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SUSTAINABLE DEVELOPMENT AND
THE SONORAN DESERT BIOSPHERES

by

John Stewart Anderson

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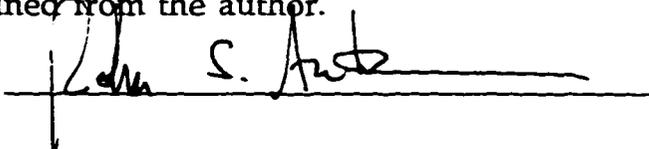
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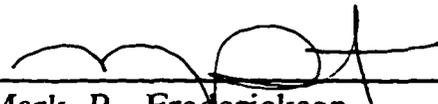
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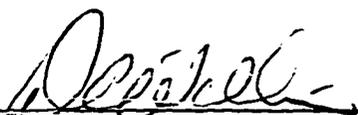
SIGNED: 

APPROVED BY THESIS COMMITTEE

This thesis has been approved on the date shown below:


 Mark P. Frederickson
 Professor of Landscape Architecture

5.16.97
 Date


 Donovan C. Wilkin
 Professor of Landscape Architecture

5/16/97
 Date


 Kenneth N. Clark
 Professor of Planning and Architecture

5-16-97
 Date

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ABSTRACT

The international border region of the Sonoran Desert is unique in that it is the site of three Man and the Biosphere Reserves in two countries. Unlike national parks and other means of conservation, biosphere reserves provide a unique approach to resource protection by encouraging the sustainable development of outlying communities. The concept of sustainable development is examined as are its implications for regional planning. The international border region adjacent to the biosphere reserves is profiled and planning issues outlined. The efforts of others to incorporate sustainable development are reviewed as are the experiences of those who have applied their efforts to the region in question. A methodology for the protection of the natural attributes of the region is proposed.

CHAPTER I

A. Introduction

Straddling the Mexican-United States international border, there exists one of the largest relatively intact arid landscapes in the world. In the Sonoran Desert of southwestern Arizona and northwestern Sonora is an area that until recently was relatively free of the development and population pressures that other border regions have faced. Consequently, many ecosystem processes are still largely uncompromised by human impact. It is also an area that has been influenced by three distinct human cultures-- Native American (prehistoric and modern), Spanish and Anglo. In addition, only 142 years ago it was a region undivided by an international border. The border has not yet completely obscured the pre-existing ecological and cultural patterns.

The period of benign neglect which has protected this area is drawing to a close and the region now stands at a crossroads. There are increasing developmental pressures in the region, especially in Mexico. Local economies are changing as industries based on resource extraction (fishing and mining) close down. Tourism and service industries are becoming increasingly important to local communities. In addition, the social consequences of the border as a divisive element are being felt. These include fragmented political authority, the division of the O'odham nation, growing economic disparity, and the war on drugs.

At the same time, there is a growing effort on both sides of the border to protect the resources of the area and to guide the changing economies in

directions that are sensitive to the region's unique environment and history. In June of 1993, the Mexican government declared the upper Gulf and the Sierra Pinacate/Gran Desierto as Man and the Biosphere (MAB) reserves. In the United States, Organ Pipe Cactus National Monument is already a biosphere reserve. As will be discussed later in this paper, biosphere reserves are unlike other more traditional forms of land protection in that sustainable development is expected to be an intimate component of any management plan. In addition to these efforts at the federal levels, local residents from all three cultures have expressed an interest in assuming an active role in planning for their communities as indicated by large turnouts at regional meetings organized by the International Sonoran Desert Alliance, a binational non-profit organization.

B. Objectives

In this thesis I argue that if the outstanding environmental and cultural attributes of the region are to be protected, then land use planning efforts must proceed in a holistic fashion; that is, they must include ideas for appropriate, sustainable development. As part of this thesis, I also propose a planning process the goal of which is regional sustainable development.

C. Scope and Organization

Chapter II provides a theoretical background for biosphere reserves and sustainable development. The key objectives of this chapter are to: (a) introduce the two conventional schools of planning theory, illustrate the inherent drawbacks that these schools incorporate, and describe the need for

an alternative, holistic planning approach; (b) introduce and evaluate the concept of biosphere reserves as a holistic planning approach and as a logical alternative to standard planning approaches; (c) briefly describe other holistic planning theories; (d) describe and discuss sustainable development as a key aspect of any holistic planning process. The objectives of this chapter are realized by a review of appropriate published literature.

Chapter III provides an introduction to the region and some of the planning issues it faces. The purposes of the chapter are to (a) briefly describe the natural, cultural, and economic histories of the study region, thereby demonstrating that this region has numerous remarkable attributes that are worth protecting as well as lessons that are valuable for future planning efforts; (b) describe some of the more outstanding planning issues of the region as they relate to sustainable development. The information in this chapter is gained from a variety of sources including published literature, interviews, and local publications (publications by chambers of commerce, local newspapers, etc.).

Chapter IV is a review of case studies of other planning efforts that sought to incorporate sustainable development. The case studies chosen hold lessons for application in the study area. The studies were gathered from reviews of appropriate published literature.

Chapter V is a summary of interviews that I conducted with individuals who are currently involved with planning and conservation efforts in the study area. In addition, each of my interviewees is or was a professional or voluntary member of a non-governmental organization. My interview process was largely an informal and heuristic one in which I

explored various areas of interest according to the experiences and expertise of the interviewee.

In Chapter VI, I outline a planning approach that is a hybrid derived from several planning methods. It is one which incorporates the objectives of the MAB program and which responds to the specific types of planning issues found in the study area.

CHAPTER II

A Review of Pertinent Concepts

Introduction

Chapter II provides a theoretical background for biosphere reserves and sustainable development. The key objectives of this chapter are to: (a) introduce the two conventional schools of planning theory, illustrate the inherent drawbacks that these schools incorporate, and describe the need for an alternative, holistic planning approach; (b) introduce and evaluate the concept of biosphere reserves as a holistic planning approach and as a logical alternative to standard planning approaches; (c) briefly describe other holistic planning theories; (d) describe and discuss sustainable development as a key aspect of any holistic planning process.

A. Traditional Planning

Planning in general can refer to any field of practice or, indeed, to any action (Catanese, 1979). It is a discipline which is "... evolutionary and responsive to its own history of development and to the wider developments taking place in society as a whole..." (Glasson, 1978, p. 4). Consequently, it is perhaps too much to expect a consensus on what constitutes planning.

Traditionally, planning has been divided into two broad schools of thought: physical planning and economic planning, as described by Glasson (1978, pp. 5-6):

Physical planning is the planning of an area's physical structure--land use, communications, utilities and so on, and has its origins in the regulation and control of town development, which [historically]

outstripped the ability of the market to control. Economic planning is concerned more with economic structure of an area and its overall level of prosperity. It works more through the market mechanism than physical planning which relies heavily on direct controls.

It is also traditional that these two broad schools of planning have historically had little interaction with one another. As Glasson (1978, p. 5) notes, "Many see this physical/economic division as absolute". The dichotomy between the two schools may be illustrated by examining more extreme examples of the theories which underlie each.

1. Frontier Economics

At one extreme lies what Colby (1991) describes as the "frontier economics" paradigm, an approach which is "completely disembodied from nature" (p. 198). Nature exists solely for man's benefit and is to be "remade according to man's image, transformed so as to be more suitable to humans' needs and desires" (p. 198). The flow of resources from nature into the economy and the flow of wastes back out into the environment does not enter into this philosophy because the 'environment' is "believed to be infinite in extent" (p. 195). There is no biophysical environment to be managed since it is seen as "irrelevant to the economy" (p. 195).

By ignoring the the physical dynamics of the natural resource base and relying on economic indicators as a measure of national prosperity, most governments and development agencies overstate progress. Brown (1993) notes that

the internationally accepted system of national economic accounting used to calculate gross national product rightly subtracts the depreciation of plant and equipment from the overall output of goods and services. But it takes no account of the depreciation of natural

capital, such as the loss of topsoil from erosion, the destruction of forests by acid rain, or the depletion of the protective stratospheric ozone layer (p. 4).

Consequently, development policies that produce economic returns are promoted regardless of their impact on the environment (Brown, 1993; Redclift, 1987). Those impacts are evident today in most if not all of the earth's biomes.

Regional development planning serves as an example of economic planning which fails to recognize the relationship of development to natural processes. Catton and Dunlap (1978, cited in Palmer, 1989, p. 4) argue that because regional development planners are uniformly blind to environmental factors, all recognized theoretical development frameworks should be lumped together into a Human Exceptionalist Paradigm. Simon (1990, p. xi) reports that one basic problem with regional planning has been "... an inappropriate conception of space as somehow separate from other dimensions of society, economy and polity." Redclift (1987, cited in Palmer, p. 4) notes that development planners have for the most part ignored the physical dynamics and finite limits of the natural resource base. He asserts that development strategies have been responsible for accelerating environmental degradation in developing countries.

2. Deep Ecology

At the opposite end of the economic/resource polarization is what Colby (1991) describes as the "Deep Ecology" paradigm.

Deep ecologists advocate merging appreciation of some of the more scientific aspects of systems ecology with a 'biocentric' (non-

anthropocentric) or 'harmonious' view of the relationship between man and nature (p. 199).

In practice, this approach would make "man subservient to nature, the reverse of the frontier economics hierarchy" (p. 200).

