Carrying Capacity Analyses for Tourism and Growth Managment in Coastal Communities

CARRYING CAPACITY ANALYSES FOR TOURISM AND GROWTH MANAGEMENT IN COASTAL COMMUNITIES

Master's Project

Submitted to the Faculty of the
Department of Landscape Architecture & Regional Planning
in Partial Fulfillment of the Requirements for the
Master's Degree in Regional Planning

by

Carol Shaw

February 1991

Approved as to style and content by:

Scott Bollens, Chair

Rodney Warnick, Member

John R. Mullin, Department Head

ACKNOWLEDGEMENTS

I wish to thank my Project Committee, Professors Scott Bollens, Chairman, and Rod Warnick, and also Dr. John Mullin for their continuing support and advice throughout the duration of this project. Also, thanks to Mr. Jerry Scanlon for his assistance in helping me obtain financial aid for this project through the Agnes Lindsay Scholarship Program, and to the staff of the Eastern Mid-Coast Regional Planning Commission for their encouragement and input. A number of people including islanders, town officials, and fellow researchers, generously contributed their time, information and perceptions on tourists and tourism. Although their names are too numerous to list here, their invaluable assistance is gratefully acknowledged.

Carrying Capacity Analyses for Tourism & Growth Management in Coastal Communities

TABLE OF CONTENTS

	Page
Acknowledgements	
Abstract	i
I. Purpose and Introduction	1
A. Purpose	1
B. Scope of Project	2
C. Definitions of Terms	3
D. Introduction	4
II. Literature Review	9
A. Research on Tourism Impacts	9
B. Carrying Capacity Concept	12
C. Types of Capacities	13
D. Factors Influencing Carrying Capacities	15
E. Tourism Development Thresholds	17
III. Methods	21
IV. Review of Coastal Case Studies	23
A. Carrying Capacity Issues in Coastal Tourist Communities	23
B. Management & Regulations Based on Capacities of Island Tourist Communities	26
1. Island Water Resource Management	27
2. Island Solid Waste Management	30
3. Management of Other Island Infrastructure	31
V. Methodology for Carrying Capacity in Recreational Settings	33
A. Formula-Based Approaches	33
B. Standards-Based Approaches	35
C. Visitor Impact Management (VIM) Approach	36
VI. Examples of Capacity Methodology & Planning in Tourist Communities	40
A. Prince Edward Island, Canada	40
B. "Belle Isle", Florida	44
C. Hatteras Island, North Carolina	46
D. Isle au Haut, Maine	48
VII. Beyond Recreation Applications: Carrying Capacity in a Community Setting	51
A. Constraints of Carrying Capacity Analyses	51
B. Carrying Capacities and Growth Management	53
C. Procedure for Determining Carrying Capacity in a Tourist Community	55
VIII. Summary and Recommendations for Future Study	62
IX. References	66
Appendices	
A. Growth & Tourism Management Tools	70
B. Island Case Study Communities	72

ABSTRACT

The rapid growth and uncontrolled development associated with mass tourism severely impacts the quality and supply of natural resources and impairs the functions of public facilities and services in small tourist communities. Island tourist communities are highlighted as an example of tourism's "fragile magnets". These areas are attractive to tourists because of their special natural and scenic resources, but the resources are highly vulnerable to the impacts of tourism and development. The methodologies for assessing visitor impacts on recreational resources are discussed for their applicability to tourism management in a community setting. The carrying capacity concept can be modified from its applications in recreation management to meet the objectives of tourism and growth management programs. Planning based on capacities enables tourist communities, or any area that is experiencing a high growth rate, to determine the limits to growth and to guide the amount and type of growth according to the community's ability to accommodate it.

I. PURPOSE AND INTRODUCTION

A. Purpose

The rapid growth of tourism in recent years is pushing rural tourist communities to their limits. The natural resources, facilities and municipal services in small towns are unable to accommodate the high volumes of visitors and associated development. Often, the most popular tourist areas are ecologically "fragile magnets" (Bosselman 1978). These are areas of exceptional scenic and environmental quality that attract great numbers of tourists, but they are highly sensitive to the impacts of mass tourism. This is particularly true for coastal areas, which have experienced a tremendous increase in tourism development and growth in general.

Strategies for managing tourism impacts have been developed from recreation management which focuses on maintaining the resources to provide quality visitor experiences. Managing the impacts from contemporary tourism requires a broader approach that encompasses the whole tourist community. Municipal planning in a tourist community must be based on the capacity of the resources to accommodate use and development that is directly or indirectly related to tourism. An understanding of the critical, limiting environmental factors in a tourist community is necessary to protect the resources, to maintain the economic viability for tourism and other industries, to provide visitor satisfaction, and to preserve the quality of life for the residents. Carrying capacity analyses can help determine the amount of use or development an area can withstand before the resources are adversely affected or destroyed. Incorporating carrying capacities into the planning and growth management programs is important for any community, regardless of its size or location. However, it is imperative for those areas which are particularly sensitive to high use and development as is the case in many rural tourist communities. The purpose of this project is: 1) to provide a basic understanding of the carrying capacity

concept; 2) to outline the methodologies for conducting recreation environmentally-based carrying capacity analyses and how they can be applied to the whole community; and, 3) to show how the information generated by these analyses can be used by municipal officials and planners to develop tourism and growth management programs.

B. Scope of Project

The focus of this project is on rural tourist communities with small year-round populations that are subject to seasonal and even more dramatic daily population fluctuations due to tourism. Research on tourism impacts and carrying capacities encompass a range of disciplines such as ecology, economics, sociology and psychology. The interrelationships between environmental, social, and economic impacts make it difficult to discuss each type of impact in isolation from the others. The different types of tourism impacts can and often do overlap, but are ultimately tied to the quality and quantity of natural resources. For the purposes of this project, emphasis is placed on environmental impacts and the capacity of the natural environment to accommodate tourism growth and development. Included in the discussion of environmental impacts are the capacities of man-made systems, particularly water supply, sewage treatment and solid waste disposal facilities.

This project summarizes case studies of island and other coastal tourist communities that were previously conducted by the author, in addition to examples of capacity planning found in a subsequent literature review on managing recreation and tourism impacts. Section II reviews the literature on tourism impacts, and explains the principles of the carrying capacity concept, the types of capacities, and the evolution of capacity planning from biological applications to the field of recreation management, and finally to municipal planning and growth management programs. Case studies of coastal tourist communities (primarily islands) are described in Section IV and focus on the impacts of tourism and the

community's management and planning responses. The literature review and the island case studies provide a background for the discussion on the methodology for conducting recreation and environmentally-based carrying capacity analyses, and the applicability of recreation and tourism-based capacity analyses to municipal planning and growth management programs. Section V outlines the methodology for conducting a capacity analysis in a recreational setting. Section VI describes the methods that were used to determine the capacities of four tourist areas, and how the information generated by the analyses was used to develop growth and tourism management policies and regulations. Section VII evaluates carrying capacity applications beyond the field of recreation management to that of local growth management. The constraints of conducting carrying capacity analyses and implementing the results of capacity studies are discussed. The procedure for conducting a carrying capacity analysis in a tourist community is outlined. Examples of regulatory and non-regulatory implementation tools for tourism and growth management are contained in the appendices.

C. Definitions of Terms as Used in this Project

Carrying Capacity: the optimum level of use or development that can be accommodated without a significant degradation of the quality or depletion of the supply of natural resources, or the impairment of functions of physical facilities or municipal services.

Recreation Management: the preservation of natural resources and management of support facilities and services to provide a satisfactory visitor experience within specified management guidelines for a given area.

Tourism Management: similar to recreation management, but takes a broader perspective of the impacts on (or opportunities to enhance) natural resources, the local economy, municipal services and facilities, schools, housing, etc. Tourism management includes the residents' needs and desires, not just the visitors'.

Tourist Community: a municipality in which tourism is a significant contributor to the local economy and also influences the physical, social and cultural character of the community.

D. Introduction

The tourism industry has grown tremendously in the past two to three decades. The personal desire and the means to travel is increasing. The opportunity to travel for personal enrichment and enjoyment has become a significant component of a desirable life style. Compared to other industries, tourism is relatively stable - even during recessions, so it has been aggressively promoted for its economic benefits. Increasing travel demand accompanied by growth in the retail trades and services sectors are predicted to make tourism the leading industry in the nation, and in many regional and local economies by the year 2000 (Hunt 1989).

Tourism is a catalyst for growth and development in small communities and can be an effective economic stimulator in depressed rural areas. Forty years ago tourism was viewed as a non-consumptive, non-polluting and non-intrusive industry. It was believed that the supply of the resources on which it depended was unlimited. Tourists were seen as admirers - not consumers - of the landscapes, customs, and monuments of destination areas. However, with the rapid expansion of tourism came the realization that it, like other industries, competes for scarce resources and capital, and that its non-consumptive attributes do not necessarily prevent the erosion or alteration of the environment or socio-economic resources of the community (Murphy 1985).

The foundation of rural tourism is an area's natural, historical and cultural resources. Rarely does rural tourism rely on some "fabricated attraction", such as a theme park or casino, as the main attraction (Stansfield 1978). Rural communities offer visitors a variety of outdoor recreation opportunities, exceptional scenery, a "small-town" atmosphere, and the chance to see and experience traditional lifestyles. Murphy (1985) describes the relationship between tourism and the environment as a symbiotic one. Tourism depends on healthy, high-quality natural resources to lure visitors to a destination area. Therefore, resource conservation is beneficial to the tourism industry. However,

"the symbiosis breaks down with the physical deterioration of the environment, due to an imbalance between tourist demand and the physical carrying capacity of the destination area" (Murphy 1985, p. 60).

In their pursuit of the economic benefits of tourism development (e.g., employment and tax revenues), many communities overlooked the industry's negative impacts. Unmanaged tourism development threatens natural resources, creates land use conflicts, increases municipal costs and demand for services, and increases housing costs. Tourism also disrupts the normal life and activities of the residents of the host community. These impacts are not always the result of tourism alone, but of rapid growth in general (Mid-Coast Economic Development Council 1989). De Kadt (1976, p. 14) noted that "tourism's impacts can be powerful but it is difficult to isolate the impacts of tourism, or tourists as such, from other forces of change." Tourist communities which have the desirable natural and cultural amenities that attract growth and these areas would probably grow despite tourism. However, the impacts of growth in a tourist community are exacerbated by the influx of thousands of transient visitors (daytrippers) and seasonal residents that swell a year-round population of a few hundred into tens of thousands each day. Hunt (1989, p. 25) stated that "blaming tourism for the problems created by vacation home development, commercial strips, or gentrification is too simplistic. These problems may be related, but it is the environment which encourages these activities to flourish, and our inability to manage these activities within the limits of the environment."

The rate and intensity of tourism development often exceeds the ability of the community to accommodate it. This results in the loss of the features that initially made the community attractive to tourists (i.e., "killing the goose that laid the golden egg") and the loss of the quality of life for the people who live in the tourist community. Lured by the potential economic gains, communities embraced tourism as a means to recover from economic slumps. In the absence of careful analysis and consideration of the

consequences, these communities were led "into a quicksand of false expectations" (Murphy 1985, p. 176). Few rural communities are prepared to manage the impacts of mass tourism and associated tourism development on their small towns. They often lack managerial and fiscal resources to support the service demands created by mass tourism, including people willing or capable of filling additional municipal service positions (e.g., volunteer boards, committees, and emergency services), and funds to maintain and improve public facilities such as water, waste treatment, solid waste disposal, and roads. The quality and quantity of natural resources, particularly fresh water, are threatened by increasing use and development. These threats are magnified by the rapid growth pressures created by mass tourism.

Some tourist areas have already reached a crisis situation wherein capacity levels have been reached or exceeded, and have had to resort to restricting use to protect the resources and special attractions from further degradation. For example, visitor controls are enforced at Stonehenge in England (Mathieson and Wall 1982), in Yosemite National Park (Sax 1980), and on rivers in some wilderness areas (McCool 1978). Acadia National Park on Mount Desert Island, Maine, has wrestled with an exponential growth in visitor numbers (over 4.5 million annually) over the past decade. Vigorous measures such as a barrier gate at the park entrance and mandatory public transportation within the park itself are being explored as ways to restore this "prized jewel of America's National Park system to its former luster" (Bourgeault 1989, p. 9). A tourist community has less direct control over regulating visitor numbers than do the managers of public recreation areas, even if the community has actually exceeded its physical capacities to accommodate the current volumes of tourists. North Conway, New Hampshire, is one example. The capacities of the local roads and the community's sewage treatment facility have both been exceeded, and threaten public health and safety. Yet, for political and economic reasons, the town cannot "close the gates" to tourism and development (Bunnell 1989).

Island tourist communities are under even greater pressure from mass tourism than mainland communities. Island tourism is becoming an important supplement to the other diminishing or unstable traditional industries. Increasing demands on limited island resources threaten the viability of their economies. Traditionally, island economies have depended on local natural resources for fishing and other marine-related industries, for farming and forestry -- and more recently, for tourism. Island resources are highly vulnerable to degradation and depletion by inappropriate uses. The impacts of tourism are nowhere more severe than on islands. Popular island destinations have become so congested by tourists that the "island experience" is no longer much different from other tourist areas (Shaw 1988). However, alternatives for coastal island communities to cope with mass tourism are limited, due to geographic isolation and an island's inherent physical and ecological characteristics. The need for better tourism management is more immediate in island tourist communities than anywherelse.

