PLANNING FOR COASTAL RECREATION OPPORTUNITIES NEAR LARGE URBAN AREAS:

A Study Relating Transportation and Recreation

Prepared for:

OFFICE OF WATER RESEARCH AND TECHNOLOGY
U.S. DEPARTMENT OF THE INTERIOR
WASHINGTON, D.C. 20240

INTASA

CRANE STREET • MENLO PARK, CALIFORNIA 94025

INTASA

1120 CRANE STREET • MENLO PARK, CALIFORNIA 94025 • (415) 323-9011

Final Report July 1975

PLANNING FOR COASTAL RECREATION OPPORTUNITIES NEAR LARGE URBAN AREAS: A Study Relating Transportation and Recreation

Prepared for

Office of Water Research and Technology
U.S. Department of the Interior
Washington, D.C. 20240

The work upon which this publication is based was supported wholly by funds provided by the United States Department of the Interior as authorized under the Water Resources Research Act of 1964, Public Law 88-379, as amended.

Supervision:

N.V. Arvanitidis

Edited by:

S. Davenport

Project Team:

D.P. Lijesen, Project Leader
Y. Snir
J. Rosing
K. Skurski

Contract No. 14-31-0001-4234
IRP 73-02

FOREWORD

A. Purpose

With respect to our scarce coastal resources, different viewpoints exist related to their development or conservation. In addition, in case of development, plans for recreational use of coastal resources almost invariably conflict with other possible and proposed development goals. In the investigator's opinion, these conflicts should be addressed in the process of developing recreation plans if they are to be resolved and if the recreation plans are to be implemented ultimately. The primary purpose of this study, therefore, is to contribute towards a solution to this decision-making dilemma by developing and demonstrating an analysis capability for examining the quantitative implications of alternative viewpoints and for clarifying conflict situations. In meeting this objective, it became apparent that recreational planning is not simply a calculation of deficiencies and development of an associated plan to meet such deficiencies. A more flexible approach is called for.

It is hoped that the approach presented in this report will improve the recreation planner's ability to present the public with information on the basis of which a clear choice can be made regarding the recreational use of coastal resources.

B. This Research in Perspective

Various recreation research studies and recreation planning efforts have been undertaken over the years which are documented in the literature. Examples of research studies include behavorial studies -- e.g., why people recreate, and the more general area of water resources development studies -- e.g., the Hotelling-Clawson approach for assessing the economic benefits of a recreation project. In the latter case, the multiplicity of research efforts directed towards economic benefit evaluation of multipurpose reservoirs may be due to the requirement that recreation be evaluated in a manner similar to that used for other projêct purposes such as flood control. This type of research has resulted in methodological developments included in proposed planning procedures such as the one adopted by the U.S. Army Corps of Engineers.

Turning to recreation planning for a moment, the local agencies responsible for recreation planning regularly propose and publish plans which indicate how, when and where capital resources are to be committed for providing recreation opportunities within their areas of jurisdiction. These agencies frequently rely on the State Comprehensive Outdoor Recreation Plan (SCORP), which, if adopted, serves as the coordinating umbrella for local planning efforts because these must be consistent with the SCORP plan in order to qualify for Federal funding.

Although both the research studies and planning efforts deal with the provision of recreation opportunities, it is the investigator's opinion that it is frequently difficult to discern how they contribute to informed decision making. It is also difficult to see how research results have helped to shape recreation plans or how planning needs have oriented the direction for research. The study reported herein attempts to bridge this gap in one planning situation: planning for coastal recreation opportunities near large urban areas. The central theme was to determine what type of information should be developed by the planner during the planning process in order to arrive at plans that include the issues of concern to people who will ultimately accept or reject a plan.

A sensitivity approach is proposed to develop information on level and geographic distribution of recreational visitation, a key input toward determining the final implications associated with recreation plans. Thus the research was oriented toward modeling the accessibility to recreation resources as a function of the demand for activities, supply of opportunities and the highway network connecting demand centers and supply zones.

C. Outline of this Report

- Chapter 1: presents project summary, conclusions and recommendations.
- Chapter 2: discusses comprehensive recreation planning and information needs, and focuses on accessibility as one of the key concerns in arriving at recreation plans.

- Chapter 3: develops a methodology for joint consideration of demand for recreation activities, supply of recreation opportunities and alternative transportation networks.

- Chapter 4: presents an application of the developed methodology in a case study related to the provision of coastal recreation opportunities along the California Central Coast Zone.

- Appendix A: presents technical information regarding the proposed accessibility model.

- Appendix B: presents a simplified description of the computer program developed in this effort.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

ACKNOWLEDGEMENTS

We want to thank the people who contributed to this study by their timely interaction and cooperation with the project team. In particular, Dr. W.A. Hall, previous Director of the Office of Water Resources and Technology (OWRT), Dr. S. Ware, previous project monitor, and Mr. T.G. Roefs, current project monitor for OWRT, were very supportive of our approach and a source of encouragement throughout this project. We would also single out Mr. Frank Lodato of the California Central Coastal Zone Commission who assisted us in focusing on the significant issues; we appreciate his important contribution to this study. In addition, we received extensive cooperation from many recreation-related agencies in the San Francisco Bay area. We are grateful to the many individuals in these agencies who, through too numerous to thank individually, gave generously of their time and expertise.

CONTRIBUTIONS OF INTASA STAFF

The research results, documented in this report, represent the combined effort of various INTASA staff members. Mr. D.P. Lijesen and Dr. J. Rosing developed the basic approach for the analysis. Mr. Snir assisted in the development of the methodology and the associated computer program, developed the case study, and maintained extensive contacts with local agencies. Ms. Skurski was instrumental in the analysis performed in Chapter II. Mr. D.P. Lijesen was responsible for synthesizing the research results and for writing this final report.

INTASA

[signature]

N.V. Arvanitidis, President

Chapter I

PROJECT SUMMARY

A. Background

On January 9, 1973 INTASA's proposal IRP 73-02 "Analysis and Evaluation of Recreation Opportunities Provided by Urban Water Resource Projects" was submitted to the Office of Water Resources and Technology (OWRT) pursuant to Title II of the Water Resources Research Act of 1964. The initial intent of the proposed research was to investigate the relevancy of various recreation evaluation techniques to planning water-oriented urban recreation. The proposed research was based on the fact that there is a vast difference between recreation in an urban setting and recreation at reservoirs outside urban areas; traditionally the latter has received more emphasis in the literature. On September 10, 1973 OWRT informed INTASA that although the proposed research was considered favorably, the priority assigned to the proposal was not sufficient to qualify for funding.

Subsequent involvement with the California Central Coastal Zone Commission during the latter part of 1973 motivated INTASA to request that OWRT reconsider their decision. In a letter dated October 15, 1973, INTASA indicated an intent to redirect the previously submitted proposal towards the development and demonstration of an analysis capability dealing with coastal recreation opportunities near large urban areas. This type of analysis and evaluation is an important concern in the National Coastal Zone Management Program whose activities are of interest to various agencies within the Department of the Interior. In addition the subject is of prime concern to the California Central Coastal Zone Commission whose members are charged with planning for coastal areas in close proximity to the San Francisco metropolitan area. Therefore, recognizing an opportunity to combine needed research related to coastal zone management with practical application in a real planning environment, OWRT accepted INTASA's proposal, and on May 9, 1974 contracted the company to investigate the subject. This final report describes the results of that investigation, undertaken under Contract No. 14-31-0001-4234.

B. Scope

Specific objectives of the research effort are stated as:

". Expand and, if deemed useful, modify current methodology for determining effective participation rates of socioeconomic populations in water-based recreation.

. Improve current procedures for determining the value of recreational opportunities in metropolitan areas."

In meeting the above objectives, INTASA saw an opportunity to develop an operational procedure which advances the state-of-the-art towards a comprehensive methodology for urban recreation planning. The need for a methodology to assess, measure and evaluate the social, economic and environmental impacts associated with the recreational use of water-related resources in urbanized areas has been established. It is also clear that in addition to evaluating recreational benefits of proposed water resources projects, such a methodology must be useful for planning urban water resource recreation development as well. That is, it should allow the recreation planner to identify the scope and direction that his plans must include in order to devise a set of recreation opportunities which are optimal with regard to the social well being, environmental quality, and regional development objectives in addition to national economic development. In response to this need and to the study objectives, the Scope of Work included the following tasks:

- Identify spatial units relevant to recreation.
- Devise a means for separating the urban population into community groups having homogeneous behavior in recreational activities.
- Identify recreational resources which need to be analyzed and characterize their attraction for potential users.

- Determine factors involved in the "cost" of urban recreational participation as well as other pertinent components which may be deemed significant.
- Review previous studies and examine statistical models employed as well as assessing operational usefulness of results obtained.
- Identify the key variables which most consistently explain variation in site demand.
- Formulate functional relationships among cost, key variables and site demand in order to analyze the consistency of a general framework for development of the functional transformations which yield demand estimates.
- Review studies dealing with estimation of recreation needs in terms of desired leisure-time spending.
- Develop a model to show the relationship between recreational resources availability and satisfaction of needs with long-term socioeconomic implications.
- Synthesize a set of methodological principles.

The above tasks were undertaken from the perspective of (1) planning for coastal recreation opportunities near a large urban area, and (2) demonstrating and applying the research within the context of the California Central Coastal Zone Commission's planning problem. With regard to the latter, work elements within some tasks have been considerably expanded in order to address the practical problems in coastal recreation planning; the basic intent has been to develop and apply a methodology that is transferable to other planning situations with similar problems. Specifically, Chapter II of this report deals with those tasks that are oriented towards further defining and focusing the coastal recreation planning process. Chapter III then synthesizes the results of those tasks which are oriented towards methodology and develops a model to assess the satisfaction of recreational demand in terms of the visitation that can be expected to occur at the available resources. Finally, Chapter IV provides a demonstration of the applicability of the methodology to the case study.

C. Project Organization

1. Project Personnel

Dr. N.V. Arvanitidis and Mr. D.P. Lijesen were principal investigators for this research effort. While various INTASA staff members were involved in this team effort -- including Drs. L.T. Brekka, C.H. Jolissaint, and J. Rosing, Messrs. W.R. Seelbach, Y. Snir, M. Hilleary, and Ms. M. Daniels and K. Skurski -- Messrs. D.P. Lijesen and Y. Snir, Dr. J. Rosing and Ms. K. Skurski were primarily responsible for the work.

2. Project Activities

The project was monitored until January 1975 by Dr. S. Ware, Water Resource Scientist of OWRT, and after that date by Mr. T.G. Roefs of OWRT. Regular progress reports were submitted and on March 25, 1974 a meeting was held in Washington attended by Dr. S. Ware and Mr. L. Brown of OWRT, and Mr. D.P. Lijesen of INTASA. The objective of this meeting was to present OWRT staff members with information regarding the specific orientation of the present research effort in terms of the individual tasks in the Scope of Work and the case study to be conducted in order to reach agreement on the content. A brief review meeting was held in San Francisco on April 22, 1975, attended by Mr. T.G. Roefs of OWRT, and Drs. N.V. Arvanitidis and C.H. Jolissaint and Mr. D.P. Lijesen of INTASA. The objective of the meeting was to report progress on preparation of the final report.

During the course of the project, there was extensive interaction with various local and State recreation and planning agencies, and with individuals knowledgeable about recreation and other planning aspects related to the California Central Coastal Zone. The objectives of this interaction were (1) to gain insight into the practical aspects of coastal recreation planning through meetings and correspondence, (2) to collect as many locally relevant reports as possible, and (3) to collect the necessary data on participation, preferences, recreation resource supplies, etc. Information was requested from over 30 local agencies as part of the effort. It is impractical to list each incidence of interaction; however the following list indicates the agencies which made the most significant contribution:

- California Central Coastal Zone Commission, Planning Committee, Santa Cruz.
- California State Department of Parks and Recreation, Sacramento.
- California Department of Transportation, San Francisco District.
- California Department of Transportation, Monterey District.
- Marin County Department of Public Works.
- Santa Clara County Parks and Recreation Department.
- San Mateo County Planning Department.
- San Mateo County Harbor District.
- Santa Cruz Parks and Recreation Department.
- Santa Cruz Port District.
- Sunnyvale Department of Parks and Recreation.
- East Bay Regional Park District, Oakland.
- Metropolitan Transportation Commission, Berkeley.
- Golden Gate Bridge Highway and Transportation District, San Francisco.
- Association of Bay Area Governments, Berkeley.

D. <u>Report Summary</u>

The key issues addressed in this final report relate to identifying, developing and demonstrating the type of information that the recreation planner must generate in the recreation planning process in order to be able to (1) analyze and evaluate recreation opportunities provided by coastal resources, and (2) account for the fact that recreation planning is but one facet of comprehensive planning which interfaces with planning efforts in other functional areas (transportation, housing, etc.). The latter is particularly relevant in the case of coastal zone management where recreation competes with other uses for the same scarce and valuable resources. This final report is organized on the basis of the above-mentioned key issues: Chapter II identifies the type of information that must be generated, Chapter III addresses how this information can be developed by means of a structured methodology, and Chapter IV demonstrates the use of this information in recreation planning and relates it to other planning efforts. Each chapter is briefly summarized in the following subsections.

1. Chapter II

Chapter II begins by reviewing the need for coastal recreation planning and by discussing the problems in comprehensive recreation planning. A key observation made is that comprehensive recreation plans generally do not contain sufficient information to assess impacts and tradeoffs between recreational use and other uses of the same resources. It is contended that analysis and evaluation of recreation opportunities provided by specific resources should be focused on these impacts and conflicts; however a "colored map" indicating where open spaces or recreation facilities are planned is not sufficient for this type of assessment. It is further postulated that impacts occur as a result of visitation to a site, and that information regarding the level and distribution of this visitation is needed to display the impacts' significance. In other words, in order to analyze whether a recreation plan for coastal resources is "good", "bad", "sufficient", "adequate", or anything else, the planner needs to determine what its effect will be on the environment, the local economy, and other impact categories of importance to people. Providing the planner with an insight into how many people will use the recreation resources is an elementary, but crucial, first step.

Subsequently, Chapter II briefly discusses the type of information, commonly available to the planner, related to surveys on existing participation and people's preferences and to facility design. In most cases this information is sketchy and incomplete. It is asserted that, in all likelihood, it will remain sketchy and incomplete for years to come because the state-of-the-art in behavioral research of the recreation market is not at the same level as similar research of markets for other goods or services, and also because initiating this type of recreation research is generally quite costly. If it can be assumed that it is close to impossible to accurately assess the recreation market, in particular with respect to the future, a viable alternative is to postulate a set of assumptions that will allow the recreation planner to calculate and hypothesize various visitation levels which then allow for an assessment of impacts. For example, rather than attempting to outguess the future in terms of how many swimmers will be at location X in 1990, it is desirable to concentrate on the underlying assumptions and to orient the analysis towards determining the sensitivity in the level of visitation as a result of varying basic assumptions. The results of this type of sensitivity analysis, when presented to the public, may prove to be more insightful and conducive to actual decision making.

Following the discussions on the required orientation for an effective recreation analysis and the type of information needed for such an analysis, Chapter II then addresses the problem of determining the level of use of resources. That is, in order to determine the level and geographic distribution of visitation it is necessary to explicitly establish the link between demand generated by people and supply provided by resources. This link can be established by focusing on the transportation network that connects demand centers and supply zones. Thus, central to determining visitation is recognition that accessibility to the resources is a key determinant in the recreation analysis.

2. Chapter III

Chapter III develops a methodology to calculate an expected daily level of visitation (i.e., level of use) within individual recreation supply zones as a function of: (1) a set of assumptions regarding recreation demand for certain activities that are generated at various population centers, (2) a set of assumptions regarding the capacity of the supply zone to accommodate recreationers, and (3) a set of assumptions related to capacity characteristics of the connecting highway network. In order to tie the three sets of assumptions together in an operational procedure to assess visitation, the concepts of a trip demand curve and a trip supply curve are introduced in a similar manner as the traditional demand and supply concepts in economic theory.

In a simplified version, the basic idea can be described as follows. Since the network is the first impediment to recreational visitation, the network can be considered as supplying trips to those who demand them. The trip demand curve establishes the relationship between the number of trips that people from specific geographic areas (i.e., demand centers) demand as a function of the average travel time needed to reach a particular recreation facility (i.e., supply zone). Generally it is assumed that the longer it takes, the fewer people are willing to drive to the facility and vice versa. The trip supply curve is determined completely by the highway network; it establishes the relationship between number of trips on the network as a function of the average travel time necessary to reach trip destination. Generally, the higher the total load on the network, the longer it will take to reach the recreation destination. The intersection of the trip demand and trip supply curves, for a particular demand center-supply zone combination, determines the expected level of visitation at the supply zone and provides an indication of the average travel time from demand center to supply zone.

Trip demand curves generally are based on modeling recreation behavior of people. This type of sophisticated modeling is not further pursued in this report. Instead, the simplified model proposed is designed to identify the maximum demand generated in a demand center that can be expected on a peak summer Sunday. Although the model is based on an analysis of observed participation, it is noted that application of the model is not a straightforward extrapolation of observed participation "numbers" but requires judgment from the planner. It is further noted that the model is not used to determine the exact demand but rather the sensitivity of visitation to variations in demand.

In order to determine the trip supply curves for a particular highway network and a set of demand centers and supply zones, a computer program (RECTRIP) is presented which calculates points on the trip supply curve using essentially gravity-flow concepts but modified to incorporate necessary changes due to overloading and saturation of network links. Program input includes information with respect to (1) demand for recreation activities at the demand centers, (2) effective supply to satisfy visitation with respect to these activities in the supply zones, and (3) network characteristics such as highway capacity and speed limit. Given the above information the following steps are needed to calculate points on the trip supply curve: (1) choose a trip production level at the demand centers corresponding to some level of demand; (2) determine routes to be used from demand center to supply zones accounting for the saturation effects of highways when the trip production level increases; (3) calculate the average travel time from each demand center to each supply zone, by activity, as a function of the trip production level; and (4) combine individual average travel times to arrive at aggregate average travel time.

Finally, the range of planning information that the model is capable of generating is indicated. This includes the ability to determine the sensitivity of visitation with respect to the following parameters: (1) changes in the carrying capacity in the supply zone; (2) changes in demand by activity type; (3) improvements in the transportation network. It is noted that the ability to conduct sensitivity analyses of these parameters is the most important use of the model because the information provided allows the planner to further investigate the implications associated with proposed plans.

3. Chapter IV

The purpose of Chapter IV is to apply the accessibility model and the RECTRIP program to recreation planning along the California Central Coastal Zone. The key objective is to show what type of information the recreation planner must generate in order to clarify and seek resolution for several controversial issues related to proposed and contested changes. These changes relate to planned improvements in the transportation network affecting access to the coast and to concerns for preserving the coastal environment.

Based on alternative planning scenarios, two alternative highway networks are formulated which connect the San Francisco-Oakland-San Jose and Fresno metropolitan areas to the California Central Coastal Zone. The preservation scenario emphasizes "minimal" highway development, thereby implying limited growth and limited destruction of the environment. In contrast, the development scenario emphasizes "maximum" highway development to accommodate anticipated and desired growth in the residential, recreational and tourism industries in the California Central Coastal Zone. It is noted that the rationale for assuming a particular future for the coastal area under consideration is directly related to assumptions regarding access.

Results of applying the RECTRIP program to each highway network are described as a function of increases in demand at 14 demand centers to be satisfied by the effective carrying capacity of 11 supply zones on the coast. Four resource-oriented recreation activities are considered: (1) beach use, (2) boating and fishing, (3) park use, and (4) sightseeing and driving for pleasure.

The results relate to four different subjects: (1) aggregate analysis of demand and supply where the objective is to consider all demand centers and all supply zones as two "super-nodes", and to investigate what level of visitation may be expected under each highway alternative; (2) congestion analysis where the objective is to consider individual elements of the network in an effort to discern where the most critical access problems can be expected; (3) trip supply curves where the objective is to indicate the specific information that can be derived from these curves; (4) level and geographic distribution of visitation where the objective is to investigate whether different forms of access will lead to a change in visitation by activity and/or whether it will lead to changes in recreation-travel patterns by people visiting the coast.

Finally, interpretation of the results of the model and the REC-TRIP program in light of the previously developed scenarios is discussed. The key point is to ascertain whether or not the visitation associated with a particular transportation network contributes towards or detracts from achieving the essential goals embedded in each scenario. For example, based on interpreting the results it is possible to see whether the visitation that can be expected under a minimal highway network will indeed lead to improved preservation of the environment or whether the resulting levels of visitation indicate that additional safeguards are necessary because people are still overcrowding the beaches.

E. Conclusions and Recommendations

The research documented in this report touches on many subjects dealt with theoretically in recreation literature and concretely in actual planning efforts; as such, it is quite broad in scope. Based on the experience gained, it would be possible to formulate many general conclusions and recommendations for future efforts. However, it is felt that advancing the state-of-the-art towards development of a comprehensive methodology for urban recreation planning, in particular as related to planning for coastal recreation near urban areas, is the priority issue. Therefore the conclusions and recommendations made are specifically addressed towards this need.

The following conclusions are drawn based on the results of the present effort.

- The current trend in comprehensive recreation planning is to focus primarily on acquisition of resources, delineation of institutional arrangements, and preparation of "colored maps". This is understandable given that there is no proven normative methodology for recreation planning, and recreation "plans" are frequently drawn up in response to a statutory requirement rather than developed in their own right. The emphasis is in general more on deriving some "plan" than on providing the rationale behind a particular recreation proposal. However, it is concluded that understandable though the current situation might be, it is no longer sufficient to perform recreation planning without better substantiation of the conclusions. In order to provide the basis for informed decision making, the recreation planner should make the public aware of issues surrounding a plan, for example: Why should the investment be made in acquiring land for recreational use? How can scarce resources, including capital, be best allocated to satisfy recreation needs? What are the implications of a plan in terms of actual concerns that the ordinary citizen has in contrast to an abstract formulation of community goals? A clear exposition of concerns such as the above is elementary when decisions are to be made committing valuable natural resources and capital for recreational development.

A lack of precise information regarding people's desires, preferences and needs to engage in recreation activities is frequently cited as the major stumbling block for more efficient and effective recreation planning. While granting that more behavioral research is needed to investigate recreational patterns, it is concluded that results of such studies have limited value in practical planning efforts, and further that this situation will probably remain unchanged for some time to come. For example, in order to accurately predict recreation demands, phenomena such as the impact of the energy crisis and recession on recreational patterns must be taken into account. Research is ongoing to seek answers to these and other questions, but it is in the infancy stage.

Obviously recreation planning must proceed and commitments for the future recreational use of resources must be made before the above problems are resolved. As the situation stands, these decisions will be based on insufficient information which adds to the uncertainty of their future outcome. Based on the results of this research effort, it is concluded that the uncertainty and complexity of recreation planning can be reduced by using a sensitivity analysis approach to gain insight into expected levels of visitation. That is, by shifting away from an attempt to merely outguess the future -- and towards an analysis of the sensitivity of visitation to various assumptions regarding recreation demand, effective supply, and access -- the recreation planner's understanding of the feasibility of future situations will be enhanced. For example, the California State Department of Parks and Recreation estimates that approximately 236,000 people will demand recreation activities at the California Central Coastal Zone on a peak day in 1990. The analysis cited in this report indicates that this level of visitation can be met by the available supply. However, it is also shown that the capacity of existing highway alternatives for 1990 will not be sufficient to accommodate the traffic generated by that many people, and therefore the validity of the projections is questionable. While this interpretation cannot be taken as exact because of the probability of improved public transit to provide additional access in 1990, it illuminates the need for recreation planners to consider issues related to access in their plan formulation efforts.

- In addition to formulating plans, the recreation planner must be able to communicate the implications that these plans have in terms that resolve questions in the public's mind. For example, to simply state a level of visitation does not convey much information. Rather the public would like to know what this level of visitation means in terms of disruption of the environment, impact on the local economy, and other important concerns. It is concluded that an information base regarding level and geographic distribution of visitation as a function of access is a valuable first step not only towards improving the planner's understanding of a plan's implications but also towards explaining major issues to the public.

Based on the above conclusions, and guided by the research results documented in this report, the following is recommended.

- A key issue raised in this report is that in contrast to planning in isolation, recreation planning should be related to other types of planning efforts for resource use such as second home development, industrial development, and environmental quality planning. Therefore, it is recommended that the sensitivity approach presented herein be further developed and formalized in order to improve coastal recreation planning by specifically addressing conflicts between various resource uses.