Traditional nature parks and wilderness areas are perhaps the closest modern approximation to this approach. There are a number of problems which these areas face which may be related to the fact that within this approach, socioeconomic issues are not addressed in any sort of comprehensive fashion:

(1) If the purpose of natural parks is to maintain the integrity of representative ecosystems, then perhaps the most obvious threat to those systems is that parks are simply too small and too few in number. In both developed and less developed countries, "the space problem appears to be the main limitation to conserving the biotic richness of the vast majority of ecosystems. It seems impossible to base conservation only on core areas or on other systems of completely protected areas" (Halffter, 1987, p. 191). Given the current rate of population growth and the pace at which humans are developing the earth's surface, it would appear that parks alone will never make up a large enough percentage of the earth to ensure that most types of ecosystems are protected. In addition, many existing parks are becoming isolated "islands" surrounded by human development. There is a fear that the isolation of species within these islands will lead to the loss of biological diversity and increase the chances for local extinctions (Harris and Gallagher, 1989).

(2) Closely related to this island concept is the fact that many threats to the integrity of natural processes within protected parks originate outside of the legal boundaries of these areas. In the United States, the adverse impact of land-use activities and development outside of park boundaries is described as one of the primary threats to the National Park System (National Parks and Conservation Association, 1991). This problem is frequently exacerbated by fragmented jurisdiction over the resource base outside of park boundaries.

(3) With respect to many less developed countries (LDC's), to ignore economic issues in attempting to manage a park is to ignore the sociocultural context which lies at the heart of the environmental crises in many of those countries. Although the causes of resource degradation in LDC's are complex (as they are in all countries), it is frequently associated with the rural poor and especially with indigenous populations who bear the consequences of (i) national economic policies which promote the export of a few primary products and (ii) the concentration of political power and productive land in the hands of a relative few who benefit from this type of development (Guha, 1989; Palmer, 1992; Samater, 1984; Shanmugaratman, 1992; Thrupp, 1992). Displaced from their original lands as the result of global economic processes and political disenfranchisement, the rural poor often migrate to burgeoning urban slums or into more remote undisturbed (and often agriculturally marginal) areas. If that new area happens to be in a national park or other protected environment, the desire to survive will probably outweigh any other considerations, especially since enforcement is unlikely given that many parks in LDC's are understaffed and underfunded (Halfpter, 1985). Park

planning and management in LDC's, therefore, is affected by local, national and international socioeconomic and political economic issues.

3. The Need for a Holistic Alternative

Development and natural resource management are inseparable. The assumption that natural resources are infinite, as proponents of "frontier economics" insist, appears to be incorrect as indicated by increasing resource degradation. Conversely, evidence suggests that the management of natural resources cannot successfully take place wholly within a traditional system of protected areas. Environmental and resource management issues of today cut across multiple boundaries in both developed and developing countries.

With respect to the latter, Shanmugaratnam (1989, p. 16) notes that

environmental degradation coexists with degradation of the social, economic and cultural conditions of life for the mass of people: two processes which appear to be mutually reinforcing... Rehabilitation of [developing countries] has no meaning outside the challenging tasks of rehabilitation and transforming the social, economic and cultural conditions of the people. Therefore, development--sustainable development--is the solution to the environmental crisis in [developing countries].

The implications are clear: natural resource planning must be integrated into a larger socioeconomic and sociocultural context if it is to be successful. The mirror image of this implication is also suggested: there is a need to incorporate human activities into the larger ecological picture. Halffter (1985, p.15) notes that at "... the present time, the great challenge of world conservation policy is to address the apparent dichotomy between protected areas and regional development by developing new strategies having a solid ecological, social and economic foundation."

What is sought is a more systemic or holistic approach to planning, one which emphasizes the understanding of different aspects of planning in a region and their functional relationship with the whole. In a holistic research approach, one studies certain wholes or systems (for example, an organism) without knowing all the details of their internal functions (Zonneveld, 1990, p. 9).

[H]olism permits the simplification of scientific activity by reducing analytic observations to better understand very complex structures and processes. At the same time it warns against attempting to study wholes by analyzing them in separate pieces without connecting them with each other (*ibid*, p. 9).

What is needed is a planning method based on a holistic approach. The Man and the Biosphere program in general and the biosphere reserve concept in practice would appear to fill this need.

B. Biosphere Reserves

1. Man and the Biosphere

The Man and the Biosphere (MAB) Program was launched in 1971 by the United Nations Educational, Scientific, and Cultural Organization (UNESCO) to address the broad range of human activities and their effects on the natural environment (UNESCO, 1984). At that time, 13 themes of concern were suggested, one of which was "the conservation of natural areas and the genetic material they contain" (*ibid*, p. 1). The rationale behind this theme was "the need to counter the increasing loss of living species, the lack of scientific knowledge on how to conserve them, as well as the inadequacies of traditional approaches to nature protection" (Vernhes, 1987, p. 7).

2. Biosphere Reserves

In 1974, the MAB theme of conservation was further developed by calling for special sites, or "biosphere reserves," through which the concerns of the MAB program could be realized. Several objectives were identified for each individual reserve site, as follows:

- (1) To conserve the diversity and integrity of biotic communities of plants and animals within natural and semi-natural ecosystems, and to safeguard the genetic diversity of species on which their continuing evolution depends (conservation concern) (Vernhes, 1987, p. 8);
- (2) To provide an area for MAB research and monitoring activities, including accompanying training and information exchange, and to act as part of an international network (logistic concern);
- (3) To associate environmental protection with land resource development as a governing principle for research and education activities (development concern) (Hinote, 1992, p. 4).

This emphasis on combining several functions into a single site and on linking these sites into an international network gave biosphere reserves a unique approach to the protection of natural resources. Perhaps more profound, however, was the idea that human development had a constructive role to play in the protection of natural resources and that, vice versa, the biosphere reserve could contribute to the development of its region (Vernhes, 1987, p. 8). In hindsight, such an approach makes perfect sense in both developed and developing countries where the shortcomings of natural resource protection through exclusive reserves have been demonstrated.

In an ideal form, the different functions of a biosphere reserve are realized in part by a system of zonation of three more-or-less concentric circles. These three zones include the core area, the buffer zone and the transition or cooperative zone. They may be described as follows:

(1) The core area consists of examples of minimally disturbed ecosystems characteristic of one of the world's terrestrial or coastal/marine regions. With secure legal protection, only non-destructive activities that do not adversely affect natural ecosystem processes are allowed (Vernhes, 1987, p. 9). Core areas should be large enough to be effective as in situ conservation units and, whenever possible, have "value as bench-marks for measurements of long-term changes in the biosphere and in the ecosystems they represent" (Batisse, 1986, p. 7). "The core area assures that the evolution of life will continue in each ecosystem of the biosphere without human disruption. It also permits ongoing studies of the natural evolutionary processes in which we participate and to which we must adapt if we are to survive" (Engel, 1987, p. 22).

(2) The buffer zone adjoins or surrounds the core zone. Its boundary is also legally described and usually corresponds with the outer limits of a protected area such as a national park. This zone acts as a buffer to protect the core zone from harmful outside disturbances. More diverse activities that serve the multiple objectives of the reserve are permitted such as basic and applied research, environmental monitoring, traditional land use, recreation and tourism, general environmental education, and specialist training (Vernhes, 1987). Engel (1987, p. 22) describes the buffer zone as one which "preserves

traditional economies and societies that have proven their capacity to sustain themselves over many generations, and at the same time experiments with new technologies and ways of life that will improve the capacity of the social and cultural heritage to adapt and survive in the future."

(3) The outermost zone of the biosphere reserve is the transition area. It is usually not strictly demarcated but includes an ever-expanding cooperation zone where

the work of the biosphere reserve is applied directly to the needs of the local communities in the region. Thus, the transition zone may contain settlements, fields, pastures, forests and other economic activities which are in harmony with the natural environment and the biosphere reserve. This zone of cooperation is particularly useful in helping the biosphere reserve to integrate into the planning process of its surrounding region. In other words, the protected area of the core and the buffer participate through the transition/cooperation area in the development of the region to which they belong (Vernhes, 1987, p. 9).

Biosphere reserve zones do not necessarily have to be contiguous.

They can also be several discreet areas, referred to as cluster reserves (Batisse, 1986).

These areas and centers are not usually administered by the same entity and hence the overall management of a cluster biosphere reserve calls for coordinating mechanisms through which the various administrative authorities concerned--as well as the local population--will cooperate (Batisse, 1986, p.9).

Von Druste (1987, p.4) argues that because large, disjunct and diverse areas are protected under coordinated management at strategic locations, cluster reserves provide particularly good insurance for biological conservation in times of possible global change.

3. Biosphere Reserves: A Holistic Planning Approach

The concerns and goals embraced by the biosphere concept cover a lot of ground, more than do traditional planning methodologies. It is this combining of diverse objectives into a single planning approach that characterizes and differentiates biosphere reserves. Batisse (1986) notes that

...a biosphere reserve that does not have a protected core area is not a true biosphere reserve. A national park that has no concern for the sustainable development of the surrounding area is not a true biosphere reserve either. An area that combines conservation with research and education for ecosystem development can only become a proper biosphere reserve if it joins the international network of research, monitoring and information (p.7).

Gregg (1984) refers to biosphere reserves as "master integrators" of functions performed individually or severally by traditional planning methods. Von Droste (1985, p. 4) notes that the value of biosphere reserves results from

the importance of fostering scientific and educational uses and multi-faceted cooperation: among scientists of different disciplines; between basic and applied research sites within the biosphere reserve; between protected area administrators and rural development agencies; among scientists, administrators, and local people; and, through the international network, between and among developed and developing countries.

