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COMPUTER MODELING AS A TOOL TO DEVELOP WETLAND DESIGN AND MANAGEMENT STRATEGY

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Introduction.

In yesterday's plenary session a panel of scientists from environmental and vector control agencies discussed the need for coordination of efforts to develop and manage wetlands. We found that the issue was critical because over 100,000 acres of wetlands is scheduled to be created or enhanced in the near future in California. A good deal of effort was expended on the part of the vector control panelists to make a case to assure that vector control interests would be involved at the early stages of wetland design. If we succeed in becoming involved with a multi-disciplinary planning team on wetlands, however, other very serious problem arise that need to be addressed. It is our experience that the team members have great difficulty communicating effectively together because they operate in different paradigms. The result could be serious conflict that can develop into an adversarial rather than a cooperative relationship between team members. This paper discusses a tool that may help resolve the problem: STELLA modelling. Properly used, it can help illustrate to each team member the consequences of his recommendations on the wetlands.

The objective of this paper is two-fold. First, it discusses the use of computer simulation as a tool to aid in design and management of wetlands. Secondly, and perhaps most importantly, it raises the question of how to best solve the planning problems that arise when experts from various disciplines come together to plan wetlands. The intent of the presentation is not to introduce a valid or robust new model of wetlands. We intend to present a case history of the development of a simulation model which has been designed for use as a planning tool.

It is important to state early in the discussion that the wetland model developed by the authors was not utilized officially by the wetland planning team in their decision or policy making. The authors developed the model simultaneously as the planning progressed, involving only five of the team members directly in model development. The authors feel, however, that the exercise provided sufficient positive benefits to warrant recommending the approach be incorporated into wetland planning processes.

Background.

Wetland restoration, creation, and enhancement has been occurring in Alameda County, California, since the early 1970s. It is driven by public policy, supported by environmentalists, and carried out by governmental agencies. Salt marshes that were once "reclaimed" by levees are being restored to tidal action, restoring their function ecologically and providing for the recovery of wildlife populations. More recently, these "diked marshes" have been recognized by wildlife specialists as important as "seasonal wetlands" providing valuable habitat for additional species of wildlife. These wetlands, with levee systems in place, are now being preserved and enhanced to maximize their wildlife value. Both the tidal and the seasonal wetlands represent an extremely valuable resource, supporting wildlife, and protecting endangered species, as well as providing aesthetic, educational, and recreational benefits to man. The salt marshes of Alameda County make up a vital portion of the total San Francisco Bay ecosystem, much of it belonging to the San Francisco Bay Wildlife Refuge.

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These wetlands are all the more valuable because they are adjacent to highly urbanized cities in the San Francisco Bay area, totalling millions of residents.

Problem.

The authors have recognized that a major problem occurs in the process of planning wetlands because of conflicts arising from policies and objectives of various governmental agencies. The authors recognize that conflicts also arise because of the influence of differing paradigms on the participants. The clash of paradigms creates different "realities" different "blind spots" and an inability to communicate effectively (Horgan 1991). Often representatives of agencies take positions that may have severe consequences to other agencies and seem blind to consequences of their proposed actions. They also, at times, are unwilling to give serious consideration to alternative approaches. The authors felt computer simulation could be a valuable tool to be used in the planning process by showing participants the consequences of their positions and by testing alternative approaches to reaching stated objectives. In general, the authors felt that a properly developed model would assist all participants in replacing linear thinking patterns with systems thinking. We are reporting on our first attempts at developing a computer simulation as a tool to wetland planning.

STELLA.

STELLA is computer simulation software developed for the Apple MacIntosh computers. It has emerged from the system dynamics paradigm developed at M.I.T. in the 1950s by Jay Forrester and others. STELLA has features that make it particularly suitable as a planning tool:

1. The simulated systems are represented by easy to understand graphical representations of the parts: Stocks (state variables) depicted by a rectangle which evokes the image of liquid accumulating in a container; flows depicted by a pipe with a valve to regulate the rate of flow through the pipe; converters represented by a circle which convert input to output; connectors depicted by curved arrows that connect stocks to connectors and connectors to connectors.
2. STELLA requires only the first two steps of the typical fours step modelling process (conceptual, diagrammatic, mathematical and computer programming). Computer and math fear are not a factor in the process since difference equations are created automatically for the user based upon the diagramming process.
3. Simulation models can be created fairly rapidly and modifications of a model can be made almost instantly.
4. Graphical representations of the output are easily and quickly generated.

The Planning Conflict.

The major conflict that emerged from the planning process was between representatives of mosquito control and those representing the endangered species. Ground cracks that develop seasonal wetlands create ideal habitat for the California salt marsh mosquito, *Aedes squamiger* (Coquillett). The representatives of mosquito control felt that disking the cracked ground every 7-10 years was necessary if mosquito control was to be effective over the long term. They argued that deepening of the cracks and increased growth of vegetation would increasingly impair the effectiveness of a biorational pesticide program, resulting in increased applications, rising costs and ultimately intolerable numbers of mosquitoes. They felt, because the vegetation regenerated rapidly, that disking relatively small portions of the marsh (phase disking) over a period of years would allow the population of the endangered salt marsh harvest mouse (*Rethrodontomys megalotis*) to recover from any effects of the disking.