- A second issue discussed in this report relates to the desirability of improving the planning efforts of agencies responsible for developing recreation proposals. Therefore it is recommended that the sensitivity approach be further developed by using case studies of ongoing recreation planning efforts in which all major issues are examined in terms of their sensitivities. This will identify where application of sensitivity analysis can be most helpful to the planner in contrast to a research-oriented study which touches on only certain parts of the problem.

- Finally, this report postulates that recreation planning must be improved in order to respond to the concerns of people. It is assumed that in order to conduct a successful public participation program the planner has to communicate with a generally well-educated and informed public and that he must therefore provide the type of information that the public can respond to. (This report provides an example of one type of information that could serve as a basis for effective communication.) Therefore, it is recommended that a separate investigation be undertaken aimed at soliciting the views of various groups of people regarding their concerns for the implications associated with recreation plans, and identifying the vested interest of each group. The study should not be focused on identifying obvious concerns such as the desire to spend more available leisure time in recreation activities; rather the intent should be to determine what people are willing to give up such as an undisrupted coastal environment in order to gain recreation opportunities.

Chapter II

ACCESSIBILITY: A KEY DETERMINANT IN ANALYZING AND EVALUATING COASTAL RECREATION OPPORTUNITIES NEAR LARGE URBAN AREAS

A. Introduction

This chapter focuses on the planning process for coastal recreation opportunities near large urban areas, accounting for the fact that coastal resources in such areas constitute a scarce commodity for which, generally, there are conflicting development objectives. The emphasis here is on isolating the type of information that the recreation planner must generate in order to systematically proceed with the development, analysis, evaluation and implementation of particular plans.

One main point is advanced in this chapter: in order to be able to assess and evaluate the implications of a particular recreation plan in terms of beneficial and adverse effects, it will be necessary to consider several factors simultaneously. These include: the demand for coastal recreation opportunities, the supply of opportunities provided by the resources and facilities, and, the transportation network connecting areas where demand originates with areas where demand is satisfied. This simultaneous consideration is necessary to recognize and account for the fact that the level and geographic distribution of expected participation in various recreation activities -- the driving force behind adverse and beneficial effects -- depends on (1) size, location and availability of resources and facilities, and (2) public preferences for, and accessibility to, these resources and facilities. In the next chapter a methodology is formulated for simultaneously approaching demand, supply and accessibility, and for assessing expected participation as a function of these main elements. Chapter IV then demonstrates the methodology in a case study dealing with the provision of recreation opportunities along the California Central

Coastal Zone near the San Francisco-Oakland-San Jose and Fresno metropolitan areas. A comparative analysis is presented, analyzing the differences in participation and the associated implications resulting from differences in accessibility to coastal resources.

Simply stated, coastal recreation planning is performed in order to arrive at policies and decisions regarding the recreational use of coastal resources. To put this problem in perspective, Section B addresses the coastal recreation planning problem in the context of comprehensive recreation planning and introduces the California Central Coastal Zone case study. Subsequently, Section C briefly evaluates the type of information commonly available to recreation planners. Finally, Section D isolates the quantification of level and distribution of expected visitation as the most important input to policy-making, and delineates the basic requirements for the methodology developed in Chapter III.

B. Coastal Recreation Planning

1. The Need for Planning

The widespread concern for wisely using and developing the nation's coastal resources has led to legislation enacted by State and Federal governments to initiate more orderly and planned development. Coastal areas in close proximity to urban areas are under particularly heavy pressure to develop; this coupled with the fact that coastal land in such areas is a scarce commodity which must be carefully managed underscores the urgent need for more effective planning. It can be concluded that coastal resources generally are regarded as possessing unique aesthetic, recreational, and ecological characteristics which have a value to people from far away as well as to residents close by, and have a great potential value to future generations. Future development plans including recreation plans, must account for these values and must balance conflicting objectives.

In the first nationwide Outdoor Recreation Plan -- "Outdoor Recreation, A Legacy for America" -- prepared by the Bureau of Outdoor Recreation (BOR) of the Department of the Interior, the need for recreation planning of coastal resources is clearly recognized (Ref. 1). It states:

> <u>Shorelines, Beaches, and Estuaries</u>: Recreational opportunities at the water's edge offer popular and rewarding experiences. The Nation's ocean and Great Lakes shoreline and beaches are capable of providing many of these recreation opportunities. However, population within 50 miles of seashores is increasing rapidly, and natural shorelines are being lost to development and exclusive private interests.
>
> Many estuaries in and adjacent to major metropolitan areas have remained undeveloped and constitute great open space resources. These estuary systems can be the settings for urban outdoor experiences and can influence urban growth.
>
> Individual States have initiated comprehensive studies and inventories of their shoreline and coastal areas. Several have also enacted legislation limiting development until detailed studies and plans can be completed.
>
> Concentration of human activity, combined with the distinctive natural qualities of shorelines and estuaries, intensifies use conflicts and magnifies adverse impacts on the environment. Fishing and other recreational uses, when not excessive, have the least damaging effect on the natural environment and on other uses.
>
> There is a tremendous opportunity for conservation organizations, States, and the Federal Government to cooperate in the protection of the Nation's remaining shorelines and estuaries for the benefit of all citizens. Shoreline protection depends primarily on State and local government land use controls. Instead of ribbon development sprawling along the water's edge, shoreline conservation calls for concentration of commercial and residential development in limited areas.
>
> It requires upland conservation measures to protect beach access and scenic visats; it requires area-wide management; and it requires policies to open beaches to the public for their use and enjoyment. Also necessary are strong intergov-

ernmental relationships, because the benefits of shoreline conservation go beyond jurisdictional boundaries.

> In order to take full advantage of the recreation and fish and wildlife opportunities afforded by shoreline resources, Federal agencies are called upon to accelerate the evaluation of their holdings in the coastal zone to determine which beaches and shorelines can be made available for increased public recreation use.
>
> States can complement this Federal action by evaluating present laws relating to ownership and access and, where necessary, taking steps to provide public access to beaches and shorelines.
>
> State and local governments also should develop plans and programs to utilize Land and Water Conservation Fund monies for acquisition of beaches, shorelines, and estuaries with recreation values, and should encourage and assist conservation organizations in purchasing and obtaining donations of key parcels of shorelines.

Although it is recognized that: (1) the National Outdoor Recreation Plan possibly is designed as a policy statement regarding future coastal recreation planning, and (2) various interpretations of what constitutes a plan are possible, the above quotation allows for the following observations considered relevant to the problem of coastal recreation planning:

> There appears to be a general feeling that more and more areas are "lost to development and exclusive private interests". It is difficult to escape the impression that recreation planners are putting themselves in an adversary role against other "bad" types of development; moratoria are often placed on all development, as is the case with coastal development in California. It is clear that there is a need to address recreation planning more constructively; i.e., recognizing that there are tradeoffs between various types of development (e.g., recreational, residential, industrial). Given the validity of that judgment, the recreation planner must provide more detailed information regarding desired and expected recreational use of coastal resources so that decision makers understand the implications of various possible uses of a scarce resource.

- Not uncommon to most recreation planning, the quotation from the BOR plan emphasizes acquiring particular areas. This is probably based on the premise that it is better to "grab up" the resources now, irrespective of how they will be developed, before they can be used for other purposes. However, merely stating that a resource should be acquired does not constitute a plan; the recreation planner needs to provide information on why certain areas should be acquired and how they should be developed before decisions can be made. Again the emphasis is on attempting to delineate more precisely the desired and expected recreational use of the resources involved so that the decision makers understand the plan's implications.

2. The Problem in Comprehensive Recreation Planning

On the basis of the previous section it can be concluded that if recreation planning is to become compatible with, and receive a priority status similar to, planning efforts in other functional areas (e.g., transportation planning, residential development planning), it is important to first develop a clear rationale for allocating resources to recreational uses with full consideration of both the beneficial and adverse effects associated with such uses. Instead of merely developing general plans (i.e., the traditional "colored maps" with accompanying descriptive material), uncertainties inherent in such plans should be resolved so that the decision maker has a clear picture of the effects associated with the plan. This would provide the setting for making a rational choice between using a particular geographic area as a recreation park or, for example, as a nuclear power plant site. In this respect private users of resources are generally better prepared to argue their case than are the proponents of public uses (e.g., recreation, preservation, conservation). A recourse frequently followed by the latter group is to involve the political process in order to delay, correct or stop actions considered to be not in the public interest.

A lack of information regarding expected participation is the problem frequently perceived as inhibiting the development of recreation plans which then can be analyzed for their effects. For example, if the number of swimmers or campers who could be expected at a particular location and at a particular time could be determined, <u>then</u> recreation considered as a resource to augment urban recreation opportunities; (3) pressures to develop coastal strips for recreational and other uses is supported by local communities on the coast as a result of increases in recreation visitation; (4) public concern regarding orderly development of the area was expressed by passage of Proposition 20 on November 7, 1972 which resulted in the California Coastal Zone Conservation Act, and creation of the California Central Coastal Zone Commission and other commissions covering other zones; (5) the Commission expressed interest in analyzing and evaluating the recreation opportunities provided by the resources within their jurisdiction.

The California Central Coastal Zone covers over 200 miles of ocean coastline from San Francisco in the north to the Monterey-Carmel Peninsula in the south. It includes four urban development areas: the Cities of Pacifica, Half Moon Bay and Santa Cruz, and the Monterey-Carmel Peninsula. It also includes parts of four California Counties: San Francisco, San Mateo, Santa Cruz, and Monterey. As access to the coastal areas is provided by relatively few and frequently narrow passes through the Santa Cruz Mountains, there is a severe congestion problem on summer days.

A principal declaration of the aforementioned California Coastal Zone Conservation Act establishes the California Central Coastal Zone as a "distinct and valuable natural resource" for which it is necessary to preserve the ecological balance of the resources and to provide for the enjoyment of the coastal resources for current and succeeding generations.

The Commission is charged with preparing, adopting, and submitting a California Coastal Zone Conservation Plan to the Legislature for implementation. The broadly-stated goals of this conservation plan relate to:

- The maintenance, restoration, and enhancement of the overall quality of the coastal zone environment, including, but not limited to, its amenities and aesthetic values.
- The continued existence of optimum populations of all species of living organisms.

- The orderly, balanced utilization and preservation, consistent with sound conservation principles, of all living and nonliving coastal resources.

- Avoidance of irreversible and irretrievable commitments of coastal zone resources.

The Act specifies that certain specific elements are to be included in the Conservation Plan. For example:

- A comprehensive definition of the public interest in the coastal zone.

- Ecological planning principles and assumptions to be used in determining the suitability and extent of allowable development.

- Designation of specific land and water areas in the coastal zone for certain uses, or the prohibition of certain uses in specific areas.

- Recommendations for the governmental policies and powers required to implement the coastal zone plan.

The goals and planning considerations of the Conservation Plan apply to the many uses of the coastal zone, e.g., residential and commercial development, oil production, port development, recreation and agriculture. Any public or private developer must apply for a permit and receive approval from the Coastal Commission before development can take place. In principle, approval is granted if it can be demonstrated that the proposed development agrees with and is part of the comprehensive plan developed by the Commission.

The Commission's general orientation in developing a comprehensive plan is to consider four major plan elements and to analyze the major interactions among these. The elements include:

- Transportation: this element addresses the type and form of allowable and desired transportation networks.

- Recreation: this element addresses the extent to which the coastal zone can and should be used for recreation.

- Public Access: this element addresses what areas are to be designated for maximum visual and physical use and enjoyment of the coastal zone by the public.

- Public Services and Facilities: this element addresses general location, scale and provision of public services and facilities in the coastal zone (housing, industry, power plants, harbors, etc.) in a manner that is least destructive to the environment.

A key problem in developing the plan is to account for the relationships between the various elements. For example, in studying and planning for recreation, it is apparent that both transportation and recreation are closely interrelated since the level of use of recreational facilities is a function of both the size of the facility and the public's accessibility to it. This relationship is also important in planning for coastal transportation since the major demand on the network is due to people outside the coastal area coming to the coast for recreation. A recent public issue related to this relationship is the widening of one of the major highways (i.e., Highway 17) to the coast. Widening would most likely reduce travel time and safety hazards. On the other hand recreational visitation would increase with the associated effects of congestion at existing facilities and strain on the local economies. It is also not clear whether the existing resources have the carrying capacity for the development of additional facilities. This example illustrates the importance of determining the relationship between accessibility and recreational use levels when developing a comprehensive plan for the recreation element; i.e., the recreation planner must go beyond considering only the demand for recreation opportunities and the supply provided by resources and facilities and must include accessibility. Thus, transportation routes, planned for or in existence, and their capacity are important considerations when planning and designing recreation facilities. If facilities are located in an area without adequate highway and in-road access or without capacity to carry a corresponding number of users to the site, resources have been misallocated. As a result of this type of planning, recreation facilities will be unused (due to no access), highway networks will be saturated (due to lack of capacity), or facilities which have not planned for such levels of use will be overcrowded.

The methodology and case study developed in this report is specifically directed to address the interface between transportation and recreation and to identify the type of information that is needed to focus on issues such as those discussed in the previous paragraph. The perspective is taken that the recreation planner charged with developing a comprehensive coastal recreation plan needs to explicitly address accessibility to recreation resources and facilities in order to be able to analyze the implications associated with recreational visitation to the coast.

C. Synopsis of Existing Information for Comprehensive Recreation Planning

The purpose of this section is to illustrate the type of quantitative and qualitative information commonly used by the recreation planner in order to investigate the relevancy of this information to comprehensive recreation planning. It is noted that the emphasis is on information actually used in practice, in contrast to theoretical information (e.g., narratives on recreation research results).

1. Quantitative Information

Information in this group is characterized by the fact that it can be recorded, collected and transmitted in some quantifiable form. Examples include estimates of demand and supply, records of visitation at particular recreation sites, visitor preferences for certain activities and locations, and a continuum of values assigned to different recreation activities. The case of coastal zone recreation illustrates how this class of quantitative information is used by recreation planners. Initially, the need for recreation planning is justified on the basis of the number of "recreation days" spent at the coast as a percentage of the total number of recreation days in the State; e.g., 25 percent of the 1969 total recreation days in California were spent at the coast. Based on these estimates of participation and on population estimates, demand is projected for the number of recreation days per year that will be needed at some future time. Surveys of visitor preferences and values for the attractiveness and desirability of the coastal zone ranking this area as a prime attraction are used to further support any projections made.

When special recreational activities are considered, further quantitative information is used by recreation planners. For example, one prominent recreational use of the coast takes place in beach parks. An analysis to determine a demand, supply and subsequent value estimate for parks may take the following form. Beginning with an existing park, both total acres and beach acres are identified and total visitor days are determined from attendance records. Additional items frequently used are the number of days that the capacity of a park is exceeded, national standards for acreage per capita, and number of picnic tables, beach houses, etc. This array of available information is then transformed by recreation planners into some measure of the potential number of visitor days per acre. When this measure is combined with population projections, the future demand for recreational activities is estimated. Normative values may then be applied to various activities (e.g., a park is valued at $1.00 per day) to arrive at an estimate of the "income" provided per acre of park. Likewise for determining supply, recreation planners use national design standards and figures for acreage availability to calculate the available supply and to design facilities. Similar procedures using quantitative data can be applied to recreational activities other than beach park use, for example:

- Boating: number of registered boats, dock facilities, people per boat trip, etc.
- Fishing: number of licenses, party boat trips, number of fish caught, etc.

Quantitative information of the variety described above is used to calculate deficiencies in supply and to provide the rationale for acquiring additional resources and designing new facilities. However, it should be noted that first, while measured participation may provide some indication of future demand, it certainly is not sufficient to accurately estimate demand for facilities or resources in the future. Second, because visitation records are quite expensive to collect, the general situation is that records are kept for only a small fraction of total recreation visitation, and therefore, a large portion of the recreational pattern is undetected. And third, the use of design standards in planning has serious flaws which are best illustrated by the wide spread in existing design standards. Clearly the above remarks imply that quantitative information of the sort described may provide a starting point for planning but it should not be relied on in absolute terms or as a sole source. That is, it can be used to scope the planning problem but not to solve it.

2. Qualitative Information or Frequently Held Assumptions

Information in this category is not as neatly coded as in the first but nevertheless it is relied on heavily in practice. This category consists of common truisms that have penetrated the planning field, such as: "If you provide access, visitation will come automatically". Whether this is a valid assumption depends completely on the particular planning context. For example, narrow winding roads, although in existence and providing access to a site, often deter many potential recreation users. Another example of this second group of information is: "Whatever supply is available will be used". This may be correct in situations where there is a serious recreation supply deficiency as might be the case when an urban regional park is very crowded on peak days, while the available recreation supply of coastal parks still has remaining capacity. However, until existing or planned supply is actually accessible to the public, the level of use cannot be easily predicted. A supply cost (e.g., travel time, quality of access road, etc.) for planned facilities must be considered to give the planner an insight into the tradeoffs perceived by the public. One final example of qualitative information used by planners is: "The consumption pattern for particular recreation activities measures the corresponding demand for those activities". This statement takes the recognition, and well-known and available experience factors, as expressions of preferences. However, because alternative outdoor recreation opportunities are lacking, it does not follow that different and unfamiliar recreation activities should not be provided. Until people have more information regarding the types of recreation opportunities that could be provided, the cost of providing them, and their other implications in terms of benefits and costs, it is impossible to predict the public response to innovative recreation plans.

Assumptions such as those indicated above have frequently been used to circumvent the need to analyze and determine whether certain aspects of recreation plans are justified based on "expected use" as currently derived. It is contended that qualitative information must be used carefully and in conjunction with further analysis to determine the validity of accepting one of these assumptions as a basis for planning; used alone, decisions based on common truisms can lead to poorly planned recreation resources.

D. Conclusion: Focus of the Report

The purpose of this section is to further examine the general trend in recreation planning, and to isolate the key factors needed to improve comprehensive recreation planning. In regard to general trends, the BOR's National Outdoor Recreation Plan (Ref. 1) notes:

> Due primarily to certain peculiarities associated with the outdoor recreation market and the limited availability of useful data, there are numerous difficulties associated with an analysis of:
>
> 1. The amount of additional capacity required to meet future demands;
>
> 2. The amount of investment (public and private) which will be required to meet the projected capacity needs; and
>
> 3. Where the additional capacity will be required.
>
> It is precisely this type of information that can be of most use to those who are responsible for planning for and meeting the outdoor recreation requirements of the public. Thus, in the Appendix mentioned earlier, a model is developed which is used to analyze these three aspects of supply, from a nationwide frame of

reference, as they relate only to the outdoor recreation activities of golf and developed camping. The basic concepts of the model and the results of the analyses are reported in the Appendix submitted in conjunction with this Nationwide Plan, entitled "Outdoor Recreation: An Economic Analysis".

The Plan then presents a set of findings based on extensive interviews regarding current recreation trends in America. The results are quantitative statements related to activity rates and participation figures, for example:

- People swim more than they participate in any other outdoor recreation activity. (744 million activity days of swimming occurred in 1972).

- The majority of the participation in outdoor recreation takes place on the weekends.

- People with family income less than $8,000 make up 44.6 percent of the adult population but do not account for as much as 44 percent of the participation in any outdoor recreation activity.

Using this type of information, projections based on perceived trends are made to create a future outdoor recreation scenario. This overview of present and future outdoor recreation activity is interesting information; however, its value, or better its use to the recreation planner as a tool for making planning decisions has not been demonstrated.

In the appendix to the report, demand and supply estimates are made using visitation rates and capacity standards. Subsequently a distribution model based on distance travelled (expressed in 1972 prices) for the populations of 171 BEA economic areas is used, and capacity requirements are calculated for each of the areas and related to a national norm.

The above summary is a simplication of the techniques and amount of analysis conducted in one example of national outdoor recreation planning. While much work goes into the development and calculation of these efforts, it is concluded that although elaborate techniques are presented to actually calculate the magnitude of future outdoor recreation deficiencies at various parts of the country, there is not a clear tie to other types of planning or to the implications associated with recreation plans as these are perceived by people. The value of this type of planning in isolation is questionable.

The discussion above addresses recreation planning; with regard to recreation research Jim Tang of the U.S. Army Corps of Engineer's Institute for Water Resources Research notes:

> It is significant to note that in its proposed Principles and Standards, the WRC (Water Resources Council) does not recommend any one methodology for the evaluation of recreation use and benefits. Instead, it suggests several alternatives with the remark that these alternatives are of an interim nature pending the development of improved methodology. When one carefully reads through Dr. Kalter's rather comprehensive state-of-the-art review, one cannot help but get the feeling that recreation research is still in its infancy and that all the existing methods are imperfect in some respects. (Ref. 2) They are either conceptually defective or are inadequate for implementation. While innovative research is needed, the economist perhaps can contribute to the pressing problem of evaluation in the interim by applying some of the basic principles of comprehensive planning. This would mean that the economist will have to examine any plan in the context of comprehensive planning for a community or a region. He would have to go beyond the benefit/cost analysis to evaluate all possible alternatives best suited to the people and the community. He would have to study not only the recreation supply and demand per se, but evaluate the recreation plan as one element of a larger master plan including plans for urban development, utility expansion, transportation, school, sanitation, and other functions. The ultimate payoff of this approach would be greater than concentrating exclusively on economic issues. (Ref. 3)

Accepting the above orientation, that recreation analysis and thereby recreation planning should be directed towards being responsive to people's needs in relation to many functional areas, it becomes apparent that recreation planning is not simply a calculation of deficiencies and development of an associated plan to meet such deficiencies.

Rather, in contrast to the general trend, it is necessary to adopt a more flexible approach which allows for modifying the recreation plan based on the fact that a plan's implications may run counter to desired achievements in other areas of a total community plan. Of a host of possible variables in a recreation plan, the approach developed in this report concentrates on analyzing differences in the expected recreational use of resources (i.e., visitation) as a function of assumptions regarding demand for and access to opportunities, and on supply of opportunities as provided by resources and facilities. Thus the interface between two functional planning areas are examined: recreation planning and transportation planning.

The key variables in such an approach are level and geographic distribution of recreational visitation which are functions of demand, access and supply. Where demand and supply appear as pseudo independent variables, the access variable ties the two together and allows for modeling the level and geographic distribution of visitation. Thus it can be seen that accessibility to recreation resources for participants from different demand centers becomes a critical factor in this modeling effort. Chapter III develops this methodology in detail for a number of demand centers and a set of supply zones connected by a particular transportation network. It is emphasized that the methodology is not designed to generate a plan but rather to generate information on level and geographic distribution of visitation as a function of basic recreation system variables: demand, access, and supply. If under particular assumptions regarding these variables it is possible to estimate the number of people who can be expected to overuse or underuse the resources and facilities, it will then be possible to relate recreation planning to other types of planning.

Chapter III

THE ACCESSIBILITY MODEL FOR RECREATIONAL USE

A. Introduction

This chapter presents the methodology used in analyzing level and geographic distribution of recreational visitation as a function of the demand for opportunities and the access to recreational supply resources. The methodology centers around a modeling effort which incorporates accessibility of recreation resources for participants from different demand centers into a more traditional demand/supply type of analysis. The key concept introduced is the notion of a trip supply curve which, for a particular transportation network, represents the number of trips as a function of time for each combination of recreational activity, demand center and supply zone. These can then be combined into aggregate trip supply curves from all demand centers to the coastal zone, from a particular demand center to the coastal zone, or from all demand centers to a particular supply zone. The California Central Coastal Zone planning problems, presented in the previous chapter, are used to illustrate the reasoning behind the choice of approach as well as its application.

Section B introduces some basic terminology used in the remainder of the report. In Section C the use of trip demand and trip supply curves for studying the accessibility of recreational resources is discussed from a conceptual point of view. Section D then discusses the main elements of the accessibility approach presented, and indicates the main assumptions using the California Central Coastal Zone planning problem as an example. Section E discusses how trip supply curves can be used to provide information for comprehensive recreation planning. Additional assumptions as well as the computational procedures followed in deriving trip supply curves and the computer program used are described in Appendices A and B.

B. Description of Terms

Table III-1 indicates the general relationship between the terms briefly defined below and further explained in the remaining text.