Ray (1987, p. 76) states that biosphere reserves "offer a flexibility of design, in contrast to the 'hard' lines that separate conservation and development in other resource management categories." He goes on to note that the concept "forces systematic thinking and action," and that it is an attempt "to break down the boundaries between social forces and... treat the traditionally conflicting interests of conservation and development together." The

International Coordinating Council of the Program on Man and the Biosphere (UNESCO, 1993, p. 19) reports that the

decision-making process is becoming increasingly complex and often involves many groups pursuing narrow, specialized interests. MAB could play an extremely valuable and policy relevant role by providing integrated and scientifically credible information that focuses on humankind and the natural world as well as on humankind and the built environment.

Halfpeter (1987, p. 202) summarizes these thoughts and concludes:

In our time, the tremendous uniformity imposed by the ways of working and the uses and necessities of industrial society threaten as never before not only our natural but also our sociocultural richness and diversity. The biosphere reserves represent small islands of natural heterogeneity and diversified use of the natural resources; it is our responsibility to derive from them useful lessons of what to do with the rest of the Earth that is, and will be, outside of any protected system.

4. Application of the Biosphere Reserve Concept

Because it incorporates multiple and often conflicting objectives which are not placed in any sort of hierarchy, the compatible integration of these objectives in a given biosphere reserve is frequently a rather complex problem. Compounding the difficulty of multiple objectives is the fact that each reserve inherits its own unique opportunities and constraints from its native environment. Consequently, there is no universal model of a biosphere reserve and the relative importance of each objective varies from one biosphere to another (Hinote, 1992; Batisse, 1986). For example, von Droste (1985, p. 2) defines the core area as a "primitive wilderness, strictly protected and maintained free of human disruption." However, Sokolov (1987, p. 107) points out that in the densely populated countries of Europe, no

undisturbed ecosystems remain. He notes that when "development is excluded from such territories, the ecosystems of these territories begin to be transformed and their diversity often declines rather than increases." The question arises, Does human manipulation always preclude an area from being a core region? Clearly, the relative importance of the different objectives will vary from one reserve to another. The key word for the implementation of biosphere reserves is flexibility (Batisse, 1986).

Within developed countries which have a tradition system of legal land management systems, most biosphere reserves have been "imposed hectare-for-hectare on national parks and other strictly protected areas" (Miller, 1983; cited in Gregg, 1987, p. 35). The greatest difficulties in implementing the biosphere reserve concept in these countries have been in the buffer zones where jurisdictions are often fragmented among various public agencies and private landowners. The biosphere concept would appear to offer an opportunity for coordination. In the United States, however,

park managers have tended to see the designation as a gratuitous honor, rather than an opportunity to obtain perspective for solving management problems and to strengthen bioregional cooperation. Managers of multiple use areas, on the other hand, have worried about loss of management prerogatives because of the perceived dominance of strict conservation areas (Gregg, 1987, p. 35).

As will be discussed in Chapter IV, Hinote (1992) reports that in the United States, voluntary cooperation of the type encouraged by biosphere reserves has begun recently in some reserves, such as the Southern Appalachian Reserve.

In contrast to developed countries with well-established conservation systems, the main difficulties with natural resource management in less

developed countries frequently originate with the displacement of rural poor coupled with inadequate protection of core areas. Halffter (1987, pp. 193-4) notes that in such settings,

there are no legal rules which can prevent by themselves, in the long term, the penetration of the protected area and the resulting deterioration of flora and fauna. For the hungry peasant, the only possible solution to conservation is to help him produce what he needs without destroying the natural richness that belongs to all.

Consequently, the challenge for biosphere reserves in developing countries is to demonstrate the value of resource management to the rural poor. In Mexico, biosphere reserves have become focal points for integrating natural resource conservation with sustainable development (Halffter, 1985, 1987). Gregg (1987, p. 35) reports that Mexico has "successfully demonstrated the practical benefits of biosphere reserves as a legal category of protected area," one in which multiple roles are clearly specified.

C. Other Holistic Planning Theories

The biosphere reserve concept is but one of several holistic planning approaches. In fact, in the histories of both human and natural resource planning, there have been numerous individuals who saw and spoke out for the need to incorporate human activity into a broader context. John Muir and Aldo Leopold are but two of the more outstanding examples of those who addressed the need for a broader vision in man's relationship to the natural environment. More specifically, Firey (1960) described the need and a means for a holistic approach to land use planning. He maintained that three aspects of planning should be considered when devising management policies:

The first [ecological concerns] takes the physical habitat as its point of departure; the second [ethnological concerns] starts with the culture of the human being; the third [economic concerns] begins with the attribute of scarcity which attaches to human activities (p. 20).

Human ecological planning utilizes ecology and human values as the foundations from which to explore the potential uses of a given area. Risser (1983, p. 8) notes that "[u]nderstanding landscapes requires that we deal with human impacts contributing to the landscape phenomenon, without attempting to draw the traditional distinction between basic and applied ecological science or ignoring the social sciences." In their study of the New Jersey Pinelands, Berger and Sinton (1985) noted the need for planners to look from the inside as well as from outside, from the effective viewpoint of the users as well as from the scientific view of the academics. They propose that planners develop a framework "... in which to understand the workings of a region from its highest to lowest level and the ways in which these levels interact" (pp. 214). McHarg (1980) reports on the need for the issues within a specific region to drive the planning process. He states that "[u]nderstanding the process of interaction between the landscape and the people who inhabit it provides a basis for assessing the opportunities and constraints afforded by the environment, and the needs and desires of the population which can be combined to present alternative futures" (p. 109). He maintains that planners "... must be able to describe regions as interacting socio-bio-cultural systems..." (p. 113).

Ecosystem management "is a management philosophy which focuses on desired states, rather than system outputs, and which recognizes the need

to protect or restore critical ecological components, functions, and structures in order to sustain resources in perpetuity (Moote, et al., 1994, p. 1). Utilizing a holistic approach, it examines "... the dynamic interrelations of systems components--including social, political, economic, biological, and physical features--and requires better understanding of each of these components and their interrelations. Humans are recognized as a part of ecosystems... Ecosystem management means management across ecological, political, generational and ownership boundaries." (*ibid*, p. 1).

Political ecology links theories of ecology and political economy. Social and environmental degradation are seen to be inextricably related and causes of environmental degradation are recognized as complex and dynamic. Political ecology generally requires a "bottom-up" orientation, relying on anthropological or sociological methods to gain the perspectives of local actors affecting the resources in question (Blaike, 1987; cited in Thrupp, 1992, p. 5).

Then, the analyst traces the linkages to the wider political economy through analysis of the social structure of any given problem. The main general argument is that the causes of environmental/human degradation are not only ecological and technical, but most importantly, social and political economic factors (Thrupp, 1992, p. 1).

Political ecologists advocate "[p]opular participation in the design of strategies, policy decisions, and project implementation, [thereby enabling] local people to take leadership roles in all stages of development processes and projects (Thrupp, 1992, p. 22). This approach would seem to be particularly relevant in less developed countries where the gap between rich and poor classes

frequently reflects the unbalanced allocation of political power. Implications of political economy include

major political changes and challenging power relations, empowerment of marginalized people, including women, poor classes, and ethnic minorities, upholding cultural and epistemological diversity, and legitimization of local knowledge which has been displaced with the hegemony of Western scientific reductionism (Thrupp, 1992, p. 5).

D. Sustainable Development

Central to biosphere reserves and other holistic planning theories is the concept of sustainable development. Although it is rather vague and poorly defined, sustainable development is generally based on the notion that physical resources on the Earth are finite and that human civilization (and its attendant economies) must come to grips with this limitation. The idea of Earth as a finite resource system was probably first popularized by the epoch-making Limits to Growth, published in 1972 by the Club of Rome. The authors of the text predicted an apocalyptic conclusion for humankind within a century due to the exhaustion of resources and the accumulation of pollution. The term "sustainable development" was probably first popularized in 1987 by the World Commission on Environment and Development in a text commonly referred to as the Brundtland Report. The commission defined the term as development "that meets the needs of the present without compromising the ability of future generations to meet their own needs" (cited in Brooks, 1993, p. 3). Although they succeeded in generating an ongoing debate regarding the nature of development, the authors of the report failed to draw out the implications of their definition.

Consequently, there is a great deal of disagreement as to what sustainable development exactly is. Herman Daly of the World Bank asks, "[I]f you say you are committed to sustainable development, what are you doing differently than you did back when you didn't believe in it or proclaim it as a doctrine? Most [United Nations] agencies would have a difficult time answering that question... [A]cademia has been no help" (cited in Lerner, 1991, pp. 39-40).

According to Toman (1992, p. 3), the term sustainability originally referred to a "harvesting regimen for a specific reproducible natural resource that could be maintained over time (for example, sustained-yield fishing)." He reports that ecologists have broadened that meaning "in order to express concerns about preserving the status and function of entire ecological systems (for examples, the Chesapeake Bay, the biosphere as a whole)." Toman notes that on the other hand, economists have used the concept to emphasize "the maintenance and improvement of human living standards, in which natural resources and the environment may be important but represent only part of the story" (p. 4). Finally, he reports that "other disciplines (notably geography and anthropology) bring in concerns about the condition of social and cultural systems (for example, preservation of aboriginal knowledge and skills)" (p. 4).

It appears that these three areas of study—ecology, economics, and culture—are central to the concept of sustainable development. However, implementation is hampered by continued disagreement about basic concepts and terms of reference. It may be helpful first to identify the salient elements of sustainable development.