Wildlife representatives argued that the mouse population was just now recovering in the salt marshes from a variety of man-induced impacts, and that disking would place the population at risk. They felt that continued applications of biorational pesticides would suffice. The committee as a whole felt that if this conflict could not be resolved, the committee would have to look to novel water management strategies to prevent soil cracking.

Seasonal Wetland Management Model.

The authors (Page and Roberts 1990) felt the model should focus on the disking conflict and, therefore, developed the Seasonal Wetlands Management Model to test alternatives of mosquito control on a seasonal wetland with respect to costs, effectiveness of mosquito control, and impact on the salt marsh harvest mouse. The authors developed the model by interviewing various members of the planning committee representing the fields of wildlife management, mosquito control, and wetlands research. Literature was reviewed as necessary to fill in gaps in the knowledge. Where assumptions or guesses had to be made, the best approximation of an expert was used. The completed model consisted of sixty-one variables. Management options (decision variables) included:

1. Selection of a level of mosquitoes (threshold level) that would trigger an application of biorational pesticides.
2. A depth of soil cracks that would trigger disking.
3. A stocking rate for the planned introduction of salt marsh harvest mice as well as an immigration rate from the surrounding marshes.

The major stocks (state variables) were depth of cracked soil, biomass of pickleweed, number of mosquito larvae, mosquito control costs, number of mosquito complaints by citizens, number of saltmarsh harvest mice, and number of marsh hawks. A time horizon of thirty years was established for the model.

Model Operation and its Impact on the Experts.

The completed model functioned remarkably similar to predictions by the experts, tending to verify the conclusions of the committee (Page and Roberts 1990). Three alternative mosquito control options or scenarios were tested:

1. No mosquito control.
2. The traditional mosquito control program consisting of an established spray threshold of one larval mosquito per dip and disking every seven years (A pint dipper is used in a standard sampling technique to provide a relative measure of mosquito density).
3. No disking with a spray threshold at <0.5 larval mosquito per dip.

Scenario one created a simulated nightmare of mosquito problems as expected. It also showed, as suggested by the wildlife experts, inherent instability of the salt marsh harvest mouse population associated with random flood events on the wetlands. Scenario two solved the mosquito problem, but had severe impact on the salt marsh harvest mouse population because of the impact of disking. Scenario three, the compromise, did not negatively affect the mice but created a mosquito control program which was judged too costly and of limited effectiveness. The model had verified the nightmares of the mosquito control experts; no disking meant increasing costs and decreasing effectiveness of mosquito control efforts. It had also verified the concerns of the wildlife specialists that disking would have devastating and lasting effects on mouse populations that were already unstable. The model, therefore, supported the committees decision to search for other approaches to preventing soil cracking, such as water management.

For the most part, the various experts were interested and positive about the results of the model. A mosquito control expert, while disappointed that his control recommendations (scenario two) did not appear feasible because of negative impact on endangered species, was, however, gratified to see that the simulation did show cost-effective mosquito control. The views of the wildlife experts tended to be supported by the simulations and as would be expected, they did not appear negative to the modelling approach. At the same time, it must be said that they did not appear to have a great amount of enthusiasm for the approach either.

Conclusions.

The simulation model focused on the problems created by disking cracked ground and relying upon pesticides (biorationals) for the purpose of mosquito control. The committee concluded that disking was inconsistent with proper management of the marsh - a conclusion also supported by the model. The committee is currently looking into the possibility of water management as a means to prevent cracking. The model, with some modifications, may also serve to test proposed water management alternatives.

It is the opinion of the authors that computer simulation is a useful tool in planning wetlands. Such an approach could be of value by testing alternative design and management strategies. More importantly, the authors feel computer simulation in an multi-disciplinary setting may be most valuable in helping individuals see and address the negative consequences of their recommendations.

Epilogue.

It must be evident by now that the major problem addressed by this paper is the problem posed when individuals from different disciplines, with their differing paradigms, come together to plan a complex ecosystem. Kuhn (1962) explained how powerful a paradigm can be to a scientific community by providing a fruitful view of reality. He also warned us that there is no one correct paradigm and that all paradigms have their blind spots. Finally, he explained that communication breaks down between adherents of different paradigms (Horgan 1991), and defined this as incommensurability.

When individuals of differing disciplines are brought together to plan wetlands, they spotlight only that part of reality that is visible from the perspective of their paradigm. Much that is important may be left in darkness. The problem of incommensurability creates additional problems because communications between the disciplines is distorted. The resulting frustration may further impair communication. The group view of reality that ultimately emerges is likely to be incomplete and distorted, with many shadowy areas. The problem cries out for a paradigm broad enough to shine a floodlight on the problem while providing a basis for effective communication. Our use of simulation modeling is an attempt at solving the problems.

We realize that planning wetlands is just one part of total environmental planning. We expect that the problems posed by numerous disciplines coming together is currently occurring throughout the country in many planning settings. We feel that an important reason for presenting this paper to the Conference of the California Mosquito and Vector Control Association is to assist members in developing the needed tools and the perspective to be effective partners in wetland planning.

References.

Horgan, J. 1991. Profile: reluctant revolutionary. Sci. Amer. 264(5):40-49.

Kuhn, T.S. 1962. The Structure of Scientific Revolutions. University of Chicago Press, Chicago.

Page, B. and F.C. Roberts. 1990. Seasonal wetland management model. A report presented to Department of Anthropology and Cybernetic Systems, San Jose State University, San Jose, California.