- Study Area: geographic area encompassing the demand and supply areas.
- Supply Area: geographic area covering the recreation resources of the California Central Coastal Zone.
- Demand Area: geographic area outside the supply area where the majority of the demand for recreation in the supply area originates.
- Demand Zone, Supply Zone, Supply Subarea: geographic subdivisions of the demand area and supply area, respectively.
- Demand Center, Supply Center: centers of gravity for the demand zone and supply zone, respectively.
- Visitor Day Demand: expression of total number of visitor days that is assumed to originate within a demand zone on a particular day for a recreational activity.
- Visitor Day Supply: expression of total number of visitor days that can be accommodated on a particular day by a specific supply source for a recreational activity.
- Trip Demand and Trip Supply: derived by converting visitor days into an equivalent number of trips demanded or supplied.
- Trip Demand Curve, Trip Supply Curve: expression of trips demanded by people and trips supplied by the network respectively, as a function of time for each combination of activity, demand center and supply center.
- Expected Visitation: number of visitor days expected during a particular day at various resources.

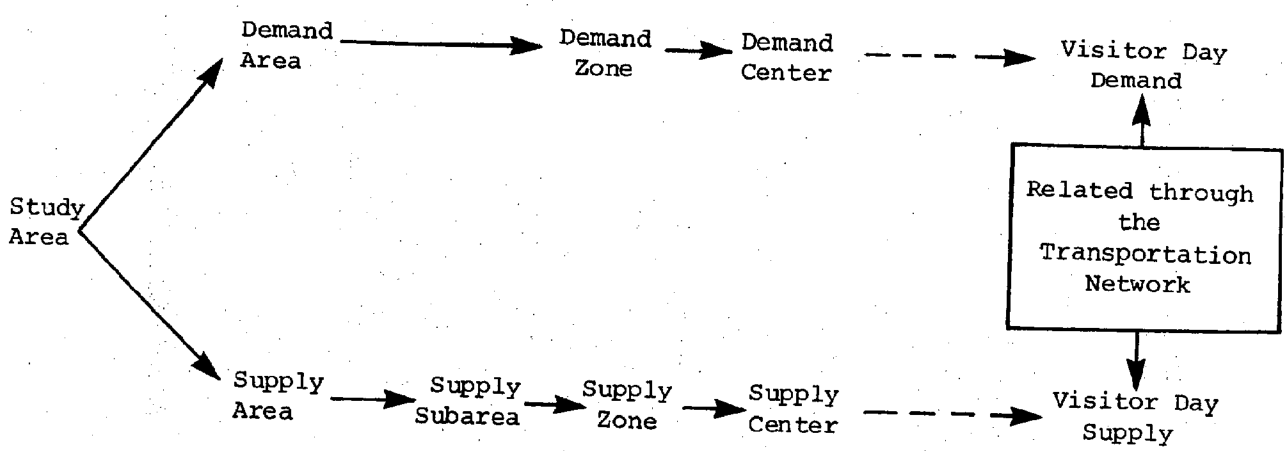
C. Recreational Use and Accessibility

The purpose of this section is to conceptually discuss recreation demand, supply and accessibility as a point of departure for the methodology presented.

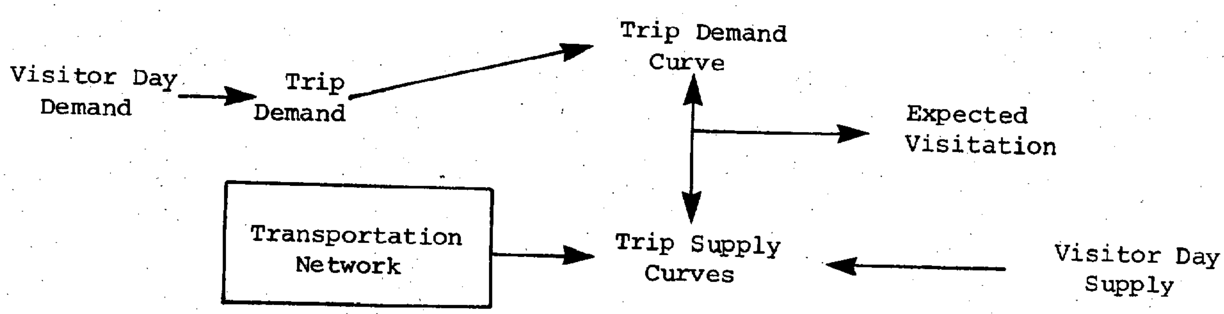
The use of a recreational site(supply zone) depends on its accessibility which can be expressed as an average of travel times from different demand centers. A hypothetical set of trip demand and supply curves is presented in Figure 3.1, for the simple case of one aggregate demand center and one aggregate supply zone. As shown, the demand for recreation trips decreases as travel time increases. In the trip demand

Table III-1

RELATIONSHIP BETWEEN TERMS



(a) Geographic Delineations



(b) Demand-Supply Delineations

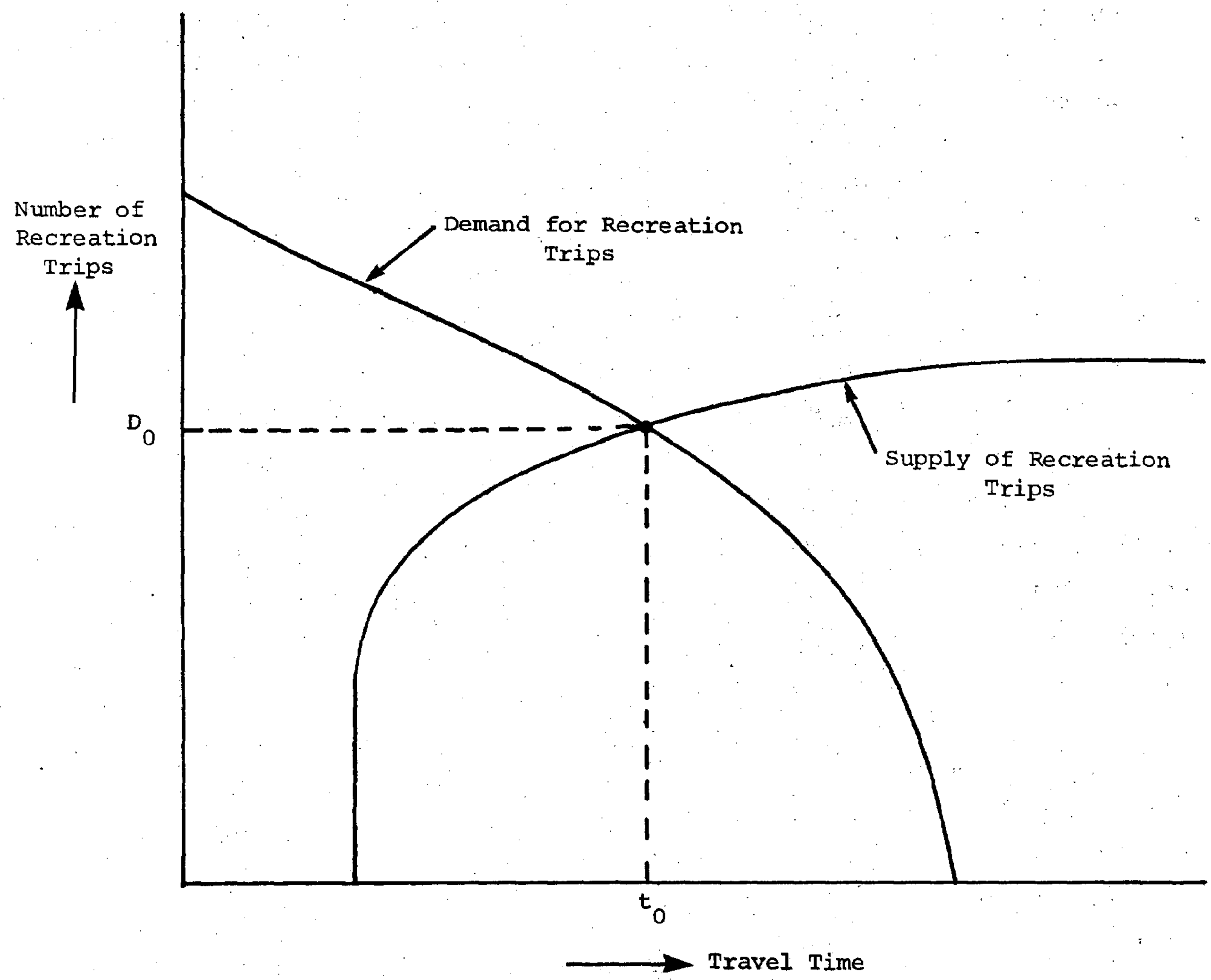


Figure 3.1 TRIP DEMAND AND SUPPLY CURVES FOR RECREATION TRIPS

curve a close to linear decrease is assumed initially, while a sharp decrease is assumed when time becomes excessive in comparison to time remaining for recreation; above a certain travel time no demand for recreation trips is expected. In regard to the trip supply curve, it is shown that up to a certain traffic volume the number of recreation trips does not influence travel time because there is no congestion. Once congestion starts to act, the supply of recreation trips will increase only with increased travel time; this marginal increase in trips will decrease with increased travel time which results from heavier use of access roads, and will approach zero as access roads become saturated. In the set of curves presented in Figure 3.1, assuming no constraints on the capacity of the recreation site, the demand and supply are in equilibrium when the recreation trips to the site are D_O and the average travel time is t_o.

If the demand and supply curves described above were available, they could be used to study accessibility problems of recreational resources and to study resulting visitation. As an example, three different situations corresponding to alternative recreation resource capacities are presented in Figure 3.2. First, if the demand D_O at equilibrium is larger than the capacity C_1 there will be overcrowding at the recreation site. In other words, the capacity of the recreation site is below that of the transportation network, and the problem is not one of accessibility but rather one of capacity of recreation resources. On the other hand, if the capacity C_2 is larger than the demand D_O, there is an accessibility problem. The capacity would be used if either the transportation network is improved, or if the demand shifts upward in the future, or if both occur simultaneously; the latter is indicated in the figure by the dotted curves. Finally, if the capacity C_3 is much larger than the demand D_O, the total available capacity will only be used if both the demand increases and the transportation network is improved.

There are several problems associated with implementing the above approach in order to analyze recreational accessibility. First, estimates of present or future trip demand as a function of travel time are

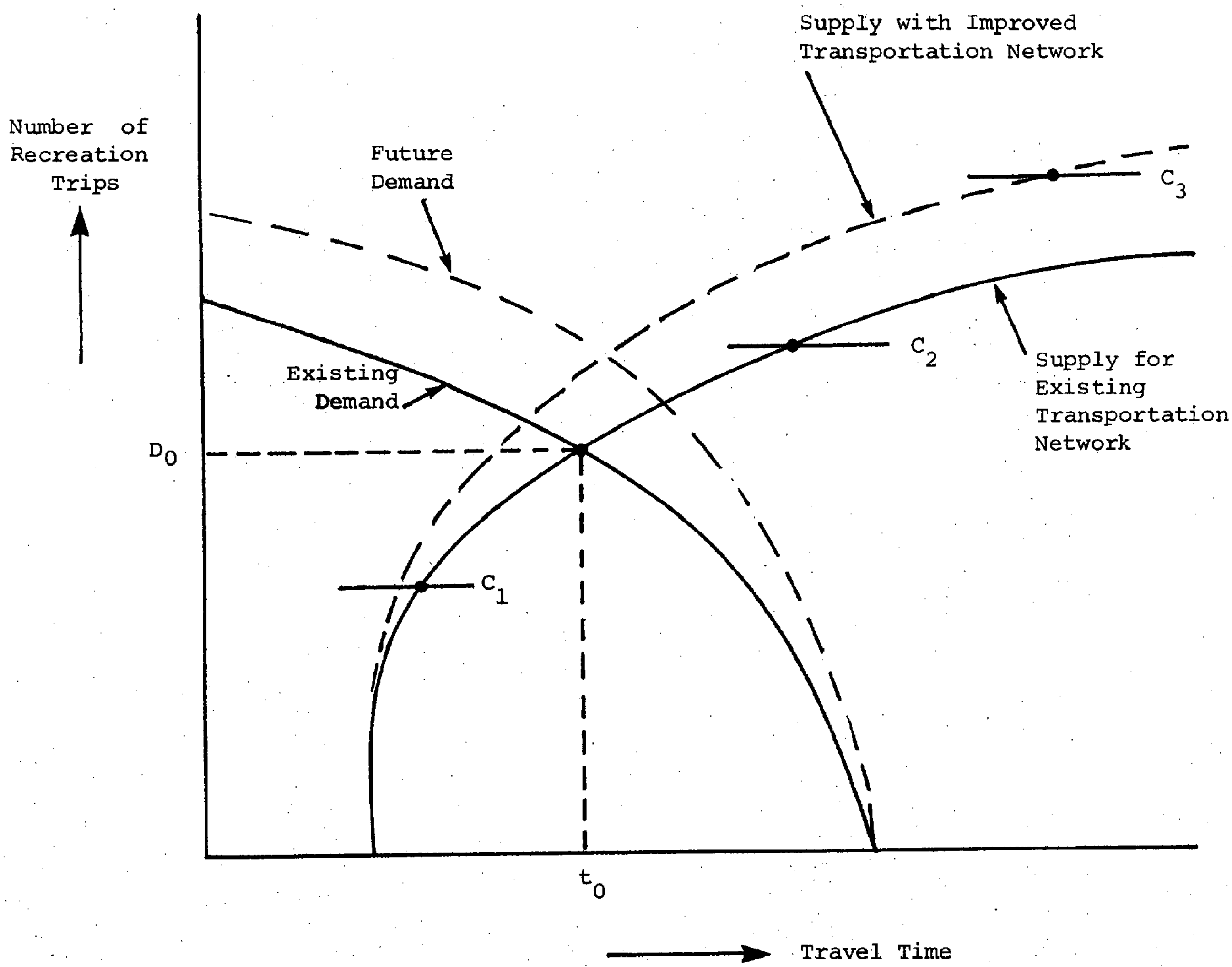


Figure 3.2 CAPACITY OF RECREATION SITE AND DEMAND-SUPPLY CURVES

not available because there are no existing procedures for estimating demand as a function of travel time. Second, an aggregate trip supply curve is based on individual supply curves from demand centers and supply zones. Since the allocation of recreation trips from demand centers to supply zones is not unique, several assumptions are required in order to derive these supply curves. Third, demand and supply curves can only be compared in the aggregate, because supply curves depend on the demand at all centers as a result of common usage of the transportation network, and also because demands are generally satisfied by more than one supply zone. These and other aspects are discussed in more detail in the next section in formulating the accessibility model.

D. The Accessibility Model

The purpose of this section is to discuss the main elements of a recreation system as these relate to accessibility: (1) the recreational demand at the demand centers, (2) the recreational supply at supply zones, (3) the connecting transportation networks, and (4) the trip supply curves. A simplified version of the California Central Coastal Zone planning problem is used for illustration purposes; the main elements, shown in Figure 3.3, include three demand centers D_1, D_2, and D_3, two supply zones S_1 and S_2, and a transportation network with eight links (I in the figure represents a node in the network). Two recreation activities are considered: park use and beach use. Table III-2 provides the supporting data for the transportation network.

1. Demand

Definitions of "outdoor recreation activities" and an "activity visitor day" are important in studying accessibility and recreation use. Various recreation agencies list up to 30 detailed outdoor recreation activities (Refs. 4, 5, 6 and 7). For purposes of facility planning, estimates of demand for these outdoor recreation activities are obtained as the sum of every period of participation in the activity. If the interest is in visitation this may result in double-counting because during one trip a person may be involved in several recreational activities. An approach that combines activities

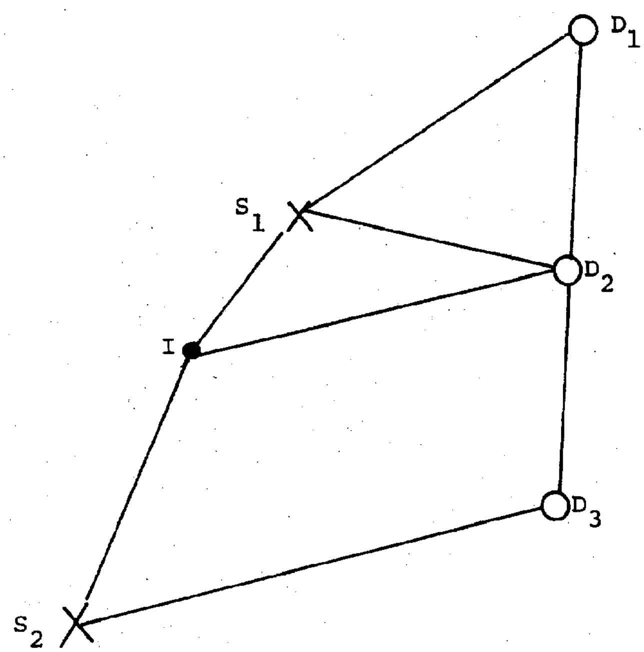


Figure 3.3 SIMPLIFIED RECREATION SYSTEM

Table III-2

SAMPLE DATA FOR TRANSPORTATION NETWORK

Link (Either Direction)	Distance (Miles)	Max. Speed (MPH)	Travel Time (Minutes)	Carrying Capacity (Cars/Hour)
$D_1 - S_1$	30	40	45.0	1,500
$D_1 - D_2$	25	55	27.3	8,000
$D_2 - D_3$	25	55	27.3	8,000
$D_2 - S_1$	15	35	25.7	800
$D_2 - I$	35	30	70.0	800
$D_3 - S_2$	35	45	46.7	1,800
$S_1 - I$	10	45	13.3	1,000
$S_2 - I$	50	45	66.7	1,000

requiring only one round trip is more relevant for the purpose here. This aggregation of various individual activities results in four resource use categories: (1) beach use, (2) boating and fishing, (3) park use, and (4) pleasure driving. The composition of each use category is presented in Table III-3. These uses are typically planned for a single day which requires round trip transportation.

As previously discussed, procedures for obtaining demand as a function of travel time are nonexistent at this time. Although efforts to obtain demand functions including such factors as sex, level of income, education and age (Refs. 6 and 7) have been made, these have not resulted in reliable procedures for demand estimation in the sense discussed in the previous section. Frequently, the only information available on the demand side is an estimate of expected visitation based on empirical data on the use of recreational facilities. For practical reasons, this data is used to estimate the expected annual demand as the product of the population in the demand zone, the participation rate of the population in the outdoor recreation activity, and the average number of annual participation days per participant. Daily demands are then obtained as a percentage of the annual demand. In Table III-4 the expected peak day demand is shown for the sample recreation system; these estimates were derived using the above procedures. (The detailed estimation formula used for this study is presented in Appendix A.1.) It is emphasized that this simple representation cannot be used to predict demand per se or to construct the demand curve. Rather the information on demand is used to arrive at trip supply curves for a particular network configuration as explained in Part 4 of this section. The important implication of the above with respect to the previous section is that no "equilibrium" points between demand and supply can be established.

2. Supply

Carrying capacity for various uses at a recreation site is related to the characteristics of the site, in particular to its intensive use area. A site's carrying capacity for a particular use is determined by the size of the intensive use area designed to support that use, and by the number of trips that an intensive use acre can accommodate per day. (The detailed formula used in this study for the carrying capacity calculation is presented in Appendix A.2.)

Table III-3

COMPOSITION OF RESOURCE USE CATEGORIES

Resource-Use	Outdoor Recreation Activity
1. Beach Use	Swimming
	Sunbathing
	Scuba Diving
	Beach Picnics and Games
2. Boating and Fishing	Sailboating
	Power Boating
	Water Skiing
	Fishing
3. Park Use	Picnicking
	Nature Walks
	Sightseeing
	Hiking
	Horseback Riding
	Bicycling
4. Pleasure Driving	Pleasure Driving
	Sightseeing

Table III-4

EXPECTED DEMAND ON AVERAGE PEAK DAY FOR BEACH AND PARK USE

Demand Center	Population	Average Peak Day Demand in Number of Trips: For Beach Use	For Park Use
D1	800,000	21,912	54,000
D2	250,000	5,870	15,000
D3	500,000	9,783	33,750
Total	1,550,000	37,565	102,750

In converting intensive use acres into carrying capacity the recommended design standards presented in Table III-5 are used. These standards, selected based on a comparison of various agencies standards (Ref. 9), give the unit densities, average group size and turnover rate for each activity. The intensive use acreage and resulting carrying capacity of the supply zones in the sample recreation system are shown in Table III-6 for beach use and park use.

3. Transportation Network

The transportation network is characterized by links of approximately uniform characteristics. These links connect demand centers and supply zones where more than one link may be needed for one connection. The distance, maximum travel speed, associated travel time, and carrying capacity in cars per hour are needed for each link. In addition, a relationship between reduced travel speed as a result of increased traffic volume is required. The relationship used is presented in Figure 3.4, where the travel speed is given as a function of the ratio of traffic volume over carrying capacity. It is noted that when traffic volume approaches the road carrying capacity, traffic speed approaches zero or traffic comes to a standstill. For the simplified recreation system and the network, the associated data are presented in Figure 3.3 and Table III-1, respectively.

4. Trip/Supply Curves

Given the above information on demand, supply and transportation networks, points on the trip supply curve are determined by presenting the network with different trip production levels. The following steps are needed to determine each point on the trip supply curve:

a. Choose Trip Production Level: for this purpose, the total trip production assumed at all demand centers for each recreation activity is divided among the individual centers in proportion to the expected peak day demands. Thus, in the simplified recreation system, if the total level of trips for beach use is 8,000 these are allocated among D_1, D_2, and D_3 in proportion to the average peak day demands. The results are presented in Table III-7.

b. Decide On Routes Used: routes from demand centers to supply zones for each activity are chosen, accounting for saturation of links. This distribution of trips over the network is not

Table III-5

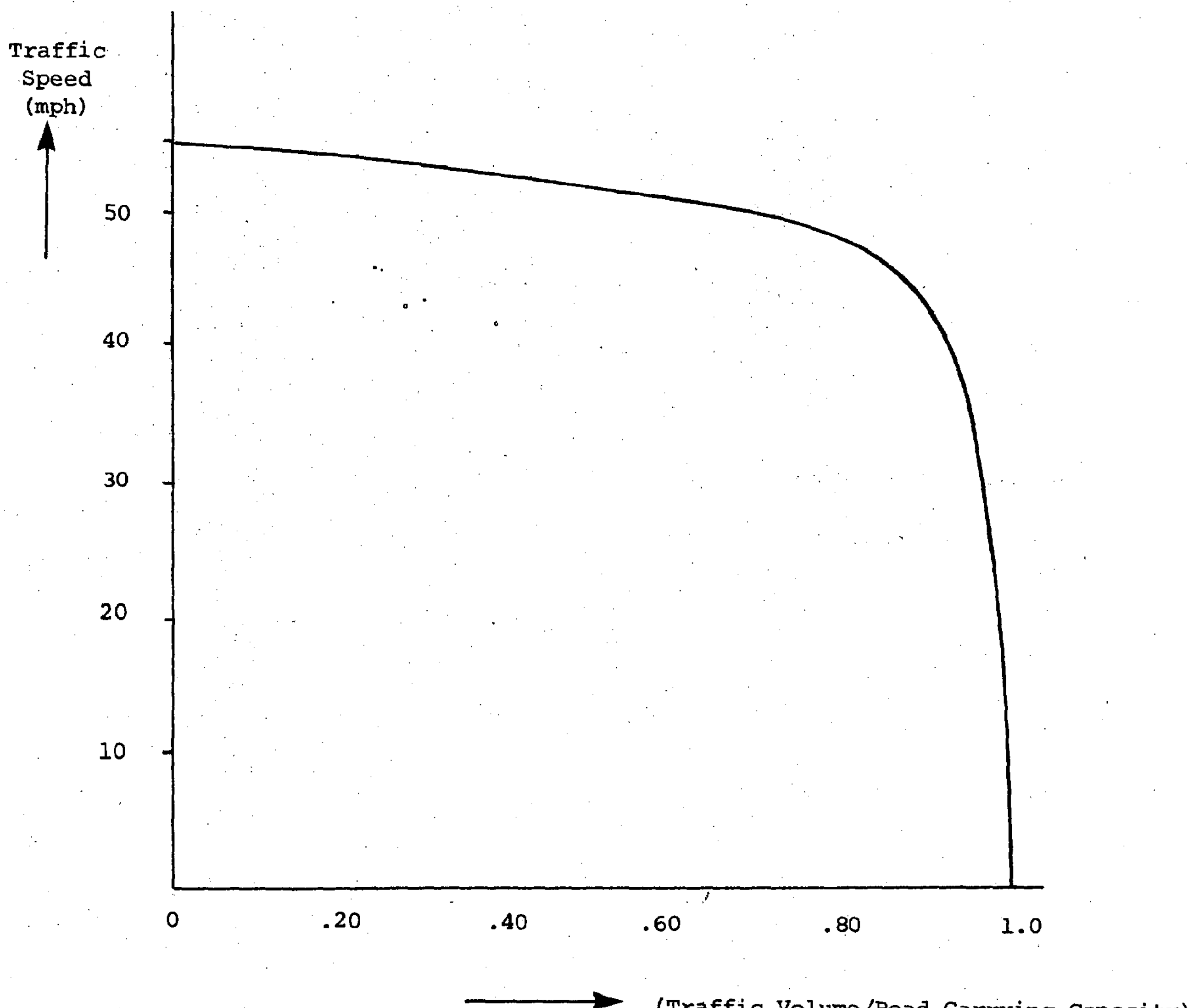
RECOMMENDED DESIGN STANDARDS

Activity	Unit Density	Average Group Size	Turn Over Rate	Recreation Design Standard Y (Unit Density Per Participant Per Day	Inverse Recreation Design Standard $1/_Y$ (Average Number of Participants Per Day Per Unit)
Beach Use	.0092 acres/group	1	2	.0046	217 par./acre
Boating and Fishing	.0080 launching ramps/boat	3.5 person/ boat	2	.0011	875 par./ramp
Park Use	.0625 acres/group	4 person/ group	2	.0078	128 par./acre
Pleasure Driving	.0133 miles/car	3.9	30	.0001	8797 par./mile
	1 parking lot/ car	3.9	10	.0256	39 par./lot

Table III-6

INTENSIVE USE ACREAGE AND DESIGN CARRYING CAPACITY
FOR SAMPLE RECREATION SYSTEM

Supply Zone	Beach Use Intensive Use Area (in acres)	Daily Carrying Capacity (in # of trips)	Park Use Intensive Use Area (in acres)	Daily Carrying Capacity in # of Trips
S_1	110	23,870	85	10,880
S_2	536	116,312	25	3,200
Total	646	140,182	110	14,080



Source: TRANS-CAL (Ref. 10) and Highway Capacity Manual (Ref. 11)

Figure 3.4 SPEED VS. VOLUME/CAPACITY RATIO CURVE

Table III-7

TRIP PRODUCTION LEVELS OF THE SAMPLE RECREATION SYSTEM

Demand Center	Average Peak Day Demand		Trip Production Levels		
	Beach	Park	Beach Use	Park Use	Total
D1	21,912	54,000	1,250	3,079	4,329
D2	5,870	15,000	335	855	1,190
D3	9,783	33,750	557	1,924	2,481
Total	37,565	102,750	2,142	5,858	8,000

unique and requires modeling: the relative attractiveness of different routes to the user, the decreased desirability resulting from reduced speed as traffic volume increases, and ultimately the limitations imposed by the carrying capacity of the links.

c. Calculate Average Travel Time: this is performed from demand centers to supply zones for each activity. This is a straightforward calculation based on traffic volumes for the different routes between demand center and supply zone, the traffic volume on each link, and the curve in Figure 3.4 that gives speed as a function of traffic volume.

d. Combine Individual Average Travel Times to Get Average Travel Time: this is performed for each activity from the demand centers to the supply zones. This is a straightforward calculation based on the average travel time between demand center and supply zone and the number of trips between each demand center and supply zone. Similarly, the average travel time from a demand center to the coastal area, and the average travel time to a supply zone from all demand centers can be calculated.