1. Key Conceptual Issues in Sustainable Development

(a) Scale

Brooks (1993, pp.3-4) attempts to clarify the concept by refining the label, stating that the correct term is "sustainable development," as opposed to "sustainable growth." He reports that although this distinction may appear simplistic, it is important. "Growth, for instance, means to increase in size by adding material... Sustainable... refers to limits." Therefore, the two concepts do not mix. Development, on the other hand, is "the realization of potential." Thus, sustainable development "means limits placed on potential; quality [and therefore the economy] can always be expanded, and in many more ways than mere physical size.

In addressing the issue of growth, Brooks identifies one of the central elements of sustainable development: scale. If one acknowledges that physical resources on Earth are finite, then it seems apparent that the human economy is rapidly growing in relation to those resources and to the ecosystem as a whole. Daly (1987) notes that because the economy depends on the ecosystem as "a source for low-entropy inputs and a sink for high-entropy waste outputs" (p. 5), the growth of the economic "subsystem" is ultimately limited by the finite size of the total ecosystem. The problem with this arrangement is that standard economics does not address this limitation; it "does not ask how large the economy should be relative to the ecosystem" (p. 1). Instead, Daly notes, economics "promotes an ever-expanding scale of resource use by appealing to growth as the cure for all economic and social ills" (p. 1). As the economy grows in relation to the ecosystem, goods and

services that were once free at a smaller scale of development become scarce and are turned into economic goods and services for which prices are established. Standard economics views this transition as positive since overall Gross National Product (GNP) increases. "Indeed, we now count the extra economic activity made necessary by the loss of free natural services as further growth. If the source of our drinking water becomes polluted, then we need more purification plants, and up goes GNP" (*ibid.*, p. 5). The costs to the ecosystem of resource scarcity are not calculated.

(b) Intergenerational fairness

Toman (1992, p. 4) notes that traditional economists discount the costs and benefits of development to future generations. They do so because they assume (a) that people prefer benefits right now to those in the future (and weigh current costs more heavily than future costs), and (b) that income in the future is less valuable than income at the present because from the standpoint of the current decision-maker, present income can be invested to create more income. Toman argues that the capital growth argument (money generates more money) for intergenerational discounting is suspect because basic environmental resources--the capacity of the Earth to absorb carbon dioxide, for example--are inherently limited in supply. Discounting encourages resource consumption at a rate that may preclude opportunities for future generations. (Toman does not argue that discounting should be entirely abolished, especially since this could increase current exploitation of natural and environmental capital. He does suggest that discounting might best be applied in tandem with safeguards on the integrity of key resources

such as ecological life-support systems.) Toman also questions the ethics of invoking economic impatience as a defense for discounting. He wonders whether "the preferences of an 'average' member of the current generation should be the sole or even primary guide to intergenerational resource tradeoffs." Lastly, Toman notes that "[e]ven if one accepts that human values should occupy center stage, it is difficult to gauge what the values held by future generations might be" (p. 4). Daly (1987, p. 6) argues that "there is a sense in which the unsustainable scale is simply an unjust distribution with respect to future generations."

(c) Ecosystem substitution

Toman (1992, p. 4) states that traditional economists view all resources--the natural endowment, physical capital, human knowledge and abilities--as relatively fungible sources of well-being. Thus, large-scale damages to ecosystems are not intrinsically unacceptable; "the question is whether compensatory investments for future generations in other forms of capital are possible." Investment in the seemingly endless capacity for human learning is one solution that is currently popular. However, ecologists argue that physical laws limit the extent to which other resources can be substituted for ecological degradation. Toman notes that "for natural life-support systems, no practical substitutes are possible, and degradation may be irreversible." He also notes that opportunities for resource substitution in general are greater at the scale of a nation or the globe than they are at the smaller scale of a region or a local community. Economies geared to such a

scale are apt to overlook the "unique attributes of particular ecosystems or local constraints on resource substitution and systematic adaptation."

2. Implementation of Sustainable Development

(a) General proposals

Brooks (1993, p. 3) argues that sustainable development is an "alternative economics, not an alternative to economics." Nevertheless, it is a dramatically different approach to development that will require far-reaching changes. Several authors have described the actions that they see as necessary for implementation of sustainable development.

The World Commission on Environment and Development (1987, cited in Brooks, pp. 4-5) lists five broad requirements necessary for implementation:

- (1) Integration of conservation and development.
- (2) Satisfaction of basic human needs.
- (3) Achievement of equity and social justice.
- (4) Maintenance of ecological integrity.

The Commission further states that "[t]hese challenges are so strongly interrelated that it is difficult, and indeed unhelpful, to arrange them in hierarchical or priority order. Each is both a goal itself and a prerequisite to the achievement of the others."

Friedman (1992, p. 131) argues that "[r]ich and poor countries constitute a single world system, and the overdevelopment of the first is closely linked to the misdevelopment of the second. Neither 'development' is sustainable

in the long run..." He describes four steps necessary to initiate sustainable development (pp. 126-129):

- (1) Get the prices of commodities right by internalizing the social and environmental costs of production in the price structure.
- (2) Achieve food security.
- (3) Increase environmental research in order to measure the effects of development on the environment.
- (4) Build energy-conserving cities.

Daly (cited in Lerner, 1991, pp. 40-41) lists three rules of thumb that move towards sustainable development:

- (1) The rate of renewable resource extraction should not exceed the rate at which they are generated.
- (2) Wastes should not be generated at a rate greater than the rate at which the environment can assimilate them.
- (3) Non-renewable resources should be depleted at a rate equal to the rate at which we can develop a renewable substitute.

Daly (1987, pp. 1-2) describes an alternative to traditional economics, a concept that he calls a "steady-state economy" (SSE). A SSE is based on the idea that levels of input and output of people and artifacts are limited in size so as to be within the "regenerative and assimilative capacities of the ecosystem." He argues that just as we need ethical criteria to help determine the distribution of income in an economy, so too do we need ecological criteria to help us determine appropriate limits to the scale of an economy. In a SSE, society seeks an optimal scale of total resource use relative to the ecosystem. Daly

compares the concept of SSE to a steady-state library in which the various uses of natural resources are likened to the stock of books:

Whenever a new book is added an old one must be gotten rid of. The rule would be to add a book only if it were qualitatively better than some other whose place it would take. The steady-state library would continue to improve qualitatively, but its quantitative physical scale would remain constant. Likewise for a steady-state economy. The end of physical accretion [as an economic goal] is not the end of progress. It is more a precondition for future progress, in the sense of qualitative improvement (p. 2).

The Greater Yellowstone Coalition (1991, pp. 118-19) asserts that in striving towards sustainable development "transition strategies must be created and custom-tailored to the economic, cultural, and environmental characteristics of each community." It describes the steps necessary to achieve this transition:

- (1) Know the local ecosystem.
- (2) Identify the short-and long-term impacts of development.
- (3) Understand socioeconomic, cultural and demographic factors; planning should be community based and viable economic alternatives should be offered.
- (4) Market prices should reflect and incorporate the costs of ecosystem protection, maintenance, and rehabilitation.
- (5) Plan for growth management and where necessary, take appropriate measures to limit growth.

Lastly, the United States Agency for International Development (USAID) (1993, p. 3) states that

Sustainable development is characterized by economic and social growth that does not exhaust the resources of a host country; that does

not damage the economic, cultural, or natural environment; that creates many incomes and chains of enterprises; and that builds indigenous institutions that involve and empower the citizenry. Many factors determine whether development is sustainable, but four issues are fundamental: Population and Health, Economic Growth, Environment, and Democracy. Development is "sustainable" when it permanently enhances the capacity of a society to improve the quality of life. Sustainable development enlarges the range of freedom and opportunity, not only day to day but generation to generation.

The agency goes on to state that "USAID has decided to focus on sustainable development because it is the best way to ensure that the achievements of our foreign assistance are not ephemeral" (p. 4).

(b) Traditional land use

A number of authors argue that traditional land use by indigenous cultures may hold valuable lessons for sustainable development. Brown (1993, pp. 85-91) states that traditional land uses which have developed over scores of generations "could only thrive by encoding ecological sustainability into the body of practice, myth and taboo that passes from parent to child." In its 1984 Action Plan, UNESCO states that traditional land use systems illustrate

harmonious relationships between indigenous populations and the environment. These systems often reflect centuries of human experience and can provide information of immense value in improving the productivity and sustainability of modern land use and management practices (p. 3).

Guha (1989, p. 77) writes that "[m]any agricultural communities do have a sophisticated knowledge of the natural environment that may equal (and sometimes surpass) codified 'scientific' knowledge." More specifically, Posey et al. (1984, p. 101; cited in Palmer, 1989, p. 9) note that indigenous agricultural

systems have "fewer harmful effects on the soil than other agricultural practices." Johnson (1993, p. 27) reports that "[u]nder conditions of low population density, traditional pastoral nomadism represents a form of extensive rotational grazing that is ecologically sound." Felger and Nabhan (date unknown) state that native cultures in the Sonoran Desert utilize diverse sources of plant foods which may be useful to modern societies. And although it is not a study of traditional land use practices per se, Rola and Pingali (1993, p. 56) conclude from their study of Phillipine agriculture that current methods of crop production which rely heavily on the use of chemical pesticides are economically unsound if health care costs related to pesticide poisoning are incorporated.

Incorporating the knowledge of indigenous peoples into land use planning may involve more than simple data collection. Shifts in basic philosophical attitudes may also be necessary to fully appreciate traditional knowledge. In his study of the Tsembaga people, Rappaport (1974, cited in Palmer, 1989, p. 9) attributes the tribe's success in social and physical sustainability to the regulatory functions of their sacred rituals. He compares the Tsembaga's "respectful" approach to the natural environment with conventional industrialized society which approaches nature through scientific knowledge. He writes:

It could be argued that increased knowledge of ecosystems results in decreased respect for them... and thus leads men to be guilty of... what might be called ecological hubris. It is perhaps the case that knowledge will never be able to replace respect in man's dealings with ecological systems, for... the ecological systems in which man participates are likely to be so complex that he may never have sufficient comprehension of their content and structure to permit him to predict the outcome of many of his own acts.

