A conceptual model of suburban wildlife management: a case study of beaver in Massachusetts

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Abstract

The work of wildlife professionals today is often as much about people as it is about wildlife. As some wildlife populations become overabundant and move into human-dominated environments, conflicts between people and wildlife increase. Suburbs are an interface between people and wildlife, and sites for such conflicts. The beaver (*Castor canadensis*) is a common species in Massachusetts' suburbs and often a source of structure and property damage. Since 1996, when Massachusetts passed a ballot initiative limiting trapping, beaver numbers have increased, the harvest has decreased, and complaints about beaver from the public have increased. We designed a conceptual model, which incorporates population dynamics, landscape ecology, human dimensions, and political and economic variables, and applied the model to beaver with specific details for management in suburban areas of Massachusetts. From an analysis of spatial data by town, we found a significant correlation between the state's complaint data set and suburban forests with beaver habitat. Although we need additional data on causal factors before and after the ballot initiative, our results suggest that the growing beaver population and increasing suburban development in parts of Massachusetts are causing increasing conflicts between beavers and people. Our understanding of public values and perceptions of beaver and their management is much less than our understanding of ecology of beaver.

INTRODUCTION

The wildlife profession is facing a major dilemma. The field was founded on ecological studies of wildlife, habitat, and population regulation. Professionals have been attracted to the field by the lure of wilderness work and opportunities to study remote populations of charismatic fauna (Kennedy and Mincolla 1985). However, actual issues facing wildlife and their management today are often in sharp contrast with the profession's origins. Current problems that many professionals encounter are less about wildlife populations and habitats and more about working with diverse publics (Thomas 1986) who are often in conflict with the natural resources. Some wildlife professionals have identified themselves as "combat biologists" because of their encounters with strong public response and opinions about their management actions (Kennedy and Thomas 1995).

A prime site for wildlife-human conflicts is suburbia. The irony of the suburbs is that there is still enough habitat to attract many wildlife species, yet the landscape is dominated by human activities and infrastructures. The results are increasing encounters between wildlife and people.

Effective wildlife management in suburban communities requires skills to work with the public, to address concerns and interests from diverse

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groups about management decisions, and to understand the attitudes, values, and perceptions of stakeholders, in addition to knowledge of wildlife ecology. But what do we know about these stakeholders and the associated social issues, and how do we incorporate them into wildlife management plans? The purpose of this paper is to present a conceptual model, weaving together wildlife and social components, and illustrating the functional process among those components. We applied the conceptual model to a specific wildlife management issue, management of populations of beaver (*Castor canadensis*) in suburban Massachusetts, to illustrate operation of the model and the current level of our knowledge. To work part of the model, we compared distributions of beaver habitat, suburban forests, and public complaints about beaver.

MODELING SUBURBAN WILDLIFE

Management models for urban and suburban wildlife require a balance between people and wildlife ecology (VanDruff et al. 1994, Kennedy and Thomas 1995). Wildlife management professionals have long recognized the importance of understanding human desires relative to wildlife management (Lovejoy 1936), yet our scientific knowledge of the associations between these components remains woefully inadequate (Lovejoy 1995; Brunckhorst and Rollings 1999).

Kennedy and Thomas (1995) presented a model for understanding the interdisciplinary nature of resource management. It is composed of 4 interrelated systems: social, political, economic and natural environment. The social system contains elements such as human values, attitudes, and behavior. The political system represents policy, laws, courts, public agencies and their mandates. The economic system focuses on human attitudes, behavior, and institutions related to the allocation of land, labor, and capital. The natural environmental system includes the biosphere elements, such as human and wildlife populations, natural resources, and ecosystem components and processes. The authors argued that natural resource values originate in the social system, and are expressed to natural resource managers via the social, economic, and political systems. Thus, management activity is largely guided by social values: "there are no universal laws or principles of ecology that mystically establish natural resource values or guide their management on some obvious, pre-ordained path" (Kennedy and Thomas, 1995: 314). Successful resource management requires development of an adequate information base and understanding of each system within the model, and how these systems relate and interact in the management setting.