If the special qualities that lure tourists are to be preserved, the impacts of increasing use must be carefully monitored and regulated. Unfortunately, regulations are usually imposed as reactionary, rather than preventative measures. Rarely has there been an "effort towards guiding land use that fosters rather than restricts tourism, yet protects basic environmental resources" (Gunn 1987, p. 230). Since tourism already contributes significantly to the economies of these areas and is predicted to increase in importance in the future, it is imperative that tourism planning become part of the community's overall planning framework.

Murphy (1985) proposed a more sensitive and cautious approach to tourism management that compares the tourist community to an ecosystem. The complexity of natural systems and their inter-relationships fit well into the tourist community ecosystem model. Understanding the impacts on different elements of the system (environmental, economic, and social), and the implications of those impacts on each other will help the

community integrate tourism into its general planning program, and will aid in coordinating facility developments into the physical and social fabric of destination areas.

An essential component of tourism planning, especially related to protecting the resources that support tourism, is to determine the carrying capacity of the destination area. As a planning tool, a carrying capacity analysis provides the framework for analyzing the different types of resources, considers the impacts of different levels of use and development on the resources, and determines the implications for future planning (Schneider et al. 1978). Islands in particular are prime areas for carrying capacity analyses and planning, due to their ecological fragility and their popularity as tourist destination areas. The tourist island cases reviewed in this project illustrate the delicate balance that exists bewteen resource use and maintaining the quality of these resources, and the difficulty in maintaining this balance when faced with rapid growth.

Although changes to any community are inevitable, the application of carrying capacity can indicate the degree and direction of change and aid in the assessment of the acceptability of such changes (Mathieson and Wall 1982). Sound planning strategies will enable a tourist community to manage tourism as a renewable resource industry and help preserve the quality of life enjoyed by the residents and visitors.

II. LITERATURE REVIEW

A. Research on Tourism Impacts

Early tourism studies focused on the economic impacts, due in part to the industry's revenue contribution to governments and its increasing significance in local, regional, and national economies. The bias towards analyzing the positive, monetary benefits rather than the negative physical and environmental effects of tourism is also a reflection of the research resources that have gone into the two areas (Frechtling 1987). A 1980 survey conducted by the U.S. Travel Data Center examined the types and priorities of research conducted by U.S. state and Canadian provincial travel offices. They found that a greater emphasis was placed on studying the economic benefits than on the environmental and social costs of tourism (Ritchie and Goeldner 1987). The tourism industry has grown so much that it is no longer possible to overlook the costs, both real and perceived, imposed on the tourist communities. The massive scale and the extent of the impacts of contemporary tourism have caused a re-orientation of tourism research. Over the past two decades there has been a shift toward a more balanced perspective which critically examines the long-term impacts of tourism on destination communities (Mathieson and Wall 1982).

Tourism impact analyses, a term that includes visitor impact assessments for recreation management and carrying capacity analyses, have been conducted by researchers from a variety of disciplines. In addition to travel and recreation specialists, tourism studies have conducted by biologists, ecologists, geographers, sociologists, psychologists, economists, and anthropologists. Tourism impact analyses assess the effects of tourism on the different types of resources in the tourist community: the economic and fiscal, physical (natural or man-made), and social systems. This is a difficult task because of the complex interactions between the tourists, the residents of the host community, and the destination area itself. However, the numbers and scope of tourism impact studies are increasing,

indicating a shift towards a more comprehensive view of the interactions of the various elements of tourism development (Mathieson and Wall 1982).

Early environmental impact studies supported the view that tourism and the environment had a purely complementary relationship. It was believed that the environment provided the basis for tourism, and that tourism enhanced the environment. The negative side effects of the industry were not recognized. This was the perspective of the U.S. Congress in 1872 when it established Yellowstone National Park to preserve areas of exceptional natural qualities for the public's *use* and *enjoyment.* The unfortunate paradox is that "use and enjoyment" often conflicts with preservation, particularly in heavily-visited areas. Too often the integrity of the natural resources suffers from the "predatory effects of seasonal migrations of visitors" (Pigram 1980, p. 56). The effects of intensive tourism and recreational activities on the natural environment, particularly in terms of resource depletion and degradation, surfaced in the literature in the 1970s (Wall and Wright 1977).

Cohen's (1978) paper on the environmental impacts of tourism is regarded as one of the classics on this subject. He identified four types of determinants of environmental impacts: site-use intensity, ecosystem resilience, the tourism developer's time perspective (short-term economic gains versus long-term planning for renewable benefits), and environmental transformations. He concluded that as tourism development progresses and becomes a major industry for the destination area the benefits to the environment from tourism are lost. Intensive development of delicate environments which hold a special attraction to tourists, often accompanied by a speculative real estate boom, is bound to lead to a far-reaching environmental transformation (Cohen 1978).

The detrimental effects of excessive visitation on ecologically-sensitive areas are quite obvious and well studied in the National Parks and Forests. Overuse of natural areas damages plants, wildlife and their habitats, and disrupts ecological processes. For

example, millions of feet treading the trails of the National Parks have compacted soils, reduced vegetative cover, and increased soil erosion. Sand dune destruction by thousands of beachcombers is also a problem at popular seashores like Cape Cod in Massachusetts (Sax 1980). Acadia National Park in Maine is the nation's second most-visited national park with annual visitation rates well over 4.5 million, and is one of the smaller national parks in size (40,000 acres). The air quality in Acadia has declined due to the exhaust from thousands of cars driving through the park, as well as to other external sources of air pollution (Bourgeault 1989).

Early recognition of fragile environments and determining appropriate intensities of use and development is necessary to preserve the resources. However, much of the research on the physical impacts of tourism has been limited to after-the-fact analyses. As such, these studies are constrained by certain methodological problems: the difficulty in distinguishing between impacts caused by tourism, and those that are the result of other activities; and, the lack of baseline conditions upon which the degree of change can be assessed (Wall and Wright 1977). In order to reduce or prevent the impacts of tourism, a tourist community must consider certain questions as it develops a growth and/or tourism management program:

- How many tourists are too many?;
- How much growth and development can be accommodated before resources are destroyed, and the natural amenities (the reason for tourism) are lost?; and,
- What are the warning signs that capacities will soon be reached or exceeded?.

These questions can be addressed through carrying capacity analyses which attempt to establish safe, acceptable levels of use or development *before* substantial degradation occurs. It is important to note that any activity or development will result in some physical impacts, but the application of capacity planning can help identify the amount and direction

of that change, and allow various controls and management policies to be implemented before unacceptable levels of change are reached (Williams 1987).

B. Carrying Capacity Concept

The concept of carrying capacity essentially states that there are limits to the amount of development or use an area can withstand before the public health, safety and welfare and the functions of the natural environment are seriously impaired. The carrying capacity concept is not new. It has been the basis for wildlife and habitat management for several decades. The initial purpose of wildlife and range management was to maintain an optimal number of animals, based on the physical and ecological characteristics of their habitats, to support hunting and fishing. Ecological capacities became an important element of managing natural resources to enhance recreational opportunities.

Since the early 1970s, the amount of research on carrying capacity has grown, particularly in the field of recreation management. Recreation managers seek to identify visitor impacts on the resources and the ability of the site or area to accommodate use. Carrying capacities for recreation areas include an assessment of ecological elements that are primarily based on objective and scientific analysis. Psychological elements of carrying capacity that influence the visitor experience (e.g., perceptions of crowding on wilderness trails) are based on subjective, or less quantifiable, measurements. The link between resource integrity and quality recreation experiences has been recognized. Recreational capacity analyses have become the focus for the "challenge of integrating human values into resource management decisions. Maintaining opportunities for certain kinds of experiences requires the same care and planning as maintaining habitat for certain plant or animal species" (Shelby and Heberlein 1986, p. vii).

Tourism management takes the carrying capacity concept one step further than its recreation management applications. A tourist area, as the term is used in this report, is

more than just a recreation area, but includes all elements of a normal type of a human and physically-based community. The tourist community is more than a recreation site for visitors. It is home to the residents who live and work there year round. The residents enjoy the benefits and bear the costs of tourism in their community. As the tourism industry grows so does the need to evaluate the impacts on host communities, not just the impacts and capacities related to visitor satisfaction. The application of the carrying capacity concept to tourism management - and in non-tourist community planning - is relatively new, but as growth pressures increase (for whatever reason) and limits are reached, capacity planning becomes inevitable. Not surprisingly, the areas where carrying capacity studies have been done and the products of those analyses have been incorporated into planning and zoning regulations are among the most heavily-used and developed tourist areas.

C. Types of Capacities

The carrying capacity concept sounds simple; in actuality it is broad and complex. Pigram (1980, p. 563) describes carrying capacity as an "elastic and dynamic concept open to manipulation by management, that does not readily lend itself to generalization." Carrying capacity applies not only to the natural environment, but to social and managerial systems as well (Archer 1978; Butler 1974 and Bosselman 1978). Definitions of the types of capacities vary widely, and terms have not been used consistently. For example, physical carrying capacity can refer to the spacial requirements for a certain activity (e.g., a football field for a football game), or to the spacial limitations relative to physical crowding (e.g., the number persons on a beach). Biologists refer to physical carrying capacity in terms of ecological, rather than spatial considerations. Shelby and Heberlein (1986) describe four types of carrying capacities as they apply to recreation management: ecological, physical-space, physical-facility, and social capacities.

Ecological carrying capacity refers to the impacts on natural resources and systems. Ecological capacity analyses establish the level of use that can be sustained before there are serious impacts to plants and wildlife,or soil, water or air quality. Examples of such ecological or biological impacts are species diversity, vegetative cover (usually ground cover), soil erosion, or colliform counts in soil or water.

Physical capacities can be classified as "space" (land area), or "facility", which is the built (man-made) environment. The amount of land that is suitable for development or other activities is finite for physical, economical and political reasons. The only opportunity to increase physical space is through more efficient utilization of space (Shelby and Heberlein 1986). Man-made systems are characterized by their limited capacity to provide service. Waste treatment and disposal plants, public water systems, road networks and parking lots, and accommodation facilities (campgrounds, hotels, motels) are examples of the "built" environment. Facilities can almost always be expanded to increase their capacities, but usually not without substantial public or private expenditures. Carrying capacity studies that focus on man-made systems determine the critical population (or visitation) thresholds to indicate at what point these facilities would have to be expanded to handle additional demands (see discussion of "Belle Isle" in Section VI) (Schneider et al. 1978).

Also included in the physical capacity category (under Shelby and Heberlein's definition) are the managerial and fiscal resource capacities. Both the private and the public sectors have constraints on capital improvement budgets and operating staff and may not be able to handle mass tourism. This is particularly true in small tourist communities which lack qualified personnel for emergency medical service, police and fire protection, and traffic control and enforcement during the peak tourist season. Ritchie and Goeldner (1987) state that with the great growth in tourism and recreation, lack of staff and budget

constraints are probably the greatest limitations in tourism management in small communities.

Social carrying capacity in the recreational sense refers to impacts on the visitor's experience. Social capacity is influenced by each visitor's values, perceptions and expectations of the recreational experience. This type of capacity is difficult to determine because of the difficulty in establishing quantitative parameters and methods to evaluate them. The physical systems, both natural and man-made, are more comprehensively covered in recreation and tourism research, due in part that the most obvious impacts are likely to be on natural resources, but also because "it seems easier to come up with biological capacities for animals than than social capacities for humans" (Shelby and Heberlein 1986, p. 10).

Until recently, social capacities had been the least studied of the various types of capacities. As recreation managers and tourism operators recognize the need to "sell" the destination area, the focus turned to the types of experiences tourists are seeking and how these experiences can be provided. Research on social carrying capacity is growing, and now covers not just visitor satisfaction but also the local perceptions of tourists and tourism development (Archer 1978; Butler 1974; LaFlamme 1979; Pigram 1980 and Pizam 1978).

D. Factors Influencing Carrying Capacity

An understanding of the various factors that affect tourism impacts and carrying capacities is useful to help in the development of management programs for recreation areas and tourist communities. Graefe et al. (1987) conducted an extensive review of carrying capacity literature and identified the common themes on the subject. Their report listed eight principles and numerous corollaries to illustrate the complex relationships between visitor impacts and carrying capacities. Some of the elements of environmental capacities are highlighted here.

Carrying capacities vary by area, and even between different sites within the same area, depending on the site characteristics. There is no single, predictable response to the impacts of use and development. Numerous factors influence the level of use a site or area can withstand and the degree of impact on the site. The resiliency of the site to tolerate use is one factor which determines the extent of impacts. Some areas are highly vulnerable to even a limited amount of use or development or have limited abilities to recover from overuse. Examples of these areas are beaches and sand dunes, wetlands, areas with shallow, highly-permeable or erodible soils, and areas containing certain wildlife or plant species which have limited tolerance to human disturbance (Cohen 1978 and Williams 1987). Also, the types, patterns and time (seasonality or length of use) of activities influence the degree of impacts. Any amount of use, no matter how small, will cause some transformation of the area. It is often hard to distinguish human-induced changes from natural changes (e.g., ecological succession). Tourism development or any rapid development may only hasten natural events. Natural processes such as the erosion of lakeshores or beaches may remain the same, but the rates at which these processes occur may be altered dramatically by development (Williams 1987).

The complex interactions between different environmental elements make it difficult to attribute the extent of the impacts that are caused by tourists and tourism development. The difficulty in determining the cause and effect relationships between impact and use is further complicated by the incremental effects on natural resources of use or development. However, a threshold will eventually be reached where impacts can be considered serious, although the specific cause may not be identified (Graefe et al. 1987; Wall and Wright 1977 and Williams 1987).