The concept of holism discussed earlier in this paper would seem to be consistent with this argument to shift away from an incremental approach toward studying regional land use.

(c) Local participation

Also consistent with this shift in basic data collection is a change in the way that information is incorporated into management plans. While recognizing the valuable contributions that indigenous cultures can make towards sustainable development, several authors warn that ethical problems can result if this knowledge is simply "mined." Chambers (1979, cited in Palmer, 1989, p. 11) argues that to do so is to repeat "... the familiar pattern of dominant outsiders extracting new materials, in this case nuggets of information, to be processed somewhere else and then used to act on the rural environment from outside..." He argues that less obvious, but perhaps more important than bits of local knowledge "... are the processes whereby knowledge is generated, communicated, adapted, incorporated and transmitted, and who controls all this." He concludes that "... rural people can [and should] participate in and control these processes." Halffter and Ezcurra (1987, p. 199) warn that "[t]raditional uses are not always... in equilibrium with the environment." They argue that "[w]hat is really important is not to lose sight of the main principle of taking into account the [local] people." As part of its strategy for fostering sustainable development, USAID (1993, p. 4) states:

Sustainable development requires participation. It must evolve out of the experiences of ordinary people, their notion of what problems should be addressed, and their consultations with government,

development agencies, and among themselves. It must involve, respond to, and be accountable to the people who must live with the results of the development effort. And it must help them build institutions of free discourse and consensual decision-making.

(d) Implications for biosphere reserves

From this brief review, it would appear that implementation of sustainable development can only succeed if three areas of concern are addressed: ecology, economy, and culture. In addition, these concerns need to be addressed at a broad range of temporal and physical scales, from present to future generations and from local landscapes to global economies.

The concept of sustainable development seems to be consistent with holistic planning theories and the goals of the Man and the Biosphere program. With respect to the latter, the areas of concern listed above are the very same that are integral to the biosphere reserve concept. In addition, the transition zone is expressly designated for the implementation of sustainable development. However, as might be expected for what is essentially a revolution in planning and management, the actual implementation of sustainable development in the transition areas of biosphere reserves appears to be quite rare. Batisse (1986, p. 10) writes that little attention has been paid to this zone.

One major reason for this neglect lies in the open, undelineated character of the transition zone. Whereas administrative responsibility for the core areas and the delineated buffer zone is usually very clearly established--and in a majority of cases rests upon a single authority--the administration of the transition area is almost inevitably split among a variety of public and private bodies, with little or no attempt made to coordinate their activities. This situation is demonstrated by the relatively large number of biosphere reserves which have no real transition area, which are in fact limited to a core area, surrounded or

not by some kind of buffer zone, and which often merely bear the name of an already existing national park or conservation area."

However, as noted earlier in this paper, it is this very concept of fostering development that is consistent with ecosystem viability that is key to the long-term survival of both. With respect to biosphere reserves, Solokov et al. (1987, p. 108) notes that "[c]ontradictions between biosphere reserves and local populations can be avoided only if the reserve's activities are of actual use to the local population and promote the socioeconomic development of the entire region... Orientation to a maximally effective interaction of nature conservation and research with development is... necessary."

On a more positive note, from a conservation point of view sustainable development and biosphere reserves appear to be more politically attractive than conventional protectionist measures, especially in developing countries. Price (1993, pp. 1-2) notes that conventional natural reserves are often considered elitist and indifferent to the needs of the underclass. She reports that by explicitly linking questions of land stewardship with the needs of the poor through the concept of sustainable development, conservationists have successfully blended ecological issues and political action, thereby increasing their chances for success. As noted earlier, Mexico has designated a number of biosphere reserves. It seems logical to assume that Price's conclusions at least partially explain this fact.

CHAPTER III

A Regional Profile

Introduction

Biosphere reserves and the concept of sustainability suggest that three areas of concern should be examined in addressing issues of land use planning. These three areas include ecological, cultural, and economic concerns. In this chapter, the histories of these concerns are reviewed with respect to the study region. In addition, some of the more outstanding modern planning issues as they relate to the concept of biosphere reserves are presented.

A. Natural History

1. Geology

The terrestrial portion of the study region may be generally characterized as a part of the Basin and Range Province in which granitic mountains are oriented in a southeast to northwest fashion. Within the study area are found several unusual environments, such as the Gran Desierto de Altar. The sand dunes of the Gran Desierto form the major part of the largest sand sea, or area of moving dunes, in North America, covering about 5000 square kilometers (about 1800 square miles) (Felger, 1992). The sands that form the dunes originated in the Colorado Plateau and were transported to the region by the Colorado River. Due as much to the lack of diversity of habitat as to the low aridity and harsh conditions brought on by blowing sand, the Gran Desierto is home to only 85 plant species, a tiny number for such an immense system (*ibid.*).

Also located within the terrestrial portion of the study area is the Sierra Pinacate, a series of volcanic peaks, flows and calderas which describe an area roughly 56 by 40 kilometers and which are located 53 kilometers north and east of the town of Puerto Peñasco. The area has been sporadically active over the past 2-3 million years and relatively young lava flows are common throughout the region (Lynch, 1981). The landscape can be spectacular. The largest volcanic crater on the North American continent is found in this region, measuring almost a mile in diameter (Thayer, 1993). The several craters of the area are hydro-volcanic in origin, formed at least partly by groundwater coming into contact with upwelling magma, resulting in a flash explosion. It may be interesting to note that during the last ice age, 13,000 years ago, heavier rainfall filled some of the craters, forming lakes (Hartmann, 1989). It is also interesting to note that because livestock and vehicles cannot gain access to the bottom of the larger craters, these serve as valuable sites for studying the long-term effects of climate on vegetation (Felger, 1992; Hastings and Turner, 1965). It appears that the volcanic activity of this area occurs in 3,000-year cycles (Thayer, 1993) and that the most recent episode of eruptions probably took place at least 1,000 years ago (Hartmann, 1989). Although large caves are absent from the Pinacate region, lava tubes are common and several are quite large. Two of the largest are located on the flank of Carnegie Peak, the second-highest peak of the complex. The upper tube is approximately 30 meters in penetrable length (May, 1973). According to Lumholtz (1912), O'odham Indians consider the tube to be one of the homes of the god Iitoi, or Elder Brother.

Planning issue: Degradation of the volcanic landscape in the area.

Within the Pinacate region, there are several mining operations which extract volcanic cinders. According to Burquez and Castillo (1993, p. 126), the cinders are largely exported to the United States. These same authors state that these operations have grown dramatically in the last ten years and that there are increasing animosities between the mine's owners, who live in Puerto Peñasco and Sonoyta, and the local residents and land owners. These mines are located for the most part on the north and northeastern sides of the volcanos, at the edges of the lava flows and relatively close to Mexico Highway 2. According to Burquez and Castillo (1993), the mines are degrading the biological and visual values of the landscape not only through the operations themselves, but also as a result of the network of roads which lead to them and into the surrounding areas. This impact is noteworthy if nature tourism is promoted in the area as a means of ecologically sensitive development, as some have suggested.

The study region also includes the marine environment of the upper Gulf of California. The Gulf as a whole is an extension of the San Andreas Fault system and seems to be an area of sea-floor spreading (Reichle, 1975). Despite the fact that it is relatively narrow, the entire Gulf was quite deep in its early geologic history. It is thought that sediments from the Colorado and other rivers were trapped in the northern portion of the Gulf by the Midriff Islands (Angel de la Guarda and Tiburon), which effectively split the Gulf into two parts. Today these sediments form a layer up to five kilometers thick (Phillips, 1964, cited in Case and Cody, 1983, p.30). Consequently, the

majority of the waters of the Gulf north of the Midriff Islands are relatively shallow, measuring less than 200 meters for the most part (Villa Ramírez, 1993). As will be discussed later in this report, these and other differences between the southern and northern portions of the Gulf lead many to describe the latter as a "sea within a sea" (Turk-Boyer, 1992). The northern (or upper) Gulf is considered to be that part that lies between the delta of the Colorado River and the northern end of Angel de la Guarda (Villa Ramírez, 1993).

2. Climate

The study region incorporates what William Hartmann (1989) calls the "heart" of the Sonoran Desert. It is one of the hottest and driest places on the planet. In North America, the Pinacate region is second only to Death Valley for minimum rainfall (Campoy, 1993). May (1973) reports that within the Sierra Rosarios in the Gran Desierto, a period of 34 months passed without precipitation. As if to add insult to injury, this drought was broken by a rainfall of a paltry 1.0 centimeter (0.40 inches). With respect to temperatures in the Pinacate/Gran Desierto region, May (1973) states that during summer months, 60 to 90 consecutive days of temperatures that exceed 37.8 degrees Centigrade (100 degrees Fahrenheit) are not uncommon. He has recorded temperatures of 56.7 degrees Centigrade (134 degrees Fahrenheit) in some of the more narrow canyons and valleys of the region. Summer minimum temperatures in the area rarely drop below 18.3 Centigrade (65 Fahrenheit). North and east of the Pinacate/Gran Desierto, rainfall is more frequent and

temperatures are cooler, with winter frosts occurring more frequently (Burgess, 1992).