A MODEL FOR MANAGEMENT OF SUBURBAN BEAVER

Expanding from the Kennedy and Thomas (1995) model, we developed a conceptual model that addresses management of beaver in Massachusetts (Figure 1). To better understand the dynamics of beaver management, our model contains 5 basic components that influence development of alternative solutions and management decisions. They are (1) beaver population dynamics, (2) landscape ecology variables, (3) human knowledge, attitudes and behavior, (4) economic variables, and 5) political variables. These 5 components can contribute to solutions of wildlife conflicts, especially via information and education involving the public, political action, and ultimately wildlife management strategies (Figure 1).

Components of the Model

Beaver population dynamics include reproductive rate, mortality rate and dispersal. Mortality is controlled primarily by predation and disease. Beavers are prolific rodents, producing 2-6 kits per year (Novak 1987). A potential life expectancy of 10 years allows a pair of beaver to produce 618 descendants within their lifetime. Adult beavers live with their offspring in a lodge within a wetland. Their diet consists of woody vegetation found in the wetland or via trees felled from nearby uplands. At 2 years of age, offspring disperse to procure mates and occupy adjacent wetlands. As beavers disperse, wetland occupancy rates increase and dams are erected. Brooks turn into ponds and human property including roads, wells and septic systems become flooded.

The flooding affects landscape ecology variables such as wetland vs. upland acreage, human land use, hydrology, and wildlife habitat. Beaver ponds usually increase the diversity of wildlife, but beaver flooding may have deleterious impacts on many human landscapes. For example, town drinking water well systems are usually associated with protected wetlands. When beaver increase wetland water levels, town wells may become inundated.

Beaver damage can be reflected in economic variables. Costs associated with beaver activities can be quantified and documented. They include, for example, flooded basements and ruined septic systems, inundated roads, and flooded agricultural land and lost crops. Similarly, there are costs associated with management solutions that can also be estimated. In addition, macro-economic impacts of solving beaver damage can be evaluated on a regional or statewide basis (e.g. roads, railroad tracks, regional drinking water).

Our level of information and understanding of the social system (human knowledge, attitudes, and behavior) relative to beaver management is inadequate. We know little about the public's values regarding beavers and their knowledge of beavers, beaver management, or the variety of means for controlling their numbers. Similarly, we have little understanding of their tolerance for impacts resulting from the natural activities of beaver, or how their attitudes will shift as these impacts increase in frequency and severity. When wildlife exceeds this "cultural carrying capacity", valuable wildlife resources become viewed as pests (Ellingwood and Spignesi 1986). Enck et al. (1998) found in New York that stakeholders' beliefs about severity of beaver damage had the greatest influence on acceptance of this species.

Current management of beaver in Massachusetts has been driven by passage of the 1996 ballot initiative ("Wildlife Protection Act" [Massachusetts General Law, Chapter 131, Section 80A]), an example of social values (as held by the voting public) expressed through the political system (the initiative process) to resource managers. Regulated beaver trapping as a form of population management existed until 1996 when the ballot initiative was passed by a 2-1 margin via general election (Deblinger et al. in press). Among other changes, the ballot initiative prohibited the use of foothold traps and restricted (by permit only for flooding-complaint sites) the use of Conibear traps under water for beaver. Live traps, such as box and cage traps, were permitted. In addition, large "clamshell" traps, such as Bailey and Hancock traps, were permitted.

The beaver harvest in Massachusetts before 1996 was approximately 1,500 per year. After passage of the ballot initiative in 1996, only a few licensed trappers continued to trap, resulting in fewer than 100 beaver harvested annually since 1996. Consequently, the Massachusetts beaver population surpassed the statewide goal of 18,000 to a current high of 52,000. Similarly, the number of beaver flooding complaints increased from 352 in 1995 to 689 in 1998.

As the beaver population and conflicts continue to increase, will impacts from beaver activity reach a point where public attitudes change and legislation is proposed to reverse the ballot initiative? If so, what options for beaver control are most acceptable, and acceptable to what portion of the human population? The options within the political system are, in part, controlled by what happens within the social, ecological, and economic systems.

METHODS

The study area for our evaluation of beaver habitat in suburbia and associated public complaints was the state of Massachusetts, about 2.4 million ha in area and divided into 351 towns. In 1985, Massachusetts was about 62% forested, 12% agricultural, 6% urban, 3% non-forested wetlands, 15% suburban, and the rest transportation and miscellaneous (MacConnell et al. 1991).