Man-made systems such as transportation, water, sewage and waste treatment facilities also have their limits. The built environment is intimately related to natural systems. Man-made facilities can be expanded through public or private investment or

through changes in technology, and will affect the capacities of natural systems to accommodate use and development. At the same time, these facilities can contribute to the degradation of natural resources (Schneider et al. 1978).

E. Tourism Development Thresholds

There is seldom a finite point or "magic number" that can be established as the ultimate numerical limit of a particular capacity. Rather, the carrying capacities will vary within a certain threshold range over time (Cohen 1978 and Schneider et al. 1978). Threshold ranges can be identified beyond which greater intensities of use or development will seriously effect the site or community. The threshold ranges can be used to indicate when an area is nearing a critical level. Then management decisions must be made to mitigate existing capacity problems and to prevent further detrimental impacts. For example, when comparing a given population threshold to the existing capacity of the infrastructure, planners can identify when new facilities will become necessary to accommodate a certain population level (Schneider et al. 1978). (See "Belle Isle" example in Section VI).

The carrying capacity concept is illustrated by Butler's (1980) description of the successional stages of tourism development. Six development phases were graphed on an "asymptotic" (S) curve (Figure 1). These stages include exploration, involvement, development, consolidation, stagnation, and rejuvenation or decline. The development pattern was based on the product life cycle concept. The sales of a product - in this case tourism - proceeds slowly at first, experiences a rapid rate of growth, stabilizes, then declines unless management strategies are implemented as remedial or protective measures against further degradation. Butler's curve is analogous to a carrying capacity curve. It is determined by the number of visitors, the types and intensities of activities, and the effects of tourism on the capacities of the economic, physical and social systems of the

community. As tourism development progresses, the community structure and its capacity to absorb additional growth changes:

> Eventually, the rate of increase of [development and] visitation will decline as levels of carrying capacity are reached. These may be identified in terms of environmental factors (e.g. land scarcity, water quality, air quality), of physical plant (e.g. transportation, accommodation, other services), or of social factors (e.g. crowding, resentment by local population). As the attractiveness of the area declines relative to other areas, because of overuse and the impact of visitors, the actual number of visitors may also eventually decline (Butler 1980, p.6).

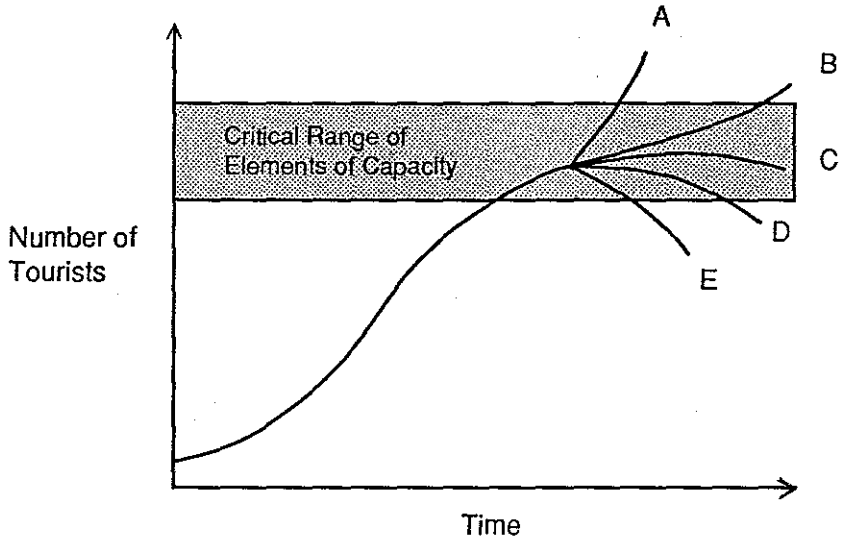

Figure 1. Carrying Capacity Curve of a Tourist Community.

A: Continued growth following major expansions or improvements to facilities;
B: Minor adjustments to capacity levels to allow continued growth at a reduced rate;
C: Readjustment to meet all capacity levels to enable a stable level of visitation;
D: Continued overuse of resources, no improvements to facilities leads to decline in resource quality and appeal for tourism; and
E: Catastrophic events causes immediate reduction in tourism and impairment of resources.

Source: Butler 1980.

Some capacities may be expanded through human intervention, thus delaying the time until thresholds are reached. For example, water supply and waste disposal and treatment facilities can be improved or expanded to accommodate higher demands or management may elect not to expand these systems in order to control the rate of growth. Some of the methods used to alter the capacities of natural or man-made systems include land use regulations, pollution controls, regulating visitor numbers and activities, investments in public infrastructure and management systems, and altering human behavior patterns (e.g., public education on resource conservation techniques) (Mathieson and Wall 1982; McCool 1978 and Schneider et al. 1978).

Another consideration in determining the carrying capacity of a tourist community or recreation area is the decision about the type of threshold level on which to base management decisions. Shelby and Heberlein (1986) identified three different threshold levels: minimum, maximum, and optimum. From the tourism or recreation management perspective, the minimum threshold refers to that number of visitors that is necessary to keep tourist facilities open during periods of low visitation. The maximum level refers to the upper limit or peak level where no additional use or development can be safely accommodated. The optimum capacity is the threshold level where conditions will not seriously impair the ability of the area or system to handle existing use levels and development activities, and where conditions can be safely maintained.

The optimum threshold is where higher numbers are traded for other benefits including public health, safety and welfare, and visitor satisfaction. Although it may represent the "best" capacity level, the optimum threshold is "often plagued by value conflicts between those in charge of identifying management objectives and the alternatives by which to achieve those objectives" (Shelby and Heberlein 1986). In a tourist community, the optimum levels of various systems and facilities involved would have to be determined through the local planning process. The issue of capacities is a key element in a

community's growth management program (see Section VII Carrying Capacity in the Community Setting). Each community must decide "How many tourists?" and "How much growth?" The desired levels would become the acceptable limits of change, and would enable the community to direct their goals accordingly. Reaching a concensus on these and other growth issues can be difficult, but is necessary to establish a community plan for future.

III. METHODS

This project draws on two previous research efforts conducted in the summer of 1988 and the spring of 1989. The Island Carrying Capacity Study (Shaw 1988) examined the issues of high use and increasing development on more than a dozen island tourist communities around the U.S. and Canada. Two of the major concerns related to island tourism development were addressed: solid waste disposal and water resource management. The findings were presented in a report to the Maine State Planning Office and the Maine Department of Economic and Community Development, Office of Comprehensive Planning. The information gathered for the Island Study is helping Maine state agencies and regional councils formulate special policies and development standards for resource protection, growth management, transportation, and economic development for Maine's 14 year round island communities, plus several hundred other semi- and undeveloped coastal islands. The Island Study also facilitated communication between island communities, especially the popular tourist islands, around the country which are seeking ways to improve island resource and tourism management.

Additional information on tourism impacts was obtained through case study analyses of five Massachusetts tourist communities. These case studies were completed as part of a larger study to assess the fiscal impacts of tourism on rural tourist communities in Massachusetts. The case studies focused on the impacts of tourism on the quality of life and on municipal fiscal resources. Data was collected on: 1) local tourism characteristics (e.g., accommodations, attractions); 2) attitudes towards tourists and tourism development; 3) the community's economic base; 4) fiscal impact issues, including expenditures related to the capacities of natural and man-made systems; and, 5) local government finances.

This project expands on the Island Carrying Capacity Study and the Massachusetts case studies in that it reviews carrying capacity methodologies for recreation areas and

tourist communities, and evaluates these analytical frameworks for their application to general community growth management and planning. Additional sources of information and recently completed studies are also included in this project.

Telephone and personal interviews provided much of the information and insight on the each community's perspective of tourism and development issues. Literature reviews and interviews with other researchers provided the background information on carrying capacity analyses, solid waste management, and water resource management. The literature cited in this report represents a fraction of the rapidly growing carrying capacity literature. Other researchers interested in recreation management and capacity planning are encouraged to refer to "VIMDEX", a computerized bibliographic database containing nearly 3,000 references related to carrying capacity and visitor impact management. VIMDEX was recently developed by the National Parks and Conservation Association to identify the numerous references in this field, and to increase the availability of this information to recreation managers and planners (Vaske et al. 1989).

IV. REVIEW OF COASTAL CASE STUDIES

A. Carrying Capacity Issues in Coastal Tourist Communities

The issues of greatest concern regarding rural tourism are the impacts on the environment, especially water, open space and scenic resources, that result from uncontrolled development and overuse. Improper waste disposal practices and inefficient transportation systems both directly and indirectly effect the integrity of the natural resources. Coastal areas in particular have received the full force of tourism and recreational activities and the associated impacts. Even without tourism, however, the growth pressures on the coast are high. Demographic forecasts indicate that a growing percentage of the nation's population will live on or near the nation's shorelines by the year 2000 (Horsley & Whitten, Inc. 1988). In addition, coastal areas are the sites for other industrial activities such as cargo ports, power generation facilities, and oil refineries. Tourism and related development adds to the already intense pressures imposed on sensitive coastal systems (Mathieson and Wall 1986).

Perhaps the most vulnerable natural system in every community is the freshwater supply. Wetlands and aquifers (underground water reservoirs) are highly susceptible to degradation by various land use activities. Groundwater is the largest source of freshwater in the world. The saturated subsurface zone holds 97% of the earth's unfrozen freshwater. It is also the zone where we dispose of most of our waste and waste by-products (Dunne and Leopold 1978). Rapid growth and development have increased demand for freshwater, while adversely affecting its quality.

Coastal areas often depend on aquifers for most, if not all, of their freshwater supplies. Aquifers are recharged primarily by rainfall. The amount of water that flows into an aquifer depends on the characteristics of the soil and bedrock, topography, and vegetative cover. These factors also influence the quality of the recharge water as they

determine the filtering capacity, or the ability of the soils to trap pollutants. The highly permeable, sandy soils of the coast, and/or the shallow depth to bedrock permit little time for the soils to filter contaminants before they reach the groundwater. Due to the interconnected nature of groundwater systems, contamination is a serious threat and can render an entire aquifer useless as a source of potable water.

Although sometimes caused by naturally occurring factors such as high mineral content, groundwater contamination is more often the result of land use activities in the watershed. The major sources of contamination are excessive nutrient loads from agricultural runoff (more noticeable in surface water bodies than in groundwater), faulty sewage treatment systems, and activities involving the use, storage or disposal of toxic substances. Hazardous leachates from landfills, leaking underground fuel storage tanks, and runoff from herbicides and pesticides are among the various sources of chemical pollutants in the groundwater. Along the coast, saltwater intrusion into freshwater wells and aquifers is a problem. Excessive drawdowns of fresh groundwater upsets the natural equilibrium that exists between fresh and saline waters, causing saltwater to seep into the freshwater system. The only way to prevent saltwater intrusion is to limit the amount of freshwater that is pumped out of coastal wells and aquifers (Dutram 1988 and U.S. Congress / OTA 1984).

Closely tied to the demands for and the impacts on freshwater resources is the issue of solid and sewage waste disposal. Traditional methods of solid waste disposal include landfilling, incineration, or ocean dumping by both coastal and island communities. More stringent environmental laws to control air and water pollution, and technological improvements to waste treatment and disposal facilities have reduced some environmental hazards posed by these methods. Still, the waste management problems and the threats to natural resources remain. Old landfills have been closed or will soon be filled to capacity, but the potential for groundwater contamination from landfill leachates remains.

Communities are physically limited by the lack of environmentally-safe disposal sites. Additional constraints to siting new disposal areas are legislative. Recent state laws (e.g., Maine, Rhode Island) restrict or prohibit the creation of new landfills for waste or incinerator ash disposal. The latter has created a crisis situation in Maine communities, particularly for those in the more developed southern and mid-coast regions where the tourism and development pressures are the greatest. These communities face a tripling or quadrupling of their per-ton waste disposal fees to the two major regional incinerator facilities.

Inefficient and inadequate transportation systems in small communities also effect the qualities of natural and visual resources in these areas. Lack of parking in downtown and waterfront commercial areas, increased traffic volumes and reduced levels of service on local roads, and conflicts between vehicles, bicycles and pedestrians are the results of uncontrolled tourism and development. Vehicle and pedestrian traffic congestion is a major issue in rural tourist communities. Small downtown areas can not efficiently accommodate heavy traffic during the peak tourist season. Vehicle emissions are also seriously affecting the air quality in congested areas. Commercial strip development presents both safety hazards and architectural eyesores amidst traditional rural settings.

The most severe impacts of tourism and growth in general vary by community, and depend on the critical limiting factor(s). The limiting factor is that which is the most vulnerable to the impacts of use and development. For example, this may be an aquifer that provides the public's water supply. Management alternatives therefore focus on the critical limiting factor which has been identified for each site or community. Island and coastal tourist communities have attempted, with varying success, to employ some creative techniques to manage tourism-induced growth and development.

B. Management & Regulations Based on Capacities of Island Tourist Communities

Islands are perhaps the best examples of what Bosselman (1985) described as tourism's fragile magnets. Their finite land area, fresh water supplies, sensitive natural systems and unique wildlife and plant life cannot tolerate heavy use and development. Isolated island communities must be virtually self-sufficient in terms of energy and water supplies and waste disposal. The cost of obtaining these resources from the mainland can be prohibitively expensive. Likewise, the costs of hauling municipal waste off an island are high, but the alternatives for on-island waste disposal are limited. Island landfills, many of which are at, or will soon be filled to capacity, can contaminate the water supply, due to hydrogeological characteristics of island soils.