Further details on the assumptions of the accessibility model are summarized in Appendix A.3, while a simplified description of the procedures and computer program used to derive trip supply curves is included in Appendix B.

E. Program Application

The methodology and associated program described in the previous sections and in the appendices has several applications, one of which is further discussed in the next chapter. In this case a comparative analysis is performed of the two highway networks connecting the demand area with the supply area. The level of trip demand is incrementally increased and the changes in level and geographic distribution of recreation visitation by specific activity are investigated as a function of the difference in highway network as well as the increases in demand. This comparative analysis is motivated by the desire to gain insight into (1) how many people can be expected to visit different parts of the California Central Coastal Zone if access at particular points is improved assuming a particular level of trip demand in the metropolitan demand center, and (2) the implications on coastal environments and local economies resulting indirectly from highway network or access changes and directly from visitation changes.

In addition to a comparative analysis, the methodology and program can assist the recreation planner with answers to questions such as the following:

- Where do visitors to a particular supply zone originate?
- How will the origin of visitors to a supply zone change in case of development of new sites in the area, improvement of sites or changes in facilities?
- Which activities along the California Central Coastal Zone are oversupplied or undersupplied and at what locations?
- What will it cost at a particular location to absorb an increase in visitation?
- How will visitation change if public transit becomes a viable option? Will it increase, decrease or merely cause a change in geographic distribution?

It is noted that such questions are difficult to answer unless demand and supply are tied together through the transportation network. It is also emphasized that in answering the above questions it is not the absolute magnitude of the change that is of interest; it is the sensitivity of changes in visitation with respect to basic parameters in the recreation system that is important. In general the sensitivity to the following parameters can be investigated with the model:

- Increased carrying capacity of a supply zone for a particular activity or addition of new supply zones. This will result in a change in the routing of trips from demand center to supply zones, and depending on the location of the zone, may result in an upward and/or downward shift of the trip supply curves.
- Change in demand for activity type. This will result in routing changes, and if demand increases, in an upward shift of the trip supply curve.
- Improvement of transportation network, either by increasing capacity of certain links, adding new highways, or providing public transportation. This will result in rerouting of trips and a downward shift of the trip supply curves, where the shift differs for different combinations of activity type/demand center/supply zone.

In conclusion, it is emphasized that changes in visitation are, except for their input to recreation facility planning, not important in and by themselves. Rather they present the first step in linking recreation to concerns and values that people may have in other areas. For example, the burden of cleaning and maintaining public recreation areas is sometimes a concern to the general taxpayer in local communities along coastal areas. No general solution exists unless some indication as to who recreates at these areas can be presented. It is one of the purposes of the methodology developed in this chapter to find solutions for such a situation without extensive interviews, but rather by careful modeling of the recreation and transportation systems.

Chapter IV

COMPARATIVE ANALYSIS OF TRANSPORTATION NETWORKS WITH RESPECT TO COASTAL RECREATION: A CASE STUDY

A. Introduction

In this chapter the accessibility model described in Chapter III is applied and demonstrated in a case study which addresses planning for recreation along the California Central Coastal Zone. The objective is to show what type of information the recreation planner must generate in order to clarify and seek resolution for several controversial issues associated with proposed and contested changes. These changes relate to: (1) planned improvements in the transportation network leading to improved access to the coast, and (2) providing more recreational visitation along the coast while simultaneously preserving the natural characteristics of the area as much as possible. The basic premise underlying the analysis presented is that unless controversial issues are addressed early, and as an integral part of the overall process of recreation planning and facilities design, follow-on efforts will probably be contested. As a result, the chances for implementing policy recommendations for recreational use of the coast will be seriously impeded.

The basic controversy addressed in the case study can be polarized as follows. If access to the coast improves, local communities will be in a better position for future growth. Not only will improved access accelerate the development of coastal communities because of easier access to employment centers in the San Francisco-Oakland-San Jose metropolitan area, but also, and probably more important, it will increase recreational visitation providing the economic stimulus for sustaining future growth because of the associated recreation-type development. On the other hand, concern is widespread that accelerated development of local communities fed by an increase in the already heavy visitation to the coast will cause environmental stress beyond the capacity of existing natural resources. This will lead to irreversible deterioration of the unique and irreplaceable coastal environment. The problem in attempting to resolve this controversy is that there is no existing information base that can be used to clarify the tradeoffs involved, thereby providing a mechanism for informed decision making; thus the issues continue to be heavily debated. The needed information base can be developed by applying the accessibility model which ties the important aspects of coastal zone management together -- i.e., transportation and recreation -- thus illuminating the choices that people have with regard to development along the central coast.

Section B describes the case study in terms of geographic delineations, and presents two planning scenarios which represent the above polar situations. A specific transportation network describing the envisioned access is associated with each scenario. Subsequently, Section C describes the data aspects related to recreation demand and supply, and to the transportation networks. The results of applying the accessibility model are contained in Section D. Finally, Section E addresses the implications of changes in access and visitation, in terms of the two scenarios, based on the results of Section D.

B. Case Study Description

1. Geographic Delineations

Figure 4.1 depicts the general location of the study area in relation to the major California metropolitan centers. Using the terms defined in Chapter III, Section B, the study area encompasses the demand and supply areas. The supply area consists of coastal areas in the counties of San Francisco, San Mateo, Santa Cruz and Monterey. These coastal strips are bounded to the east by the Santa Cruz Mountains. The demand area consists of the greater San Francisco-Oakland-San Jose and the Fresno metropolitan areas; the population in the supply area is excluded. It is assumed for analysis purposes that demand for recreation activities, to be satisfied along the California Central Coastal Zone, originates exclusively in these areas. This assumption recognizes that while other areas will also contribute to the total

CALIFORNIA MAJOR METROPOLITAN CENTERS

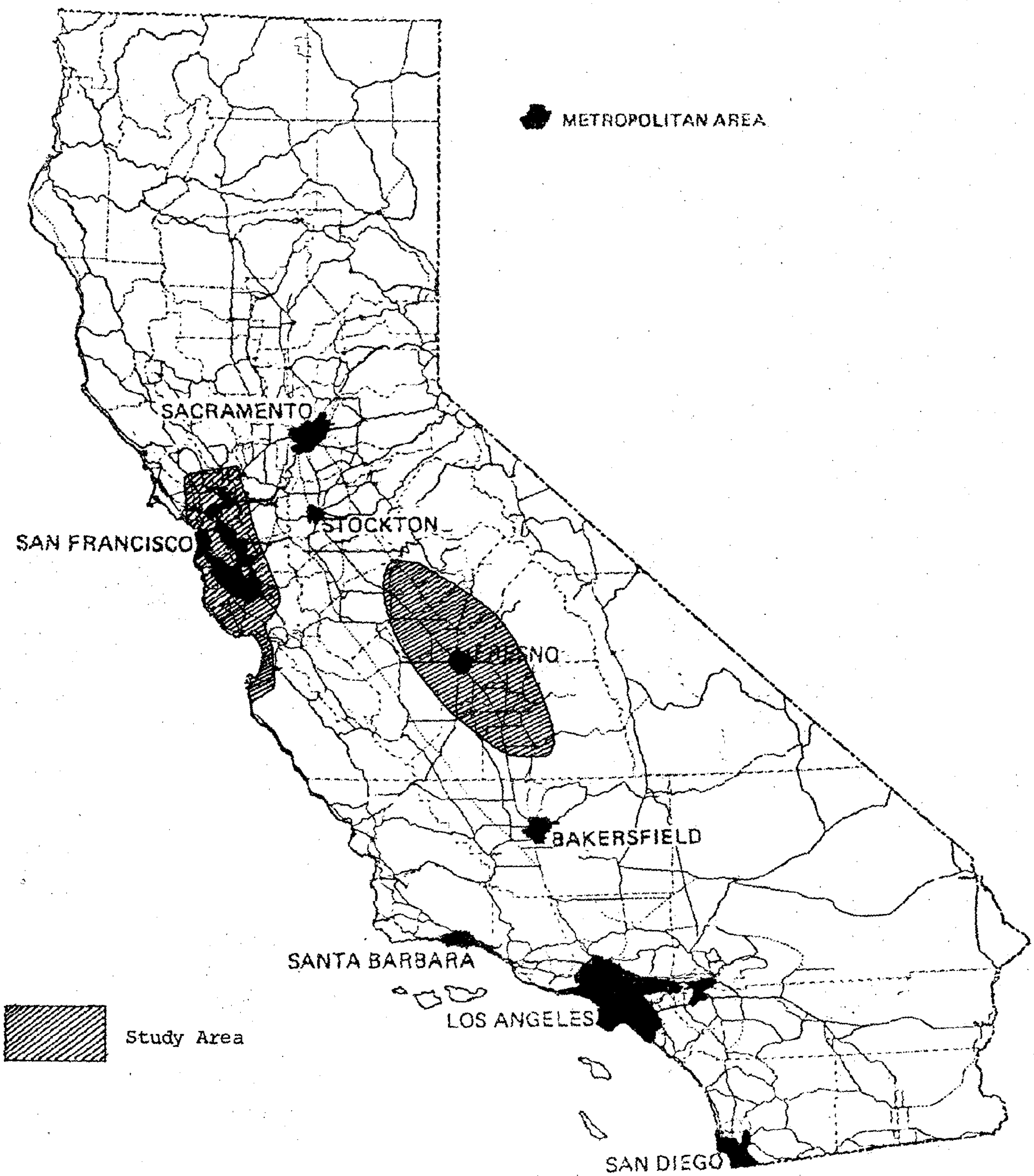


Figure 4.1 LOCATION OF STUDY AREA

demand, their proportionate share will be significantly smaller due to alternative recreation opportunities in closer proximity.

Figure 4.2 provides a further delineation of the study area and indicates: (1) boundaries of demand and supply areas; (2) boundaries of demand and supply zones; (3) boundaries of supply subareas; (4) demand and supply centers; (5) the main existing (1974) transportation network providing access to the supply area; and (6) major coastal cities. The following is noted:

- The demand area is divided into 14 demand zones; the supply area is divided into 11 supply zones. Table IV-1 lists these zones and indicates the recreation activities presently taking place in each supply zone. (Recreation activities are defined according to resource-use characteristics as discussed in Chapter III.) In addition, Table IV-1 provides information on type and capacity of individual elements in the main transportation network.

- Based on the transportation network's specific configuration and on geographic characteristics, the supply area is divided into the following three relatively independent subareas:

  - Northern Subarea: includes the Pacifica and Half Moon Bay supply zones. It covers the coastline from the San Francisco County line to the southern edge of developments in Half Moon Bay including the Cities of Pacifica and Half Moon Bay. Currently this subarea is connected to the population centers of San Mateo County and San Francisco with three roads: Highway 92 from Half Moon Bay to San Mateo; Highway 1 to San Francisco via Devil's Slide; Sharp Park Road from Pacifica to San Mateo.

  - Central Subarea: includes the San Mateo Beaches, North Santa Cruz County, Santa Cruz, and Big Basin supply zones. It contains the large urbanized area in the vicinity of Santa Cruz. Highways 1 and 84 connect the northern portions of the subarea to Bay Area communities; Santa Cruz is connected with the Bay Area and the Fresno area via Highways 17 and 9.

  - Southern Subarea: includes the Southern Santa Cruz County, North Monterey Bay, Fort Ord and Monterey supply zones. It contains ocean frontage from Santa Cruz to Monterey. Although mostly agricultural, this subarea includes a large urbanized area in the vicinity of Monterey and Carmel. Recreational trips to this area come mostly via Highway 101 and then via one of the following east-west connectors: Highways 156, 152, 129 or 68.

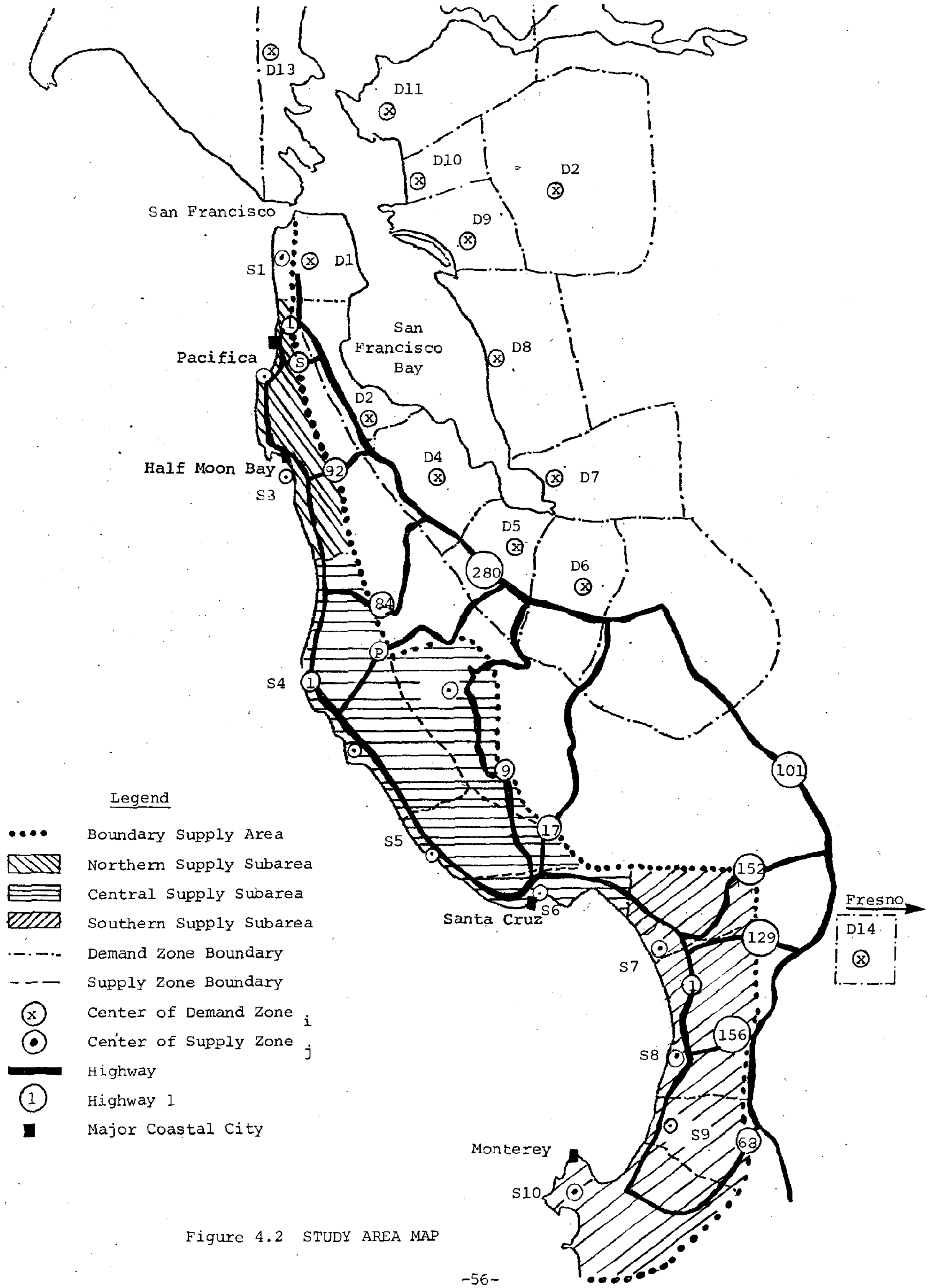


Figure 4.2 STUDY AREA MAP

Table IV-1

DEMAND ZONES, SUPPLY ZONES AND CONNECTING TRANSPORTATION NETWORK

Demand Zones		Supply Zones						1974 Main Transportation Network		
				1974 Recreation Activities						
No.	Name	No.	Name	Beach Use	Boating & Fishing	Park Use	Sightseeing and Driving for Pleasure	Hwy. No.	Type	Capacity* V.P.H. (in one direction)
D1	San Francisco	S1	San Francisco	X	X		X	1	Expressway	2,400
D2	San Mateo	S2	Pacifica	X		X	X	S**	Urban Road	1,200
D3	Redwood City	S3	Half Moon Bay	X	X	X	X	92	Rural Hwy.	880
D4	Palo Alto	S4	San Mateo Beaches	X		X	X	84	Rural Hwy.	800
D5	Sunnyvale	S5	North Santa Cruz Co.	X	X	X	X	P***	Rural Rd.	800
D6	San Jose	S6	Santa Cruz	X	X	X	X	9	Rural Hwy.	1,000
D7	Fremont	S7	South Santa Cruz Co.	X	X	X	X	17	Expressway	1,500
D8	Hayward	S8	North Monterey Bay	X	X	X	X	152	Rural Hwy.	1,300
D9	Oakland	S9	Ford Ord	X				129	Expressway	2,500
D10	Berkeley	S10	Monterey	X	X	X	X	156	Expressway	2,500
D11	Richmond	S11	Big Basin			X	X	68	Expressway	2,500
D12	Concord									
D13	San Rafael									
D14	Fresno									

* Capacity of the road is determined by minimal capacity of links

** Sharp Park Road

*** Pescadero Road

2. Planning Scenarios and Alternative Transportation Networks

This subsection describes the two planning scenarios used in the case study and indicates the transportation networks that are assumed for each scenario. It is noted that there is not necessarily a one-to-one relationship between a particular planning scenario and a particular transportation network; rather the transportation networks are chosen on the basis of their contribution towards the basic objective of the scenario.

a. Preservation Scenario

Protection, restoration and enhancement of the natural environment in the coastal areas is a major force behind the California Coastal Zone Conservation Act. Protection and enhancement may be achieved by: (1) limiting the growth of coastal communities, (2) minimizing destruction of the environment by road construction or urban development, and (3) developing the existing recreational sites in harmony with the natural environment, that is without complete destruction of existing resources. The emphasis in this scenario is on improving the existing recreation sites in an environmentally acceptable manner. From this viewpoint, recreational facilities may contribute towards environmental enhancement as long as there are safeguards against their overuse or overcrowding by visitors. Thus in this scenario, the basic charter of the California Coastal Zone Conservation Act to protect the coastal area for "present and future residents of the state and the nation" is interpreted as: (1) increasing the effective recreation supply to meet the recreation demand by careful development of existing sites, and (2) limiting urbanization of coastal communities.

It is assumed that a transportation policy responsive to the above-stated objectives calls for minimal future development and construction of highways in the area by limiting planning efforts primarily to safety improvements in the existing network without the development of major additions to the network. For the purpose of the case study, this policy is assumed to mean that: (1) highways currently under construction will be completed; and (2) those parts of current transportation plans which are approved by all agencies concerned will be implemented. A schematic of the 1990 transportation network following this policy, labeled as Alternative 1, is depicted in Figure 4.3.

b. Development Scenario

The previous scenario reflects a particular bias based on interpretation of the California Coastal Zone Conservation Act -- an interpretation which is not uncontested. Several local communities which rely on recreation as a main source of income expect and plan for considerable growth. From this viewpoint, recreational use of the coastal zone by the "present and future residents of the state and the nation" implies the development of recreational facilities on the coast to supply the needs of as many visitors as possible under "acceptable" environmental constraints. Development possibilities include construction of second homes, restaurants, stores and other types of business to attract and support tourism and recreation. A key consideration here is the tax base of local communities which could be significantly broadened by the recreation and tourism industries. For the case study, this scenario is based on the assumption that full development of the coast will occur in order to benefit local communities.

It is assumed that a transportation policy associated with this scenario calls for making every possible effort to increase access to the coastal area so as to attract visitors and recreation-type investments. For the case study, this policy is interpreted as meaning that all road construction which has realistically been proposed will occur, in contrast to the transportation policy in the previous scenario which essentially calls for no major changes. Figure 4.3 provides a schematic for the associated transportation network, labeled as Alternative 2, which assumes the construction or improvement in the carrying capacity of the following roads in the study area.

- Road Improvements in the Northern Supply Subarea
  - Extension of Interstate 380 (I-380) from the intersection with I-280 to Pacifica as a four-lane freeway. This would replace Highway 162.

