10 Remote sensing technique for microtopography in endangered species habitat

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History and setting

There is perhaps no more obvious an example of boundary conflicts of human and natural systems in the whole world than the Florida Everglades. Over the last 100 years, the human population of South Florida has exploded from mere thousands to 5 million. The conflicts in values expressed in alterations to the landscape reflect how the human values have changed.

Dividing to conquer

The Everglades are all about the need to control water. The first concerted effort, which took place in 1906, drained Lake Okeechobee to provide water for vast sugar cane and produce farms. Devastating hurricanes in the 1920s caused widespread flooding, the loss of over 1,200 lives, and a public outcry for flood protection. The U.S. Army Corps of Engineers dammed the lake's southern end, and a wider web of drainage canals spread across the wetlands to drain the excess water to the Atlantic Ocean. In 1947, environmentalists succeeded in creating Everglades National Park. In 1950, the state took management control of the water-control structures, such as gates, weirs, and levees, under the Central and Southern Florida (C&SF) Project. The creation of the Big Cypress National Preserve in 1974 added to the sheltered areas, but the booming crush of tourism-borne immigration in the 1970s and 1980s cemented the water conflicts between thriving populations and natural systems.

The physical and political fragmentation of the original Greater Everglades Ecosystem caused the compartmentalized form and function of current managed areas. More than half of the natural function of the original, natural Everglades—once comprising 10,800 sq mi—has been lost to agricultural conversion or urban development.

Dilution of powers

The federal government is the largest steward in South Florida, with about 2.3 million acres, but the South Florida Water Management District jurisdiction encompasses the entire hydrologic drainage basin. However, over 40 management agencies, special districts, departments, and organizations oversee over 75 distinct managed areas. A federal coordinating task force was organized through an interagency agreement in 1993. The 1996 Water Resources Development Act formally integrated 25 member organizations of tribal, state, and local governments into the comprehensive restoration scene.

As NPS Regional Director John J. Reynolds wrote, in a presentation co-authored with Christine Schonewald:

> Science will and must occupy a crucial center in the management of protected areas in the future. The scope of our paper does not focus on the biological or physical sciences.... Rather, it focuses on the interests of people and their values, and the need to bond protected areas to the societies within which they exist. It turns the early 20th century idea of 'boundary' inside out—no longer is a boundary

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> a line of certain demarcation.... No, today a boundary must be seen as something like a 'diffusion filter.' But what a change! (Reynolds and Schonewald 1998).

The two key points of those statements are that we must focus on peoples' values, and that administrative boundaries are fuzzy illusions. Scientific laws, however, follow immutable rules that define the core issues.

Hanging in the balance

Extinction is an irrevocably crossed boundary. The Cape Sable seaside sparrow is a federally listed avian species that is *only* found in the freshwater prairies and marshes of the Florida Everglades. Loss of vegetative habitat and disruptions to its nesting and breeding cycles are the most prominent reasons for the decline of the species. The unifying cause is the water-management scenario—both cumulative and current (Lockwood and Fenn 2000; Mayer 1998). Besides flooding nests, unnatural alterations in the inundation duration have caused vegetation succession that has depleted the grassland habitat of the sparrow's preferred plant species, which is also linked with human management of the natural wildfire cycles (Bass and Kushlan 1982; Lockwood and Logan 2000). Most professional researchers agree that the species' demise may be perilously close (Pimm 1998).

Summarizing the situation, the U.S. Fish and Wildlife Service (USFWS) report *Balancing on the Brink (*USFWS 1998) stated that only three populations of the bird remain. The eastern (Ingraham Highway) population is at risk from fire and catastrophic weather events. The flood-endangered northeastern population, now at 50% of its former size, is not recovering. The Big Cypress population, at only 10% of its former size, is nearly lost (Curnutt et al. 1998).

These almost-sedentary birds move only about 160 m in the nests' home range (Morrison and Dean 2000). Their survivability is intrinsically linked with the hydrology and deep soils for nest-protection vegetation density (Orians et al. 1996).

The management phrase "adaptive planning and management" acknowledges the fact that policy and practice are tenuous experiments, to be modified as additional knowledge accumulates. Adaptive management is composed of three elements: models, support studies, and monitoring. *Models* frame the concepts, *support studies* lead to management alternative options, and, after an alternative is chosen, information from *monitoring* the effects of implementation will refine the conceptual models or alternative options. There are very significant gaps in the basic information and project design. These "certainty factors" have yet to be resolved: resolutions in time and space; process assumptions; the amount, frequency, and quality of data; calibration of the models; and acceptable ranges of error (Goodwin 2001)**.**

"Bathtubs and barriers"

Models used in management of the Everglades hydraulics, hydrology, and animals include the following.

