce unpermitted wetlands loss in Massachusetts (MassDEP, 2006).

Brazil is an emerging example of how geospatial technologies have been integrated into enforcement protocols where a program to control deforestation has been in place since 1999. With the use of imagery from Landsat and the Brazil-China CBERS satellite, deforestation areas >1ha are manually identified and digitally mapped. Areas of deforestation are printed on paper maps and FEMA (Mato Grosso's State Foundation for the Environment) technicians validate the source and potential infraction on the ground using GPS. All infractions are publicly listed on the internet serving as an additional deterrent for land owners. With identifying 95% of clearings over 200 ha being illegal, the Brazilian Institute for Environment and Renewable Resources (IBAMA) and FEMA have been able to target large landholders as the source of most infractions and at least in part attribute declines in deforestation during the late 1990s to improved licensing and control programs (Fearnside, 2003).

In Massachusetts, the Department of Environmental Protection (MassDEP) has substantially increased their ability to track and prosecute illegal wetlands alterations through the application of remote sensing, GIS, GPS and integrated spatial database management. Since the mid 1990s MassDEP has been involved in statewide mapping and monitoring initiatives in an effort to improve tracking of illegal wetlands losses using before and after time-series image analysis. Assessments revealed that over half of wetlands alterations were illegal. In a 5-year period, MassDEP executed 370 higher-level enforcement actions, assessed $3.8 million in penalties and required the restoration of over 50 acres of wetlands (MassDEP, 2006). In fact, penalties imposed in the first 18 months of the program were greater than the cost of the initial investment in technology. More recent developments have focused on the integration of wetlands databases with enforcement records and streamlining the permits and review process through informing policy channels in an effort to develop proactive conservation and enforcement initiatives – before the wetlands loss occurs (MassDEP, 2006).

3.0 Course Development and Officer Training

In the fall of 2006 Space for Habitat partnered with the Smithsonian Institute to develop training material for wildlife law enforcement officers in the use of GPS, GIS and earth observation tools for conducting inspections according to standardized protocols. Specifically, the objectives were to help enforcement officers and support staff through providing: (1) improved inventorying methods and documentation of legacy information; (2) the ability to do spatial data queries and analysis; (3) efficient field navigation and officer safety; (4) improved daily productivity and; (5) supportive geospatial evidence for investigations – all through the appropriate use of geospatial technologies. In designing the course material the goal was to provide a balance of theory and practical field exercises to develop participant skills in using geospatial technology

In 2007, the initial phase of this pilot project successfully provided introductory training for 15 federal and provincial enforcement and conservation officers in addition to 15 support and technical staff mainly within Environment Canada and Parks Canada. Introductory training was offered on campus at Carleton University and involved classroom and lab time to develop participants understanding in the fundamentals of geospatial technology. The field component of the course was carried out in naturalized areas on and surrounding campus. Through completion of the course, participants became aware of the many sources and limitations of geospatial data and its effective use. Participants also developed skills in interpreting and collecting geospatial data and acquired confidence to better communicate their needs with geomatics professionals.

This initial investment in learning the theory about data projections, positional and attribute accuracy and database management standards was essential in providing participants with the baseline knowledge that separates recreational and professional application of geospatial technology. The course was also translated and offered in French with the help of the Quebec region's Canadian Wildlife Service. Overall strong management support has allowed for the continuation of this pilot project with follow up training in the spring summer of 2008 involving the application of geospatial technology at protected area sites across Canada.

In rolling out the pilot course we choose to use tablet PCs with WAAS enabled GPS giving spatial accuracies of 3 to 5 m. The ruggedized touch screen technology was coupled with ArcPad mobile GIS software to provide the user interface for field data collection. Officers were provided with tablet PCs which were loaded with all available archived data for their region. For backdrop information during navigation and data collection, the NRCAN 1:50,000 CanMatrix topographic maps were supplied for the entire EC protected areas network. Additional Landsat and IKONOS satellite imagery were provided when available. In the spring of 2008, 2.5 m SPOT imagery was added for the Prairie Northern Region (PNR).

Outside of the building of custom data collection forms in ArcPad Studio, we provided minimal customization of the user interface in ArcPad understanding that refinement would come from officer feedback. The custom data entry forms were developed for: inspection reports, landcover validation, infrastructure features, wildlife observations, sign information and establishing GPS control points. Use of electronic forms allowed for some standardization of attributes and data quality control. For example, forms were designed with certain required fields that when activated data capture would not proceed unless the required fields were input i.e. observer name.

A series of quick start reference keys were also developed for field use to outline the landcover validation and data capture protocols in an effort to encourage standards and to help troubleshoot in the field. Quick start guides enabled officers to familiarize themselves with data collection protocols without having to invest extensive time flipping through manuals in the field. These standard protocols were an effective way to establish a routine data collection process that was essential for building confidence in using the technology.

4.0 Putting Technology to Work For Habitat Protection

Enforcement officers have already been applying geospatial technology for recording sign information in Spiers Lake National Wildlife Area, and for investigations and Species at Risk protection of the Small-Flowered Sand Verbena in Suffield National Wildlife Area.

For example, in mapping the Small-Flowered Sand Verbena, the ephemeral nature of the population makes it a challenge to protect. Surveys of all known sites in 2001 revealed only two plants, while more than 3000 were counted on similar repeat surveys in 2002. Its growth and abundance are highly dependent on rainfall. Moreover, the plant is an annual so its location is not likely to be apparent outside the growing season. However, given its listed status, knowing the location of seed banks will be useful for critical habitat designation and recovery of the species. GPS surveys have been valuable for collecting baseline reference data on the location of Sand Verbena populations along with geo-tagged photographic evidence.