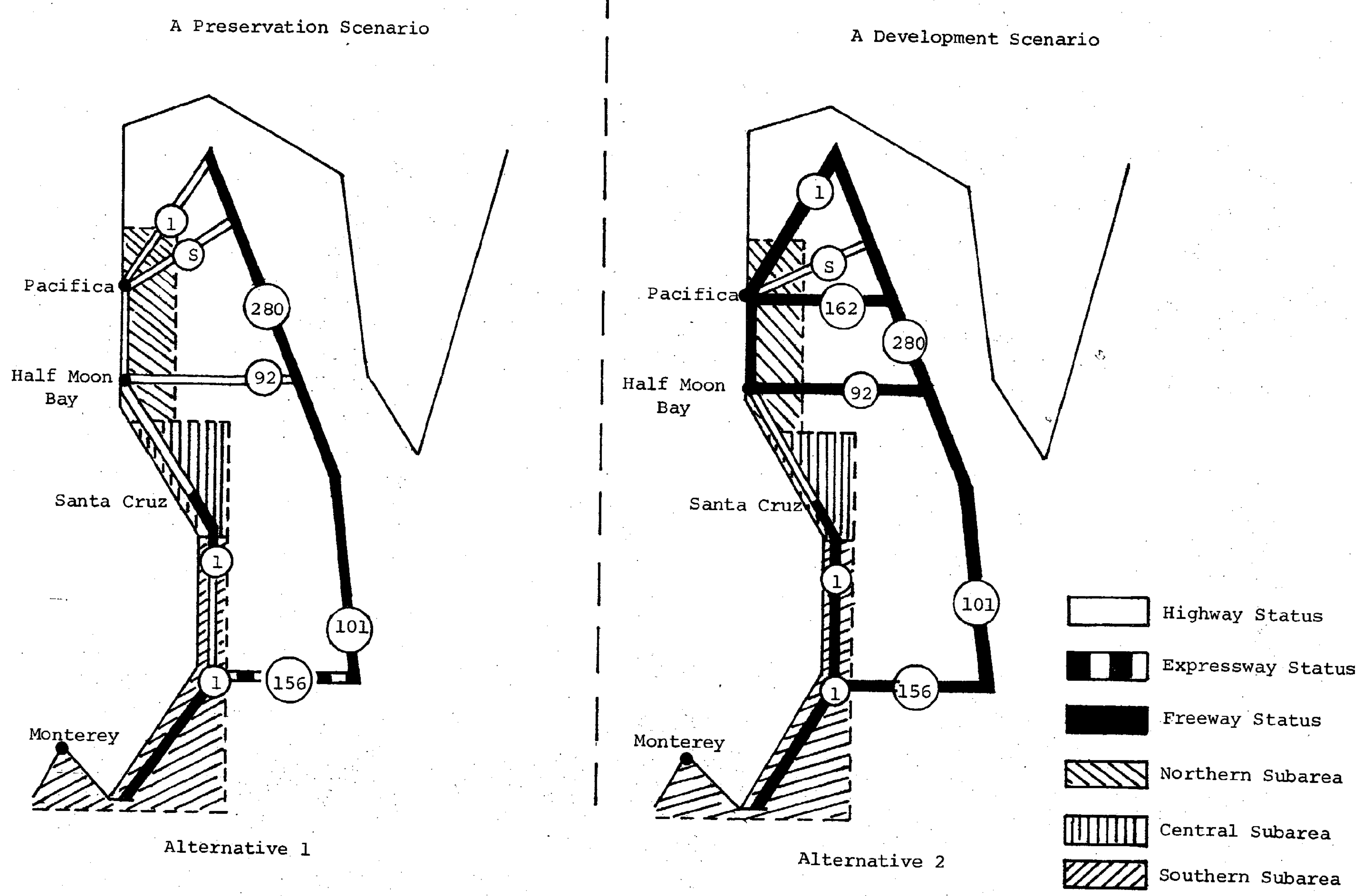


Figure 4.3 ALTERNATIVE TRANSPORTATION NETWORKS

- Construction of Highway 1 from Pacifica to Half Moon Bay as a four-lane expressway.

- Widening of Highway 92 from the intersection with I-280 to Half Moon Bay to a four-lane freeway.

- Construction of a bypass on Highway 1 to avoid congestion at Devil's Slide.

. <u>Road Improvements in the Southern Supply Area</u>

- Widening of Highway 156 from the intersection with Highway 101 to Highway 1 at Castroville to a four-lane freeway.

- Construction of Highway 1 from Castroville to Watsonville as a four-lane expressway.

c. <u>Transportation Network Carrying Capacities</u>

Based solely on characteristics of the alternative transportation networks, expressed by their carrying capacity in Vehicles Per Hour (VPH), the following observations are made regarding the maximum number of trips that can enter the supply area and subareas under each alternative:

. Table IV-2 lists the carrying capacity in VPH of the main entrance roads from the demand area to the supply area under both alternatives. It is shown that under Alternative 1 17,380 vehicles can enter the supply area during any one hour. The corresponding carrying capacity under Alternative 2 is 28,600 vehicles, an increase of 65 percent. As these figures can be interpreted as estimates of upper-bounds on the traffic that can enter the supply area, they provide a benchmark for the constraints imposed by the network on visitation to the supply area.

. Similar to the above, Table IV-3 shows the maximum number of trips that can enter each supply subarea under the two alternatives. It is noted that no adjustments have been made for the relationship between supply subareas, which results in a larger total carrying capacity to the three subareas than the carrying capacity to the supply area shown in Table IV-2. However, Table IV-3 provides insight into the differences between the two alternatives, indicating that the carrying capacity to the northern, central and southern subareas increases by 177, 49 and 43 percent, respectively, under Alternative 2.

Table IV-2

MAXIMUM NUMBER OF TRIPS PER HOUR FOR
ALTERNATIVE TRANSPORTATION NETWORKS
FROM THE DEMAND AREA TO THE SUPPLY AREA

Transportation Entrance to the Supply Area \ Transportation Alternative	Alternative 1 Maximum Number of Trips (V.P.H. in One Direction)	Alternative 2 Maximum Number of Trips (V.P.H. in One Direction)
California Highway 1	2,400	4,000
Sharp Park Road (S)	1,200	1,200
California Highway 162		5,000
California Highway 92	880	4,000
California Highway 84	800	800
Pescadero Road (P)	800	800
California Highway 9	1,000	1,000
California Highway 17	1,500	1,500
California Highway 152	1,300	1,300
California Highway 129	2,500	2,500
California Highway 156	2,500	4,000
California Highway 68	2,500	2,500
Total Carrying Capacity	17,380	28,600

Table IV-3

MAXIMUM NUMBER OF TRIPS PER HOUR INTO SUPPLY SUBAREAS FOR ALTERNATIVE TRANSPORTATION NETWORKS

Subarea	Transportation Alternative / Transportation Entrance to Supply Subarea	No. 1 Maximum Number of Trips (V.P.H. in One Direction)	No. 2 Maximum Number of Trips (V.P.H. in One Direction)
Northern Subarea	Calif. Hwy. 1 (North)	2,400	4,000
	Sharp Park Road	1,200	1,200
	Calif. Hwy. 162		5,000
	Calif. Hwy. 92	880	4,000
	Calif. Hwy. 1 (South)	1,000	1,000
	TOTAL CARRYING CAPACITY	5,480	15,200
Central Subarea	Calif. Hwy. 1 (North)	1,000	1,000
	Calif. Hwy. 84	800	800
	Pescadero Road	800	800
	Calif. Hwy. 9	1,000	1,000
	Calif. Hwy. 17	1,500	1,500
	Calif. Hwy. 1 (South)	1,000	4,000
	TOTAL CARRYING CAPACITY	6,100	9,100
Northern Subarea	Calif. Hwy. 1 (North)	1,000	4,000
	Calif. Hwy. 152	1,300	1,300
	Calif. Hwy. 129	2,500	2,500
	Calif. Hwy. 156	2,500	4,000
	Calif. Hwy. 68	2,500	2,500
	Calif. Hwy. 1 (South)	600	600
	TOTAL CARRYING CAPACITY	10,400	14,900

- In order to relate the maximum number of trips into the supply area and subareas to maximum daily visitation to these areas, the following assumptions are made: (1) traffic during the peak hour constitutes 20 percent of total daily traffic, (2) the average number of people per car (i.e., the car pooling factor) is 3.5, and (3) during the peak hour all entrance roads are used to capacity. Table IV-4 shows the results of converting the information in Tables IV-2 and IV-3 into maximum daily visitation using these assumptions. It is emphasized that the numbers presented are estimates of the upperbounds on visitation based only upon transportation network characteristics. As such they provide insight, but they do not represent the maximum visitation that may result in reality. The latter results from the interaction between the recreation demand in demand centers, the supply of opportunities in supply zones, and the specific network configuration.

3. Objective of Case Study

The objective of the case study is to demonstrate and develop the type of information that the recreation planner must generate in the process of formulating policies and plans for recreational use of the California Central Coastal Zone. As stated in Chapters II and III, the essence of this information base consists of the level and geographic distribution of recreational visitation to the coast under certain assumptions regarding demand, supply and access. Both number of people and the specific locations where they recreate are needed to evaluate the implications associated with recreational use of the coast. Results of this evaluation will allow for more informed decision making regarding recreational policies and plans.

The above information allows for quantitatively addressing the recreational implications of each scenario and associated set of assumptions previously described. This type of assessment provides insight into the desirability and feasibility of attempting to achieve the objectives underlying each scenario. In this way the rationale underlying the basic controversies regarding level of use of coastal resources is illuminated.

Assessing the level and geographic distribution of recreational visitation is accomplished by applying the accessibility model and

Table IV-4

MAXIMUM DAILY VISITATION IN THE SUPPLY AREA
AND SUPPLY SUBAREAS BASED ON THE TRIP SUPPLY CAPACITY OF THE ENTRANCE ROADS

Area	Maximum Number of Trips Per Hour		Maximum Number of Trips Per Day		Maximum Daily Visitation (Visitor Days)	
	Alt. 1	Alt. 2	Alt. 1	Alt. 2	Alt. 1	Alt. 2
1. Supply Area	17,380	28,600	86,900	143,000	304,150	500,500
2. Northern Supply Subarea	5,480	15,200	27,400	76,000	95,900	266,000
3. Central Supply Subarea	6,100	9,100	30,500	30,500	106,750	106,750
4. Southern Supply Subarea	10,400	14,900	52,000	74,500	182,000	260,750

developing a set of trip supply curves for each demand center/supply zone combination described in Subsection 1, and for each highway alternative described in Subsection 2. In addition several other results can be obtained in the process of applying the RECTRIP program. Illustrated in Section D for the case study these relate to the program's intermediate outputs; e.g., the sequence in which various subareas become closed for recreational traffic when loading on the network is increased as a result of an increase in demand at the demand centers. To summarize, the objective of the case study is to develop an information base consisting of level and geographic distribution of recreational visitation and other information, designed to identify acceptable recreation policies which can lead to implementable recreation plans because basic controversies are addressed early in the process versus once plans have been formulated.

C. Data Specification

The analysis addressed in the case study deals with comparing the two previously described highway alternatives for the year 1990, under varying levels of trip production at the demand centers. Data used in the RECTRIP program is specified in the following subsections.

1. Demand

Table IV-5 illustrates the demand estimation procedure described in Chapter III and Appendix A. The table indicates the expected 1990 visitor day demand for the aggregate coastal recreation activities by demand center for a peak summer day. Various levels of trip production (i.e., demand) input to the RECTRIP program are developed by scaling the 1990 expected visitor demand in the demand centers in the same proportions. This is indicated in Figure 4.4, which illustrates that total 1990 demand emanating from the demand area corresponds to 39,340 VPH during the peak hour and that alternative inputs are chosen corresponding to a total of 20,000 VPH, 15,000 VPH, 10,000 VPH, and 6,000 VPH respectively.

The following is noted with respect to the estimations in Table IV-5. Figures chosen for the participation rate and the annual average

Table IV-5

EXPECTED 1990 VISITOR-DAY DEMAND FOR AGGREGATE COASTAL RECREATION ACTIVITIES BY DEMAND CENTER

Demand Centers		1990 Population* (N)	Participation Rate (u)				Annual Average Participation Days Per Participant (v)				Peak Day Participation as % of Annual Participation (w)				Central Coastal Zone Attractiveness Rate (α)				1990 Expected Visitor-Day Demand				
No.	Name		Act. 1	Act. 2	Act. 3	Act. 4	Act. 1	Act. 2	Act. 3	Act. 4	Act. 1	Act. 2	Act. 3	Act. 4	Act. 1	Act. 2	Act. 3	Act. 4	Act. 1	Act. 2	Act. 3	Act. 4	TOTAL
D1	San Francisco	941,627	.43	.45	.50	.65	12.0	12.5	18.0	24.0	.91%	1.25%	1.0%	.56%	.80	.25	.50	.50	35,372	16,552	42,373	41,130	135,427
D2	San Mateo	225,141	.40	.40	.45	.55									.65	.40	.70	.70	6,392	5,629	12,765	11,650	36,436
D3	Redwood City	231,547	.40	.40	.45	.55									.65	.40	.70	.70	6,574	5,789	13,129	11,981	37,473
D4	Palo Alto	149,869	.40	.40	.45	.55									.65	.40	.70	.70	4,255	3,747	8,498	7,755	24,255
D5	Sunnyvale	296,084	.33	.40	.45	.55									.65	.40	.70	.70	6,935	7,402	16,788	15,321	46,446
D6	San Jose	578,538	.33	.40	.50	.65									.65	.40	.70	.70	13,551	14,463	36,448	35,379	99,841
D7	Fremont	251,115	.30	.40	.45	.55									.65	.40	.70	.70	5,341	6,278	14,238	12,994	38,857
D8	Hayward	325,411	.28	.35	.45	.55									.45	.25	.50	.50	4,477	4,449	13,179	12,027	34,132
D9	Oakland	481,779	.28	.45	.50	.65									.45	.25	.50	.50	6,629	8,469	21,680	21,044	57,822
D10	Berkeley	148,137	.28	.45	.50	.65									.45	.25	.50	.50	2,038	2,604	6,666	6,471	17,779
D11	Richmond	277,417	.28	.35	.45	.55									.45	.25	.50	.50	3,817	3,793	11,235	10,253	29,098
D12	Concord	579,290	.28	.40	.50	.55									.45	.25	.25	.25	7,971	9,051	13,034	10,705	40,761
D13	San Rafael	294,629	.40	.45	.50	.55									.20	.25	.25	.25	2,574	5,179	6,629	5,445	19,827
D14	Fresno	600,000	.20	.45	.50	.65									.50	.15	.15	.15	6,552	6,328	8,100	7,862	28,842
	TOTAL	5,380,584																	112,484	99,733	224,762	210,017	646,966

Note:

Act. 1 : Beach Use

Act. 2 : Boating and Fishing

Act. 3 : Park Use

Act. 4 : Sightseeing and Driving for Pleasure

Source: * Population, Employment and Land Use Projections, San Francisco Bay Region 1970-2000, ABAG and MTC, 1973

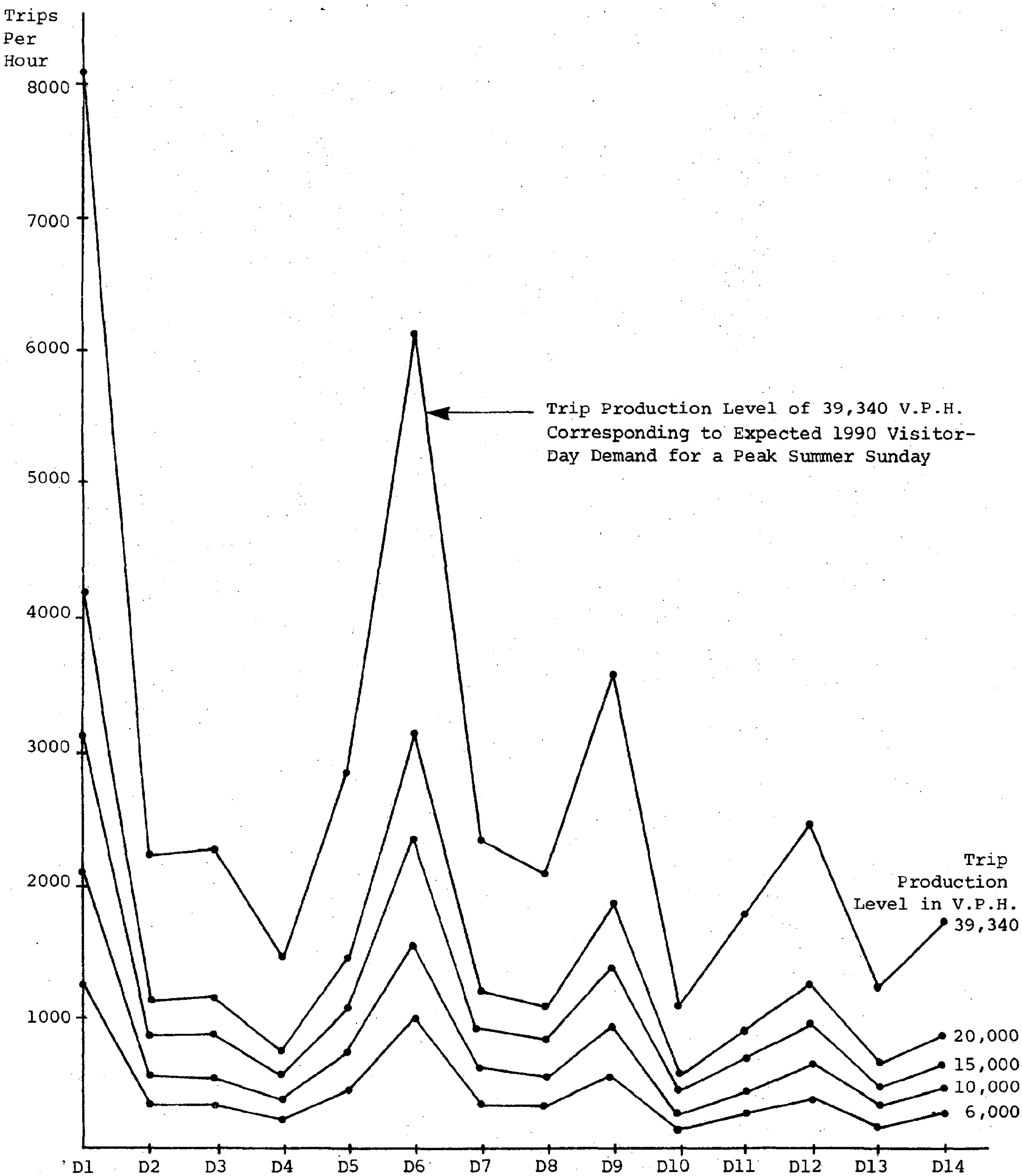


Figure 4.4 TRIP PRODUCTION FOR ALL DEMAND CENTERS

participation days per participant are based on interpreting the results of National Surveys performed by BOR (Refs. 4 and 5) and on a local survey performed in one county in the study area (Ref. 12). It is emphasized that the numbers generated by the above surveys are interpreted and not merely used; that is, the judgment of local planners has been incorporated to arrive at the 1990 estimates. Percentages derived expressing peak day participation as a percentage of annual participation are based on investigating the visitation characteristics at existing parks. The Parks and Recreation Information System (PARIS) of the California State Park and Recreation Department maintains a computerized data base of daily visitation to most of the state parks in the study area; these daily visitation charts are used to calculate the percentage of annual participation days that will occur in a peak summer Sunday.

The peak summer Sunday demand for coastal recreation, as contrasted to elsewhere is computed by applying a central coastal zone attractiveness rate (Ref. 14). This factor represents the portion of total number of trips, originating in a particular demand center, that has the California Central Coastal Zone as a destination. Specific origin-destination studies performed by local transportation planners as well as origination surveys in state parks are used to compute this factor (Refs. 15, 16 and 17). Finally, the number of visitor days is translated into a number of trips using car pooling factors established for each specific activity. The source used is the eighth Trip End Generation Report published by the California Department of Transportation (Ref. 18). Using these car pooling factors the total 1990 number of visitor days -- 646,966 -- translates into a peak hour loading on the network of 39,340 vehicles. To compute the latter it is assumed that the peak hour traffic constitutes 20 percent of the total daily traffic.

2. Supply

The 1990 carrying capacity of recreation resources in the supply area in terms of visitor day supply is calculated using the procedure described in Appendix A. Table IV-6 illustrates the results of the

Table IV-6

EXPECTED 1990 VISITOR-DAY SUPPLY FOR AGGREGATE COASTAL RECREATION ACTIVITIES BY SUPPLY ZONE

Supply Zone		Physical Capacity				Effective Area				Supply**, i.e., Number of Visitor-Days That Can Be Accommodated				
		Act.1	Act.2	Act.3	Act.4	Act.1	Act.2	Act.3	Act.4	Act.1	Act.2	Act.3	Act.4	TOTAL
No.	Name	Acres	Boat Ramps	Acres	Scenic Rd. (Miles)	Effective Acres	Boat Ramps	Effective Acres	Effective Scenic Rd. Miles					
S1	San Francisco	925	1	0	8	555	1	0	5	123,321	250	0	4,605	128,176
S2	Pacifica	160	1	1,455	40	84	1	69	10	18,665	250	8,625	9,211	36,751
S3	Half Moon Bay	958	4	1,262	15	400	4	51	6	88,880	1,000	6,375	5,526	101,781
S4	San Mateo Beaches	1,101	0	7,668	28	300	0	75	11	66,660	0	9,375	10,132	86,167
S5	North Santa Cruz Co.	500	1	1,680	15	100	1	125	6	22,220	250	15,625	5,526	43,621
S6	Santa Cruz	1,200	6	2,500	6,000*	720	6	125	6,000*	159,984	1,500	15,625	210,000	387,109
S7	South Santa Cruz Co.	500	3	200	5	200	3	20	2	44,440	750	2,500	1,842	49,532
S8	North Monterey Bay	700	6	450	7	280	6	40	3	62,216	1,500	5,000	2,763	71,479
S9	Fort Ord	400	0	0	0	80	0	0	0	17,776	0	0	0	17,776
S10	Monterey	700	5	800	5,000*	420	5	24	5,000*	93,324	1,250	3,000	175,000	272,574
S11	Big Basin	0	0	13,000	20	0	0	130	5	0	0	16,250	4,605	20,855
	TOTAL	7,144	27	29,015	138 11,000*	3,139	27	659	48 11,000*	697,486	6,750	82,375	429,210	1,215,821

* **Parking Lots**

Source: INTASA Working Memorandum

** Recommended Design Standard

Act. 1 – Beach Use – 222.2 Visitor Days Per Effective Acre
Act. 2 – Boating and Fishing – 250.0 Visitor Days Per Boat Ramp
Act. 3 – Park Use – 125.0 Visitor Days Per Effective Acre
Act. 4 – Sightseeing and Driving for Pleasure – 921.05 Visitor Days Per Effective Scenic Road Mile
35.0 Visitor Days Per Parking Lot

procedure for each supply zone. The following is noted. Physical capacity within each of the zones in 1990 is based on an evaluation of the 1969 Recreational Site Inventory performed by the California State Department of Parks and Recreation, and plans and ideas of various recreation agencies (Refs. 19, 20, 21, 22, 23 and 24). The total effective area within each supply zone is based on an evaluation of the intensive use areas at particular sites in the zones which support the specific recreation activity. Finally, the 1990 carrying capacities are calculated by applying recommended design standards to the effective area in each zone (Ref. 9). Carrying capacities can either be expressed in number of trips that can be accommodated using a car pooling factor or number of visitor days that can be accommodated.

3. Transportation

Elements of highways in the study area that are identified by their two junctions, or terminal nodes, are called links. A set of all highway links completely describes the highway network. Link information, such as traffic direction, speed, length, travel time and road carrying capacity are input to the RECTRIP program. Specifications of the two highway alternatives are based upon information from the California Department of Transportation with respect to highway plans as well as on interviews and other sources (Refs. 22 and 23).

D. Results

This section discusses the results of applying the accessibility model in the case study. Results relate to four subjects: (1) aggregate analysis of demand and supply under two highway alternatives, (2) congestion analysis, (3) trip supply curves, and (4) level and geographic distribution of visitation. Before presenting the results it is desirable to further exemplify the program in order to facilitate understanding of these results. In executing the RECTRIP program, different levels of total trip production (i.e., demand) were used which correspond to the total trip production levels indicated in Figure 4.4. For a particular trip production level during the peak hour of 15,000 vehicles originating in the demand area and destined for the supply area,

Figure 4.5 indicates, in schematic form, the inputs and partial outputs of the RECTRIP program. The following is noted:

- Figure 4.5 (a) provides the input data prescribing how the total number of 15,000 trips is divided over the individual demand centers and recreation activities. For example, in peak hour traffic to the coast there are 692 trips coming from San Francisco for beach use. It is emphasized that this particular 1990 trip demand is a fraction of the total trip demand on a peak summer Sunday. Furthermore the demand indicated represents demand on the network during the peak hour which constitutes 20 percent of total daily traffic.

- Figure 4.5 (b) provides results of the RECTRIP program and indicates the final loading of the two alternative highway networks. As indicated in Chapter III, Section E, the program iterates until all 15,000 trips are assigned to a particular road and it is assured that a trip reaches a supply zone. Of particular interest is the comparison between the two alternatives, which shows that a different highway-use pattern emerges under Alternative 2 in terms of total number of vehicles using a particular road.