Island communities have developed and implemented innovative and sometimes controversial techniques to cope with the impacts of tourism and related growth pressures. These tools are aimed at controlling the use of, and impacts on, the resource or resources that is/are deemed the most critical limiting factor(s) of growth on the island. The greatest tourism-related impacts on islands are on the quality and quantity of their fresh water resources, the capacity for solid waste disposal and sewage treatment facilities, and on infrastructure facilities (e.g., roads, parking, etc.). Although the growth issues faced by islands are similar to those in other communities, their problems are more complex and the management alternatives more limited. Each of these capacity issues is discussed as they apply to the island situation to illustrate the "worst-case scenarios" in terms of the impacts of mass tourism and rapid development on the resources in small communities. However, any community could benefit from the management techniques described below. A comprehensive discussion of the issues of island resource capacities, and of the case study tourist island communities (listed in Appendix B) can be found in the Island Carrying Capacity Study (Shaw 1988).

1. Island Water Resource Management

Freshwater supply is a critical limiting factor on islands, particularly those which have been designated as "sole source aquifers" (SSA) under the federal Safe Drinking Water Act of 1974. The SSA designation requires federal EPA review of any federally funded projects for potential impacts on groundwater resources, it promotes public awareness of the vulnerability of water resources, and provides federal funding for water resource protection. A number of coastal islands around the country have SSA designation status: Martha's Vineyard and Nantucket, Massachusetts; Block Island, Rhode Island; Island County (Whidbey and Camano Islands), Washington; Monhegan, Vinalhaven, North Haven, and several other Maine islands.

In most cases, the actual quantity of water is not in jeopardy. Rather, it is the potential for polluting the only source of fresh water. A single aquifer may be shared by all island residents, or by several communities. Some aquifers can extend from areas far inland to outlying barrier islands, as is the case in the southeastern states (e.g., Florida, North and South Carolina). If an aquifer is contaminated and rendered unsafe for domestic use, all who depend on it would lose their source of fresh water.

Islands have addressed water resource management by combining established and innovative regulatory and non-regulatory techniques. Many of the dozen or more islands contacted for the Island Carrying Capacity Study (Shaw 1988) have conducted water studies on which to base these controls. Hydrology studies were conducted to determine a "water budget." A water budget relates the capacity of the water resource to the demand for water. It is the amount of groundwater that can be withdrawn without seriously depleting the supply. Unfortunately, not all of the water resource management techniques recommended by those studies were implemented.

The threats to water supplies were serious enough in some island communities that absolute limits to growth were imposed through strict zoning and development controls.

Sanibel Island, Florida was one of the first areas to undergo a comprehensive carrying capacity analysis in the early 1970s. This eventually led to a citizen-initiated comprehensive plan that would allow reasonable amount of growth while protecting the island's resources. Development pressures on this narrow barrier island and tourist visitation rates escalated when a causeway was built to connect it to the mainland in 1963. Growth control were implemented by zoning to regulate the types and intensities of development to keep the total number of dwelling units within a pre-determined range that would not threaten the health, safety and welfare of the public. Sanibel's interior wetlands, although not used as a water supply, were considered valuable for their role in the island's ecological system, despite the fact that they have been contaminated by urban run-off, nutrient-laden wastewater, and saltwater intrusion. The relation of population and residential density to the pollution loading threshold of the island's wetlands was calculated, and used to determine the maximum allowable housing and population densities that the island could safely support. Sanibel also adopted stringent septic system performance standards which exceed Florida's minimum requirements, to protect water quality (Clark 1976).

Nags Head, North Carolina, a barrier island along the Carolina coast, based its planning and regulatory controls on build-out scenarios and demographic analyses to determine the island's carrying capacity for water supplies. As a result, the island adopted a Water Consumption Ordinance which regulates the distribution of Nag's Head water allocation from the county water system. This ordinance requires a water tap permit for all development proposals. Permit approval is based on the type of development (e.g., single or multi-family dwellings, hotels, commercial or office), and on the projected demand for water. A $2,000 impact fee is charged if the permit is granted and the money is used to fund improvements to water distribution facilities and sources (Beatley et al. 1988).

Santa Catalina, California, a tourist resort island off the southern California coast, employs similar restrictions on new development by requiring water allocation permits from the privately-owned water company, Southern California Edison (SCE), in addition to a regular building permit. SCE conducted water supply and utilization studies to calculate the "safe annual yield", and permits new buildings and remodelling proposals only if the projected use falls within the water system's existing capacity. SCE denied an expansion permit for a condominium project because it would have exceeded its permitted allocation. The developer would have had to build a reverse osmosis plant (a method of desalinizing seawater for use as freshwater) to meet the projected water demand, but the expense was prohibitive.

Water quantity is not as limited on the islands of the northeast and northwest coasts as it is in the southern coastal areas. Islands in New England (Martha's Vineyard, Nantucket, and Block Island) and in Puget Sound,Washington (San Juan, Whidbey, and Camano) instead direct water management and regulations towards protecting the quality of their water resources. Water quality controls enforced through zoning and performance standards focus on the sources of contamination: private septic systems, underground fuel storage tanks, and solid waste leachates.

Coastal tourist communities (not islands) such as those on Cape Cod, Massachusetts, also focus on water quality protection instead of enforcing strict regulations of supplies. For example, the Town of Falmouth adopted a nutrient loading bylaw and subdivision regulations to minimize the amount of nutrients entering the water system from residential septic systems. The standards are based on the nutrient carrying capacity of the receiving waters, which are determined by an intensive analysis of the hydrogeological characteristics of the site. The zoning bylaw delineates recharge areas as overlay zones within which special development permits are required for all construction activities. The subdivision regulations require the developer to determine the nutrient loading of the

proposed development compared to the established critical level. The applicant must also identify mitigation measures that would be employed if the project would contribute pollutants in excess of the allowable level (Whitten undated).

2. Island Solid Waste Management

Waste disposal on islands is limited by their finite land area, and by island soils that are poorly suited (either too shallow or too permeable) for landfilling. Transporting waste to the mainland from remote islands is extremely expensive. As landfills reach their capacities, most island communities are turning to the common-sense approach to the waste disposal problem: reduce, reuse, and recycle. This integrated approach to waste management emphasizes source reduction and resource recovery in order to reduce hauling costs and the need for new landfills. Unlike non-tourist communities, tourist communities must deal with the problems of seasonally fluctuating populations. Difficult decisions must be made concerning the expansion of infrastructure and facilities to accommodate the peak demand. Waste disposal facility capacities are an example of this dilemma. It is not easily decided whether a community should provide an oversized facility (for waste or sewage disposal) to serve peak seasonal populations and daytrippers when it would be largely under-utilized the rest of the year.

As part of their waste management programs many communities voluntarily recycle, or mandate it through local ordinances. Maine, Rhode Island and Vermont now have legislation which requires statewide commercial, governmental and residential recycling programs. In addition to recycling, some of the island communities studied have initiated or are considering composting biodegradable wastes at local facilities (Nantucket, Massachusetts; Block Island, Rhode Island; Island County, Washington). The advantage of composting is its flexibility. The size and operation of the facility are determined by site size, location, types and volumes of wastes, and compost markets. Composting is less

costly than other high-tech disposal systems. It is also environmentally safer, provides soil enhancement for soil-deficient areas, and is a publicly acceptable method (Alpert and Epstein 1988).

3. Management of Other Island Infrastructure

Traffic congestion on narrow island roads, limited parking in village areas and at ferry terminals (for those islands that are accessible only by boat), and conflicts between cars, mopeds, bicycles, and pedestrians were among the most critical capacity and safety problems cited by island residents and officials interviewed for the Island Carrying Capacity Study (Shaw 1988). Manipulation of ferry or bridge tolls seems to have limited success at controlling the number of vehicles going to an island. Rate manipulation also raises legal and political questions concerning special rates and reserved passage for islanders versus those for non-resident. Privately-operated ferries are more difficult to regulate than state-owned or subsidized ferries in terms of prices or the number of trips. Those islands that are served by state-operated ferries, such as Nantucket and Martha's Vineyard, Massachusetts, Block Island, Rhode Island, and several islands in Maine, must work cooperatively with state transportation officials to solve these problems.

Parking and traffic regulations to deal with limited parking capacity and vehicle congestion at ferry terminals and in village areas have been considered by some island communities. Resident parking permits, designated spaces near community services (post offices or banks), satellite parking lots, taxis and shuttle services are among the traffic management options which have been considered or implemented. Public transportation on the islands was frequently described as inadequate and ineffective in reducing traffic impacts. Moped licenses are limited on Block Island in an effort to reduce the safety hazards created by too many vehicles on the island's roads.

The capacity issues discussed here are present in many communities. However, the magnitude of these problems may be greater in tourist communities because of the demands placed on resources and facilities in areas where visitation is high, or growth and development exceed the towns' abilities to meet the demands. The remainder of this report addresses the relationship between impacts of use and development, and how the carrying capacity concept can be used as a proactive planning tool to reduce or prevent undesirable impacts.

V. METHODOLOGY FOR CARRYING CAPACITY ANALYSES IN RECREATIONAL SETTINGS

The previous discussion of tourism impact issues and the management responses of tourist communities provide some insight into the relationships between tourism and carrying capacities. However, the Island Carrying Capacity Study did not specifically address the *process* for determining carrying capacities or threshold levels in a tourist community or recreation area. Much has been done recently on developing a standardized methodology for analyzing recreational carrying capacities. The models range from formula-based carrying capacity models to broader land use planning models that incorporate qualitative impact and capacity issues within their scope. Emphasis is placed on acceptable levels of use which will provide the greatest visitor satisfaction with the recreational experience.

This section highlights some examples of the methods to analyze recreation impacts and to determine recreational and environmental carrying capacities. The purpose of this section is to provide an overview of the methodologies developed for recreation management. These methodologies could be applied to tourism management in a community setting, or to local growth management programs in general (see Section VII). A detailed discussion of each of these models can be found in the original sources.

A. Formula-Based Approaches

Formula-based models provide an estimated numerical capacity to achieve both ecological objectives (e.g., pollution loading in lakes and ponds) and social objectives (e.g., the number of hikers on a trail that will not reduce the "wilderness experience"). Value judgements, or qualitative data, are not readily incorporated into formula-based models, and thus present some difficulties to recreation managers.

One approach in Yosemite National Park did involve value judgements in the form of "fragility scores." The equation to estimate the carrying capacity of Yosemite's backcountry was based on standardized coefficients for the number of people at one time (PAOT) per acre and the number of PAOTs per trail, and four ecological determinants of the relative fragility of the system. The relative fragilities were scored on a scale from 0 (least fragile) to 9 (most fragile). The ecological determinants measured were: the relative uniqueness of the system; the relative vulnerability of the system; the relative resiliency; and, the relative ease of repair or restoration of the system by man. These numbers are then used to determine a numerical capacity expressed in PAOT units for specific zones. This number was then adjusted for the ranger's field experience, the ease of administration, and the manager's perceptions of the public's acceptance of establishing and enforcing that use limit (Graefe et al. 1987).

Another example of determining numerical capacities was described for Ayers Rock, a popular tourist attraction in Australia (Bosselman 1978). The basic formula for determining the tourist capacity of the site was:

$$K = S \times k_o / N$$

where:

K = the maximum capacity of the tourist area;
S = the total area;
k_o = a correction factor, determined as a function of hypsometric characteristics, which accounts for engineering, geological, hydrological, landscape and other considerations;
N = the standard area per person in square meters per person.

The total capacity of the area (K) must be greater than or equal to the volume of the stream of tourists (number of visitors) to the area. Most studies on the incremental effects of use and development on the environment recognize that these formulas must somehow incorporate subjective values to be meaningful (Bosselman 1978).

B. Standards-Based Approach

Recreational capacities are frequently expressed in terms of the amount of use above which unacceptable consequences will occur. The basis of this approach is the identification of standards, which are based on management objectives, to determine when an unacceptable condition is reached. "Unacceptable" is a subjective term. Management objectives must clarify what unacceptable conditions are (Graefe et al. 1987).

For example, the carrying capacity study conducted for the National Park Service on Isle au Haut, Maine (see Section VI. D) defined unacceptable degradation of natural resources as: "a) damage which is significant to plant and animal population survival; b) damage which is irreparable through natural processes; c) damage which interferes with major natural processes, such as nutrient cycling; and, d) damage which causes physical degradation, such as large scale erosion." The Isle au Haut study defined high quality visitor experience in backcountry areas as that which "consists of hiking along remote trails and beaches . . . within the park area and involves only limited contact with other hikers" (Martin et al. 1987).

The procedure for the standards-based approach begins with the identification of the management objectives and standards for desirable conditions. Then existing conditions and use levels are inventoried and compared to the desired standards. If the results are within an acceptable range, management would focus on protecting existing conditions. If the results indicate substandard conditions, management would be directed towards improving or restoring conditions to an acceptable level. This method, proposed by Washburne (1982), emphasizes a monitoring program to identify unacceptable impacts and to predict deteriorating conditions (i.e., "red flags") so that management efforts can be directed towards critical areas before impacts become serious or capacities are exceeded.

Another standards-based approach is the "Limits of Acceptable Change" (LAC) model developed for wilderness recreation areas by Stankey et al. (1985). The nine-step

process is a modification of the recreational carrying capacity concept. The main emphasis is on achieving desirable range of resource and social conditions instead of establishing a numerical use limit for a recreation area. The LAC model attempts to: 1) define how much change should be allowed; 2) identify appropriate management actions to maintain or restore conditions to the desired state; and, 3) monitor and evaluate the effectiveness of management actions. The conditions evaluated in this model relate to the "wilderness experience" for backcountry campers (e.g., the number of encounters on a trail) as well as to physical conditions of the area (e.g., percentage of vegetative cover on trails or coliform counts in streams).

