A group model-building intervention to support wildlife management decisions

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Abstract

A variety of approaches are being developed to elicit knowledge from clients and develop that knowledge into conceptual maps and formal simulation models. We completed a project that provides a case example where the "standard method" was adapted for use in a group model-building intervention. We worked with a group of 10 wildlife managers to support system conceptualization, model formulation, and management response to an increase in negative human-black bear interactions in residential areas of New York State. This article discusses the procedural and conceptual steps, insights, and lessons learned from our model building intervention. Our paper focuses on model-building process and learning outcomes, rather than quantitative validation of a simulation model.

Keywords: Group model building, Scripts, Standard Method, wildlife management

Introduction

Building system dynamics models with client groups has a long tradition in our field and is well documented (cf. Morecroft and Sterman 1994; Richardson and Andersen 1995; Vennix 1996). In the literature several approaches to group model building are discussed (cf. Richardson and Pugh 1981; Roberts et al. 1983; Vennix 1994) with varying stages on how the process of constructing a computer simulation model involves a number of conceptual activities.

Richardson and Pugh (1981) define seven stages in building a system dynamics model: problem identification and definition, system conceptualization, model formulation, analysis of model behavior, model evaluation, policy analysis, and model use or implementation. Roberts et al. (1983) suggest a similar approach to construct a simulation model. Otto and Struben (2004) adapted the "standard method" (Hines 2001) for use to increase understanding about policies to revitalize the fishing industry in Gloucester, Massachusetts. While the standard method consists of similar iterative activities to elite knowledge from a client and then conceptualizes a model, as the approaches noted above, the standard method specifies steps that a system dynamics modeler should consider in a consulting environment. For example, it emphasizes the importance of identifying key variables, which usually involves in-depth discussion with the client, a reference mode to express a "hope" and "fear" scenario, and in-depth analysis of the different loops in the system. The standard method thus uses the lens through which a consultant would look at a model building initiative. While we do not consider our involvement in the project as consultants but facilitators we applied the standard method driven by the previous experience gained in a group modeling initiative for the Gloucester Fishing community.

This article discusses the procedural and conceptual steps, insights, and lessons learned from our model building intervention. Our paper focuses on model-building process and learning outcomes, rather than quantitative validation of a simulation model.

The Bureau of Wildlife in the New York State Department of Environmental Conservation (DEC) is responsible for black bear (*Ursus americanus*) management in New York State. Black bears occur throughout New York State, with primary populations inhabiting three core ranges. Complaints to wildlife agencies about problems with black bears have been increasing over the past decade in New York and throughout the northeastern United States (IAFWA 2004). Complaints to wildlife agencies serve as an indicator that people are experiencing a range of negative economic, psychological, and physiological effects. Of particular concern in New York State is the increasing level of complaints about negative human-bear interactions in residential areas (Schusler and Siemer 2004). Residential development in New York's bear ranges is increasing and so is the frequency of human-bear interactions in those areas (NYSDEC 2003a).

DEC and other wildlife management agencies in the northeastern U.S. are responding to bear-related problems in residential areas, but doing so is costly (IAFWA 2004). It puts a strain on the small staffs of wildlife agencies and reduces the level of funding available for other management activities. Managers and others also worry that negative interactions with bear may lower tolerance for bears and reduce public support for black bear conservation.

Wildlife agency documents provide a source of information on what wildlife managers perceive as the source of these problems. Managers believe that increases in a bear population lead to increases in complaints (and New York's black bear population is growing and becoming more widely distributed, especially in southern New York [NYSDEC 2003a]). They believe that availability of anthropogenic food sources (e.g., garbage, bird seed, pet food, gardens, crop fields) influences the frequency and severity of negative human-bear interactions. In New York and other states, complaint records do reveal a strong association between problem interactions and bear attraction to human food sources. Managers believe that problems with black bears can be reduced through interventions such as regulated bear hunting and problem prevention education. However, some of the assumptions underlying these policies have not been rigorously evaluated and uncertainty remains on the nature of this problem and possible solutions. Research designed to reduce some of this uncertainty could help wildlife managers develop better problem definitions and better evaluate how proposed management actions are likely to affect clearly defined problems.

Understanding the factors driving increased complaints about problems with black bears has broad practical importance to wildlife management agencies. Understanding the systems that generate negative impacts (the important negative effects that people contact an agency to complain about [Riley et al. 2002]) in this context is likely to help managers understand a suite of contemporary wildlife management issues unfolding on the urban-rural interface. The dynamic interactions occurring between people and black bears in residential areas may be similar to those occurring between people and coyote, white-tailed deer, and mountain lion living in the same ecozones. Thus, wildlife managers in New York have a keen interest in understanding the system of factors that explain why problems with black bears are increasing in residential areas.

In 2004, we began working with a team of 10 wildlife managers to support system conceptualization, model formulation, and management response to an increase in negative human-black bear interactions in residential areas of New York State. This specific project was part of a larger effort to inform decisions within a new bear management planning framework (NYSDEC 2003b). Our work culminated in a system dynamics model, which served to improve wildlife managers' understanding of the complex interactions occurring between community residents, wildlife agencies, hunters, and black bears.