- The eminent South Florida Water Management Model (SFWMM, or WMM) is the source of other models' topographical inputs. Used for water allocations since the late 1970s, it is a regional simulation of the hydrologic cycle: rainfall, evapotranspiration, infiltration, surface and groundwater flow, canal hydraulics, and withdrawals. Its analysis cell-size of 2x2 mi simulates *regional* effects very well.
- The Natural Systems Model (NSM) simulates the hydrologic response to the pre-drainage (pre-modern human) landscape based on estimated original vegetation. Elevation inputs are from SFWMM. NSM relies strongly on rainfall inputs and evapotranspiration.
- The SIMSPAR carrying capacity model uses cells of 500x500 m to represent areas of similar vegetation, topography, and hydrology, as well as

breeding territory density habitat type for Cape Sable seaside sparrow populations. The life history and behavioral characteristics are based on field observations of the species over a 15-year period, and were validated using historical records of daily water levels (Comiskey et al, undated). Although it uses 5- to 16-cm water heights to favor nesting, it does not allow for fire vegetation-succession effects. The model predicts the impact of proposed alternative hydrologic scenarios (Nott 1998). The processes of mortality, mate choice, and dispersal are expressed as simulations.

- The Across Trophic Levels System Simulation model (ATLSS) model uses a higher-resolution form of a "pseudotopography" that is derived from the combination of current vegetation classifications and hydroperiod classifications (USGS-BRD and IEM 1998). It models the ponding-duration and water-level stage. It uses the SFWMM, 2-mi-square cells, but, because of post-processing, calculates within an area of 28.5 sq m.
- The Everglades Landscape Model (ELM) recognizes the bounding effects of levees and canals within six individual sub-basins. That is, the amount of water going *in* must equal that going *out*, less evaporative losses to the atmosphere or transpiration by vegetation. This model is the theater for the combined operational and structural tests. It is a responsive model, using field-monitoring sites and "trigger" events.

All of the models are useful at a regional scale. All models make assumptions in the absence of crucial data.

As the water levels change, there are extremely subtle topographical contour changes in sparrow habitat that form moving boundaries (also known as "drying fronts"). *Regional-scale models should not be used to form predictions on events dependent on a much finer scale of responses.*

Using micro-topographic laser-mapping techniques, the hydrologic limitations delineated by the moving inundation front could be accurately tracked in the field. Knowing the timing and duration of the flooding and "dry-downs" of the grass prairies is also necessary because of attempts to recover original conditions.

Solutions for understanding

More accurate topographic data will produce more realistic model results (DeAngelis et al. 1998). The scientists, modelers, and agricultural interests realized this need and convened the U.S. Geological Survey (USGS) Topography Interest Group. Two methods were tested.

The airborne laser terrain mapper (ALTM) sensor collects backscatter readings (incidental reflections after the light beams hit something) from up to 10,000 LASER pulses emitted per second. The source is swinging from side-to-side along a flight path. The resultant time differential indicates the relative elevation. This system produces enormous amounts of data over a 1,200-m wide swath. A digital terrain model (DTM) with vertical accuracy of up to +/-3 cm can be generated, but 10 cm is what is consistently possible. The ALTM project was a cooperative effort with the USGS Biological Resources Division, the National Park Service, the University of Florida, and Optech, Inc. Simultaneous orthophotography capture is available.

The USGS's airborne height finder (AHF) uses a helicopter-mounted global positioning system unit to precisely locate its position, then a servo-mounted probe is lowered until the servo's clutch senses a set change in the cable-lowering resistance. The cable length is read and topographic height calculated. The results are surprisingly accurate (Desmond et al. 2000). By using the tops of surveyed benchmarks, the AHF was calibrated to have approximately a 3-cm relative vertical error. This program is sampling the southern Everglades on 400-m grids that will produce a regularly sampled digital elevation model (DEM).

Action solutions

The Army Corps of Engineers and USFWS agreed to develop reasonable and prudent alternatives (RPAs) that are consistent with the USFWS Final Biological Opinion (the "Jeopardy Opinion") on the sparrows). These RPA model parameters would be tied to the Interim Structural and Operational Plan model for year 2000. The RPAs are explicit operating rules for water delivery, as measured at key field sites. As an example, a rule might read: "To ensure that the water levels at NP-205 stay below 6.0 feet for a minimum of 60 consecutive days starting March 1." There have been agreements and test programs for water releases into Everglades National Park over the years, such as the Experimental Water Release Project that was started in the 1980s (NPS 1993). The Modified Water Deliveries Project, which relied strongly on the ELM of edge-bound sub-basins, was also a monitored-release design. That project proceeded in steps, with differing alternatives (USACE, 1992; Van Lent, Snow, and James 1999). Allowances for rain-driven operations, triggering events which alter the structure-management schedules, and rules for importing or pumping between other sub-basins are today's management reality.

Lessons for management

The important, prevalently held realization is that communication is the most productive manner to resolve conflicts. Long-term collaboration is the preferred mode of negotiation, because consensus is required and the concerns are too important to be compromised. Compromise—better suited to temporary settlements while under unavoidable time pressures—does not fit these conditions.

Input from the biological community has been effective (Pimm 2000). Hydroperiod performance measures are now accountable. It is to be hoped that the effects of modified prescribed fire management and water releases, combined with monitoring the nesting and breeding success, will increase the available habitat and allow the Cape Sable seaside sparrow population to survive and revive.

The scientific community has established communications forums that involve the management and leadership councils. The formal, interagency restoration partnership provides a comprehensive management framework for the professional teams to discuss issues and strategies. The more people talk, the more we find out that no person puts *any* value on an extinction.

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