3. Terrestrial Plant Communities

The Sonoran Desert "is not uniform throughout" (Burgess, 1992, p.1) but is composed of several ecological communities. Based on differences in vegetation, the ecologist Forest Shreve (1964, pp. 49-56) recognized seven subdivisions within the Sonoran Desert. The terrestrial portion of the Western Sonoran Desert Border Area lies within two of these. The Arizona Upland subdivision, often referred to as the paloverde-sahuaro community, occurs in the northeastern portion and higher elevations of the study region. Nighttime frosts are not uncommon and "monsoon" rains typically arrive in the late summer. The community has the appearance of a low woodland of leguminous trees with intervening spaces filled with shrub and perennial succulents (Bahre, 1991). Flora typical of this region include saguaro (*Carnegiea gigantea*), the creosote bush (*Larrea divaricata* subsp. *tridentata*), the paloverde (*Cercidium microphyllum*) and the ocotillo (*Fouquieria splendens*). The western boundary of the uplands roughly coincides with the western edge of Organ Pipe Cactus National Monument.

The more arid Lower Colorado Valley subdivision to the south and west encompasses the remaining areas of the study area. Summers in this region are very warm and summer rainstorms of any consequence are rare. Annual moisture typically arrives in the winter in the form of widespread Pacific fronts which produce longlasting storms. Frosts are rare. The two plant species of the Lower Colorado Valley which vastly outnumber all others

are Larrea and white bursage (Franseria dumosa) (Shreve, 1964, p. 49). On the rocky soils of bajadas and along washes are found small trees, notably Cercidium, the smoke tree (Dalea spinosa), and ironwood (Olneya tesota). Shreve notes that the poverty of perennial plant numbers is somewhat compensated by a large number of ephemeral herbaceous species.

The study area represents a dynamic boundary between these two ecological communities, one which is constantly changing according to shifts in the local climate. As variables like rainfall and temperature change from season to season, "plants from the eastern Sonoran Desert give way to those that tolerate more arid summers, and species from the southern Sonoran Desert are stopped by too many winter frosts" (Burgess, 1992, p. 3). In combination with a widely diverse landscape which offers numerous microclimates, a patchwork of many different ecological communities evolves which is embedded within the larger subdivisions described above. For example, the limited areas in which water concentrates are marked by a disproportionate amount of life, as will be discussed below. The Pinacate, as well as other highlands in the area, are another part of this patchwork. In part because they receive a bit more precipitation and are a little cooler, they are home to approximately forty percent more species of plants than can survive in the sandy lowlands. The Pinacate and other mountains act as biological oases for desert plants and animals (Hartmann, 1989).

Planning issue: Precipitation and human development

The bottom line in this discussion of precipitation is that because life is dependent on water and because rainfall in this region is so variable, the

natural communities in the study area are not stable. "The history of weather events has shaped desert communities through stress, mortality, and bursts of growth and reproduction. Rainy episodes offer possibilities. Drought and cold enforce limits. Successful inhabitants incorporate uncertainty into their life histories" (Burgess, 1992, p. 3).

If humans are to count themselves as among the "successful inhabitants" of the region, they too must be willing to live with uncertainty. Ecologist Tony Burgess (1992, p. 3) notes that "the climate [of this region] has not been stable in the past and is unlikely to stabilize in the foreseeable future. Decisions that protect the integrity of communities require sensitivity to the nuances of context." In an era of groundwater pumping, activities such as farming are no longer tied directly to rainfall. However, livestock grazing can have serious impacts on vegetation and wildlife, as will be discussed shortly. Grazing must be carefully monitored due to the vagaries of the region's rainfall. Burgess (1993, p. 4) notes that

[a] livestock grazing load that can be sustained in one season can cause major losses of perennial plants if it is maintained during drought. Desert peoples [must] shift their activities to conform with opportunities and limits that the changing patterns present.

Planning issue: Livestock grazing

On the south side of the international border, ranching in the study area is limited to ejidos within the municipalities of San Luis Rio Colorado and Plutarco Elias Calles (in which the village of Sonoyta is located) (Burquez and Castillo, 1993). Because the region is so arid, the number of domestic animals is minimal. Despite the small numbers of domestic sheep, cattle, and

goats, however, the region has been overgrazed (ibid., p. 130). These impacts are especially apparent near sources of water, such as at Papago Tanks (Cochran, et al., 1990). Cattle tend to remain near permanent sources of water (Hendrickson and Minckley, 1984); therefore, they overgraze the immediate area and foul the water. In a region with so few sources of permanent water, these actions have obvious consequences for wildlife, as will be discussed later.

A possibly greater threat to the ecological integrity of the study area is that caused by the introduction of non-native plants. The Sonoran Desert is considered to be the most structurally diverse arid land ecosystem in North America (Turner and Brown, 1982). In recent years, an exotic species of grass native to southern Africa has had a significant negative impact on native vegetation and is considered by some to be the greatest danger to the unique diversity of this desert. Buffel grass (*Cenchrus ciliaris*) was introduced into the United States in the 1940's by the Department of Agriculture in west Texas, but until recently the species had not become strongly established in the Sonoran desert region. Today, many Mexican ranchers clear large areas by bulldozer, reseeding those areas with buffel grass as a feed crop for their cattle. Ethnobotanist Gary Nabhan estimates that approximately one million acres of desert and tropical vegetation have been cleared in the state of Sonora since 1966 to make way for buffel grass (Kreutz, 1994). Extremely drought tolerant, the grass has spread beyond these ranches into other areas, including disturbed soils within Organ Pipe Cactus National Monument and Cabeza Prieta National Wildlife Refuge. It appears that the grass can outcompete native vegetation (it is still uncertain whether the grass can do so in

undisturbed soils). In addition, the grass is highly flammable. Native Sonoran vegetation is not adapted to withstand wildfires while buffel grass recovers quickly from such events. Perhaps not unexpectedly, ecologists note that the grass provides unsuitable habitat for native fauna.

Planning issue: Woodcutting

According to Burquez and Castillo (1993), the irrigation districts of San Luis Rio Colorado and Sonoyta are the most important sources of wood in the state of Sonoran after the municipalities of Guaymas and Hermosillo. The authors report that about 16,000 cubic meters of mesquite (Prosopis spp.) were legally harvested in 1986 and that a much larger quantity was cut illegally. The trees are almost entirely used for the production of charcoal, most of which is exported (ibid.). In addition, Burquez and Castillo report that although it is protected by law, ironwood trees (Olneya tesota) are also harvested, both as a source for charcoal as well as stock for wood carvings for sale to tourists.

The consequences of wood cutting in general within the study region are extensive and dramatic. The removal of the large trees destroys habitat for wildlife and allows for the degradation of watersheds from erosion. It is feared that as mesquite and ironwood become increasingly difficult to find, the value of these woods will increase, leading to the destruction of even the most remote copses. Burquez and Castillo (1993) report that in the isolated Sierra del Rosario, the larger ironwood trees have already all been cut. Nabhan and Suzán (1994) note that wood prices have quadrupled in Sonoyta over the last decade, reaching \$300 U.S. per cord in 1991. They also note that

unemployed Mexican farm workers, unable to pay the higher prices for wood and charcoal, have illegally entered and cut trees across the international border in Organ Pipe Cactus National Monument.

Ironwood trees are an exceptionally valuable component of the flora in the more xeric areas of the study region. The dominant species in low desert basins outside of drainage channels, ironwoods serve as "nursery trees" for a wide variety of other perennials. A significantly greater diversity and volume of perennials are found in the shade of the trees, presumably because of the protection from the sun's radiation as well as the increased soil moisture found in the trees' shade (Búrquez and Quintana, 1994). Several researchers predict a sharp decline in the populations of more ecologically restricted species that depend on this microhabitat (*ibid.*, Nabhan and Suzán, 1994).

Planning issue: Changes in streambed morphology

The Sonoyta River (the only perennial stream within the study area) is undergoing severe erosion throughout much of the Sonoyta Valley. At one time, the river formed a series of cienegas, or swamps, where it met the town of Sonoyta. Lumholtz (1912) reports that following a flood in 1891, the river began to downcut and the town was relocated to its present site. Brown (1991) states that much of the erosion has occurred in the lifetime of some of the older residents of Sonoyta. He reports that according to these residents, the level of the riverbed was once almost the same elevation as the town site and that flooding was a common occurrence. Today, the riverbed lies approximately fifteen feet below the surrounding land surface at the highway

bridge in downtown Sonoyta. This phenomenon is significant because it serves as an indicator of the overall health of the stream's watershed.

Streambed downcutting is frequently indicative of watersheds which have been overgrazed or of floodplains which have been devegetated and these are possible causes for the erosion of the Sonoyta.

4. Freshwater

The [Sonoran Desert] is a patchwork of habitats, temperature regimes, water concentrations... The mountainous topography of the desert tends to swiftly collect rainfall into arroyos and ephemeral rivers... Vegetation reflects this reality. Trees choke streams while a few yards away cacti dominate the landscape (Bowden, 1977, pp. 33-35).

Water is the principle limiting factor in deserts. Much of the floral and faunal diversity of the region can be attributed to the availability and distribution of water (Burquez and Castillo, 1993, p. 63). Within the study region, the number of locations in which perennial water may be found is quite small. The study region includes the Sonoyta River, numerous ephemeral washes, natural rock tanks (or "tinajas"), natural artesian and man-made wells (or "pozos"). (For a more thorough description of water sources on the United States side of the border, refer to Bryan, 1925.)