As part of the nationwide biodiversity project called Gap Analysis (Scott et al. 1993), the Southern New England Gap Analysis Project (SNEGAP) developed vegetation maps for Massachusetts, Connecticut, and Rhode Island from hyperclustered Landsat satellite data (1991-1993), using aerial video transects for ground truthing (Slaymaker et al. 1996). The classification system attempted to specify forest types by the dominant canopy species. Of interest here, the classification includes 4 classes of suburban forest. For this paper, suburban forest classes were extracted from the vegetation map, clipped to Massachusetts and lumped into a single class, defined as areas of suburb with a mature forest canopy, including small (< 5 ha) patches of woods abutting, or included within, the suburbs. Some larger wooded polygons were also included if they were narrow (< 100 m).

Species habitat models were developed for 273 terrestrial vertebrates by SNEGAP based on the Gap vegetation map, digital elevation models, hydrography, and other coverages available for the 3-state region (C. R. Griffin, Univ. Massachusetts, pers. commun.). The beaver habitat model consisted of identifying any deciduous or mixed forest (including suburban forest) within 100 m of a freshwater shoreline, plus both forested and emergent wetlands. The stream gradient criterion (<15%) was not used to reduce the habitat area because the available slope map was too coarse (~100 m pixels) to be of use. Therefore, useable beaver habitat is probably overestimated for the western half of the state.

Beginning in 1989, the Massachusetts Division of Fisheries and Wildlife (MassWildlife) has kept track of beaver complaints by town. Beginning in 1994, wherever possible, a Universal Transverse Mercator (UTM) location was recorded for the problem site. For this paper, we used town statistics (number of complaints by town) from 1990 to 1997 (the most recent year of complete computerized data).

Using ArcView's Spatial Analyst module, a mask of beaver habitat (1=habitat, 0=nonhabitat) was multiplied by a suburban forest mask to produce a map of areas of beaver habitat within suburban forest (suburban-beaver overlap). This map was then summarized by town (hectares of beaver-suburban forest overlap per town) and the result was joined to a town boundary map. Because beaver range was not accounted for in the beaver habitat map, suburban-beaver overlap for counties where beaver are known not to occur (southeastern Massachusetts, Cape Cod and the islands) was set to zero. The complaint database was joined to the same town boundary coverage. The resulting data file of complaints by year and suburban forest overlap by town was exported for statistical analysis and plotting. Pearson's correlation coefficients (n=351) were calculated between suburban forest and complaints (by year and total from 1990-1997). Using a significance level of 0.05 with a Bonferroni adjustment for multiple (9) comparisons means that a correlation must be greater than 0.15 to be statistically significant.

RESULTS

Suburban forest (Figure 2) covers 384,000 ha (18% of land area in Massachusetts). Urban and suburban open areas are not included in this total. Some large-lot suburbs (>5 ac) were not recognized as suburbs in this map.

The geographic information system (GIS) layer of predicted beaver habitat in Massachusetts was not adjusted for beaver range. Therefore, for the coverage of amount of beaver habitat by town that is also in suburban forest, we eliminated potential beaver habitat in southeastern Massachusetts, Cape Cod and the islands where beaver are known not to occur.

The number of beaver complaints has been rising steadily in Massachusetts, particularly in northeastern and southwestern Massachusetts. Southeastern Massachusetts and the major cities of Boston, Worcester, and Springfield have no or few complaints, probably because of the lack of beaver.

Linear correlations between the amount of suburban forest that is beaver habitat in each town, the beaver complaints by town for the years 1990-1997, and the total complaints by town over that period are provided in Table 1. All of the coefficients are significant after 1993, including the coefficient for the total. These relationships explained less than 10% of the variance at most. At this coarse level of analysis, we believe these results are suggestive of a positive trend between complaints and suburban beaver habitat.