Project description

Wildlife managers on the project team were concerned about managing a wide array of negative human-bear interactions. They decided to focus this project on understanding how to manage problems with black bears in residential areas. Human-bear interactions are also common in more rural areas and can result in a range of negative effects that managers wish to limit (e.g., damage to row crops, apiaries, and fruit trees). However, residential interactions were of special concern to the project team because they pose a very low, but real risk to human safety. Human injuries are expected to remain uncommon, but incidences of human injury and unsafe encounters with black bears in the northeast have increased in the past decade and managers are concerned that any continued increase in the rate of threatening incidents could lead to the devaluing of black bears to pest status in the eyes of wildlife management stakeholders. In order to continue managing bears as a valued resource (instead of a pest), they believe it is imperative to manage the number and severity of negative human-bear encounters in residential areas.

Expectations and challenges of the project

After a set of two workshops with the project team and independent working sessions by the modelers, we defined the following policy (or management action) questions to answer through a system dynamics modeling process. These questions are shown below.

- How would changes in *hunting policies* (i.e., the amount of land open to hunting or the date of season opening) influence the frequency and severity of human-bear interactions in residential areas?
- How would changes in the level of agency effort devoted to *prevention education* (i.e., agency resources expended on information/education actions, providing staff time for on-site technical assistance to residents) influence the frequency and severity of human-bear interactions in residential areas?
- Are there leverage points in the system creating residential problems where a wildlife management agency could reduce the frequency or severity of human-bear interactions in residential areas through novel or innovative management actions?

These are practical management questions that may appear simple at first glance. However, each is embedded in a complex set of social and ecological relationships containing uncertainty, unrecognized parameters, and nonlinear feedback structures. The project team viewed the group model building intervention as a means to understand (and later communicate with management stakeholders about) the dynamic complexity of managing a subset of negative human-bear interactions. In addition to answering the management policy questions outlined above, the objectives of the project were to: (1) explore wildlife managers' mental models of how complaints about residential problems with black bears are generated; (2) explore wildlife managers' assumptions about how bear population, housing density, availability of human food sources, and other key variables influence the rate of complaints about residential problems with bears, tolerance for bears, and attitudes towards bears; and (3) identify priorities for additional research (i.e., identify the most important variables in the system that we know the least about). Achieving these objectives was important to the project team because doing so would enable the team to implement subsequent steps in a cycle of adaptive impact management (Riley et al. 2003).

Wildlife management agencies have relied on recreational hunting as the primary means to control the size of black bear populations. There are several uncertainties and challenges associated with using that management tool to address the problem at hand. Hunting pressure is difficult to exert on bears living in or near human residential areas; availability of bears to hunters is influenced by annual variations in food availability and access to private lands; hunting targets the population of bears, not specific individual bears habituated to human food sources; and interest in bear hunting and willingness to take bears is not known.

Management agencies have also relied on educational intervention as a tool to control the number and severity of problems that people experience with bears. However, there is much uncertainty about the effectiveness of educational interventions as a tool to change behaviors that create food attractants for bears (e.g., behaviors related to bird feeding, garbage disposal, use of barbeque grills, etc.). Scholars have questioned the knowledge-attitude-behavior link assumed in many educational intervention strategies. The specific educational strategies employed by wildlife management agencies have received little evaluation (Gore 2004, Lackey and Ham 2003). Agencies have typically devoted very limited resources to these programs and it is not known what level of investment in educational intervention would produce the desired level of reduction in negative human-bear interactions.

Group model building intervention

As previously stated, we adapted Hines' (2001) standard method as a framework for guiding the project team through a model building effort. Our project included a set of on-line activities (i.e., 4 workshops with the project team) and off-line activities (i.e., the modeling team met a number times and worked independently on model development), completed intermittently over an 18-month period (February 2004 – July 2005). In the following sections we describe the steps undertaken and insights gained from our modeling process.

Diagnosing the problem

In the first step of our project we convened the project team for a half-day workshop and we used a set of “scripts” to elicit information about the clients’ perceptions about variables and relationships of concern. We asked our group of wildlife managers (members of a DEC management plan team) to think about negative impacts they wanted to manage, and then create graphs over time for any variable they thought played a role in creating or managing negative impacts. Team members created 45 different graphs during a scripted exercise called graphs over time. On these graphs were 33 different variables that we clustered into 10 broad categories. These variables became the key variables (and boundary for) our model. Figure 1 displays these variables in three sectors familiar to the project team.