(a) Sonoyta River

The largest watercourse in the region is the Sonoyta, a small, mostly intermittent river which originates in the Baboquivari and Quitojoa valleys on the Tohono O'odham Reservation in Arizona and in the highlands to the east of the town of Sonoyta (Bryan, 1925). It flows westward through that

community, then heads south to the Gulf of California; it meets the sea near the town of Puerto Peñasco. The Sonoyta Valley straddles the international border for a distance of about 45 miles. The southern portion of Organ Pipe Cactus National Monument forms part of the Rio Sonoyta watershed as well as the northern portion of the groundwater aquifer (Brown, 1991). Bryan described the river in 1925 as one that "... is dry except for occasional floods for more than 25 miles, to a point a short distance above Sonoita [sic], where water appears in the channel as a clear stream 12 feet wide and 1 foot deep" (p. 120). At the present time, the river rarely runs along its lower course, disappearing into the sand and alluvium in the vicinity of the Sierra de la Salada, approximately 11 kilometers (7 miles) southwest of Quitovaquito springs (May, 1973). The river flows to the Gulf only following storm events of sufficient size (Lumholtz, 1912).

Farming continues at the present time in the vicinity of the town of Sonoyta. The Sonora, Mexico, portion of the Sonoyta Valley is a prime site for agricultural development. Especially in its upper half, soils and water quality are excellent. In addition, the climate is ideal for year-round cultivation of a number of crops. During the first half of this century, agricultural activities consisted mainly of cattle ranching and subsistence farming. Small farms adjacent to the stream banks were irrigated with sporadic flows from the river (Arizona Town Hall, 1991). In the 1960's, the Mexican government undertook a program to develop land and water resources in northern Sonora. By 1988, the Ministry of Agriculture and Hydrological Resources (SARH) listed 165 wells that had been drilled for agricultural use of groundwater and about 20,000 acres that were under

irrigation for field crops, predominantly wheat, cotton and alfalfa. As a result of the increased agricultural production, the Sonoyta aquifer was increasingly overdrawn. Brown (1991) estimates that in 1987 the groundwater aquifer was overdrawn by 55,025 to 70,500 acre-feet per year or about two and one-half times the rate of natural recharge. In 1988, approximately 88,000 acre-feet were withdrawn, an amount of water only slightly less than that pumped annually by the city of Tucson for all uses (Arizona Town Hall, n.d.).

This groundwater overdraft has had a dramatic impact on the streamside vegetation. At one time, cottonwoods were much more extensive along the Sonoyta River to the Agua Salada reach of the stream (May, 1973). Native riparian vegetation along the river has been displaced not only by clearing for agricultural purposes, but also as the result of the changing flow regime brought on in part by groundwater pumping. As the water table has dropped, exotic species such as salt cedar (Tamarix ramosissima) have replaced native mesquite and cottonwood (Felger, 1992). The value of the river for wildlife habitat subsequently has been diminished.

Planning issue: Agriculture and groundwater overdraft in the Sonoyta Valley

The overdraft of groundwater in the valley raises several concerns. Obviously, if the water table drops far enough the agricultural industry along the Sonoyta River could be shut down, thereby reducing economic opportunities in the nearby town. The water supplies of several communities could also be strongly affected including those of Lukeville and the Organ Pipe Cactus National Monument headquarters in Arizona, as well

as those of the towns of Puerto Peñasco and Sonoyta. Finally, the loss of a source of freshwater would undoubtedly have a heavy impact on wildlife in such an arid environment. The loss of the native riparian vegetation as has already occurred is a significant one: riparian areas in arid environments provide outstanding habitats for wildlife as well as corridors for wildlife movement (Carothers, et al., 1974; Johnson, et al., 1977; Schaefer and Brown, 1992).

In Mexico, a centralized governmental structure exists to provide close control of crop production on all lands. This function is handled by the local office of SARH. In order to restrict the rate of groundwater overdraft in the Sonoyta watershed, SARH has set a limit of 32,000 acres as the maximum acreage to be developed in the valley (Brown, 1991). In addition, the agency has placed a moratorium on the drilling of new wells. However, a government-subsidized program of pump electrification has been underway since 1984 and the conversion of gas and diesel engines to electric motors is nearly complete. As a consequence of reduced operating costs, overall pumping capacity has increased substantially in the valley without drilling more wells (Brown, n.d.). Brown estimates that it is possible to double the 1987 rate of pumping without increasing the number of new wells. Therefore, despite the fact that a moratorium exists on the drilling of new wells for agriculture in the Sonoyta valley, groundwater withdrawals could increase considerably without the development of new wells.

SARH officials are also attempting to reduce groundwater overdraft by requiring that farmers shift from high-water demand crops such as alfalfa and to stop methods such as flood irrigation (Arizona Town Hall, 1991). There is

already increasing interest in vegetable production. Locating a market and transporting a perishable crop have impeded efforts to expand vegetable production. Conversely, situated as it is on the international border, the community obviously has a geographical advantage over the rest of Sonora and there is excellent potential for a sizeable vegetable industry.

(b) Tinajas

During the dry summer months, and often into early winter, the only sources of potable free water in most of the study region are approximately nineteen widely scattered tinajas, or tanks, that are recharged during storm events of sufficient size (May, 1973; Bryan, 1925). Tinajas are formed as a result of the scouring action of sediment-laden storm waters on volcanic rocks. Where runoff passes over the edges of lava flows or through narrow canyons, the tinajas take the form of plunge pools, some of which are quite spectacular. Where runoff passes through wider and more shallow canyons, its velocity decreases and it drops its load of sediments. If it does so within a rocky basin, the basin may gradually be filled with sand and gravel, eventually forming a "sand tank" (May, 1973; Bryan, 1925). Sand tanks hold less water than do plunge pools and are less apparent to the eye, but they may retain their water for a longer period because of lower evaporation. They can sometimes be located by following game trails of desert wildlife. Only a few of the tinajas of the region are able to hold water for more than a few months (May, 1973; Bryan, 1925).

Planning issue: Cattle grazing adjacent to tinajas.

Several of the ejidos (agricultural cooperatives) in Sonora, Mexico, run cattle on their properties (see Burquez and Castillo, 1993, for a detailed description) and they appear to have had an impact on a number of the tinajas. Cattle have overgrazed the area adjacent to and have polluted the Papago tanks (Cochran, et al., 1990; Hartmann, 1989). Cattle grazing adjacent to the tinajas is of concern not only for aesthetic reasons but also because of impacts to wildlife such as bighorn sheep. Denniston (1965) states that water must be available to ensure the health of a bighorn herd. At the same time, bighorn apparently feel quite vulnerable while drinking (Welles and Welles, 1961) and will abstain from doing so if other large animals are present. Bighorn are diurnal, so competition for watering holes comes not so much from deer (which are largely nocturnal) but from other diurnal animals such as livestock or feral burros. When other diurnal animals water at the same time as bighorn, the latter may leave without drinking even if they have been without water for several days (Welles and Welles, 1961).

(c) Pozos

Pozos (Spanish for "wells") are spring-like sources of potable water that occur within the estuaries and salt flats of Adair Bay where the Gran Desierto meets the Gulf. May (1973) reports that they occur in a band which begins approximately 1.6 kilometers (1 mile) inland from mean low tide levels along the coast, and extend inland as much as 6.4 kilometers (4 miles). The pozos are fed by recharge received in the sand dune belt which separates Adair Bay from the Pinacate region to the north, as well as through the formation of hydroscopic water (*ibid.*). The Gran Desierto aquifer appears to consist of

ancient riverbeds that were subsequently covered by dunes (Ezcurra, et al., 1988).

The pozos play a vital role in the ecology of the Adair Bay region. May indicates that they continue to flow during periods of drought, when the tinajas dry out. Therefore, lush more diverse flora are able to survive adjacent to these fresh waters. The springs were important sources of water to early human inhabitants of the region, as indicated by the remains of numerous campsites nearby. The pozos continue to provide a crucial source of water for wildlife. Coyotes, kit foxes, ring-tailed cats, white-winged doves, and sage sparrows all depend on the springs for their daily water (May, 1973).

(d) Springs

There are a few springs in the area, including several hot water springs. Probably the best known are Quitobaquito springs, located just north of the international border within Organ Pipe National Monument. The oasis has a long and diverse history of use and modification by several human cultures. The springs are fed by groundwater, probably from the Sonoyta watershed (Brown, 1991).

5. Marine Environment: The Upper Gulf of California

Although the Gulf of California has been described as an area of great fertility since the time of early explorers, few details are available regarding the underlying causes of this productivity (Alvarez-Borrego, 1983). It appears that primary production (upon which most life is ultimately dependent) is two to three times greater than that in the open Atlantic or Pacific at similar

latitudes (Zeitzschel, 1969). This productivity seems especially paradoxical because the Gulf is the site of some of the world's greatest environmental extremes (Alvarez-Borrego, n.d.). For example, the tides in the Gulf are among the most spectacular and dangerous in the world, with reported spring ranges of 10 meters at the northern end. Tidal currents in the narrows between islands and the coast and in the passages connecting semi-enclosed lagoons with the Gulf are very strong (Alvarez-Borrego, n.d.). (It is interesting to note that the tidal wave is progressive so that the time of high or low water is progressively later travelling north up the Gulf. The result is that low water at one end of the Gulf occurs at about the same time as high water at the other end.) Another environmental extreme is the wide variation in temperature of the Gulf's surface waters. The moderating effects of the Pacific Ocean upon the climate of the Gulf of California are greatly reduced by an almost uninterrupted chain of mountains, 1 to 3 kilometers high, in Baja California. The climate of the Gulf is therefore more continental than oceanic, a fact that contributes to the large annual and diurnal temperature ranges observed there (Hernandez, 1923). These environmental extremes may help explain the high degree of endemism in the Gulf. Ninety-two species of fish, which represent 17 percent of the total, are endemic to the area (Walker, 1960).