DISCUSSION

How well the model worked

We considered 3 components in this application of our model to beaver management: distribution of "suburban" forests (Figure 2), "good" beaver habitat (based on wetlands and forest), and the number and location of beaver complaints. The first 2 relate to beaver ecology and the last 1 relates primarily to social attitudes and values of beaver. Arguably, complaints may also serve as an index to additional economic variables. We showed that there were significant correlations between areas of good beaver habitat in suburban forests and the number of complaints. The model under-predicted complaints in some areas of western Massachusetts, especially rural or agricultural areas, where habitat was good, complaints were high, but suburban forests were not found. The model over-predicted complaints in towns southwest of Boston where there is good beaver habitat but few beavers. However, these towns are likely sites for future conflicts and increased complaints from the public, assuming that the beaver population expands its range. Advance public education programs and discussions with conservation leaders in these towns may help mitigate future conflicts.

We found some of the highest beaver complaints in southwestern Massachusetts, but there were few towns with beaver habitat in suburban forests. We suspect that there are large, wooded estates in this area of the Berkshire Mountains which bring people in contact with beavers although these developments are not defined as suburbs by our classification.

Data needs for the model

Beaver management has depended in the past on a strong foundation of wildlife and wetland ecology (Organ et al. 1998). However, despite the conflicts that beaver have caused over the past several years, there is a paucity of information on social attitudes and tolerances, political effectiveness, and economic conditions relative to suburban beaver management. Although some previous studies have examined beliefs and attitudes toward beaver (Decker 1996; Enck et al. 1997), our understanding of public values and perceptions of beaver and their management is much less than our ecological information. For example, we know little about changes in attitudes and perceptions over time. Longitudinal data collection is necessary to develop an accurate understanding of trends in stakeholders' attitudes, values, and behaviors. Cross-sectional research, which provides one-time, snapshot views of stakeholders, would not be adequate to document the changing public awareness and values towards wildlife species that are also changing in numbers, distribution, activities, and impacts. The imbalance in available information for the ecological and sociological components of our model limits our ability to develop a comprehensive and publicly accepted management program for suburban beaver.

In addition to lacking information on some of the basic components of our model, we also have identified the need for more information on interactions, correlations, and causal relationships between those components. For example, we know from past studies that pelt price influenced the number of trappers (Organ et al. 1998). Yet we know nothing of the economic factors influencing beaver complaints or attitudes towards beaver. In this study, we demonstrated with the spatial data that suburban forests and beaver complaints are correlated. These initial examinations of beaver-human interactions leave many questions unanswered about other associations among components of a balanced model for beaver management.

Future directions

Some of the relationships to explore further with our model and GIS analyses are exact location and habitat characteristics of beaver complaints and whether complaints are associated with housing development in wetland areas (allowable prior to the 1975 Massachusetts Wetlands Protection Act). Also, the distribution of predicted beaver habitat will be improved by removing those areas with stream gradients >15% where beaver would not be found. In this study, we combined 7 years of complaint data prior to the initiative (1990-1996) with 1 year of post-initiative data (1997); as additional years of data become available, we need to conduct a more complete analysis of complaint data and associations before and after the initiative.

Unlike past beaver management programs, which could rely heavily on ecological information with selected input from the public (Organ et al. 1998), sustained beaver management today requires substantially greater input from a diversity of stakeholders. The social movement to limit or prevent consumptive use of wildlife is no longer a radical fringe but a mainstream force that can influence management programs (Minnis 1998). Open communication with all concerned groups serves the purposes of establishing an informed public that can better participate in political decisions affecting management, and building (or re-building) trust between the public and wildlife professionals that may deflect future miscommunications evidenced in citizen-sponsored ballot measures (Minnis 1998). Wildlife professionals today need to become proactive in dialogs with wildlife stakeholders to avoid reactive responses to problems of wildlife-public conflict.

There are costs to co-existing with beaver, whether the population is regulated or not regulated. We can pay those costs now or later. If we pay the deferred costs of not regulating beaver populations, the bill becomes larger due to added costs of (1) managing an over-abundant beaver population, (2) increased damage to private property, roads, and lands, (3) greater time and effort from working with a public that regards beavers as pests, and (4) erosion of public confidence in wildlife management agencies and the credibility of their biologists.

Our conceptual model connects political decisions directly to wildlife population and habitat dynamics and to economic consequences. For example, increased local budgets to repair flooded roads can have future political consequences. Those political decisions may affect wildlife management practices that in turn affect the landscape. Key to any solution of suburban wildlife management lies in understanding the social system: the knowledge, attitudes and behaviors of the people.