- Figure 4.5 (c) provides both input and partial output data of the program. First, the carrying capacity by activity is indicated for each supply zone in terms of the number of trips that can be accommodated. Second, level and geographic distribution of the expected visitation under each highway alternative is indicated; e.g., in Supply Zone 1, San Francisco, 3,770 trips can be accommodated for beach use. Under Alternative 1 visitation to San Francisco consists of 379 trips, and under Alternative 2 of 390 trips. It is noted that as a result of congestion in the network under Alternative 1, trips originally scheduled for beach use, boating and fishing, and driving for pleasure are diverted to park use because destinations cannot be reached within a bound set on access time.

- In interpreting the results in Figure 4.5 the structure of the accessibility model should be kept in mind. For example, of the total trips for beach use leaving San Francisco some will be satisfied in the San Francisco supply zone and some in other zones. By the same token, some trips to the San Francisco supply zone come from places other than San Francisco. After all trips have gone through the network, a distribution results which has incorporated the influence of access on visitation to the various supply zones.

Demand Center / Activity	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	Total
Beach Use	692	125	129	82	136	265	105	88	130	40	75	155	50	127	2,199
Boating and Fishing	371	126	130	85	166	324	141	100	190	58	85	204	116	143	2,239
Park Use	950	286	294	191	377	817	319	296	486	150	252	292	149	181	5,040
Driving for Pleasure	1,082	306	315	204	403	930	342	316	553	170	270	281	143	207	5,522
Total	3,095	843	868	562	1,082	2,336	907	800	1,359	418	682	932	458	658	15,000

(a) 1990 Trip Demand

Alternatives / Network Roads	Alternative 1			Alternative 2		
	Capacity	Loading	% Cap. Used	Capacity	Loading	% Cap. Used
Highway 1	2,400	2,400	100	4,000	530	13
Sharp Park	1,200	1,200	100	1,200	0	0
Highway 162	0	0		5,000	400	8
Highway 92	880	880	100	4,000	2,170	54
Highway 84	800	800	100	800	800	100
Pescadero	800	800	100	800	800	100
Highway 9	1,000	1,000	100	1,000	1,000	100
Highway 17	1,500	1,500	100	1,500	1,500	100
Highway 152	1,300	1,200	92	1,300	1,300	100
Highway 129	2,500	2,500	100	2,500	2,500	100
Highway 156	2,500	2,500	100	4,000	4,000	100
Highway 68	2,500	220	9	2,500	0	0
Total	17,380	15,000	86	28,600	15,000	52

(b) Final Network Loading

LEGEND

DEMAND CENTERS

- D1 San Francisco
- D2 San Mateo
- D3 Redwood City
- D4 Palo Alto
- D5 Sunnyvale
- D6 San Jose
- D7 Fremont
- D8 Hayward
- D9 Oakland
- D10 Berkeley
- D11 Richmond
- D12 Concord
- D13 San Rafael
- D14 Fresno

SUPPLY ZONES

- S1 San Francisco
- S2 Pacifica
- S3 Half Moon Bay
- S4 San Mateo Beaches
- S5 North Santa Cruz Co.
- S6 Santa Cruz
- S7 S. Santa Cruz Co.
- S8 North Monterey Bay
- S9 Fort Ord
- S10 Monterey
- S11 Big Basin

408 ← Capacity in Trips
191 ← Visitation in Trips Under Alt. 1
196 ← Visitation in Trips Under Alt. 2

Supply Zone / Activity	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	Total
Beach Use	3,770	1,681	1,952	2,244	122	4,076	2,207	408	510	2,446	0	19,416
	379	59	273	162	57	480	137	191	51	287	–	2,076
	390	59	280	210	70	504	140	196	56	294	–	2,199
Boating and Fishing	25	25	100	0	25	150	150	75	0	225	0	775
	81	81	325	–	60	476	485	243	–	404	–	2,155
	83	84	333	–	83	497	497	248	–	414	–	2,239
Park Use	0	291	252	1,965	67	100	420	180	0	120	460	3,855
	–	607	449	623	683	656	176	351	–	211	1,660	5,416
	–	624	460	676	676	676	180	360	–	216	1,172	5,040
Driving for Pleasure	1,263	902	902	2,526	846	5,000	451	451	0	6,000	1,128	19,469
	56	116	69	146	69	2,627	21	27	–	2,194	28	5,353
	57	119	71	133	71	2,703	24	33	–	2,252	59	5,522
Total	5,058	2,899	3,206	6,735	1,060	9,326	3,228	1,114	510	8,791	1,588	43,515
	516	863	1,116	931	869	4,239	819	812	51	3,096	1,688	15,000
	530	886	1,144	1,019	900	4,380	841	837	56	3,176	1,231	15,000

(c) 1990 Supply Capacity and Visitation

Figure 4.5 1990 RECREATION-TRIP DISTRIBUTION

1. Aggregate Analysis of Demand and Supply Under the Two Highway Alternatives

Figure 4.6 provides an aggregate representation of the study area in which both the demand and supply areas are represented by a "super-node" connected by the transportation network. The maximum level of demand, in terms of VPH generated in the demand centers during the peak hour, is indicated with horizontal lines to provide a benchmark; the level of supply that corresponds to 20 percent of the total supply is also indicated. It can be observed that both 1970 and 1990 supplies exceed the corresponding demands.

Of particular interest is the horizontal line corresponding to the upper bound on the number of trips that can enter the supply area during the peak hour. It is seen that irrespective of the alternative the network cannot accommodate the maximum peak hour flow on a peak summer day. Both the maximum 1970 and 1990 demand exceed the upper bounds of the network as calculated in Table IV-2.

Figure 4.6 also indicates the aggregate trip supply curves for Alternatives 1 and 2 provided by the RECTRIP program. Following the discussion in Section C of Chapter III and based on the assumption that the trip demand decreases as travel time increases, a sample trip demand curve is drawn to illustrate the likely implication of the above results. At Point A in Figure 4.6 the trip demand and trip supply curves intersect. This point indicates that the network allows for satisfying only 60 percent of the maximum demand, and that the average trip to the coast would take more than 150 minutes. Clearly Alternative 1 would not be able to handle the 1990 peak day demand in any possible way. It is emphasized that the demand curve drawn has no empirical basis; a different trip demand curve would obviously change these implications, and therefore the results are illustrative rather than exact.

2. Congestion

The previous subsection concluded that under each alternative it would not be possible to satisfy the total demand for coastal recreation activities generated at the demand centers, and that approximately 50 or 60 percent of the total demand would result in visitation to the

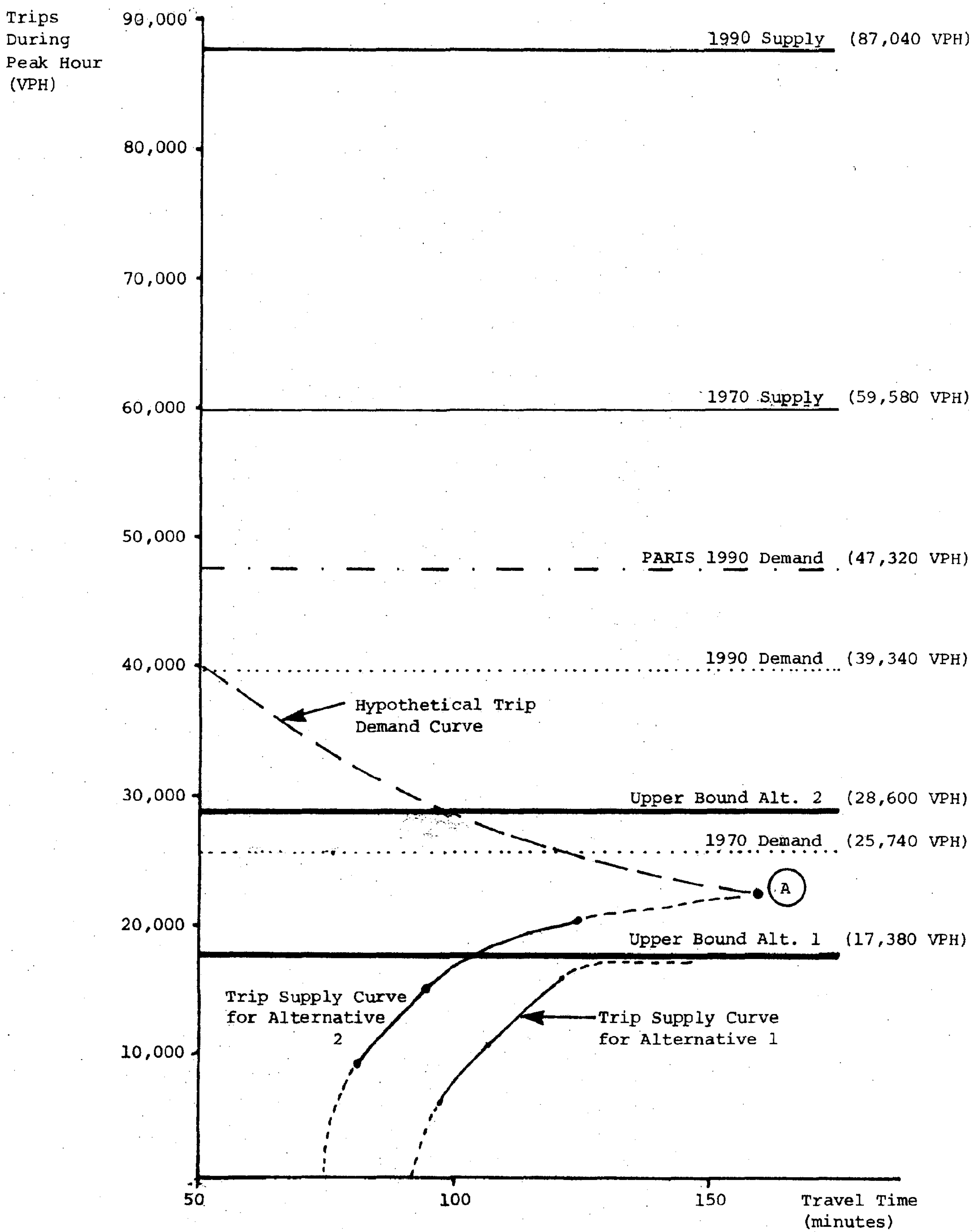


Figure 4.6 SUPERNODE CONSIDERATION OF TRIP DEMAND VERSUS TRIP SUPPLY

coast. In order to evaluate the recreation system in more detail and to find ways by which the average travel time for recreationers reaching the supply zones can be improved, it is necessary to investigate where congestion appears and to identify bottlenecks in highways during peak hour traffic.

As previously indicated, traffic loading volume is increased in steps corresponding to increases in demand. The increase in loading volume and the distribution of these trips over the different network links causes saturation of links when link-traffic volume reaches its carrying capacity. The order in which links become saturated identifies a sequence of troublesome links that create bottlenecks leading to congestion. When all main routes to a supply zone are saturated the relative attractiveness of recreation sites in the zone is diminished. As a result it is assumed that potential visitors to the particular supply zone will consider more accessible sites in other zones as better alternatives. Figure 4.7 synthesizes the analysis results in terms of the relative accessibility to the three supply subareas under each alternative as a function of the traffic loading volume or trip production imposed on the network. It indicates the residual carrying capacity allowing for entry into the three supply subareas and the loading level at which the supply subarea is closed. The residual carrying capacity consists of those roads which generally have a much longer travel time between demand center and supply zone. The following is noted:

- The maximum loading volume for Alternative 1 is 15,000 VPH. At this volume level the northern supply subarea (Pacifica and Half Moon Bay) and the central supply subarea (San Mateo Beaches and Santa Cruz) are closed while the southern supply subarea (Monterey) has a small residual carrying capacity. This maximum loading level is approximately 2,000 VPH less than the upper bound for this alternative established in Table IV-2. Corresponding to a peak hour loading level of 15,000 VPH is a daily visitation of approximately 262,000 visitors. Thus it can be concluded that the maximum visitation to the supply area on a peak summer Sunday under Alternative 1 is approximately 262,000.

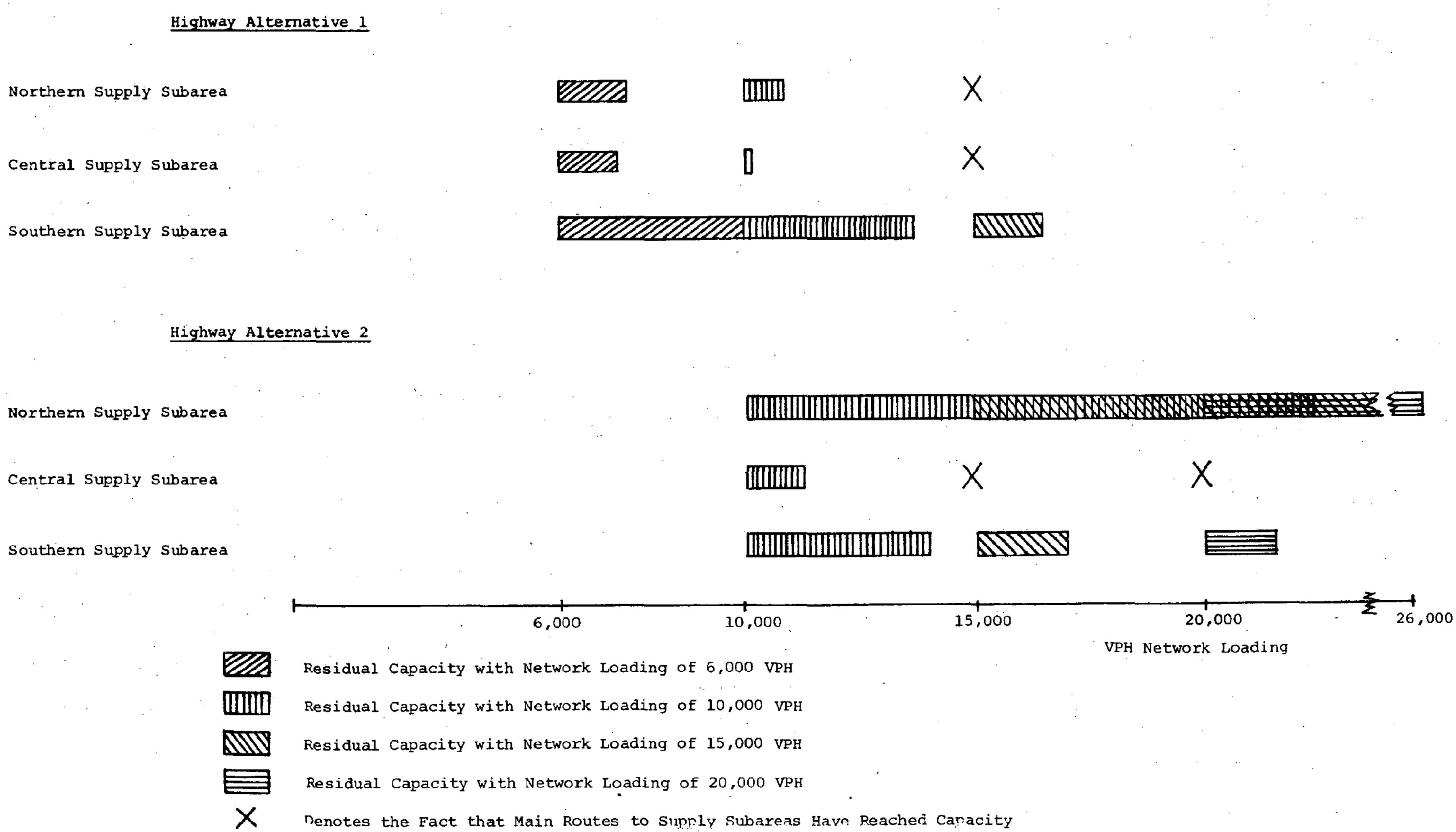


Figure 4.7 RESIDUAL CARRYING CAPACITY ON MAIN ROUTES TO SUPPLY SUB AREAS UNDER TWO HIGHWAY ALTERNATIVES FOR DIFFERENT NETWORK LOADINGS

- Where the above estimate establishes the level at which all subareas are considered closed, it can be observed from Figure 4.7 that the residual capacities to the northern and central supply subareas at lower loading volumes are relatively small. This indicates that for all practical purposes these subareas will not receive many more visitors than would be expected with total loading volumes corresponding to between 6,000 VPH and 10,000 VPH, or 105,000 and 175,000 visitors respectively. The practical implication is that the transportation network becomes a major bottleneck in reaching these two subareas when more than 175,000 people leave the demand area heading for the California Central Coastal Zone. It is noted that this level of demand constitutes only 27 percent of the maximum demand expected to be generated on peak summer Sundays (see Table IV-5).

- Examination of the network loading volumes under Alternative 2 shows a significant difference for the northern supply subarea. At 20,000 VPH the residual carrying capacity is large and visitation to the Pacifica-Half Moon Bay area can be increased by over 175,000 people per day. However, accessibility to the central supply subarea under Alternative 2 does not significantly change as compared to Alternative 1. Under both alternatives, this subarea will be closed at a loading level of approximately 10,000 VPH or when approximately 175,000 people leave the demand area and head for the California Central Coastal Zone.

3. Trip Supply Curves

The trip supply curves generated by applying the accessibility model discussed in Chapter III to the case study are a key result. Using 14 demand centers, 11 supply zones, four aggregate recreation activities and two highway alternatives, 1,232 individual trip supply curves were generated. For a specific highway alternative and a specific activity, each trip supply curve indicates the relationship between the number of trips originating in a specific demand center and the associated average travel time to reach a specific supply zone. For obvious reasons, it is neither possible or desirable to display each trip supply curve in this report. Thus the emphasis in this subsection is on highlighting and illustrating the type of information that can be ascertained from trip supply curves.

Close examination of the trip supply curves reveals that there are a few basic forms as represented in Figures 4.8, 4.9 and 4.10; all