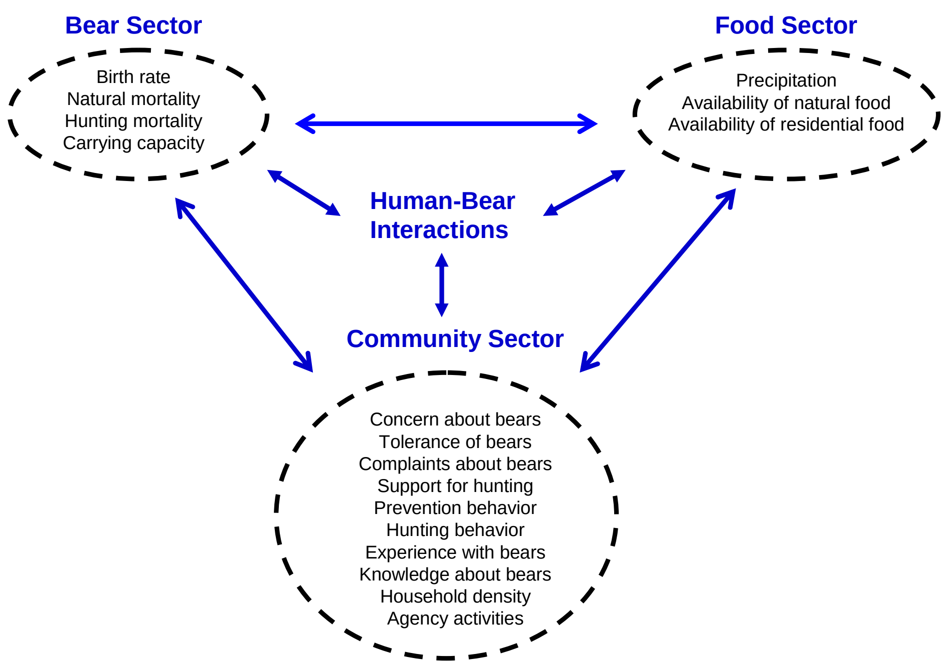

Figure 1. A summary of key variables wildlife managers believed were influencing the level of negative human-bear interactions in residential areas of New York State.

We would later go on to integrate nine of the ten key variables listed below into a simulation with six sectors (i.e., bear population, hunters, food, bear-human interactions, knowledge/interest, and agency resources).

1. **Tolerance:** Human tolerance of bears.
2. **Hunting pressure on bears:** Days of hunting; public interest in hunting/participation in hunting; number of big game hunters; public support for hunting.
3. **Bear population:** Statewide bear population, partitioned into 3 age and 2 sex cohorts.
4. **Sources of bear mortality:** Bear harvest; non-hunting mortality.

5. **Positive attitudes about bears:** Public interest in having bears present; level of public knowledge about bears.
6. **Concerns about bears:** Public concern about bears and bear management; perception that bear problems will occur.
7. **Problems with bears:** Number of complaints; timing of bear-related problems; number of negative human-bear interactions; severity of negative interactions.
8. **Habitat variables:** Natural food availability; human food availability; amount or quality of bear habitat.
9. **Level of DEC activities:** Customer service; level of public education provided by DEC; state research programs; DEC staff working on bear management program.
10. **Outdoor recreation in areas occupied by bears:** Hiker days in bear range; recreation days spent in wilderness.

After the first workshop the modelers met independently to synthesize information gained through several elicitation scripts. Our synthesis of information from workshop #1 allowed us to construct the following problem statement, focused specifically on complaints about problems with bears in residential areas.

> <u>Problem statement</u>: *Negative human-bear interaction is increasing in New York, contributing to an increase in negative impacts. Rise in the number of complaints to DEC is one indication that negative impacts are increasing.*

In the minds of these managers, some set of interventions is necessary to achieve a desired future (managing negative interactions such that the increase in complaints levels off at a socially acceptable level).

Without intervention, managers fear that negative interactions and complaints will continue to rise (Figure 2), with negative consequences for bear management stakeholders, black bear conservation, and the wildlife management agency.

With the information and knowledge elicited in the first workshop, the modelers drew the first causal feedback map (Figure 3). We used the causal loop diagram to discuss the model boundaries and scope of the project with the project team as well as with wildlife experts from the Department of Natural Resources at Cornell University. After a few iterations, the project team agreed that the causal feedback map reflected their understanding of how the variables are interconnected.

In workshops with the project team we have not shown the whole map as seen in Figure 3 on one slide, but unfolded the map loop by loop. The advantage of this layered approach was that we were able to capture individual loops and discuss the meaning and implications of balancing vis-à-vis reinforcing loops. This script proved to be very useful in getting agreement among the project team about the cause and effect of complaints from human-bear interactions. Furthermore, the causal loop diagram also improved the team's understanding of the complex interactions in this system.

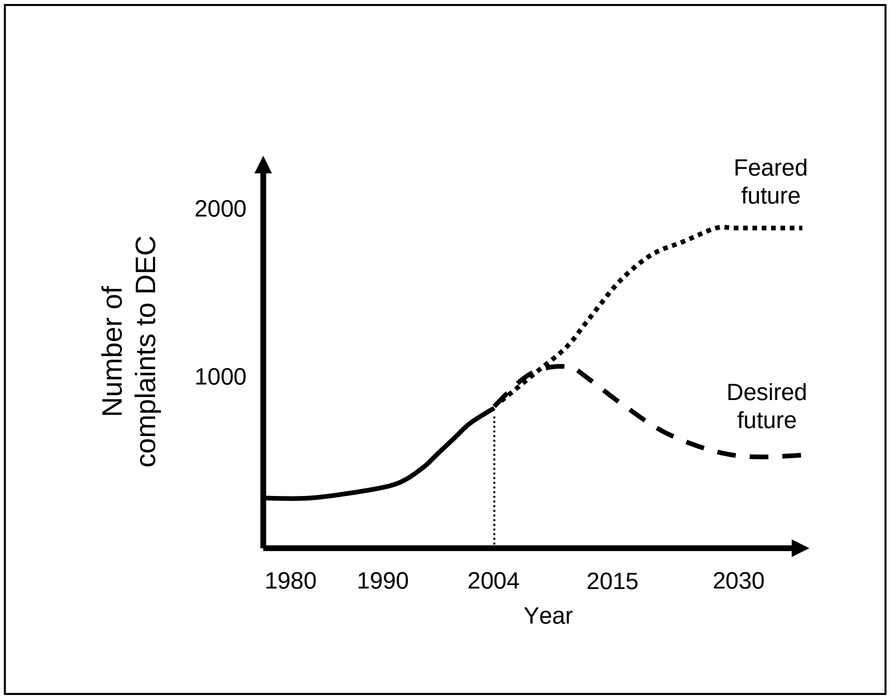

Figure 2. Problem statement (desired and feared future states) identified in 2004 by the project team.