In addition to the technical elements of this approach, the authors point out that managers must use sensitivity and value judgements to make the process successful. Public participation is also important during each step of the process, not only as a means of providing local information and expertise, but for developing an understanding of and support for the assessment process and the implementation strategies (Stankey et al. 1985).

C. Visitor Impact Management (VIM)

Graefe et al. (1987) developed a framework for carrying capacity and visitor impact assessments for the National Parks and Conservation Association (NPCA). The "visitor impact management" (VIM) process is a combination of formula-based and standards-based approaches described above. VIM attempts to incorporate the most useful elements of the previous approaches to managing visitor impacts. This method assumes that effective recreation management involves both scientific (objective) and value (subjective) judgements, and involves more than establishing carrying capacities and setting limits on the use of a recreation area.

The goals of the previous models were to determine use-quotas to reduce the impacts of visitors. However, the relationships between impacts and overall use levels are

still poorly understood (Stankey et al. 1985). The extent and severity of impacts are influenced by factors other than the levels of use.. The VIM process looks for causal relationships in order to identify and implement management strategies that will address the factors which contribute to the impact conditions. The framework is a systematic, rational process that utilizes the best available data and scientific information to document the types and extent of visitor impacts on a recreation area. The VIM process identifies undesirable conditions and provides the means for evaluating the feasibility and trade-offs between a range of management alternatives.

The eight-step procedure developed by Graefe et al. (1987) is based on three management issues: 1) identifying the problems and issues; 2) determining the cause, occurrence, and severity of those problems; and, 3) selecting management strategies to mitigate or prevent impacts. Table 1 outlines the steps, management questions to consider at each step, and the product of each step in the VIM process.

In VIM, as with any management program, the objectives should be as stated as clearly and specifically as possible (i.e., more than just "protect the resources"). In addition, judgmental decisions by recreation managers will help define the type of visitor experience to be provided and the desirable conditions to be achieved through management. Key indicators or parameters are selected as "yardsticks" to assess resource and social conditions. The choice of indicators depends on the types of impacts to be evaluated and the characteristics of the site. The best indicators are directly observable, relatively easy to measure, directly related to the management objectives, sensitive to changes in use conditions, and amenable to management.

Standards are then selected to specify in quantitative terms the appropriate levels or acceptable limits for the impact indicators. Standards serve as the basis on which existing conditions are evaluated. If the existing measures of key impact indicators are equal to or better than acceptable standards, then a monitoring program is established. The monitoring

TABLE 1. VIM Procedures, Management Questions, and Products.

Step I. Review of Existing Data, Legislative and Policy Direction

- What are the current use patterns?
- What use trends are evident (increasing, decreasing, changes in character of uses)?
- What are the major natural resources and resource problems?
- What policy or legislative constraints affect management?

Product: Summary of existing situation.

Step II. Review of Management Objectives

- What types of environmental conditions are desired?
- What types of visior/tourist opportunities should be provided?
- What type of development is appropriate (residential, commercial, etc.)?

Product: Clear statement of specific area objectives.

Step III. Selection of Key Impact Indicators (Parameters)

- What variables will best represent the desired environmental conditions identified in the management objectives?
- What site variables are most important as determinants of environmental quality or resiliency?
- Are the chosen impact indicators: observable; measurable; important; sensitive to changing conditions; and, amenable to management?

Product: List of indicators and units of measurement.

Step IV. Definition of Standards for Key Impact Indicators

- What are appropriate quantitative levels for each key impact indicator?
- What is the limit of acceptable change for each indicator?
- What is the optimal threshold for each indicator?

Product: Quantitative statements of desired conditions.

Step V. Comparison of Standards to Existing Conditions

- Do impacts exceed standards for acceptable conditions?
- When and where are impacts most severe?

Product: Determination of consistency or inconsistency with selected standards.

Step VI. Identification of the Probable Causes of Impacts

- What specific aspect(s) of use are contributing to impact problems; type of use; time of use; visitor patterns; frequency or length of peak use periods; overall amount of use?
- What site-specific characteristics influence the occurence and severity of the impacts?
- What other (external) factors may be contributing to the impact problems?

Product: Description of causal factors on which to focus management.

Step VII. Identification of Management Alternatives

- What alternatives are available, feasible, and relevent to the impact problems?
- Are these management techniques consistent with management objectives?
- Will these alternatives be effective in achieving acceptable conditions?
- Will these alternatives have undesirable side effects?

Product: Matrix of alternative management strategies.

Step VIII. Implementation and Monitoring

Adapted from Graefe et al. 1987.

program focuses on the most sensitive indicators, which serve as "red flags" for undesirable changes in environmental or social conditions. If the impact parameters are below the standards, the cause(s) of the problem must be identified. Management actions would then be directed towards improving conditions to meet the desired standards.

Management strategies should focus on the probable causes of the impacts, rather than on the impacts themselves. The VIM model recognizes that finding a single solution to a complex impact problem is rarely possible. A combination of strategies can be identified to provide flexibility in achieving the management objectives. In general, selection of the strategies depends on their consistency with management objectives, the cost of implementation, factors limiting application, potential effectiveness, and public acceptance. Implementation of the management strategies is followed by a continuous monitoring program of the key impact indicators to allow for periodic adjustments to the management strategy. Monitoring also increases the understanding of the causes of visitor impacts and enables managers or planners to take a preventative rather than reactive approach to impact management (Graefe et al. 1987).

Recreation carrying capacity analyses differ from community capacity studies in a community setting. The former examines environmental-visitor impact relationships and management goals and objectives are directed towards visitor satisfaction. A community carrying capacity analysis in either a tourist or non-tourist community must be more comprehensive in scope. A community carrying capacity analysis should consider not only the ecological and experiential capacities, but also social capacity from the residents' perspective, public services and facilities, and municipal fiscal capacities. Each area, whether it is a national park or a town, will have different critical factors to consider, and the capacity analyses and management alternatives would focus on those specific problems. The next section discusses the elements of carrying capacity studies in four island tourist areas.

VI. EXAMPLES OF CARRYING CAPACITY METHODOLOGY & PLANNING IN TOURIST COMMUNITIES

In addition to the case studies discussed in Section IV, which described the capacity issues and management responses of island tourist communities, the following examples of tourist areas which have implemented planning and growth management policies and programs based on carrying capacity warrant a brief discussion regarding the methodologies used to determine their capacities. A case study on Prince Edward Island, Canada was included in the Island Carrying Capacity Study (Shaw 1988). However, the process for assessing tourism impacts and for determining environmental capacities for PEI, which was not covered in the Island Study, is described below. The methodology for capacity planning on Sanibel Island, Florida (under the pseudonym of Belle Isle) is also discussed in greater detail here than it was in the Island Carrying Capacity Study. Hatteras Island, North Carolina is notable for its straightforward methodology for conducting a carrying capacity analysis to relate the amount and type of development to the quality of the natural and social environment. The study on Isle au Haut, Maine is discussed for its focus on both the National Park Service's recreation management objectives, and for the involvement of the island residents in the study and subsequent planning process.

A. Prince Edward Island, Canada

A tourism impact study was conducted during the mid-1970s for Prince Edward Island (PEI), Canada (Birch et al. 1976). The purpose was to examine the impacts of tourism development on the economic, environmental and social dimensions of the Island, and to create a context of information and analysis within which a balanced and comprehensive policy of tourism development could be developed. Four development scenarios were used to illustrate how different tourism management policies would affect

the Island in the next ten years. The scenarios were : 1) to continue the expected normal rate of growth and geographic distribution of tourists, without any major policy or planning changes; 2) to continue the normal growth rate, but adopt measures to redistribute future growth to lesser-developed areas on the Island; 3) to pursue policies to attract those types of tourist which would add the most to PEI's economy; and, 4) to maximize tourist growth through aggressive promotion, without any policy or planning changes. The projections were based on the following: growth, development and visitation trends; resident attitudes towards various levels, types, and location of tourism development and the number of tourists; and, the probable effects of the projected levels of population, development, and visitation on the Island's natural and man-made systems.

None of the scenarios included the assumption that a comprehensive land use plan would be developed, and none provided an ideal course of action for PEI to follow regarding tourism. It was concluded that, in the absence of planning for tourism development the Island would suffer significant negative impacts. Unregulated growth would create "intolerable" conditions, particularly increased traffic congestion, litter, sewage and waste disposal problems, strip development, "incalculable" damage to the Island's sensitive coastal zone, and other intrusions on environmental and scenic quality (Birch et al. 1976).

The PEI study recommendations included the development of a comprehensive plan for the entire island (consisting of several communities) as the best approach to managing the effects of growth. Policies were recommended to regulate the impacts of tourism and other development. These included policies that: 1) would not maximize tourism development; 2) would promote the redistribution of tourism growth to under-utilized areas through a controlled growth program (e.g., a "zero-growth" policy in heavily impacted areas and modest , but carefully regulated, growth in other areas); 3) encourage

"high value-added" tourists (the big spenders); 4) promote the spring and fall seasons to reduce peak-season crowding; and, 5) place a top-priority on environmental protection.

The Island's coastal resources were considered to be the critical limiting factor. Therefore, the absolute physical limits of growth should be determined by the sensitive coastal areas, not the other generalized problems of litter, solid waste and sewage disposal, or accommodations needs. However, baseline data on environmental resources was insufficient at the time of the study to support any conclusion regarding the ultimate physical limits of growth.

Birch et al. (1976) recommended annual assessments of PEI's tourist sector using selected performance indicators to provide comparative information for evaluating tourism impacts. Table 2 lists tourist sector variables and performance indicators which could be used by policy-makers to develop, evaluate, and periodically adjust tourism management policies and regulations.

Table 2. Types of Performance Indicators for Prince Edward Island

Tourist Sector Variables	Performance Indicators
1. Tourist profiles	Tourist exit surveys
2. User rates	Resident versus Non-resident Ratios (use of facilities/services)
3. Land use	Agriculture use versus recreational use (# land sales to nonresidents, # permits for tourist facilities, attractions, etc)
4. $ Generated by tourist expenditures	Economic simulation model
5. Islander attitudes	Annual telephone survey of residents
6. Physical impact monitoring	Resource monitoring -- baseline data collection to establish carrying capacities of sensitive areas

Source: Birch et al. 1976

Tourist profiles describe the dynamics of the seasonal population in terms of visitor types, origins, experiential expectations, activities, length of stay, and travel patterns. Conducted annually, these profiles may show the effects of tourism policy changes. User rates of the recreational facilities provide the information needed to establish density levels, and to assess complaints of congestion and crowding. User rates of municipal services are critical determinants of tourist impacts on hospitalization, law enforcement, waste disposal, etc., and allow officials to determine the amount of non-resident demand on these services. Changes in land uses can be monitored by an annual review of the number of permits for residential (year-round versus seasonal) and commercial development, and of the acreage of farmland lost to tourism development. An economic simulation model would enable Island officials to determine regional economic impacts from policy decisions affecting tourist distribution.

The researchers noted that the physical performance indicators were the most significant, but least-developed of the six types of indicators for assessing the impacts of tourism on the Island's natural resources. At the time of the PEI study, the Province had just begun to collect baseline data on environmental resources. The study recommended that the environmental database be expanded and the information be used to determine the carrying capacities of the Island's sensitive environmental areas (Birch et al. 1976).

Unfortunately, most of the specific recommendations (namely, determining carrying capacities) of the Birch study were never implemented (Baglole, personal communication). However, land use planning and development regulations, including regulations to manage tourism and second home development, have been adopted throughout the Province. The Institute of Island Studies (1989) reported that in 1973, no city, town or village on Prince Edward Island had a comprehensive plan. By 1988, 28 communities had adopted "Official Plans" with zoning laws. In rural areas that are not within municipalities, or in communities without an Official Plan, land use is regulated by

the Department of Community and Cultural Affairs using the Province's Planning Act Regulations. The province also adopted the Lands Protection Act to set the conditions for purchasing land, and to regulate the maximum land holdings of non-residents and corporations. For example, non-residents must apply for a permit from the Executive Council to own more than five acres or 165 feet of shore frontage on Prince Edward Island (Institute of Island Studies 1989).

The carrying capacities of Prince Edward Island's resources remain an issue. Between 1977 and 1988, more than half of all new single-family dwellings were built in unserviced areas and rely on individual septic systems and wells. Land use statistics show an abundant supply of approved but undeveloped cottage lots within the province (Institute of Island Studies 1989). For years Canadian officials have debated about building a bridge to connect Prince Edward Island to mainland Canada at New Brunswick. If this bridge is constructed the increased accessibility to Canada's smallest island province will have dramatic land use and development implications.

B. "Belle Isle" (Sanibel Island, Florida)

Godschalk et al. (1979) described the process through which the Sanibel Plan was developed in a hypothetical high-growth island community called "Belle Isle". This process illustrated how any community might approach carrying capacity analysis and implement growth management techniques accordingly. The "Belle Isle" Comprehensive Plan was the mechanism for identifying the problems and issues of protecting the public health, safety and welfare as they related to the sensitive natural systems of the island, and provided for implementation of growth management policies and development regulations. Three types of policies were were established to determine growth thresholds, protect the public health, safety and welfare by managing the physical systems (natural and man-made) of the island, and establish development regulations based on performance standards

adjusted to the various ecological zones on the island (e.g., beach, mid-island ridge, interior wetlands basin).