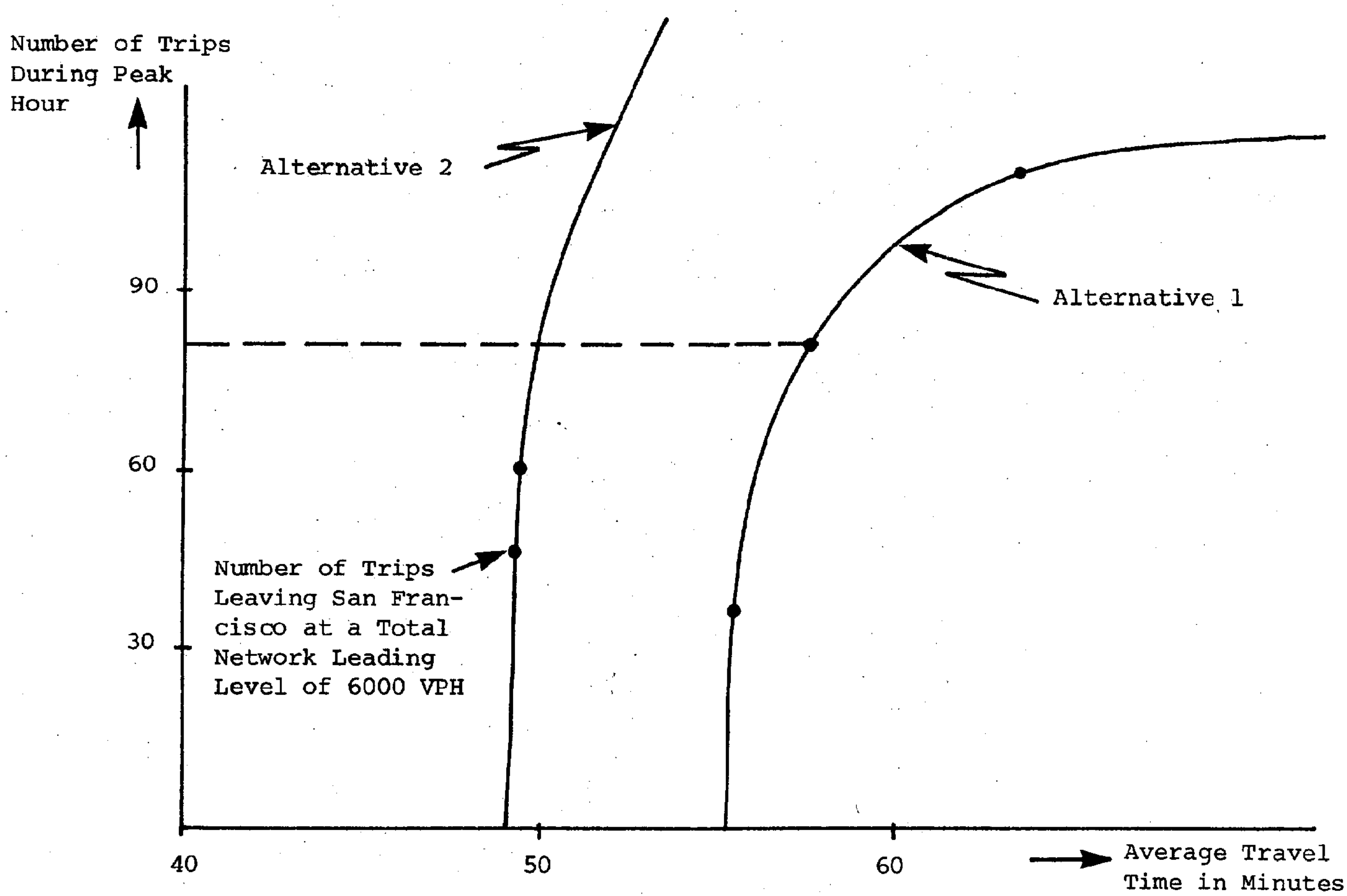


Figure 4.8 TRIP SUPPLY CURVES FOR BEACH USE FROM SAN FRANCISCO TO HALF MOON BAY UNDER THE TWO HIGHWAY ALTERNATIVES

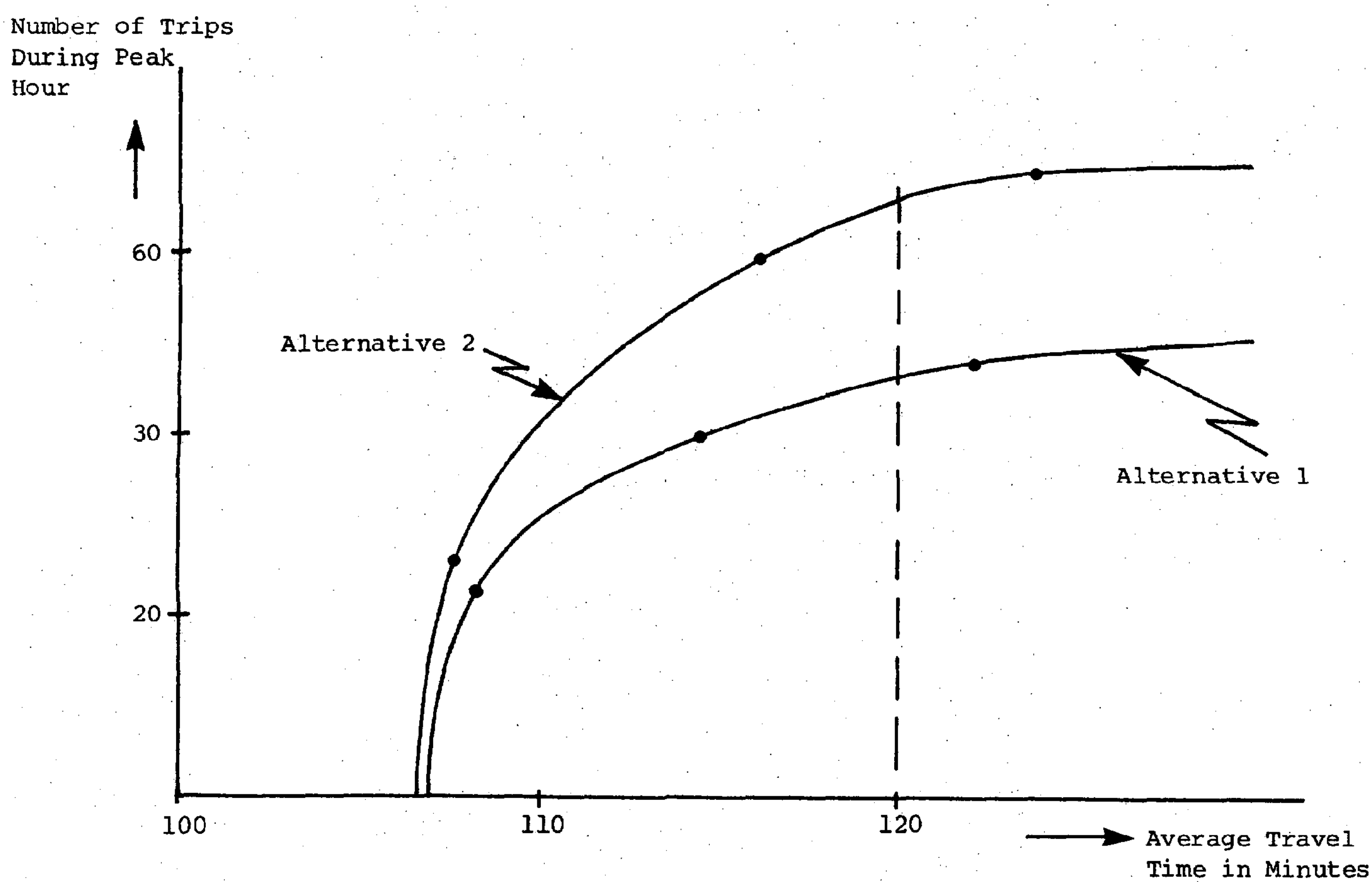


Figure 4.9 TRIP SUPPLY CURVE FOR BOATING AND FISHING FROM SAN JOSE TO MONTEREY-CARMEL UNDER TWO HIGHWAY ALTERNATIVES

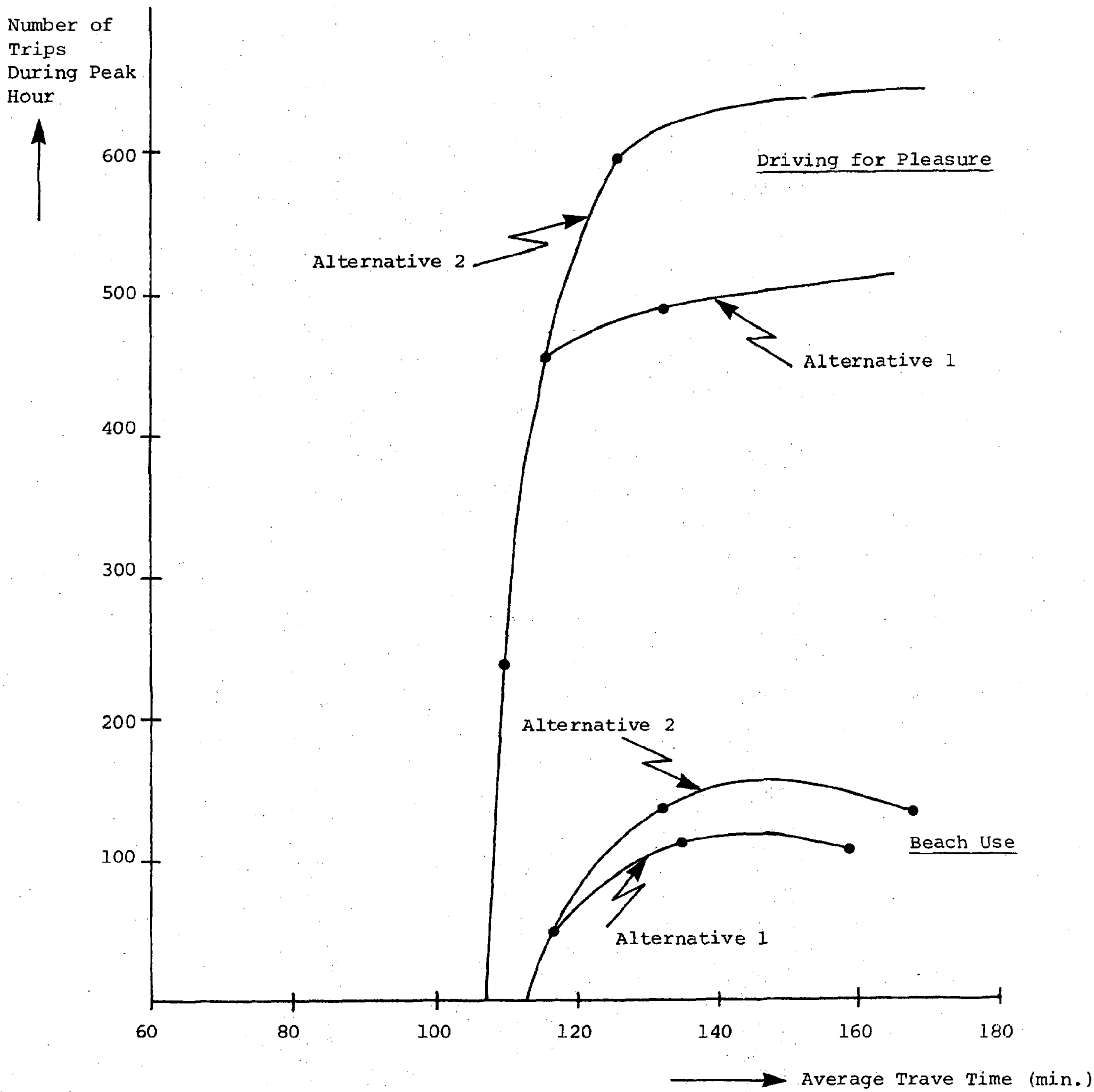


Figure 4.10 TRIP SUPPLY CURVES FOR BEACH USE AND DRIVING FOR PLEASURE FROM SAN FRANCISCO TO SANTA CRUZ UNDER THE TWO HIGHWAY ALTERNATIVES

other curves are similar to these, although specifics are different. Figure 4.8, depicting the trip supply curve for beach use from San Francisco to Half Moon Bay, is representative of the trip supply curves connecting any demand center to a supply zone in the northern supply subarea. Figure 4.9, depicting the trip supply curve for boating and fishing from San Jose to Monterey-Carmel, is representative of the trip supply curves connecting any of the demand centers to supply zones in the southern supply subarea. Figure 4.10 represents a slightly different shape, depicting the trip supply curve for beach use and driving for pleasure from San Francisco to Santa Cruz. It represents a number of trip supply curves associated with trips into the central supply subarea. The difference between this and the previous curves can be observed for beach use where the number of trips to Santa Cruz decreases while the total network loading increases. (Note: as explained in Chapter III, trip supply curves are derived by generating individual points on the curves that correspond to different total network loading volume. These individual points are represented in Figures 4.8, 4.9 and 4.10 by heavy dots.)

Using the trip supply curves presented in the figures the following type of information can be derived:

- The dotted line in Figure 4.8 illustrates that under Alternative 2, with the same number of people leaving San Francisco and headed for beach use in Half Moon Bay as under Alternative 1, it will take approximately 14 percent less travel time to reach the destination under peak hour conditions. This type of information allows for specific quantification of the advantage of opening up the northern supply subarea in terms of savings in travel time to people from different demand centers.

- Similarly, the dotted line in Figure 4.9 illustrates that within a specified travel time of 120 minutes, Alternative 2 allows for an increase of 30 percent more people coming from San Jose who desire to engage in boating and fishing in the Monterey-Carmel supply zone. It is noted that this type of information cannot always be provided as is illustrated in Figure 4.8 In this case, an increase in the number of trips having the same average travel time from San Francisco is not shown due to the large residual road carrying capacity at the loading level at which the RECTRIP program was terminated under Alternative 2.

- Based on Figure 4.10 it can be expected that Alternative 2 will lead to a shift in the usage of recreation facilities in the central supply subarea, in particular in the San Mateo Beaches and Santa Cruz supply zones. Because of the relative disadvantage of the central supply subarea in terms of additional road capacity under Alternative 2 as compared to the other subareas (as discussed in the previous subsection), it can be expected that the total number of trips for beach use, park use and boating decreases as the main routes are saturated and the average travel time increases. A decrease in these activities can be expected to result from an upsurge in driving for pleasure which apparently motivates the majority of trips to Santa Cruz, for example. Specific results from the program indicate that under Alternative 1 driving for pleasure to Santa Cruz accounts for 62 percent of all trips and 75 percent under Alternative 2, or a net increase of 8,000 visitors per day. The practical implication of the above observation is that the emphasis in recreation planning for this subarea shifts from providing facilities for beach use, etc. to accommodating the desires to drive for pleasure. Therefore, facility planning in this area should consider this shift in order to set up the proper priorities for construction of facilities.

4. Level and Geographic Distribution of Visitation

Results of the RECTRIP program illustrate the flow of recreational traffic from the metropolitan areas to the California Central Coastal Zone supply area and hence the geographic distribution and level of visitation. Information on the distribution of visitation is relevant for locating additional recreation sites or for recommending road improvement, while information on the level of visitation can be used to improve site development plans or to plan and construct facilities needed to prevent overcrowding and overuse.

Similar to the situation described in the previous subsection, the RECTRIP program generates a wealth of information related to level and distribution of visitation depending on the specific activity and highway alternative considered. Tables IV-7 and IV-8 contain a selection of this information to demonstrate its use, and, more importantly, to illustrate its implications for recreation planning. Table IV-7 provides the level of visitation, in number of visitors, to selected supply zones for the aggregate recreation activities. A total network loading volume is chosen for each alternative that corresponds to the situation

Table IV-7

LEVEL OF VISITATION IN NUMBER OF VISITORS TO SELECTED SUPPLY ZONES FOR AGGREGATE RECREATION ACTIVITIES

Visitation/ Supply Zone	Total Visitation Alt. 1 (Total Network Loading 15,000 VPH)	Total Visitation Alt. 2 (Total Network Loading 20,000 VPH)	Visitation by Activity as Percentage of Total Visitation: Beach Use Alt. 1	Beach Use Alt. 2	Boating and Fishing Alt. 1	Boating and Fishing Alt. 2	Park Use Alt. 1	Park Use Alt. 2	Driving for Pleasure Alt. 1	Driving for Pleasure Alt. 2
Pacifica	15,484	20,665	7.0	7.0	9.5	9.5	70.5	70.5	13.0	13.0
Half Moon Bay	20,022	26,712	24.5	24.5	29.1	29.1	40.2	40.2	6.2	6.2
San Mateo Beaches	32,322	32,234	12.2	12.5	3.3	1.4	72.6	79.2	11.9	6.6
Santa Cruz	76,096	73,516	11.3	7.6	11.3	6.7	15.5	10.7	61.9	75.0
Monterey	55,545	74,060	9.3	9.3	13.0	13.0	6.8	6.8	70.9	70.9

Table IV-8

PERCENTAGE OF THE TOTAL NUMBER OF TRIPS TO THE SUPPLY SUBAREAS ORIGINATING IN SELECTED DEMAND CENTERS

Supply Subarea/ Demand Center	Northern Supply Subarea (Pacifica-Half Moon Bay)		Central Supply Subarea (San Mateo Beaches-Santa Cruz)		Southern Supply Subarea (Monterey-Carmel)	
	Alt. 1	Alt. 2	Alt. 1	Alt. 2	Alt. 1	Alt. 2
San Francisco	24	16	17	22	23	24
Sunnyvale	6	7	7	7	8	8
San Jose	10	10	21	29	9	8
Oakland	8	8	8	7	12	11
Fresno	2	1	5	5	5	5
Rest	51	52	42	30	43	44

when specific supply subareas are closed due to saturation of particular roads; as discussed in the previous subsection, these volumes are 15,000 VPH and 20,000 VPH, or 262,000 and 250,000 visitors respectively. Table IV-8 provides insight into where visitors to specific supply zones originate under each alternative in order to discern possible changes in recreation patterns as a result of changes in access. Based on Tables IV-7 and IV-8 the following is noted:

- Based on the column related to total visitation in Table IV-7, it can be observed that Santa Cruz attracts by far the largest number of people. However, it is noted that the total number of people to Santa Cruz and San Mateo Beaches decreases under Alternative 2, in spite of the larger number of people who leave the demand area under this alternative; i.e., under Alternative 1, 262,000 people head for the supply area versus 365,000 under Alternative 2. In addition, based on the activity-oriented columns in Table IV-7 it can be observed that except for San Mateo Beaches and Santa Cruz no significant shifts occur in the distribution of visitors over the various activities under the two alternatives. With respect to Santa Cruz, the numbers presented provide further justification for the phenomenon depicted in Figure IV-10: the decrease in beach use, park use, and boating and fishing in favor of an increase in driving for pleasure. An additional observation relates to San Mateo Beaches where it is shown that under Alternative 2, a larger percentage of the total visitors to this zone engage in park use than under Alternative 1. The implication is that the Santa Cruz Mountain sites in the Big Basin area become more attractive when the roads to the coast become saturated.

- Changes in access as represented by the two highway alternatives lead to changes in the distribution of trips if trip origination is taken into account, as is illustrated in Table IV-8. That is, changes in access or average travel time will result in people changing their point of destination at the coast. For example, under Alternative 1, 24 percent of all visitors to the northern supply subarea came from San Francisco, and 10 percent from San Jose. Under Alternative 2, these percentages change to 16 percent from San Francisco and 16 percent from San Jose. It is concluded that under Alternative 2 distance is less of a hindrance to visiting a particular site, and that the attractiveness of the site becomes more dominant. That is, people drive farther if certain network constraints are relieved. For example, the percent of trips that originate in San Francisco and terminate in Santa Cruz increases from 17 percent to 22 percent, while the percent of trips that originate in San Francisco and terminate in Half Moon Bay decreases from 24 percent to 16 percent under Alternative 2.

E. Interpretation of Results

This section indicates how the information generated by applying the accessibility model to the California Central Coastal Zone relates to the two planning scenarios and associated highway alternatives presented in Section B. In practice this interpretation of results is the most important part of the initial planning process. That is, after establishing level and geographic distribution of recreational visitation under a set of assumptions regarding demand, supply and access, the objectives are (1) to investigate whether the findings generated further enhance or conflict with the basic objectives of the planning scenarios, and (2) to isolate areas of conflict which subsequently must be resolved. It is noted that the recreation planner is better equipped to deal with such situations at this point because he can provide an indication of the level and geographic distribution of visitation that can be expected. This type of information is a prerequisite for determining whether in fact a conflict exists and for relating recreation planning to other planning efforts.

The northern supply subarea is used for interpreting the results of the accessibility model in relation to the preservation and development scenarios. It is noted that many areas of possible conflict could be further investigated using results of the case study. For example: will the expected level of visitation accelerate second home building thereby affecting housing planning efforts along the coastline, or how will the expected level of visitation affect capital budgeting by local communities, and so forth. Acknowledging that a broad range of subjects related to level and geographic distribution of recreation visitation to the coast could be investigated, for the illustration purposes the following discussion emphasizes (1) priorities in recreation planning, (2) evaluation of existing recreation programs, and (3) the relation between recreation planning and growth.

1. Preservation Scenario

The preservation scenario for the northern supply subarea can be characterized as embodying a "No Growth" policy for the Pacifica and Half Moon Bay communities. The associated transportation network, Alternative 1, not only limits the number of visitors from the total demand area to this supply subarea, but also the ability of both places to function as bedroom communities for the metropolitan area. With respect to recreation visitation, Table IV-9 indicates that the northern supply subarea can expect 35,000 visitors or 13 percent of all visitors to the coast from a total network loading of 265,000 visitors. It is noted that when the network is totally loaded the northern and central supply subareas are closed; thus 35,000 visitors is a reasonable estimate of actual visitation, although it certainly is not representative of what could be expected if the network were not a constraint.

With respect to the subarea's ability to function as a bedroom community, Table IV-3 indicates that the carrying capacity of the road leading in and out of the area is approximately 5,500 VPH during a peak hour. Thus during a two-hour rush period, approximately 11,000 trips, or 38,500 persons could reach the employment centers of San Francisco and San Mateo. Using crude assumptions, the above road carrying capacity serves as a basis for making population projections for Pacifica and Half Moon Bay illustrated in Table IV-9 under the heading "No Growth". It is noted that the indicated growth rate for this policy of 3.7 and 8.0 percent in 1975 respectively is still larger than what is expected for the county and the region as a whole.

Based on expected visitation to the subarea, and projections of its population, it is possible to address deficiencies in aggregate recreation opportunities. Table IV-10 displays the level of visitation for each activity under each alternative and provides information on the existing and planned carrying capacities of the supply for these activities. It can be observed that the total level of visitation is smaller than the existing carrying capacity of the facilities; thus even if heavy participation from the local population is assumed, there does not appear to be an overall deficiency problem.

Table IV-9

POPULATION PROJECTIONS AND GROWTH RATE FOR THE PACIFICA AND HALF MOON BAY URBANIZED AREAS UNDER "NO GROWTH" AND "CITY PLAN" POLICIES

	Pacifica				Half Moon Bay			
	"City Plan"		"No Growth"		"City Plan"		"No Growth"	
Year	Population	Yearly Growth Rate	Population	Yearly Growth Rate	Population	Yearly Growth Rate	Population	Yearly Growth Rate
1965	30,000		30,000		3,400		3,400	
1970					4,000	3.3%	4,000	3.3%
1975	45,000	3.7%	45,000	3.7%	7,300	13.2%	6,000	8.0%
1980					11,600	9.1%	8,700	4.6%
1990	66,000	4.2%	55,000	2.0%	20,500	5.6%	13,050	2.8%
Total Capacity	90,000		70,000		32,500*		25,000*	

*Total Capacity for the greater Half Moon Bay urban area.

Table IV-10

LEVELS OF VISITATION UNDER TWO HIGHWAY ALTERNATIVES COMPARED TO EXISTING AND PLANNED CARRYING CAPACITY OF THE SUPPLY IN THE NORTHERN SUPPLY SUBAREA

		Pacifica	Half Moon Bay	Total for Northern Supply Subarea
Beach Use	Visitation Alt. 1*	1,050	4,900	5,950
	Visitation Alt. 2**	1,400	6,570	7,970
	Existing Carrying Capacity	12,444	22,222	34,666
	Planned Carrying Capacity	18,667	88,889	107,556
Boating and Fishing	Visitation Alt. 1*	1,450	5,830	7,280
	Visitation Alt. 2**	1,940	7,735	9,675
	Existing Carrying Capacity	-	750	750
	Planned Carrying Capacity	250	1,000	1,250
Park Use	Visitation Alt. 1*	10,902	8,050	18,952
	Visitation Alt. 2**	14,560	10,745	25,305
	Existing Carrying Capacity	2,812	1,500	4,312
	Planned Carrying Capacity	8,625	6,375	15,000
Driving for Pleasure	Visitation Alt. 1*	2,082	1,242	3,324
	Visitation Alt. 2**	2,765	1,662	4,427
	Existing Carrying Capacity	3,684	2,579	6,263
	Planned Carrying Capacity	9,200	5,500	14,700
Total	Visitation Alt. 1*	15,484	20,022	35,506
	Visitation Alt. 2**	20,665	26,712	47,377
	Existing Carrying Capacity	18,940	27,051	45,991
	Planned Carrying Capacity	36,742	101,764	138,506

* Total Network Loading for Alternative 1 is 15,000 VPH during the peak hour.

**Total Network Loading for Alternative 2 is 20,000 VPH during the peak hour. It is noted that at this loading level entrance roads to the subarea have additional residual carrying capacity and that visitation under this alternative conceivably is higher than indicated.

However, deficiencies in specific activities, in particular boating, fishing and park use, are expected. Deficiencies in boating and fishing activities require construction of additional marinas, piers and boat launching ramps in the Pacifica and Half Moon Bay areas to obtain a total capacity 10 times greater than the existing capacity. It is expected that even if the total carrying capacity is increased by expanding Pillar Point Harbor in Half Moon Bay (planned for 1990) and constructing a new marina in Pacifica, the supply will meet no more than 20 percent of the projected visitation to the area. Deficiencies in park use activities are of smaller magnitude than those for boating. The expected level of visitation shows that there will be a 20 percent deficiency over the planned carrying capacity. Using standards for intensive use areas developed by BOR, this deficiency amounts to 51 intensive use acres (Ref. 9). The needed carrying capacity could be achieved by constructing additional facilities in already existing parks, thereby increasing the effective supply provided by the present system. The San Mateo County Parks and Open Space Plan, however, emphasizes setting large portions of the hillsides and creeks in the Pacifica and Half Moon Bay areas aside for parks and wilderness areas (Ref. 22). As these areas would have to be acquired and some type of development planned, the cost implications far exceed the costs of increasing the effective supply in existing park areas. Finally, it is noted that the existing beach use and sightseeing facilities have a sufficient carrying capacity to satisfy the expected visitation associated with the no growth alternative.

In comparing alternatives it is concluded that with the preservation scenario and the limited capacity of associated highway network, the number of visitors to this supply subarea would be reduced and it would be possible to protect the environment by better utilizing existing facilities. In addition, limiting the population of the two largest communities through a lack of road construction implies that development of the less accessible hillsides and creeks in the area will not occur, thus allowing these to remain as open space in their natural state. Based on the findings of the case study, it appears that recreation planning efforts should (1) regard the provision of boating and fishing facilities as a top priority need, (2) reconsider the development of beach resources for beach use, and (3) expedite the development of park facilities in existing parks.

2. Development Scenario

The "City Plan" population projections for Pacifica and Half Moon Bay in Table IV-9 are based upon construction of Highway Alternative 2. Pacifica's City Plan uses the future construction of Highway 168 (expansion of Interstate 380) from Interstate 280 to Pacifica, and the expansion of Highway 1 to meet freeway standards from San Francisco through Pacifica as a base for their population projections (Ref. 23). Constructing a new Highway 92 and improving Highway 1 at the Devil's Slide by-pass, in order to increase visitation of recreationers to planned recreation facilities in the area and to improve the economy of the coastal communities, are supported by Half Moon Bay and San Mateo County (Refs. 19 and 22). As indicated in Table IV-7, the construction of these roads will increase visitation to the northern supply subarea by at least 30 percent as compared to Alternative 1. In addition to the increase in recreational trips coming from the demand area, it is noted that the local demand generated by the projected population of 122,000 people in Pacifica and Half Moon Bay may become a sizeable load on the recreation facilities.

If the coastal zone is urbanized and over 10,000 dwelling units in Pacifica and Half Moon Bay are developed over the next two decades, a large portion of open space in the vicinity of these cities will be consumed. Pressure to develop recreational resorts, summer homes and recreational facilities on presently undeveloped mountainsides will increase and additional sections of the coast may be closed to the public. In addition to urbanization of the northern supply subarea, the increase in visitation can be expected to further pressure the development of areas south of Half Moon Bay as additional sections of Highway 1 are recommended for improvement to freeway status.

It is observed that the total costs associated with implementation of this scenario are rather high. Based on the recreation deficiencies indicated in Table IV-10, rather large-scale recreation development will be necessary. Along with road and recreation facility construction costs, the cost and availability of land acquisition must be considered. Only limited portions of the coastal strip and the Santa Cruz mountainside are publicly owned, and the price of land will most likely increase very rapidly in this area once road construction begins. Damages to the environment, resulting from construction of roads, and development of housing and access roads on the hillsides must also be included in calculating cost. In addition cost will be incurred due to the increase in solid waste and sewage from urbanized areas and recreation accommodations. For the above reasons, it can be concluded that while the objective of the development scenario is most likely well served by Alternative 1, the costs associated with accommodating the increases in recreational visitation and local population may well be beyond what the communities and the public at large can afford.

References

1. BOR, Outdoor Recreation, A Legacy for America, Nationwide Outdoor Recreation Plan, prepared for the President of the United States in response to public law 88-29, Washington, D.C., November 1973.

2. Institute for Water Resources, The Economics of Water-Based Outdoor Recreation: A Survey and Critique of Recent Developments, IWR Report 71-8, March 1971.

3. "Proceedings of Corps of Engineers Economists Conference, Galveston, Texas, 22-24 March 1972", Center Paper 72-1, Center for Economic Studies, IWR, U.S. Army Corps of Engineers, Alexandria, Va.

4. BOR, The 1965 Survey of Outdoor Recreation Activities, Report, Washington, D.C., 1967.

5. BOR, The 1970 Survey of Outdoor Recreation Activities, Report, Washington, D.C., February 1972.

6. SRI, Recreation and Parks Study, Part I: An Element of the State Resources Development Program, report prepared for the State of California Department of Parks and Recreation, South Pasadena, California, December 1965.

7. PARIS, Park and Recreation Information System: Supply Demand Analysis for California Outdoor Recreation Facilities, Planning Monograph No. 2 prepared for the California Department of Parks and Recreation, Sacramento, California, November 1966.

8. Clawson, M., and Knetsch, J.L., Economics of Outdoor Recreation, report prepared for Resources for the Future, Washington, D.C., 1966.

9. BOR, Outdoor Recreation Space Standards, Report, Washington, D.C., April 1967.

10. CAL-TRANS working papers.

11. National Academy of Sciences and National Research Council, Highway Research Board, Special Report 87: Highway Capacity Manual, report prepared for the Department of Transportation, Washington, D.C., 1965.