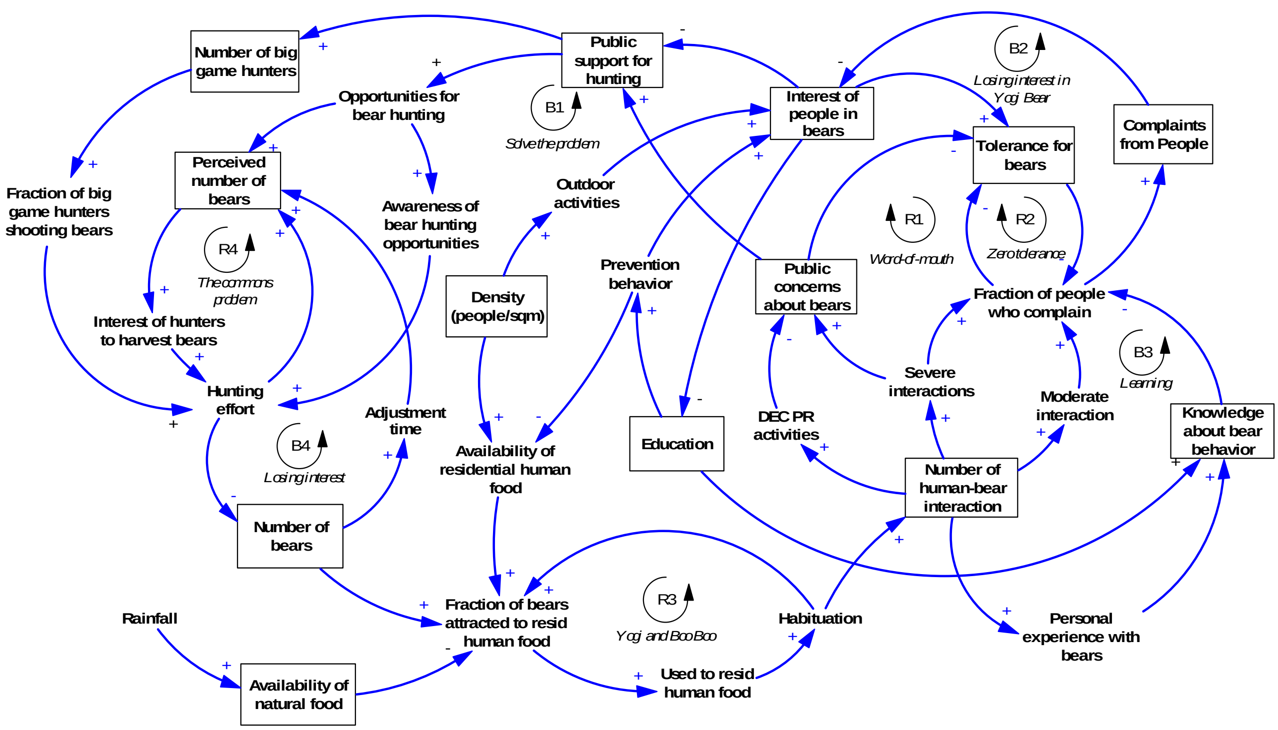

Figure 3. Original causal feedback map developed with the black bear project team.

System boundary and dynamic hypotheses

A synthesis of information obtained through two group model building workshops with the project team allowed us to develop a set of interrelated dynamic hypotheses. The dynamic hypothesis (DH) statements shown below were extracted from a conceptual map developed with the group. In our first workshop, we asked the team to select a number of variables and then draw the expected behavior of the variable over time (we also asked them to identify the value for the Y and X axis). Each DH includes hopes and fears about future behavior. Management interventions are proposed as means to achieve desired future conditions.

Number of bears (DH_1): Increase in the bear population leads to an increase in number of bears attracted to human food, more negative bear-human encounters, and complaints to DEC. The bear population eventually stabilizes at a level far above social carrying capacity. Reducing the bear population reduces negative interactions and complaints to DEC.

Hunting (DH_2): Managers hope opening new hunting areas will increase hunter days, which would reduce: the number of bears, the fraction of bears attracted to food, negative bear-human interactions, and complaints to DEC. Inability to expand hunting areas or change season dates will mean stable or declining hunting pressure (and ultimately, increased complaints).

Negative Interactions (DH_3): As human density increases, availability of human foods increases, the proportion of the bear population attracted to human food sources increases, negative bear-human interactions increase, and complaints to DEC about residential problems increase. Controlling access to human food sources reduces the fraction of bears that are attracted to and then habituated to those foods. That reduces the number of negative interactions and complaints to DEC.

Public Concerns (DH_4): As bears occupy new areas, poor garbage handling attracts bears to people, residential problems increase, and problems with bears contribute to increased public concerns about bears. Word of mouth about bear problems can elevate public concern. Concern levels off after people live with bears and gain personal experience. Personal experience and effective education interventions raise knowledge of bears, increase rate of proper garbage handling, reduce number of problems, and reduce public concerns about bears. Education prevents the elevation in concern from taking place if people only learn from direct experience.