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Table 1. Correlation coefficient (r) between number of hectares of beaver habitat in suburbs by town with the number of beaver complaints by that town in Massachusetts, 1990-1997.

	Total	1990	1991	1992	1993	1994	1995	1996	1997
r	0.27*	0.14	0.16*	0.14	0.18*	0.27*	0.27*	0.26*	0.28*

* Significant at the 0.05 level (with Bonferroni adjustment).

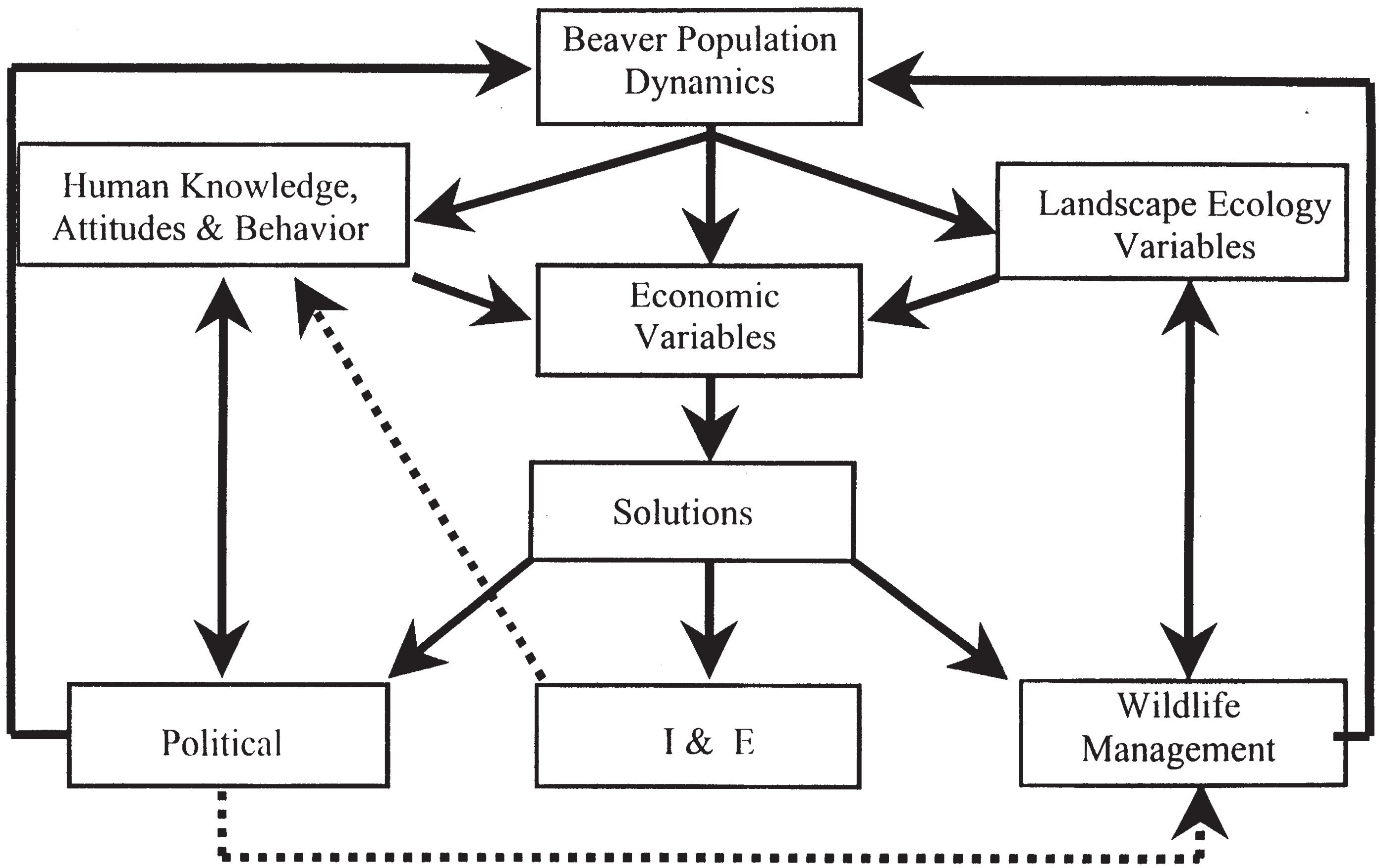

Figure 1. Model of interactions among beaver population, landscape ecology, and political components, human dimensions, and economic variables.