Growth thresholds were determined for the critical factors limiting growth on the island: emergency evacuation, water supply, traffic movement, and sewage treatment. These thresholds were benchmark population levels at which the island would need to evaluate the managerial needs for providing additional services to meet higher demands. Also considered were the budgetary thresholds for economic values, environmental values, and additional municipal services. Each factor was analyzed at a different population threshold (expressed in number of dwelling units) based on public water supply and build-out scenarios of the existing zoning capacity.

The process was illustrated using the lowest threshold alternative of a total of 6,000 dwelling units. The associated costs were then determined based on that population level. They determined that hurricane evacuation would require 42 hours' warning to allow all residents to evacuate the island via the two-lane causeway; $4.7 million would be needed for water supply; $2.5 million for roads and traffic engineering improvements; $1.9 million to upgrade sewage treatment facilities; and, $190 per capita cost for providing additional municipal services. It was estimated that at the 6,000-unit threshold, the economic value of the island as a tourist destination area could be maintained. At this level, the quality and attraction of the natural amenities would not be seriously impaired and the island could preserve its strong position in the competitive tourist market.

Policies were identified to protect the functioning of the natural systems such as the role of the wetlands in the island's hydrological cycle and in storm water control. The policies also targeted water quality protection and improvement, preservation of high-value natural vegetation, protection of public conservation and recreation areas, and efficient provision of municipal services such as fire, police, recreation and health. Performance standards were designed and implemented to regulate the types and location of

development. In addition to the usual performance standards for uses, height, densities, setbacks, etc., standards were added to provide for flood and storm-proofing, site preparation and environmental protection in each ecological zone.

A thorough hearing and review process to allow all affected parties to participate in the development and adoption of the comprehensive plan was instrumental in gaining public support for the plan. Periodic reviews allow the plan to be updated as conditions change over time, or as new information or technologies become available which will influence the threshold levels. The "Belle Isle" plan was noted for its tightly-integrated, well-documented planning that was based on a careful analysis of environmental and public service capacities. The unique and fragile nature of the island was grasped by planners and carefully forged into the plan's rationale and regulations. It demonstrated that growth management plans could be based on the available supply of natural resources and public services, as well as on the demand for such resources and services generated by growth (Godschalk et al. 1979).

C. Hatteras Island, North Carolina

A carrying capacity analysis was conducted for Hatteras Island, a barrier island off the coast of North Carolina (Hegenbarth and Shaw (eds.) 1984). The purpose of their study was to provide a comprehensive display of facts to assist Dare County, North Carolina officials and planners to manage the rate and amount of development on Hatteras Island. The study compared population and development trends and characteristics to the quality and quantity of the island's natural and social environments.

Eight factors were identified as the most critical factors that would limit or influence future growth and development on Hatteras Island. These were developable land, water supply, sewage treatment, hurricane evacuation, roads, provision of public services, recreation facilities and community character. Three build-out scenarios were done to

predict the impacts on these factors of different levels of development, and to estimate when the carrying capacities would be reached. Build-out Scenario I assumed low intensity development based on existing trends (i.e., all new development would be single-family dwellings). Scenario II, considered the most likely scenario, assumed that new development would consist of both single- and multi-family homes. Under Scenario III the island would be developed to its maximum residential density, assuming all new units would be multi-family dwellings.

The capacities of the public water supply, waste treatment facilities, hurricane evacuation, and roads were quantified in terms of dwelling units, then converted to population levels for each scenario (i.e., the average number of persons per dwelling unit by type of unit multiplied by the number of dwelling units). Data from the public water system was used to estimate the aquifer's capacity. The island's road network, and particularly the bridge capacities, was examined for its ability to accommodate increased traffic. Hurricane evacuation is a major concern on barrier islands, and the provision for safe, rapid evacuation routes in emergency situations is important. Municipal services (police, fire and medical) at each population level were compared to state averages for comparable communities. The residents were surveyed for their perceptions of community character and the impacts of tourism and development. This information was not quantified in numerical terms; therefore, the social capacity was not determined. However, the survey results provided additional information on the public's attitudes towards tourism and general development on Hatteras Island.

The results of the Hatteras Island carrying capacity analysis indicated that the capacities of the four most quantifiable factors (water supply, sewage treatment, hurricane evacuation and roads) would be reached or exceeded even at the Scenario I population level. The researchers predicted that the assimilative capacity of the island's highly-permeable soils to treat wastewater would be reached before the full build-out at the lowest

development density. Water supply would be exhausted at or near the Level I build-out. The study assumed that recreational opportunities and community character would decline with increased development.

D. Isle au Haut, Maine

Between 1984 and 1988 researchers from the Appalachian Mountain Club conducted a carrying capacity study for the National Park Service (NPS) on Isle au Haut, a remote island unit of Acadia National Park, Maine (Martin et al. 1987 and Martin, personal communication 1989). Part of the island is controlled by the Park Service and the remainder is occupied by the small town of Isle au Haut (year-round population approximately 55). The objectives of the study were to determine the level of visitation above which there would be undue adverse impact on the environment, the park visitor's experience, and the character of the Isle au Haut community. The study methodology included surveys of visitors, island residents and landowners; assessments of trail use patterns; and analyses of vegetative cover and soil erosion on trails.

A series of planning meetings with the residents allowed researchers and the NPS to share project results and tentative conclusions with the Town, and enabled the development of a cooperative long-term planning and monitoring strategy for the national park area of Isle au Haut. The planning meetings were not in the original project proposal. However, preliminary findings indicated that existing conditions, with some management modifications, would allow for increased visitation. Park managers realized that this might create considerable controversy among the Isle au Haut community. It was considered necessary to involve the community early in the project and in subsequent planning stages in order to develop locally acceptable management solutions.

A monitoring system was designed to objectively track the changes in environmental and experiential conditions in the Park area. Management objectives

concentrated on maintaining the high quality environmental conditions and visitor experience, and on minimizing visitor impacts on the community. Indicators were selected to measure changes in environmental conditions, and standards were established as benchmarks for comparison with the indicators. The indicators of environmental change were trail width, trail depth, and the amount of vegetation, litter, and bare soil at designated study sites. The acceptable standards for each of these parameters were based on existing conditions. The indicators used for monitoring visitor satisfaction relative to crowding (i.e., the impact on the "wilderness experience") were based on the responses to several questions on the visitor questionnaires. Indicators of impacts on the character of the Town were considered too difficult to objectively measure. Instead, local conditions and opinions regarding the number of visitors in the town (as opposed to the park section of the island) were noted in annual reports submitted to the park superintendent by the local officials (selectmen) and the head ranger.

The proposed monitoring program called for measuring the indicators every five years. Management strategies would be determined based on the findings of each monitoring period. If indicators do not meet acceptable standards, then management actions would be directed at restoring conditions to an acceptable level. The Isle au Haut study suggested several management techniques to control environmental and social impacts. Among these recommendations were to disperse visitors to less sensitive areas, to harden trails to withstand foot traffic and reduce erosion, and to reroute and add trails. Visitor impact education was proposed as a means of gaining public acceptance of the methods to control environmental impacts and improve the visitor's experience. The study also suggested limiting use if unacceptable conditions did not respond to other management actions. If necessary, these use restrictions could be accomplished by a self-administered permit system, unless the management determined that a stricter permitting process was needed.

The researchers noted during the four-year study that external forces beyond visitation to the park were influencing the impacts on Isle au Haut. These factors included an increase in tourism along the Maine coast in general, an increase in the number of seasonal rentals of island homes, and the greater availability of rental rooms on the island. These are community and regional issues over which the National Park Service has no control. Rather, park managers must work with the Isle au Haut community and with other communities surrounding Acadia National Park to seek regional coordination for tourism and growth management (Martin et al. 1987).

The capacity analyses conducted for the communities and areas discussed above were primarily done by governmental agencies such as the National Park Service, or by experienced planning consultants. The next section discusses how a community can conduct its own carrying capacity analysis, and how capacities fit into the general municipal planning framework. Although there are drawbacks to establishing capacities, no matter who does the analysis, the potential benefits of capacity planning outweigh the constraints of the analysis itself.

VII. BEYOND RECREATION APPLICATIONS: CARRYING CAPACITY IN A COMMUNITY SETTING

A. Constraints of Carrying Capacity Analyses

Despite the logic and benefits of planning based on capacities, there are drawbacks involved in both performing a carrying capacity analysis and in its application. First, the analysis itself can be expensive, depending on the type and availability of the data that are required. Data are often scattered, outdated, difficult to obtain or nonexistent. For example, detailed information on the hydrogeological characteristics of an area is necessary to determine the capacity of groundwater resources. However, the costs to conduct a hydrology study to obtain that information can be more than a community could afford.

Second, the analytical process can be complex and in some cases would be beyond the capabilities of local officials to conduct. Qualified professionals are often needed to conduct the more technical capacity analyses. The methods for determining capacities range from straightforward calculations to more subjective analyses of natural resource and social conditions. Computer models offer another means of measuring capacities, and add a new dimension to the technical expertise required to analyze capacities (Schneider et al. 1979).

The selection of variables to measure and the assumptions made about those variables influence the reliability of the results and their application. For example, the build-out scenarios conducted in the Hatteras Island study (Section VI) assumed that certain parts of the island, such as the area managed by the National Park Service, would not be developed. If circumstances changed and those areas were developed, the estimated threshold levels and the time at which the capacities would be reached would change dramatically (Hegenbarth and Shaw (eds.) 1984). Schneider et al. (1979) noted the danger in placing too much trust in the estimates derived from capacity analyses, because capacities can be altered by natural causes or through human intervention. Assumptions must also be

made regarding the region beyond the community or recreation area in question. For instance, how will regional growth affect local resources? How will competing destination areas effect the local tourism industry? What changes in regional or state growth and tourism policies will effect the capacities of the community or recreation area?

The application of carrying capacity in recreation, tourism or municipal planning programs is hampered by legal and political factors. In a recreational sense, restricting or prohibiting use based on an estimated capacity raises the controversial subject of allocating use; who gets to use the area and who doesn't (Shelby and Heberlein 1986). Recreation managers generally resort to rationing or prohibiting use only after all other management alternatives have been tried (Ritchie and Goeldner 1987 and Stankey et al. 1985). Local growth management programs that set growth and use limits based on numerical capacities might be considered exclusionary, because these techniques essentially establish no-growth or no-use policies. However, if these limits, such as caps on the number of building, water or sewer permits issued, are set to protect public health, safety and welfare; and, these actions are supported by local comprehensive planning, then they are not arbitrary or exclusionary growth controls.

Defensible limits are based on rational and technically-sound carrying capacity analyses and are less likely to be challenged. If the carrying capacity analysis is done properly it can be a strong argument for growth or visitor controls. If not, it can weaken the case for those controls (Schneider et al. 1979). In the "Belle Isle" case described in Section VI, the growth management plan was challenged by a developer on the grounds that his property rights had been confiscated. The developer contended that under the pre-plan zoning densities up to 1,200 dwelling units could be built on his 400-acre parcel. The plan reduced the allowable density to conform with the calculated carrying capacity of the area, such that only 54 units could be built. In the end, the plan was defended on the basis

of its thorough public review process and its logical analytical methods in determining environmental and facility carrying capacities (Godschalk et al. 1979).

Visitor quotas in recreation areas can be controversial as well. However, studies indicate that both visitors to the national parks and the residents of a tourist community would support use controls when faced with undesirable environmental and social conditions (e.g., crowding, litter and environmental degradation) (Hegenbarth and Shaw (eds.) 1984 and Martin et al. 1987).

Local politics play a key role in the successful implementation of tourism and growth management strategies based on a carrying capacity analysis. A community-wide concensus must be reached in order to implement management strategies. In a tourist community, there may be conflicting interests between the tourism business owners and operators and those opposed to unlimited, uncontrolled local tourism development. The lack of a concensus on management objectives for tourism or for growth in general, even when those objectives are supported by observable and quantifiable evidence that capacities are being reached or exceeded, results in little or no implementation of management strategies. This has been a major obstacle to effective tourism management cited by island communities interviewed for the Island Carrying Capacity Study (Shaw 1988), and by the Massachusetts case study towns investigated in the spring of 1989.

B. Carrying Capacities and Growth Management

Despite the problems, the concept of carrying capacity in municipal planning enables a community to examine critical factors regarding future growth and development, and to plan accordingly. The concept of carrying capacity and its application is an important element of a local growth management program. In fact, managing growth and development based on the capacities of natural resources and public facilities is probably the most essential part of comprehensive, long-range planning. Beatley et al. (1988, p. 7)

defined growth management as "a conscious local government program intended to affect the rate, type, location, amount and/or quality of future development" in a community. "Unmanaged growth depletes the capacity of nature to support economic activity, a high standard of living and life itself. This loss creates environmental stress" (Chinitz 1990, p. 3). Growth management becomes even more important in a tourist community, which must deal with the additional impacts of tourism development and visitors.

Until recently, a comprehensive approach to carrying capacities seems to have been the exception rather than the rule. This is changing, as the impacts of growth become evident in the reduced quality of the environment, infrastructure and services. Capacity problems with solid waste disposal, sewage treatment facilities, and water systems are major issues in nearly every community. Therefore, the concept of carrying capacity has taken a greater role in municipal growth management programs in all communities. An increasing emphasis on comprehensive planning promises a broader perspective for analyzing and planning for of all types of capacities.