Tolerance (DH_5): As bears occupy new areas, poor garbage handling attracts bears to people, and residential problems increase. Concern increases due to direct experience and word of mouth about problems, leading more residents to become intolerant of bears. Managers hope intolerance will level off as people gain knowledge about preventing problems (or they learn to live with problems).

Education (DH_6): Effective education interventions raise knowledge of bear behavior and increase problem prevention behavior. These things reduce negative interactions and the fraction of people who complain, which leads to reduction in complaints. Managers' fear that education will not occur or will be ineffective, which would mean less change in behavior, less knowledge gain, and increase in complaints.

Scope of the project

We set a time horizon of 50 years, a value we felt was reasonable to test a number of policies considering the scope of our project. A time horizon of 5 decades allowed us to simulate: birth and death of several generations of black bears (average lifespan for bears in New York is 6-8 years); turnover in hunters as they mature and drop out; public reaction to changes in hunting or education policies; and changes in food availability associated with changes in household density. Our simulation was not designed to explore the effects of broad habitat changes. The time horizon we selected is too short to examine such questions.

We used two sets of historic data as reference modes. We have data on complaints about problems with black bears over the past 15 years. We also have data on annual hunting-related mortality for bears since 1955. We used these two sources of historical data to evaluate the model structure and build the project team's confidence in the model. When we presented the model to the team, we initialized our model with settings that approximate conditions like those found in the Adirondack region of New York State.

The problem under investigation is rooted in bear population changes, human behavior patterns, and residential development that go back several decades. As noted above, we constructed a simulation that generally reflects historical data on bear take and bear-related complaints. We were trying to develop a simulation that would generate plausible behavior in terms of the frequency and amplitude of change in bear take and bear-related complaints (i.e., we wanted the simulation to produce realistic behavior). However, we were not attempting to build a simulation that would closely replicate historic data patterns or forecast precise levels of complaints in any future year (i.e., we were not attempting to develop a model with high precision).

We developed a stock-flow model with 199 variables (including 16 stocks) and six model views. We labeled the sectors: bear population, hunters, food, bear-human interactions, knowledge/interest, and agency resources. We partitioned the model into sectors to better visualize the structural components of the model, following George Richardson's advice on good modeling practice. Furthermore, having individual sectors made it easier to communicate with the project team, since the individual model sectors reflected process maps we used in our model-building workshops.

Model building process

Introduction to system dynamics

Before we presented first stock-and-flow diagrams to the client group, we introduced the methodologies of quantitative system dynamics simulation in very broad terms. We felt this short introduction was necessary to help the client understand the diagrams, which we presented in the meetings. One argument for using a direct and straightforward approach, presenting relatively detailed stock-and-flow diagrams, is time efficiency. The disadvantage is that this approach does not involve the project team in detailed conceptualization of the model structure. However, in an iterative process the team will always be able to reflect back to the model and make suggestions for changes.

Model sector views

As previously stated, this paper does not focus on the technical details of the model but on scripts to communicate with the project team and thus create ownership in the model. The sector views shown below were used to discuss structural issues with the project team and to get agreement on the level of detail. We include two sector views as examples, to illustrate the use of stock-and-flow maps in discussion with the project team. Four other sector views are omitted from this paper.

We used sector maps as scripts to get agreement on the structural representation of the model and to create ownership of the team by involving them at an early stage in the model building process. Group discussion about the sector maps exposed underlying assumptions for critical reflection. Group discussions helped us clarify connections and make refinements to the sector views in an iterative process.

Bear population sector. The model structure for the bear population is rather aggregated because we only use three age cohorts; cubs, sub adults, and adults. The structure omits immigration emigration, two variables that can influence the stock labeled total bears. However, after discussions with the project team it was decided that for the purpose of testing effects from different harvest levels, the structure as shown in figure 5 would be sufficiently detailed.

Hunter sector. The hunter sector depicts how the hunting rate is influenced by a number of variables. We are still at an early stage of the model conceptualization thus some of the assumptions in this sector need further investigation. For example, the variable “opportunities for bear hunting” is currently an aggregated view on how DEC regulates hunting rates through opening up new hunting ground or extending the hunting season. However, adding complexity to the model at the current stage of the project may not provide more insights into the fundamental dynamics.

Discussion and reflection

Population modeling is a well used and accepted practice in the field of wildlife management (Conroy 1993). Dynamic systems models have been developed to explore questions about populations of grizzly bears (Faust et al. 2004) and black bears (Patton 1997, Freedman et al. 2003, Dobey et al. 2005). Holling (1978), Walters (1986), and others have established a practice called adaptive resource management, which relies heavily on a systems approach. Their ideas have been adopted as the basis for a national system (adaptive harvest management)