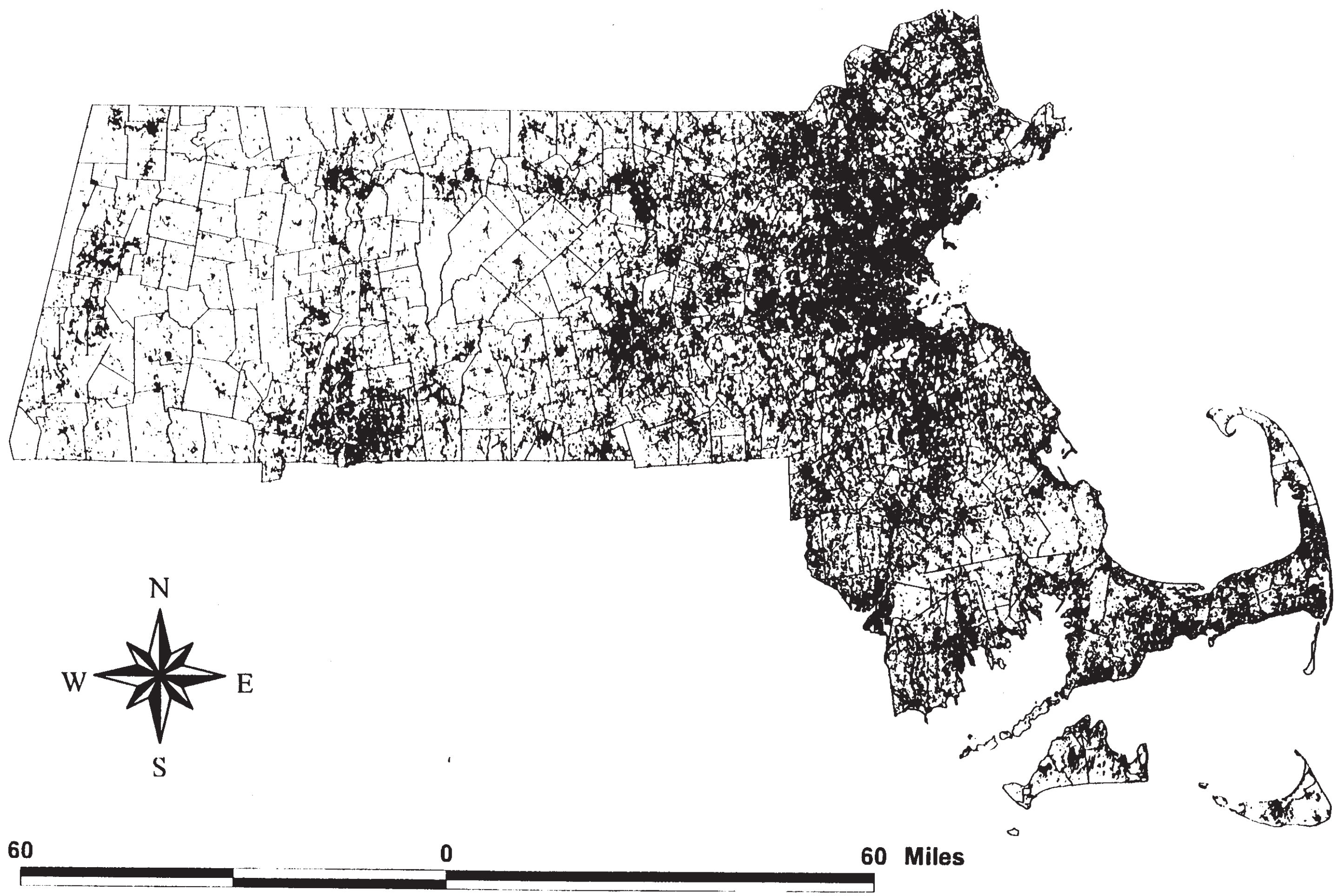

Figure 2. Suburban forests in Massachusetts. Boundaries of Massachusetts towns are overlain by areas identified as suburban forests in the Southern New England Gap Project.