As an example, Maine's Growth Management Law (30-A Sec. 4311 et seq.) requires municipalities to develop a local comprehensive plan. Planning for carrying capacities is a major premise of comprehensive plans and implementation programs. The planning process includes an inventory and analysis of the capacities of existing physical facilities (infrastructure, transportation), water resources and their vulnerability to degradation, critical natural areas (wetlands, wildlife habitat, etc.), recreation facilities, economic bases, and local fiscal capacity. All local comprehensive plans are reviewed by state agencies and by the regional councils for consistency with state and regional goals and policies. Foremost among the state goals, as well as the state's nine Coastal Policies, is the protection of natural and scenic resources. The state recognizes the economic and ecological values of its natural resources, not only for recreation and tourism, but for the residents' quality of life.

Capacity planning is also important on a regional level for those resources and facilities that go beyond town boundaries such as water resources (rivers, lakes or aquifers). In these instances, regional or interlocal cooperation is necessary to provide consistent planning and management. In the case of tourist areas, the outlying communities (gateway communities) may not hold the main attraction of the destination area, but are faced with the "spillover effects" of growth and development activity stemming from the primary tourist area. For example, the communities surrounding Acadia National Park in Maine are severely impacted by the high volume of tourists travelling to Acadia. Ineffective planning and lack of regional cooperation have resulted in commercial strip development, traffic congestion, and the degradation of natural and scenic resources which make the Mount Desert Island so alluring to tourists. Therefore, regional capacity planning is vital to preserve the qualities of the destination area as well as the integrity of the region as a whole.

C. A Procedure for Determining the Carrying Capacity of a Tourist Community

The main elements of the recreation- and community-based approaches to carrying capacity analyses discussed above are highlighted as they apply to a tourist community. The basic methodology here should be adapted to meet local needs and circumstances. The type and extent of the analysis would depend on a community's critical issues, funding, technical ability of local officials or planners, and the amount of local commitment to conduct the study and to follow-up with implementation.

Table 3 shows the steps to determine the capacities of local natural resources, infrastructure and services. The procedure would be part of the comprehensive planning process which would be followed by an implementation program. It is useful to establish a special committee to carry out the data collection and analysis and to organize public meetings. Public participation is vital not only for gathering additional information, but for

Table 3. Procedure for a Tourist Community Carrying Capacity Analysis

I. Preliminary Assessment

- Introductory public meeting to identify community issues and resources of major concern;
- Identify public perceptions of existing conditions and desired future conditions through public opinion surveys of year-round and seasonal residents, and visitors.

II. Inventory

- Collect existing data on current and historical conditions of resource and facilities (reports, studies, maps, etc.);
- Update existing or gather additional data as needed;
- Produce additional maps as needed.

III. Analysis

A. Project supply of and demands on natural resources, physical systems, public services:

- Estimate future development through build-out scenarios;
- Estimate future population and tourist visitation rates (if possible);
- Project capacities of water supply (public and private), solid and sewage waste disposal facilities, roads, etc.;
- Estimate future demands on recreation and visitor facilities and services.

B. Convert dwelling units to population thresholds and compare to projected capacities of natural resources, infrastructure and services to accommodate estimated population levels, including visitor estimates (if possible).

IV. Identify Impacts

- Identify impact indicators for critical resources or systems (see Table 4);
- Identify probable causes of impacts.

V. Policy Development and/or Revisions

- Set guidelines to direct management actions and development or visitor controls;
- Conduct a hearing to receive additional public input.

VI. Implementation of Management Actions and Regulations

- Revise ordinances, codes, etc. according to recommendations;
- Initiate or improve non-regulatory strategies (see Appendix A).

VII. Establish Monitoring Program

- Continuous evaluation of conditions through impact indicators;
- Evaluation and revisions to policies, management actions, development and visitor controls.

policy development and support for the implementation program. Public awareness of capacity issues and critical resources such as water supplies and water quality, and waste disposal is necessary to promote household and individual participation in the community's resource conservation efforts.

The preliminary assessment guides the inventory and analysis steps by targeting the important growth and development issues (including tourism) in the community. An inventory of existing data helps identify missing data as well as information that must be updated. The data collected in Step II forms the basis for projecting land uses, activities and population and visitor characteristics in Step III. Visitation rates and visitor activities in a community may be difficult or impossible to project without local statistics on tourist numbers and patterns . However, general trends in the use of lodging facilities, eating and drinking establishments, retail stores and major recreation areas can be useful to estimate future recreation and tourism demands.

Data can be obtained locally and from regional and state agencies. In addition to numerical data, maps are an important source of information. These would include: the community's zoning map; land uses; tax assessor's map; flood plains; wetlands; soils; designated or significant natural, cultural, and recreation areas; and, infrastructure (public sewer, water, and transportation network). The maps are most useful for depicting existing conditions, potential land use conflicts and development constraints, and aid in the analysis of and planning for resources and other capacities.

The analysis phase enables the community to project future demands for,, and supplies of, natural resources, physical facilities and services. This step is the actual carrying capacity analysis. The most common and perhaps the most straightforward method for determining capacities is to perform several build-out scenarios. These scenarios determine the potential number of new residential dwellings which could be built in a community, and the effects of different population levels on the community's

resources, facilities and services. One scenario would project future development density and the associated population level under existing zoning and development regulations. Other scenarios would estimate population levels that would result from either increasing or decreasing the types of residential units (single- or multi-family dwellings) or the allowable densities by altering minimum lot sizes. Dwelling units are converted to population by multiplying the town's average number of persons per type of dwelling by the number of new dwellings, and added to the existing population. Projections for daily visitation rates should be included in the build-out analysis for a tourist community, if the information is available. The various population levels are then compared to the projected capacities of resources (e.g., fresh water supply), infrastructure and various public facilities, including recreation and tourist facilities.

Not all communities have public water or sewer systems, but rely on private wells and on-site septic systems. Estimating the capacities for natural systems may require a professional assessment. For example, hydrology studies have been conducted to determine the "maximum safe yield" (i.e., the carrying capacity) of groundwater resources. Hydrology studies combine data on soils, vegetation and geological characteristics with land use information to calculate maximum population and development densities that the aquifer effectively could support (Gerber 1989).

Impact identification and impact monitoring are important for long-range capacity planning. The major impacts on resources and facilities are identified in the first three steps. Examples of impact indicators are listed in Table 4 at the end of this section. The list is not exhaustive; rather, it is a sampling of factors to monitor changes in resource, physical facility, or social conditions. These indicators are the "red flags" -- warnings that management actions must be implemented or revised. For instance, water quality might be evaluated for concentrations of particular contaminants (e.g., nitrogen, phosphorus). Acceptable levels of these pollutants for surface water bodies are usually determined by

Table 4. Impact Indicators to Identify & Monitor Carrying Capacities

Natural Resources

Water Quality Indicators (Groundwater and Surface Water Bodies)
- pH
- Salinity in freshwater systems
- Pollutant concentrations (nitrogen, phosphorus)
- Colliform concentrations
- Water temperature
- Clarity (depth of visibility)
- Visible pollution

Water Quantity Indicators
- Aquifer yield (gallons per day)
- Private well yields (gallons per minute)

Soils Indicators
- Drainage patterns
- Percolation rates
- Visible erosion
- Compaction (e.g., on hiking trails)

Wildlife & Vegetation Indicators
- Abundance
- Relative health of plant and animal species
- Species diversity
- Productivity of threatened & endangered species

Facilities, Infrastructure & Public Services

- Operation of public sewage treatment plant (gallons treated per day)
- Operation of public water system (gallons used per day)
- Solid waste disposal (tons)
- Status of landfill (estimated remaining capacity)
- Private septic system failures
- Levels of service by road or road segments (traffic counts)
- Traffic accidents
- Public transportation ridership
- Parking lot usage
- Numbers of fire, police and emergency medical personnel (volunterr and paid)
- School enrollment
- Municipal budget trends for items above

Tourism / Recreation Facilities & Tourists

- Capacities of lodging facilities (n# of rooms or beds); campgrounds (# of sites)
- Occupancy rates of lodging facilities and camprounds
- Number of visitors to public recreation areas (daily, seasonally, etc.)
- Number of visitors by type of activity
- Visitor's average length of stay
- Visitor perception of crowding; environmental impacts
- Residents' perceptions of tourism and tourists; crowding; environmental conditions, etc.

Adapted from Graefe et al. 1987 and Shelby and Heberlein 1986.

state and/or federal environmental or health agencies. The results obtained from water quality tests (conducted as part of the inventory stage) for pollutants can be compared to the acceptable standards. If an unacceptable concentration of the pollutants is found, it indicates the need to implement or adjust pollution control strategies.

Growth policies are established based on the results of the analysis of existing and projected conditions and the community's desires for the amount or direction of change that were identified through public surveys and meetings. In a tourist community, the visitors' opinions (from surveys) should also be considered for policies related to tourism. Policies must be specific and clearly stated. For example, policies related to water resources might be: "protect water resources from contamination by controlling land uses and activities which directly or indirectly affect water quality"; or, "promote water conservation through increased public awareness of the threats to the quality and supply of the community's groundwater resources."

Management actions and regulatory strategies are identified and implemented to preserve and protect critical resources, to maintain or improve the operating efficiency of facilities and services, and to enable growth to occur at a rate at which the community can accommodate it. Appendix A lists some of the management techniques and regulatory tools for tourism and growth management. The list is not comprehensive, but indicates the types of management tools that could be, and have been, implemented in tourist communities.

The assessment process is a continuous one, not just a "snapshot" of existing conditions. Capacity levels are not static but will change over time. A monitoring program must be established to provide periodic reviews and adjustments to the implementation program. The planning process requires a considerable commitment on behalf of the community to conduct the analysis and follow through with an implementation program. The greatest benefit to the community is that it provides the means to determine the direction of growth and to guide that growth according to the community's values. In a

tourist community where haphazard growth and change threaten to destroy the special qualities that make it attractive for tourism, managing growth based on carrying capacities is an absolute necessity.

VIII. SUMMARY & RECOMMENDATIONS FOR FUTURE RESEARCH

The role of tourism and recreation in local, regional and state economies has increased dramatically over the past two or three decades. The perceptions of tourists and tourism development have changed, too. The negative effects of what was once thought to be a low-impact, clean industry are now quite obvious in areas where use and development have exceeded local capacities. The deterioration in environmental quality resulting from mass tourism and uncontrolled development is detrimental to a community's character and quality of life, and makes it less attractive to tourists. In order to realize the economic and other benefits of tourism, the tourism industry must be managed like any other industry in an effort to maximize the benefits and minimize the undesirable effects.

The carrying capacity concept is not a new planning tool. However, the recent applications of capacity planning places a greater emphasis on balancing growth and resource protection in both tourist and non-tourist communities. The concept is implicit in recreation and tourism management. Demands on recreation areas are increasing faster than the opportunities to expand existing areas or establish new ones. Recreation managers must focus on optimizing the use of existing areas, within environmental and social limits, in order to protect the resources and provide visitor satisfaction. Likewise, development pressures on tourist communities calls for planning and implementation strategies to ensure that the growth occurs within each community's means to accommodate it.

The approaches for analyzing recreational capacities that were reviewed in this project can be adapted to meet the needs of a community. However, a community carrying capacity analysis requires a broader assessment of the tourism- and nontourism-related impacts of development on all types of local capacities. As such, carrying capacity is a fundamental component of a local growth management program. A carrying capacity analysis enables the community to identify the limits to future growth, and the probable

environmental, economic and social impacts of excessive growth. Most importantly, it gives the community the chance to direct the type and amount of growth before substantial degradation occurs. Capacity planning is important in any community, but it is imperative in areas where high growth pressures jeopardize the integrity of sensitive natural resources.

Tourism is so closely tied to natural resources that it is hard to believe that the tourist sector and environmental sector have been at odds, rather than working together toward common goals. In recognition of the need to facilitate communication and cooperation between tourism and conservation groups, the New England states have embarked on an ambitious program to improve tourism and recreation opportunities, and to protect valuable resources. In December 1989, the New England Governors' Conference, Inc. (NEGC, Inc.) sponsored a working conference called "Tourism and Land Conservation: A Common Agenda." The objective was to identify and "adopt common goals and strategies for protecting New England's Heritage" (NEGC, Inc. and Lincoln Institute of Land Policy 1989). The conference was in response to NEGC, Inc.'s earlier initiatives to improve regional cooperation in land preservation, and to develop a Tourism Action Plan for New England.

Conference participants were organized into four working groups for different types of landscapes: 1) mountains/rural; 2) coastal; 3) rivers and lakes; and, 4) historic and cultural areas. The working groups made recommendations to improve tourism and environmental management, and to reduce the communication gap between these sectors. Some of these recommendations are highlighted here, for their applicability to this project. They are:

1) To strengthen local and regional planning, with a greater emphasis on tourism issues;

2) To distribute tourists and tourism development to reduce impacts on over-utilized and sensitive areas and to encourage use of more tolerant sites;

3) To examine tax policies relative to using tourism revenues to help local communities manage tourism impacts;

4) To educate tourists on the impacts of tourism on host communities and on the environment;

5) To enact and improve environmental regulations and programs to protect significant natural resources, especially water;

6) To adjust transportation planning and policies to be more sensitive to tourism and conservation issues, and to encourage alternatives to private automobile use; and,

7) To strengthen and refine inventories of natural, scenic, and other resources.

By all indications, tourism and recreation will continue to be priority planning issues in the future. Tourism management must be part of the local growth management program in a tourist community, but it will also require regional coordination where the impacts extend beyond municipal boundaries. Tourism must be managed in a manner that is sensitive to the resources on which it depends. High quality resources are the reason for tourism, and resource protection and wise land use management are an absolute necessity in order to promote tourism as a sustainable industry, rather than a destructive one.