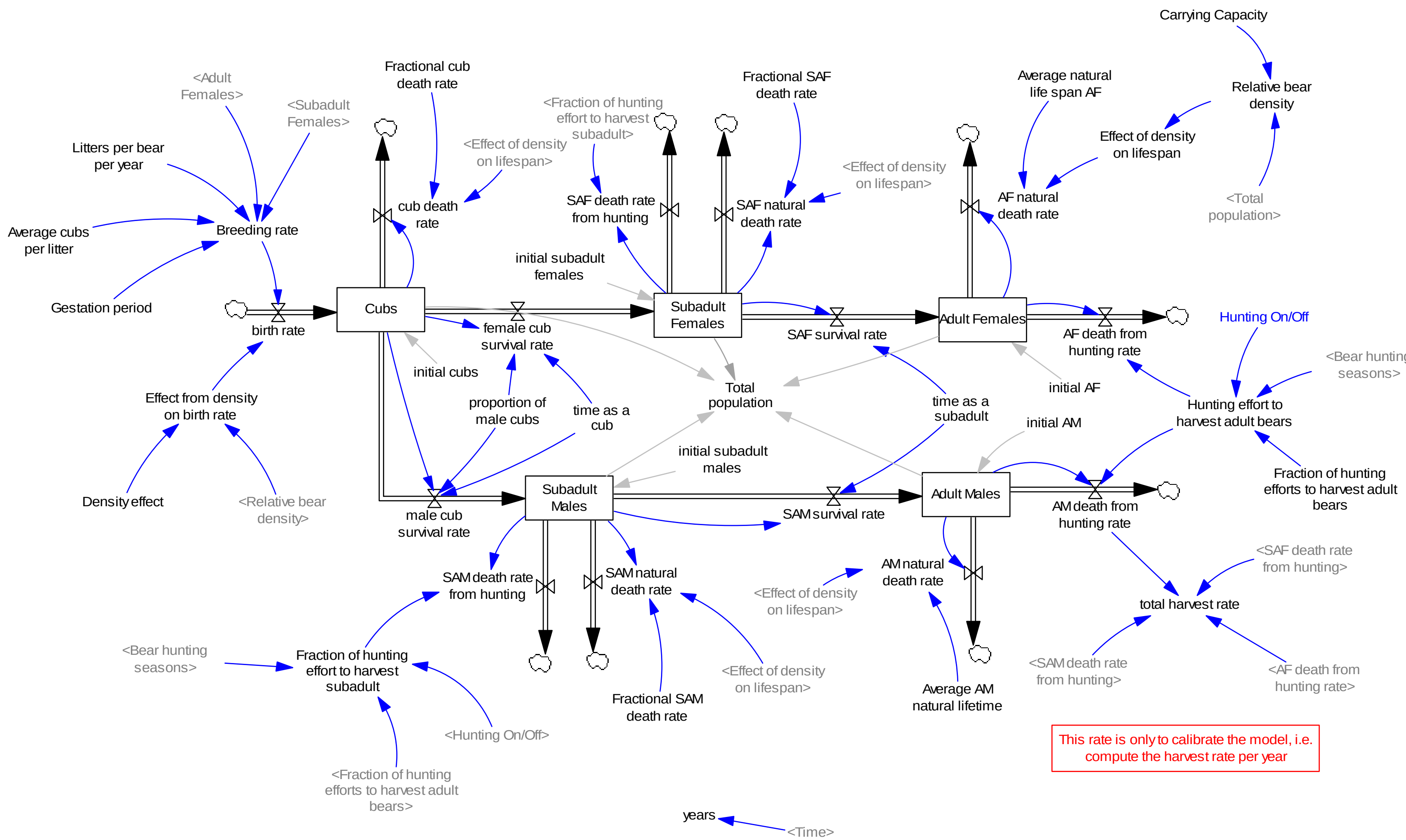

Figure 5. Sector Map for Bear Population.