12. Arthur D. Little, Inc., Santa Clara County Recreation Study, report prepared for the County of Santa Clara, San Francisco, California, May 1970.

13. ABAG and MTC, Population Employment and Land Use Projections, San Francisco Bay Region: 1970-2000, Report, Berkeley, California, August 1973.

14. McCormick, Ralph B. and Tolley, Rick, REC-TIP No. 6: Visitor Origin Patterns at Outdoor Recreation Sites in California 1965-1970, report prepared for California Department of Parks and Recreation, Sacramento, California, May 1973.

15. The Marin City-County Planning Council Visitor Enterprise and Economic Development Subcommittee, Economics Research Associates and Marin County Planning Department, The Visitor in Marin, report, San Rafael, California, 1970.

16. Marin County Planning Department, The Weekend Visitor to Marin 1969-70, Memorandum, San Rafael, California, August 1972.

17. Salinas Monterey Area Transportation Study, Visitor Travel Survey 1970-1971, Report, Salinas, California, September 1972.

18. Chang, Herman K. and Smith, Charles L., Eighth Progress Report on Trip End Generation Research Count, report prepared for the California Department of Transportation, San Francisco, California, July 1973.

19. San Mateo County Park and Open Space Committee and Regional Planning Committee of San Mateo County, Parks and Open Space, a Program for San Mateo County, Report, Redwood City, California, June 1968.

20. Whisles-Patri and Larry Smith & Company, East Waterfront Study; Urban Design and Economic Evaluation, report prepared for the City of Monterey, San Francisco, California, April 1971.

21. Sedway and Cooke, Tri County Coastal Study, Stage II: A Policy Plan for Conservation and Development, report prepared for Monterey County Planning Department, San Luis Obispo County Planning Department and Santa Cruz County Planning Department, San Francisco, California, August 1973.

22. Hawkes, Evan E., Half Moon Bay, A Proposed General Plan, first draft prepared for the City of Half Moon Bay, March 1973.

23. Duncan and Iones, General Plan and Coastal Area Plan: 1990, report prepared for the City of Pacifica, California, Berkeley, California, September 1969.

Appendix A

TECHNICAL INFORMATION FOR THE ACCESSIBILITY MODEL

1. Procedure to Calculate Trip Demand for a Recreation Activity

The procedures used to calculate the trip demand for a particular recreational activity is presented as follows:

$$TD_{ik\ell} = (N_i U_k V_k)\ W_\ell\ \alpha_k\ /\ Z_k \qquad \text{(A.1)}$$

where

$TD_{ik\ell}$ is trip demand from demand center on day ℓ_i for recreation activity k.

i is demand center.

k is recreation activity.

ℓ is day.

N_i is population of demand center i.

U_k is % of the population that participates in recreation activity k.

V_k is average annual participation days for activity k per participant.

$(N_i U_k V_k)$ is annual participation days from demand center i for activity k.

W_ℓ is % of participation on day ℓ.

α_k is % of demand for recreation activity k that goes to the central coastline.

Z_k is car pooling factor for recreation activity k.

The above procedure is illustrated in Chapter IV.

2. <u>Procedure to Calculate the Supply for Recreation Trips for a Recreation Activity</u>

The procedure used to calculate the trip supply for a particular activity and supply zone is presented as follows:

$$S_{jk} = C_j * \gamma_k * \frac{\sigma_2 \sigma_3}{\sigma_1 Z_k} \qquad (A.2)$$

where

- S_{jk} is number of recreation trips for activity k that can be accommodated by supply zone j.
- j is supply center.
- k is recreation activity.
- C_j is total area of supply zone j.
- γ_k is effectiveness factor for activity k.
- σ_1 is activity-unit density (e.g., the average acreage required by a swimmer).
- σ_2 is standard group size.
- σ_3 is turnover rate (e.g., the average number of swimmers using the same area during the day).
- Z_k is car pooling factor.

The above procedure is illustrated in Chapter IV.

3. <u>Assumptions of Accessibility Model</u>

The following assumptions underly the model:

- The population of the demand area is homogeneous; therefore, the recreation trips emanating from a demand center are proportional to the expected peak day demand for an activity in the center.
- All of the demand will be satisfied; i.e., the supply is assumed equal to or greater than the demand.

- The shortest travel time route is used to get to a destination.
- When the shortest route is congested, the next "best" way is used.
- The carrying capacity of a saturated link is allocated using the following formula:

$$A_{ijk} = \frac{T_{ijk}}{d_{ij}} C \qquad (A.3)$$

where

i	is the demand center.
j	is the supply zone.
k	is the activity.
A_{ijk}	is the number of trips to use the saturated link on route from demand center i to supply zone j for activity k.
T_{ijk}	is the number of trips assigned to the route from demand center i to supply zone j for activity k.
C	is the road carrying capacity of the saturated link.
d_{ij}	is the travel time in minutes from demand center i to supply center j.

- Highway link cannot carry more than its road carrying capacity.
- Traffic speed reduces as traffic volume reaches the road carrying capacity, using the following formula (Ref. 11):

$$\text{for} \begin{cases} V/C \leq .25 & S_1 = S_o \\ .25 < V/C \leq .85 & S_1 = (53-6.4\ V/C)\ S_o/55 \\ .85 < V/C \leq 1.00 & S_1 = (-180\ (V/C)^2 + 160\ V/C + 40)\ S_o/55 \end{cases} \qquad (A.4)$$

where

V/C is the ratio of traffic volume over road carrying capacity.

S_o is the maximum speed.

S_1 is the speed as a function of traffic volume.

- Peak hour volume is 20% of the average daily volume.

4. Technical Description of the RECTRIP Program

a. Program Overview

The RECTRIP program operates at three iterative levels: the network level, the network loading volume level which is referred to as a "run", and the model iterative level which is referred to as an "iteration". The network level requires the preparation of a network description for the various transportation models which are incorporated in the program. The network description for each network alternative under investigation is prepared by the link subprogram. Every run of the program produces a set of points on the RECTRIP curve for all combinations of demand center, supply zones and recreation activity. In each succeeding run the network is loaded with a larger volume of trips. Under the first assumption the network loading volume is distributed in subprogram DEMAND to all demand centers proportionally to the maximum recreation activity demand estimation that is derived using formula A.1. The RECTRIP program uses the network description and the trip generation data as its only input. In each iteration the highway network is loaded and the links that are assigned more trips than their carrying capacity are identified as saturated.

b. Input

Input for the program consists of two elements: the highway network description and the trip production attraction factors. The highway network description consists of one record for each directional link. The link is identified by its two terminal nodes, or by its junctions with other links. The order in which the nodes are written describes the direction of travel through the link. Additional information on the link includes the following:

- Length in miles.
- Speed limit in miles per hour.
- Travel time in minutes.
- Carrying capacity of the link in vehicles per hour.

The trip production is assigned to each demand center for every recreation activity. The attraction of the supply zone is the estimated carrying capacity of the outdoor recreation facilities for the same activity.

c. RECTRIP Program Iteration

The RECTRIP program iteration is composed of five steps, four of which are widely used transportation models, and the fifth is a rerouting procedure. The following is a stepwise description of the program.

Step 1: Shortest Tree. Under the third assumption travelers will use the shortest route available to get to their destination point. In this step, the program identifies the shortest travel time routes that exist from all demand centers to all supply zones.

In each iteration except the last, at least one additional highway link becomes saturated. Before searching for the shortest route, the program closes all saturated links by setting their travel time to infinity and adjusting the travel time through the partially loaded link using formula A.3. Due to closure of saturated links and increase of loading on the network the shortest travel time routes in each iteration are longer, or not shorter, than in the previous iterations.

Step 2: Terminal Time. A starting and terminating time is added to travel time through the shortest route. The starting time represents the time it takes the recreationer to get from home to the highway through the local streets. The terminating time represents the time it takes to get from the highway to the recreational site and to park the car.

Step 3: Trip Distribution. Trip distribution, made for one outdoor recreation activity at a time, is accomplished by the widely-used gravity flow distribution model that uses trip production, trip attraction, and travel time. Since the demand for recreation activities changes from one activity to the other, and from one demand center to the other, the distribution is done by activity.

Trips from the demand centers to the supply zones are distributed using a gravity flow type formula, as follows:

$$TR_{ij} = \frac{D_i \times S_j \times R_{ij}}{\sum_{j=1}^{n} (S_j \times R_{ij})} \qquad (A.5)$$

where

- TR_{ij} is the number of trips between demand center i and supply zone i.
- D_i is the number of trips that are demanded at center i.
- S_j is the number of trips that can be accommodated at supply zone j.
- n is the total number of supply zones.
- R_{ij} is the resistance to travel between i and j.
- R_{ij} is computed according to the "gravity" type formula as follows:

$$R_{ij} = \frac{1}{t_{ij}^{\ x}}$$

where

- t_{ij} is the travel time from i to j in minutes.
- x is an exponent to be selected and calibrated.

The gravity flow distribution model is calibrated by selecting the value of x, the travel time exponent, that will match the model results to actual data results. The assumption that the travel time factors of the present will remain in the future is stated in Reference 11. Thus, once the model is calibrated for the current data, travel time factors are used for future trip distribution.

Step 4: Loading the Network. Identification of saturated links is done when the peak hour loading volume on the link is more than 95 percent of its road carrying capacity. After the trip distribution, trips are loaded on the shortest routes from the demand centers to the supply centers and the saturated links are identified and closed.

Step 5: Closing a Saturated Link. Closing a saturated link involved two operations: allocation of the usage of the link to the demand centers and supply zone, and rerouting the excess trips that are assigned to the link over the highway network. Allocation of the road carrying capacity which limits the use of the link is accomplished using the formula stated in the previous section. The assumption is that the usage of a road is normalized directly proportional to the activity trips using the link, and inversely proportional to the travel time of the corresponding shortest route. This allocation of trips is accomplished in the following steps:

(1.) Calculation of the normalized factor δ:

$$\delta = \frac{\sum_{ij \in L} \frac{T_{ijk}}{t_{ij}}}{RC_1}$$

where

δ	is allocation normalizing factor.
i	is demand center.
j	is supply zone.
k	is recreation activity.
1	is the saturated link.

L is the set of demand centers and supply zones with shortest travel time routes passing through the saturated link 1.

T_{ijk} is the number of activity trips from demand center i to supply zone j for activity k.

t_{ij} is the existing shortest travel time route from demand center i to supply zone j.

RC_1 is the road carrying capacity of the saturated link 1.

(2.) Allocation of trips to these demand centers and supply zone with a road usage factor greater than δ, the allocation normalizing factor is:

$$RV_{ijk} = \frac{T_{ijk}}{t_{ij}}$$

where

RV_{ijk} is the road usage factor for trips from demand center i to supply zone j for activity k.

T_{ijk} is as above.

t_{ij} is as above.

(3.) Allocated trips are deducted from the road carrying capacity of the saturated link, from the activity trips production at the demand center and the activity trips attraction at the supply zone.

(4.) The residual of the road carrying capacity of the saturated link is divided by the rest of the users using the following formula:

$$PC_{ijk} = \frac{T_{ijk} \frac{T_{ijk}}{T_{ij}}}{\delta}$$

where

PC_{ijk} is the partial capacity of the residual road carrying capacity of the saturated link that is allocated to the activity trips from the demand center i to supply zone j for outdoor activity k.

T_{ijk} is activity trips, as above.

t_{ij} is travel time, as above.

δ is the allocation normalizing factor.

(5.) The partial capacity trips are deducted from the activity trips production at the demand centers and the activity trips attraction of the supply zone.

The new adjusted values of the activity trips production and attraction are used in the following iteration of the model. The saturated link is closed. The program accumulates the information of the activity trips that are assigned to the saturated link, for calculation of the average travel time.

d. Termination of a Run

A run terminates under one of two conditions: either all the network loading volume is loaded on the network and no link saturation occurs, or all the links connecting at least one supply zone are saturated. At termination the point on the RECTRIP curve for the corresponding network loading volume is calculated from the accumulated trips and their travel time.

e. Termination of Analysis for a Network

Drawing of the RECTRIP curve for all combinations of demand centers, supply zones and recreation activities is the output of the highway network analysis. The results of each run, a set of points on the RECTRIP curves, are used to draw the complete set of RECTRIP curves.

Appendix B

SIMPLIFIED DESCRIPTION OF THE ACCESSIBILITY PROGRAM

1. General Description of Program

The procedure for determining the trip supply curve, presented in Figure B.1, is repeated for each trip production level as can be seen from the flowchart. For a given production level, the RECTRIP program initially determines what routes and supply zones would be used by the different recreational activities assuming that the capacity of the network links is unlimited. The program then provides information to the planner on what links in the network are used above capacity. The planner specifies these links in the input data for the next iteration of the program. As a result the program changes the network, and reduces the trip production of the demand centers and the capacity of the supply zones by the capacity of the oversaturated links. Subsequently, the RECTRIP program is again executed and the reduced trip production is allocated over the available capacity of the network and supply zones. This iterative process is continued until no links are oversaturated, or until the access to one of the supply zones is completely saturated. At that point the information on the trip supply curve is considered complete and the program prints the following output:
oversaturated, or until the access to one of the supply zones is completely saturated. At that point the information on the trip supply curve is considered complete and the program prints the following output:

- List of saturated links and the order in which they reached their capacity.
- Number of trips and average travel time for:
  - Each combination of demand center, supply zone and recreation activity.
  - Each demand center and recreation activity.
  - Each supply zone and recreation activity.

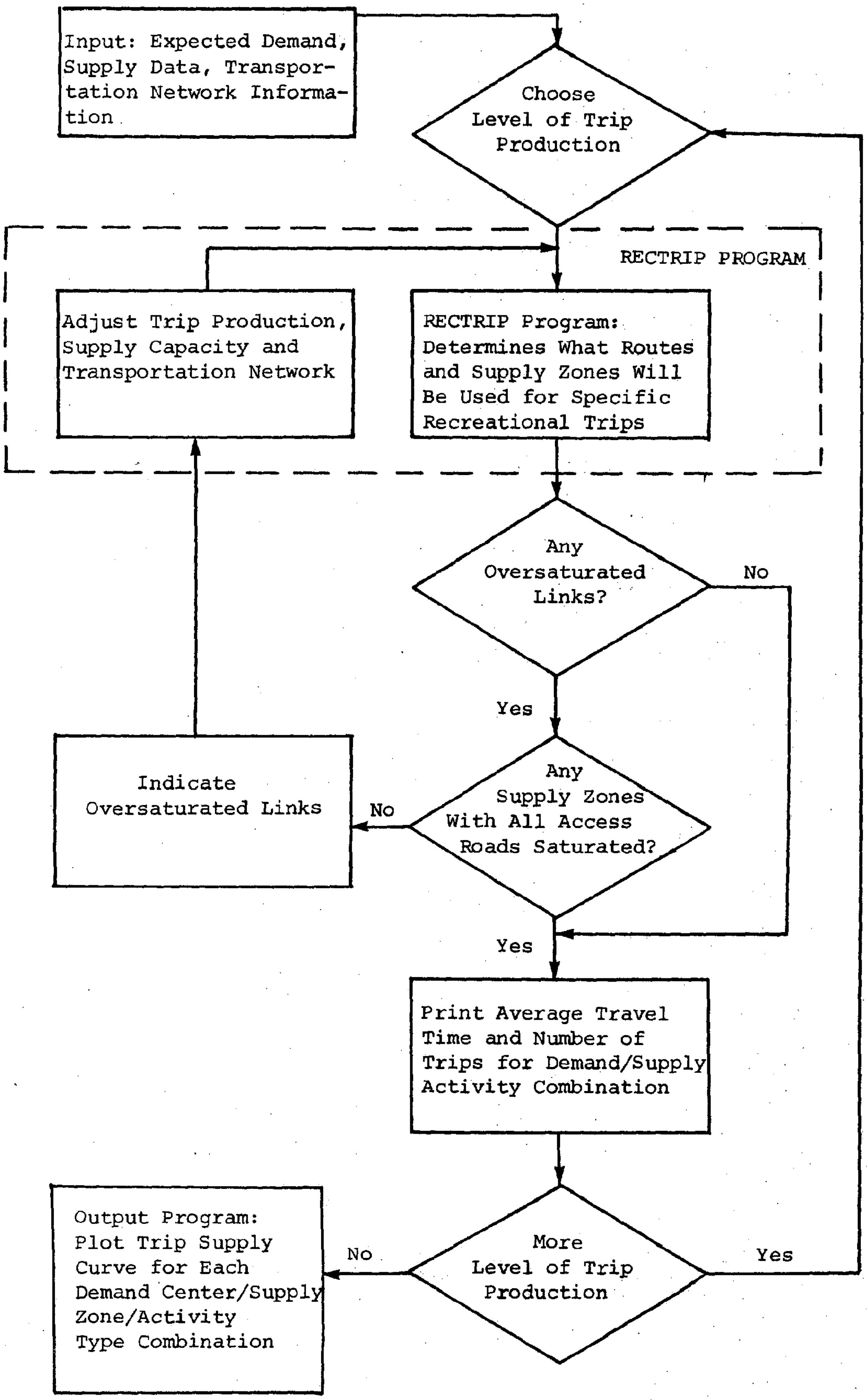


Figure B.1 PROCEDURE FOR DETERMINING TRIP SUPPLY CURVES

After the above procedure is completed for all desired trip production levels the OUTPUT program plots trip supply curves for each combination of demand center, supply zone and recreational activity.

The elements of the above procedure that require additional explanation are (1) the process for allocating trip production over the network and supply zones for specific recreational activities, and (2) the method used for reducing the trip production at demand centers and capacity of supply zones to reflect removal of saturated links. These are discussed in the next section.

2. Distribution of Trip Production Over Network and Supply Zones

Distribution of trips over the network and to the supply zones, without considering the capacities of the network links, is based on the following assumptions:

- The shortest available route between demand center and supply zone always is used.
- For each recreational activity, trips from a demand center are allocated to supply zones using a gravity flow model; this model distributes trips in proportion to the capacity of the associated recreational facilities in the supply zones and inversely proportional to the travel time of the shortest available route to the supply zone. A more detailed discussion of this assumption is presented in Appendix A.3.

The procedure for distributing trips over the network is presented in Figure B.2. The first step is to construct the shortest route travel time tables based on information regarding the transportation network and the traffic volume. The travel time table for shortest routes will differ from iteration to iteration as network links are deleted and as the traffic volumes on the links increase. For example, no traffic load is assumed in calculating travel times for the first iteration; subsequently the traffic associated with saturated links is assumed. The program uses a standard shortest path algorithm which searches for the shortest travel routes between each demand center and supply zone. The travel times of the shortest paths are augmented with an initial travel time which represents the time that is needed to get to the freeway, and with a terminal travel time which represents the time that is needed to get to the recreation site

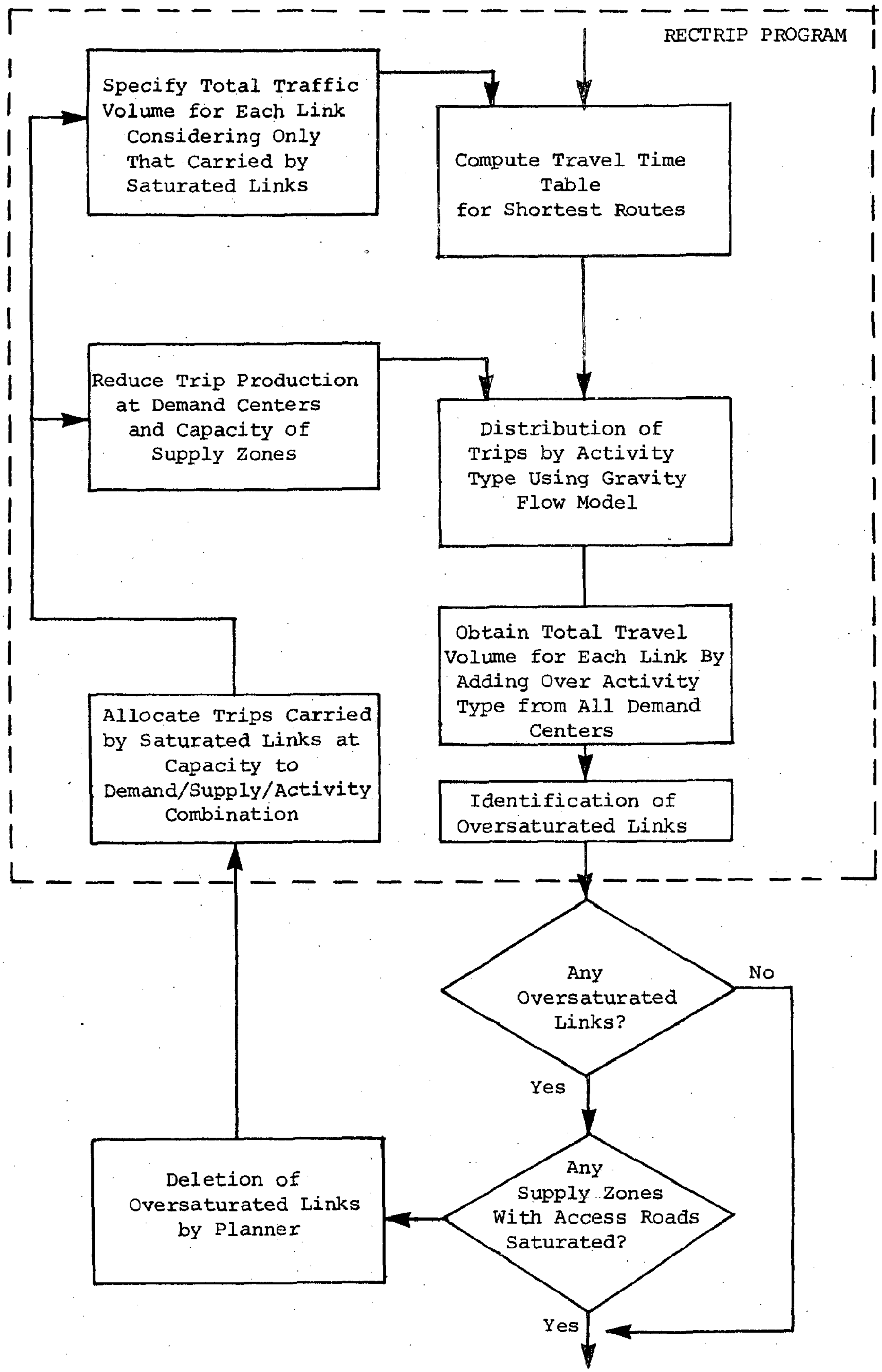


Figure B.2 TRIP DISTRIBUTION PROCEDURE

Table B-1

SHORTEST ROUTE IN SAMPLE RECREATION SYSTEM

Route From - To	Distance in Miles	Travel Time in Minutes	Total Time Includes Initial and Terminal Time in Minutes
D1 - S1	30	40	65
D1 - S2	85	101	121
D2 - S1	15	27	47
D2 - S2	60	74	89
D3 - S1	40	52	77
D3 - S2	35	47	67

through the local road system. The initial and terminal travel times are the same for all routes between a demand center and a supply zone. For the sample recreation system discussed in Chapter III, the initial shortest routs and their travel time are shown in Table B.1.

In the second step the program uses the gravity flow model for each recreational activity to distribute the associated activity trips from the demand center over the supply zones. The program distributes one recreational activity type at a time. After the initial iteration the distribution of the reduced trip production depends on the reduced capacity of the supply zones and the updated travel times of the shortest routes from the demand centers to the supply zones.

In the third step the total trips over each link are determined by adding the trips from each demand center for all activities. The total number of trips are then compared to the capacity of the link in order to identify links that would be used above capacity.

In the fourth step the distribution problem is reformulated by deleting the saturated links as well as the trips that can be carried by those links. These trips are assumed proportional to total number of trips calculated in the iteration for the particular activity type/ demand center/supply zone combination, and inversely proportional to the travel time given in the shortest route time table. Based on an allocation of the use of the saturated links, the production trips at the demand center and the capacities at the supply zones are reduced. A more detailed description of the above procedures is provided in Appendix A.4.

In the fifth step the travel time for the shortest route time table is updated, where the only traffic present is that carried by the saturated links as determined in the above step. The travel times on each link are obtained using the speed changes given in Figure 3.4 as a function of the traffic volume/capacity ratio.

Subsequently the above process is repeated until no links are used above capacity, or until all routes to a particular supply zone are used to capacity. This completes the distribution of trips for a particular production level.