Recommendations for Future Research

New and revised methodologies and management techniques are being developed to assess and control visitor impacts and enhance visitor satisfaction in recreation areas. Advancements in technology (e.g., satellite imagery, computer models) will aid in data collection and analysis, and might provide a better understanding of the causes of impacts and how to reduce or prevent them. Assessments of the use and cost of computers and special computer programs, including Geographic Information Systems (GIS), for local capacity planning would be useful for municipal officials and planners. As these high-tech

systems become more user-friendly (and perhaps less expensive) they will become important municipal planning tools.

It would be interesting and useful to update the island tourist communities that were contacted for the Island Carrying Capacity Study. Research questions should address whether or not the growth regulations and non-regulatory programs that these communities have implemented have been effective in reducing tourism impacts or growth impacts in general. A review of standards, such as setbacks, lot coverage, and other dimensional requirements, for development on islands and in other ecologically sensitive areas would be useful for communities seeking to increase protection of vulnerable natural or scenic resources.

Finally, a future project could explore other efforts (outside New England) to link tourism and conservation interests. State, regional and local entities in Northeast would benefit from the experiences and ideas from similar tourism/environmental management programs around the U.S or in other countries.

IX. REFERENCES

Alpert, Joel E., and Eliot Epstein. undated. "Case Studies of Composting Municipal Solid Wastes." E & A Environmental Consultants, Inc., Stoughton, MA.

Archer, B.H. 1978. "Domestic Tourism as a Development Factor." Annals of Tourism Research, Vol. 5, pp. 126-141.

Baglole, Harry. Director, Institute of Island Studies, University of Prince Edward Island, Charlottetown, PEI, Canada. Personal interview September 8, 1990.

Beatley, Timothy C., David J. Brower, and Louann Brower. 1988. Managing Growth: Small Communities and Rural Areas. Center for Urban and Regional Studies, Univ. of North Carolina, Chapel Hill, N.C.

Birch, James C., Howard Birnbaum, Robert Jerret, and Louise Strayhorn. 1976. Tourism Impact Study for Prince Edward Island. Abt Associates, Inc., Cambridge, MA.

Bosselman, Fred P. 1978. In the Wake of the Tourist: Managing Special Places in Eight Countries. The Conservation Foundation, Washington, D.C.

Bourgeault, Cynthia. 1989. "Tarnished Jewel: The Talk of Acadia." Downeast, August, pp. 9- 12.

Bunnell, Gene. 1989. "A Tale of Two Tourist Towns: Approaches to Tourism Development in Stockbridge, MA and North Conway, NH." Paper prepared for a conference on Tourism and Land Conservation in New England: A Common Agenda, Lincoln Institute of Land Policy and the New England Governor's Conference, Inc., November 13-15, Portland, ME.

Butler, R.W. 1974. "Social Implications of Tourist Development." Annals of Tourism Research, Vol. 2, pp. 100-111.

———. 1980. "The Concept of a Tourist Area Cycle of Evolution: Implications for Management of Resources." Canadian Geographer, Vol. 24, No. 1, pp. 5-12.

Chinitz, Benjamin. 1990. "Growth Management: Good for the Town, Bad for the Nation?" Journal of the American Planning Assoc., Vol. 56, Issue 1, pp. 3-8.

Clark, John. 1976. The Sanibel Report: Formulation of a Comprehensive Plan Based on Natural Systems. The Conservation Foundation, Washington, D.C.

Cohen, E. 1978. "The Impact of Tourism on the Physical Environment." Annals of Tourism Research, Vol. 5, No. 2, pp. 215-237.

de Kadt, Emanuel. 1976. Tourism: Passport to Development ? Oxford University Press, New York.

Dunne, Thomas, and Luna B. Leopold. 1978. Water in Environmental Planning. W.H. Freeman & Co., San Francisco.

Dutram, Paul W. 1988. The Planning Process for Local Groundwater Protection. State of Maine Executive Department, Groundwater Standing Committee and Land and Water Resources Council, Augusta, ME.

Frechtling, Douglas C. 1987. "Assessing the Impacts of Travel and Tourism: Introduction to Travel Impact Estimation." *In* Ritchie, J.R. Brent, and Charles R. Goeldner. Travel, Tourism and Hospitality Research. John Wiley & Sons, New York, pp. 333-361.

Gerber, Robert G. 1989. "Vinalhaven Groundwater Resource Study and Municipal Water Supply Evaluation." Robert Gerber, Inc., Freeport, ME.

Godschalk, David R., David J. Brower, Larry D. McBennett, Barbara A. Vestal, and Daniel C. Herr. 1979. Constitutional Issues for Growth Management. Planners Press, American Planning Assoc., Chicago, IL.

Graefe, Alan R., Fred R. Kuss, and Jerry J. Vaske. 1987. Recreation Impacts and Carrying Capacity: A Visitor Impact Management Framework (Review Draft). National Parks and Conservation Association, Washington, D.C.

Gunn, Clare A. 1979. Tourism Planning. Crane, Russak & Co., Inc., New York.

Hegenberth, Jane, and Rich Shaw (Eds.) 1984. "A Carrying Capacity Study of Hatteras Island." Dept. of City and Regional Planning, Center for Urban and Regional Studies, University of North Carolina, Chapel Hill, N.C.

Horsley & Whitten, Inc. 1988. "Land Development in the Coastal Zone: Impacts Upon Water Quality." Barnstable Village, MA. Course packet for a seminar on innovative strategies to protect coastal waters, November 15, 1988, Rockland, ME.

Hunt, John D. 1989. "Tourism and Land Conservation: A Linkage Vital to New England." Paper prepared for the conference on Tourism and Land Conservation in New England: A Common Agenda. New England Governor's Conference, Inc. and Lincoln Institute of Land Policy November 13-15, Portland, ME.

Institute of Island Studies. 1989. "Focus on the Land: Preparing for the Royal Commission." Brochure prepared by the Institute of Island Studies, University of Prince Edward Island, Charlottetown, PEI, Canada.

LaFlamme, Alan G. 1979. "The Impact of Tourism: A Case from the Bahama Islands." Annals of Tourism Research, Vol. 6, No. 2, pp. 137-148.

Martin, Burnham, Kenneth D. Kimball, and Suzanne Appelaniz. 1987. "Visitor Use and Impact Patterns on the Isle au Haut Acadia National Park, Maine: Interim Report #4." Appalachian Mountain Club, Gorham, NH.

Martin, Burnham. Project Director, Appalachian Mountain Club, personal interview July 18, 1989.

Mathieson, Alister, and Geoffrey Wall. 1982. Tourism: Economic, Physical and Social Impacts. Longman, Inc., New York.

McCool, Stephen F. 1978. "Recreation Use Limits: Issues for the Tourism Industry." Journal of Travel Research, Vol. 17, No. 2, pp. 2-7.

Mid-Coast Economic Development Council (MCEDC). 1989. Minutes of October 15 meeting, Wiscasset, ME.

Murphy, Peter E. 1985. Tourism: A Community Approach. Methuen, Inc., New York.

New England Governors' Conference, Inc. and Lincoln Institute of Land Policy. 1989. Conference Summary. Prepared for the conference on Tourism and Land Conservation in New England: A Common Agenda. New England Governor's Conference, Inc. and Lincoln Institute of Land Policy, November 13-15, Portland, ME.

Pigram, John J. 1980. "Environmental Implications for Tourism Development." Annals of Tourism Research, Vol. 7, No. 4.

Pizam, Abraham. 1978. "Tourism's Impacts: The Social Costs to the Destination Community as Perceived by Its Residents." Journal of Travel Research, Vol. 16, No. 4, pp. 8-12.

Ritchie, J.R. Brent, and Charles R. Goeldner (Eds.). 1987. Travel, Tourism, and Hospitality Research. John Wiley & Sons, New York.

Sax, Joseph L. 1980. Mountains Without Handrails: Reflections on the National Parks. University of Michigan Press, Ann Arbor, MI.

Schneider, Devon M., David R. Godschalk, and Norman Axler. 1978. "Carrying Capacity as a Planning Tool." Planning Advisory Service Report #338, American Planning Association, Chicago, IL.

Shaw, Carol. 1988. "Island Carrying Capacity Study." Report prepared for the Maine Dept. of Economic & Community Development, Office of Comprehensive Planning, Augusta, ME.

Shelby, Bo, and Thomas A. Heberlein. 1986. Carrying Capacity in Recreational Settings. Oregon State University Press, Corvallis, OR.

Stankey, George H., David N. Cole, Robert C. Lucas, Margaret E. Petersen, and Sidney S. Frissell. 1985. "The Limits of Acceptable Change (LAC) System for Wilderness Planning." U.S. Forest Service Gen. Tech. Report INT-176, January 1985.

Stansfield, Charles A.Jr. 1978. "Atlantic City and the Resort Cycle: Background to the Legalization of Gambling." Annals of Tourism Research, Vol. 5, No. 2, pp. 238-251.

U.S. Congress, Office of Technology Assessment. October 1984. "Protecting the Nation's Groundwater from Contamination." OTA-0-233, Washington, D.C.

Vaske, Jerry J., Alan R. Graefe, and Ellen B. Drogin. 1989. "VIMDEX: An Index of Visitor Impact Management References." Proceedings of the 1989 Northeastern Recreation Research Symposium, April 3-5, Saratoga Springs, NY, pp. 77-83.

Wall, Geoffrey, and C. Wright. 1977. The Environmental Impact of Outdoor Recreation. Dept. of Geography Publication Series No. 11, University of Waterloo, Ontario, Canada.

Washburne, R.F. 1982. "Wilderness Recreation Carrying Capacity: Are Numbers Necessary ?" Journal of Forestry, Vol. 80, No. 1, pp. 726-728.

Whitten, Jon D. undated. "The Falmouth Nutrient Loading Bylaw: A Regulatory Approach Toward Minimizing the Effect of Nutrients upon Fresh and Coastal Water Systems." I.E.P., Inc., Falmouth, MA.

Williams, Peter W. 1987. "Evaluating Environmental Impacts and Physical Carrying Capacity in Tourism." *In* Ritchie and Goeldner, 1987. Travel, Tourism, and Hospitality Research. John Wiley & Sons, New York, pp. 385-397.

APPENDIX A. LOCAL GROWTH & TOURISM MANAGEMENT TOOLS

The following list of tools and techniques is only a sampling of local management and regulatory options for growth and tourism management. After a comprehensive plan is developed and local issues and critical resources have been identified, these tools or techniques would become part of the community's implementation program. The selection of tools or combination of tools to use will depend on a variety of factors such as local regulatory authority, existing planning and zoning, condition of and threats to local resources and facilities, public acceptance of new or additional regulations, and other local or regional factors.

REGULATORY

Zoning Districts:

- To define growth areas, or areas for low-intensity or no development;
- To prohibit certain uses or activities in certain areas
  (e.g., fast food restaurants, underground storage tanks, motorized vehicles);
- To promote desired uses or activities
  (e.g., commercial fishing / maritime activities, agriculture);

Overlay Districts:

- Additional regulations over-ride those of the underlying district or the more restrictive regulations apply.
  Aquifer or Watershed Protection Overlay; Shoreland Overlay;
  Scenic Protection Overlay; and, Traffic Corridor Overlay.

Performance Standards:

- To allow uses within designated areas provided that the "acceptable" levels of impact will not be exceeded. Standards usually apply to the impacts of development on critical resources (wetlands, surface water bodies and aquifers, beaches) or facilities (public sewer and water systems, roads).

Other Special Ordinances or Ordinance Provisions:

- Subdivisions controls;
- Architectural Design Review;
- Sign regulations;
- Cluster Zoning / Open Space Protection; and,
- Prohibition of non-degradable packaging for take-out foods;
- Additional permits required (e.g., water allocation permits);
- Requirements for private sewage disposal and well inspections every (five) years, or upon transfer of property.

Regulation of Rate of Growth (or Use):

• To limit the number and/or types of building permits issued within a given time period, and to allow growth to occur at a rate such that capacities are not exceeded. Similar regulations may be applied to permitting use of recreation areas such as beaches, campsites.

Additional Tourism-Related Regulatory Tools:

Regulation of parking areas, users, and fees;
Restrictions on use or number of recreational vehicles (mopeds, ATVs);

NON-REGULATORY

- Acquisition of land for protection or public recreational use:
  - Purchase;
  - Conservation easements and covenants;
- Public Education Programs on resource conservation (e.g., water, recycling, etc.);
- Tourism & Recreation Promotion strategies, such as:
  - Advertise under-utilized areas that can accommodate higher use;
  - Promote "shoulder seasons" to disperse visitation over time;
  - Provide minimal impact education;
  - Advertise recreation areas by use patterns or type of experience that visitors can expect; and,
- Provide public transportation (and associated parking facilities) in village/commercial areas, between major attractions, and access points.

Sources: Beatley et al. 1988; Graefe et al. 1987; Horsley & Whitten, Inc. 1988 and Shaw 1988.

APPENDIX B. ISLAND CASE STUDIES CONDUCTED FOR THE ISLAND CARRYING CAPACITY STUDY, 1988.

Massachusetts

Martha's Vineyard
Nantucket Island

Rhode Island

Block Island

Florida

Sanibel Island

California

Santa Catalina Island

Washington

San Juan County: San Juan, Orcas, Lopez and Shaw Islands
Island County: Whidbey and Camano Islands

Annotated Case Studies:

Cananda

Prince Edward Island

North Carolina

Ocracoke Island
Hatteras Island

South Carolina

Hilton Head Island
Tybee Island