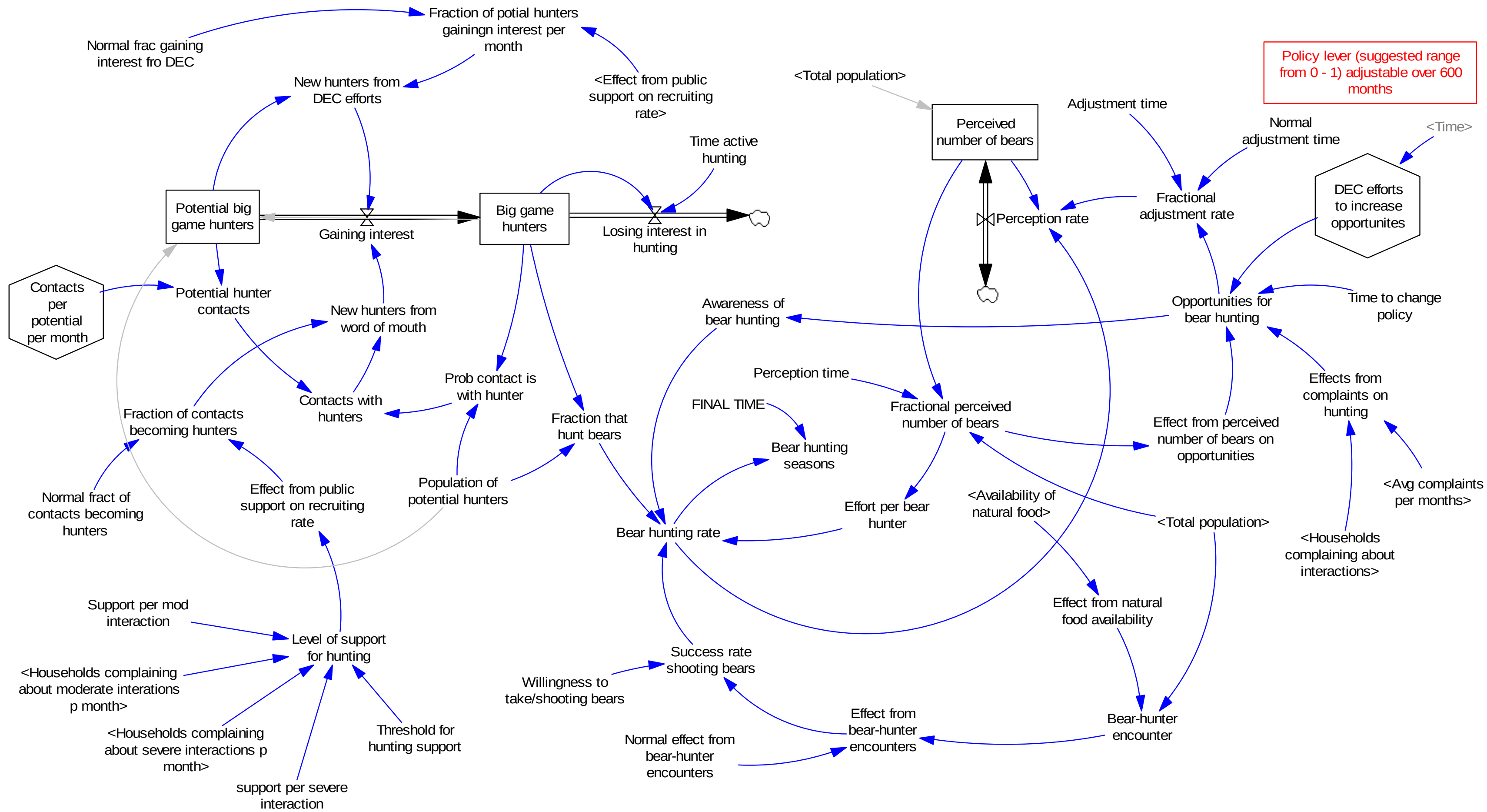

Figure 6. Model Sector to capture number of hunters and hunting rate.

to set harvest regulations for species of migratory waterfowl in the United States (Johnson and Case 2000).

However, the wildlife management profession has not embraced the full range of potential applications to which systems thinking and systems modeling might be applied. Most research and applications to date have focused exclusively on population dynamics, largely ignoring social variables, such as hunter effort (Jensen 2002). Several scholars have argued that society stands to gain as much or more benefit from modeling efforts that go beyond population dynamics, to integrate social or economic variables (Johnson and Case 2000, McKoy 2003) and involve community members and decision makers in the modeling process (Grant 1998, Sage et al. 2003). Sage et al. (2003) provide an example model (using STELLA software) with a "flight simulator" that allows the operator to learn about white-tailed deer population dynamics with simulations for different levels of habitat quality, predation, and hunting pressure. Our work is intended to provide another demonstration project, showing wildlife managers how they can use systems thinking and systems modeling to increase understanding about the dynamic complexity of a wildlife management issue. In a 1998 manuscript, W. E. Grant challenged natural resource management professionals to "be more assertive" in promoting use of a systems approach to environmental education, ecological research, and natural resources management (Grant 1998:74). He states, "*I firmly believe the only way to deliver the systems message effectively is through apprenticeships in which participants are involved actively in the process of developing and using system dynamics models under supervision of experienced modelers*" (Grant 1998:74). The project we report here is just that: an effort to provide wildlife management professionals an apprenticeship experience with assistance from an experienced modeler.

While exercising the model and providing insights to the team is a means to an end, modeling and its iterative process is a learning opportunity for the team as well as the modelers. Using a well grounded framework to guide a team through a modeling process is imperative to ensure that (a) the team takes ownership of the model and (b) it instills confidence when testing policies.

Our final workshop took place in July 2005. We will soon complete the policy testing phase of this project and then we will work with the project team to formulate project conclusions and action recommendations. We are encouraged by our early efforts to build system models with teams of wildlife management professionals. Our experience to date suggests that group model building work, using the standard method, holds promise as a means to help teams of wildlife managers gain a deeper understanding of the complex interactions in the systems they strive to manage. We have found that scripts for group model building used in this project also have communicated well with other wildlife managers not involved in the black bear model building process. Concurrent with the black bear project, we have initiated qualitative systems thinking exercises with wildlife managers focused on quality deer management, beaver management in residential areas, and wildlife disease management in national parks. Managers in each of these contexts have responded positively to scripts that produce concept maps articulating long-held assumptions.

Before the third model building workshop, we asked members of the project team to complete a questionnaire with questions about their assumptions and expectations related to the project. Now that all model building workshops are complete, we will ask members of the project team to complete a post-process questionnaire assessing key beliefs and attitudes about the model-building intervention and about the most appropriate actions to manage increasing complaints about black bears in New York. We developed the pre- and post-process assessment instruments based on the work of Rouwette (2003). We will use information from those written responses and personal interviews completed with project participants to assess changes in beliefs and attitudes, consensus about problem definition, and consensus about how the agency should respond. More rigorous assessment of insights gained and learning outcomes will be possible when that work is completed.

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References

Conroy MJ. 1993. The use of models in natural resource management: prediction not prescription. *Transactions of the North American Wildlife and Natural Resources Conference* **58:** 509-519.