5.0 Lessons Learned

During the initial pilot project we have learned a few lessons with respect to the application of geospatial technology and the transfer of knowledge and skills to non-traditional geospatial data users. In this context, project success requires: (1) selecting appropriate hardware and software interfaces; (2) fundamental geospatial technology training; (3) follow-up mentoring and clear communication of user needs that is driven by officers in the field; (4) implementing required protocols to insure data integrity and long-term database compatibility and; (5) communicating to all levels of management about the capabilities and appropriate applications of GPS, GIS and remote sensing to wildlife enforcement.

In terms of hardware choices, early indications from the pilot study illustrate that portability is key for officers in the field. Tablet PCs may be more appropriate technology for field biologists who require additional processing needs, and diverse applications that are more suited to research oriented work. As a result, we are currently moving towards using GPS enabled handheld PDA's for field data collection to work in conjunction with officer's vehicle laptop setup. Perhaps having this clear distinction of device functionality combined with a smaller device footprint will promote more frequent use and improve skill levels. Recent PDA technologies are now cost effective for equipping all officers with a device and provide a certain level of standardization in hardware. An added benefit of the PDA's is the increased security associated with portability as the device stays with the officer rather than sitting in a vehicle when not in use.

In selecting appropriate software interfaces, we learned to minimize the amount of required user input and menu searching. This was particularly important when using touch screen technology as some officers felt the transition from traditional to virtual keyboard and mouse to stylus pen interface was not intuitive. Improved touch screen technology e.g. screen sensitivity and data input through voice recognition along with more frequent use are potential avenues for improvement. We are also moving to streamline the ArcPad drop-down menu list, remove functions not used by officers and provide more efficient data capture functions through desktop icons.

In terms of the course material and officer training, it was refined and tailored to align with enforcement needs after the initial course offering. Non-traditional data users generally need concrete evidence of how geospatial technology can fit into their daily routine (Schloss et. al., 2002; O'Neil et. al, 2005). With the help of a few key officers we were able to integrate more relevant officer experience in using this technology on the job in successive course updates. It is also apparent that following initial training, there is a need for mentoring and follow up training along with timely troubleshooting and tech support. Finding ways to seamlessly integrate geospatial technology in everyday operations and increasing frequency of use is necessary for officers to adopt and become proficient in its use.

Because geospatial technology is readily accessible on cell phones, PDA's, portable GPS and other mobile devices it is not generally an impediment to get officers to pick up the technology. The real challenge is to inculcate those involved to adhere to standard protocols and insure data integrity (e.g. positional and attribute accuracy etc.). Transparency and standardization in the capture, storage and dissemination of the data are imperative. With so many types of mapping software available issues of proprietary file formats and data compatibility can hinder data sharing amongst colleagues (Sampson and Delgiudice, 2006). Standard equipment, software and data collection protocols all contribute to building a database of information for both personal and departmental needs that will help effectively enforce and manage protected areas. This is especially true in the longer term with personnel turnover. A geospatial dataset will serve as a way to both share knowledge and provide baseline data from which to assess changing ecological and enforcement dynamics within the protected areas network. In the big picture, when integrated with land cover monitoring objectives and protocols, equipping and training enforcement officers with geospatial technology will improve Environment Canada's effectiveness to follow through on commitments in their Protected Area Network.

Finally, building support for geospatial technology is a long-term investment and having overall institutional support is critical as are demonstrating interim technology and results. Motivation to move forward requires clear objectives, communication and transfer of theory and skills to all levels of the organization. At Environment Canada, keeping managers informed and involved in the process through participation in the GWE course development and seminars, and regular progress updates has helped with the acceptance of geospatial technology into decision-making and organizational planning. In turn, this overall institutional support should provide motivation to officers on the ground that their investment in learning this technology would not be wasted. The communicated message has always been that spatial technologies are a tool that provides useful data in support of targeted analysis and decision making for wildlife enforcement; however, these technologies should never be viewed as making the decisions (O'Neil, 2005).

6.0 Looking Forward

Current developments continue with enterprise database management and further implementation of mobile capabilities including secure wireless access. Adopting a formal database structure will allow for expanding access to information, streamline the database update process, and provide capability of real-time vehicle tracking for officer safety if deemed necessary. Because we foresee increased use of PDA's and wireless access in the field we are in the process of compressing database files for delivery onto the mobile technology.

In the area of officer training, we are considering the possibility of developing self-study training modules that officers could access via online streaming media. This form of training would compliment instructor-led courses, providing additional access for officers who wish to pursue independent learning, and update or refresh skills already introduced.

Reaching out beyond the immediate project, the framework protocol for technology transfer developed and implemented with the Enforcement Directorate of Environment Canada has potential for broader application amongst wildlife biologists, other field researchers and even the general public who visit protected area sites. For example, the Ecological Monitoring and Assessment Networks (EMAN) series of terrestrial ecosystem protocols on biodiversity and community based programs like Frogwatch demonstrate that public input into science can be effectively implemented.

On the international front, the Geomatics For Wildlife Enforcement training material and field protocols are currently being translated into Spanish in preparation for international co-operation with PROFEPA (Procuraduria Federal de Proteccion al Ambiente) and SEMARNAT (Secretaria de Medio Ambiente y Recursos Naturales) for the training of enforcement and conservation personal in Mexico in efforts to develop baseline maps of jaguar (*Panthera onca)* habitat and to develop monitoring protocols to help support enforcement of jaguar and other protected species in region.

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