Dobey S, Masters DV, Scheick BK, Clark JD, Pelton MR, Sunquist ME. 2005. Ecology of Florida black bears in the Okefenokee-Osceola ecosystem. *Journal of Wildlife Management Monographs* **158.**

Faust LJ, Jackson, R, Ford A. 2002. Models for management of wildlife populations: lessons from spectacled bears in zoos and grizzly bears in Yellowstone. *System Dynamics Review* **20**(2): 163-178.

Freedman AH, Portier KM, Sunquist ME. 2003. Life history analysis for black bears (*Ursus americanus*) in a changing demographic landscape. *Ecological Modeling* **167** (2003): 47-64.

Gore ML. 2004. Comparison of intervention programs designed to reduce human black bear conflict: a review of literature. HDRU Series Publication No. 04-4. Department of Natural Resources, Cornell University: Ithaca: New York.

Grant WE. 1998. Ecology and natural resource management: reflections from a systems perspective. *Ecological Modeling* **108** (1998): 67-76.

Holling CS (ed). 1978. *Adaptive environmental assessment and management*. John Wiley & Sons: New York.

Hines J. 2001. Course material: "The "standard method." Sloan School of Management, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, MA 02139-4307.

International Association of Fish and Wildlife Agencies (IAFWA). 2004. Potential costs of losing hunting and trapping as wildlife management tools. Animal Use Issues Committee, IAFWA: Washington DC.

Jensen AL. 2002. Analysis of harvest and effort data for wild populations in fluctuating environments. *Ecological Modeling* **157** (2002): 43-49.

Johnson, FA, Case DJ. 2000. Adaptive regulation of waterfowl harvests: lessons learned and prospects for the future. *Transactions of the North American Wildlife and Natural Resources Conference* **65:** 94-108.

Lackey BK, Ham SH. 2003. Contextual analysis of interpretation focused on human-black bear conflict in Yosemite National Park. *Applied Environmental Education and Communication* **2:** 11-21.

McKoy, NH. 2003. Behavioral externalities in natural resource production possibility frontiers: integrating biology and economics to model human-wildlife interactions. *Journal of Environmental Management* **69**(2003): 105-113.

Morecroft, JDW, Sterman JD (eds). 1994. *Modeling for learning Organizations.* Productivity Press: Portland, OR (Now available from Pegasus Communications, Waltham, MA).

NYSDEC. 2003a. Black bears in New York: natural history, range, and interactions with people. New York State Department of Environmental Conservation: Albany, New York.

NYSDEC. 2003b. A framework for black bear management in New York. New York State Department of Environmental Conservation: Albany, New York.

Otto P, Struben J. 2004. Gloucester Fishery: Insights from a group model building intervention. *System Dynamics Review* **20**(4): 287-312.

Patton, BC. 1997. Synthesis of chaos and sustainability in a nonstationary linear dynamic model of the American black bear (*Ursus americanus* Pallus) in the Adirondack Mountains of New York. *Ecological Modeling* **100** (2003): 11-42.

Richardson GP, Andersen DF. 1995. Teamwork in group model building. *System Dynamics Review* **11**(2): 113-137.

Richardson GP, Pugh AL III. 1981. *Introduction to System Dynamics Modeling with DYNAMO.* MIT Press: Cambridge, MA (Now available form Pegasus Communications, Waltham, MA).

Riley SJ, Decker DJ, Carpenter LH, Organ JF, Siemer WF, Mattfeld GF, Parsons G. 2002. The essence of wildlife management. *Wildlife Society Bulletin* **30**(2): 585-593.

Riley SJ, Siemer WF, Decker DJ, Carpenter LH, Organ JF, Berchielli LT. 2003. Adaptive Impact Management: An Integrative Approach to Wildlife Management. *Human Dimensions of Wildlife* **8:** 81-95.

Roberts NH, Andersen DF, Deal RM, Grant MS, Shaffer WA. 1983. *Introduction to Computer Simulation: The System Dynamics Modeling Approach.* Addison-Wesley: Reading, MA.

Rouwette EAJ. 2003. Group model building as mutual persuasion. Wolf Legal Publishers: Nijmegen, The Netherlands.

Sage RW Jr., Patton BC, Salmon PA. 2003. Institutionalized model-making and ecosystem-based management of exploited resource populations: a comparison with instrument flight. *Ecological Modeling* **170** (2003):107-128.

Schusler T, Siemer WF. 2004. Report on stakeholder input groups for black bear impact management in the Lower Catskills, Upper Catskills, and Western New York. Cornell Cooperative Extension of Tompkins County: Ithaca, New York.

Siemer WF, Decker DJ. 2003. 2002 New York State Black Bear Management Survey: Study Overview and Findings Highlights. HDRU Series Publication 03-6. Department of Natural Resources, Cornell University: Ithaca, New York.

Vennix, JAM. 1994. *Building consensus in strategic decision-making: insights from the process of group model-building.* Paper presented at the 1994 International System Dynamics Conference, Stirling, Scotland.

Vennix, JAM. 1996. *Group model building: Facilitated Team Learning Using System Dynamics*, Wiley & Sons: New York.

Vennix, JAM, Andersen DF, Richardson GP. 1997. Introduction: Group model-building—Art and science. *System Dynamics Review* **13**(2): 103-106.

Walters, C. 1986. *Adaptive Management of Natural Resources*. MacMillan: New York.