Environmental extremes are even more pronounced in the upper Gulf. As discussed earlier, the northern Gulf is relatively shallow, and can be characterized as a vast underwater plain of sand, silt and clay sediments deposited by the Colorado and other rivers of the region (Maluf, 1983). Because of the strong tidal currents and the fact that the upper Gulf is

relatively shallow, sediments from the ocean floor are resuspended, causing the water to be almost permanently turbid (Villa Ramírez, 1993, Case and Cody, 1983). Compared to the wetter, tropical Pacific region in the south, the upper Gulf is practically rainless and subject to a very high rate of evaporation. The combination of shallow depths, high surface radiation, and minimal precipitation results in seasonal water temperature variations that are much greater in the north, changing about 22 degrees Centigrade over the course of a year, compared to an annual range of about 9 degrees Centigrade in the south (Alvarez- Borrego, 1983). It is not surprising that surface water salinity in the northern Gulf averages one to two percent higher than in the south (Alvarez-Borrego, 1983; Gierloff-Emden, 1977).

In historical times, the high productivity of the upper Gulf was due to a number of environmental factors. Probably of primary importance was the Colorado River. Before its waters were delayed behind dams, the Colorado was probably the only river with freshwater input to the northern Gulf throughout the year (Alvarez-Borrego, 1983). Several researchers have noted that the river carried a tremendous load of nutrients into the upper Gulf and contributed approximately 50 percent of the total freshwater flowing into the upper Gulf (Villa Ramírez, 1993; Byrne and Emery, 1960, cited in Case and Cody, 1983, p. 30). Historian Marc Reisner (1986) lends a sense of scale to the sediment load that the Colorado carried: "If the river, running high, were diverted through an ocean liner with a cheesecloth strainer at one end, it would have filled the ship with mud in an afternoon" (p. 127). The strong influence of the river on the upper Gulf is indicated by the fact that the first Spanish sailors to explore the sea named it "Mar Bermejo", the Vermillion

Sea, because of the reddish colors of the Colorado Estuary, and not, as is often assumed, because of the red plankton blooms (Van Andel and Shor, 1964). Other rivers which flowed at least seasonally into the upper Gulf were the Rios Sonoyta and Concepción (Turk-Boyer, 1992). In effect, the entire upper Gulf acted as a giant estuary (Turk-Boyer, 1993). In addition, many miles of shoreline, seasonal changes in wind direction, water salinities and temperatures, and other factors combine to create upwelling currents that make nutrients available year-round in the northern Gulf (Alvarez-Borrego, 1987; Turk-Boyer, 1992). Finally, the region's shorelines are highly variable and provide a variety of habitats including rocky and sandy shores, estuaries, coastal lagoons and wetlands (Turk-Boyer, 1992). Together, these and other factors combined to provide the basis for incredibly productive fishing grounds. This productivity is indicated by the fact that the state of Sonora produced more fish than any other state in Mexico in 1982 (Baja California was second). Within the state, the towns of Guaymas, Huatabampo, and Puerto Peñasco were respectively the three biggest producers (Fimbres, 1985). High productivity is also indicated by the presence of large numbers of other forms of wildlife in addition to fish. Over 60 species of marine birds use the Gulf and 33 percent of all species of cetaceans are represented (Turk-Boyer, 1992).

Planning issue: Fishing in the upper Gulf

Historically, Mexico has paid little attention to its coastal areas. The nation's three largest cities, Mexico City, Guadalajara, and Monterrey, are located inland and most economic activity has been focused away from the

coasts (Merino, 1987). Beginning in the 1980's, however, the Mexican government began to recognize the economic potential of its coastal resources and coastal development has become increasingly important. Economically, the three most important coastal activities in Mexico are fishing, offshore oil extraction, and tourism (Merino, n.d.).

The three primary ports of the upper Gulf include San Felipe in Baja California, and El Golfo de Santa Clara and Puerto Peñasco in the state of Sonora. All three of these communities developed in response to the high productivity of the upper Gulf and fishing remains their most important economic activity (Turk-Boyer, 1992). In Puerto Peñasco, the industry currently is responsible for 34.7% of total employment, the single greatest employer in that town, although in terms of capitol it ranks third behind commerce and tourism (Turk-Boyer, 1992).

Although shrimping is blamed for many of the environmental problems which currently beset the upper Gulf, that industry was not the first to overexploit resources in the region. Mother of pearl, most commercial molluscs, and sea turtles have all been overfished in the past (Merino, 1987). More recently, white and blue sea trout (Atractoscion nobilis and Cynoscion parvipinnis, respectively), Spanish mackerel (Scomberomorus spp.), several species of sharks and rays and the totoaba (Totoaba macdonaldi) were heavily exploited commercially (Walker, 1960). Of these, perhaps the totoaba has received the greatest public attention.

Totoaba

Originally, commercial fishermen in the upper Gulf were interested not in shrimp but in the indigenous giant corvina of the upper gulf, the totoaba (Totoaba macdonaldi), which was prized by Asians for its swim bladder. The totoaba fishery reached its peak in 1942 when 2,000 tons were harvested (Turk-Boyer, 1992). In the 1940's, a large market for totoaba meat was opened in the U.S. However, due to ecological changes in its spawning grounds at the mouth of the Colorado River and overfishing, this fishery was near depletion by the 1970's (Turk-Boyer, 1992).

In 1975, the Mexican government declared the totoaba to be off-limits to fishing. In 1991, the totoaba and the vaquita porpoise (Phocoena sinus) were declared endangered species. (Although not specifically hunted, the vaquita occurs in the same habitat as the totoaba and drowns in gillnets used by fisherman to trap totoaba and other fish.) In 1992, the government banned the use of gill nets with mesh openings larger than 10 inches. Despite these measures, there is no evidence at the present time that totoaba populations are recovering (Turk-Boyer, 1993). Possible reasons include:

- 1) Continued illegal harvesting. Historically, there have been few restrictions placed on local fishermen in the upper Gulf. Populations of commercial fish such as shrimp, mackerel, and shark were severely depleted over the past twenty years. According to Hugo Montiel, director of research for the Department of Fishing's office in Guaymas, about 40 of the 600 small fishing boats in the upper Gulf continue to regularly hunt totoaba because of shortages of other species of commercial fish (Lazaroff, 1992). Turk-Boyer (1992) also maintains that the totoaba remains an important part of the economies of both El Golfo de Santa Clara and San Felipe. The tasty white

meat is sold in northern Mexican cities or smuggled into the United States (Lazaroff, n.d.). Although such activity is illegal, there is little awareness on the part of fishing officials on the plight of the vaquita and its relationship to the totoaba.

- 2) The lack of freshwater flowing through the Colorado River and subsequent damage to habitat.
- 3) The totoaba populations were depleted by fishing beyond the point of recovery.
- 4) The capture of juveniles by shrimp nets (Guevara-Escamilla, 1973).

Shrimp

Beginning in the 1930's, the Mexican government granted permission for the Japanese fishing fleet to harvest shrimp from the Gulf of California (West, 1993). At that time, most of the Mexican fisherman of the upper Gulf used small outboard boats (pangas), canoes, or sailboats and they were primarily interested in the totoaba. The Japanese introduced both a new market (shrimp) and a new fishing technology (trawling). Trawling for shrimp involved fishing on an entirely new scale than had been previously practiced in the upper Gulf. It is also a method that was (and continues to be) incredibly wasteful.

Shrimp trawlers typically deploy two large bottom trawls from either side of the vessel. These trawls, or "otter," are pulled over the sea floor at a speed of one to two knots for one to two hours. They are then winched back aboard the ship and the contents are emptied on to the deck. In addition to the target species (shrimp), the nets gather a great variety of other organisms,

which are variously termed "by-catch," "trash-fish," etc. The shrimp are hand-picked from the mass of the by-catch which is then shoveled overboard back into the sea. The time necessary to search through the catch for the shrimp and the rough-handling of the catch during this procedure and the subsequent heaving overboard ensure that the great majority of the by-catch is dead before reaching the water (Pérez-Mellado and Findley, 1985).

Typically, less than one kilogram (2.2 pounds) of shrimp are retrieved from ten kilograms (22 pounds) of by-catch (Pérez-Mellado and Findley, n.d.).

On his six-week collecting expedition in 1940, author John Steinbeck (1941) (a marine biologist by training) recorded the presence of the Japanese shrimp boats dredging the Gulf. He had an opportunity to board one of the dredger boats and witness the crew in action:

The dredge was out when we came aboard, but soon the cable drums began to turn, bringing in the heavy purse-dredge. The big scraper closed like a sack as it came up, and finally it deposited many tons of animals on the deck--tons of shrimps, but also tons of fish of many varieties: sierras; pompano of several species; of the sharks, smooth-hounds and hammer-heads; eagle rays and butterfly rays; small tuna; catfish; *puerco*--tons of them. And there were bottom-samples with anemones and grass-like gorgonians. The sea bottom must have been scraped completely clean.... Fish were thrown overboard immediately, and only the shrimps kept.... Nearly all the fish were in a dying condition, and only a few recovered.... The Mexican fish and game official stationed aboard was a pleasant man, but he said that he had no great information about the animals he was overseeing (pp.247-8).

Fifty years ago, Steinbeck was concerned about management of the Gulf, and wondered if "a very short time will see the end of the shrimp industry in Mexico" (*ibid.*, p.250). The Mexican government banned Japanese trawling in the gulf in the 1940's, in part because the outbreak of World War II but also

because of the fleet's wasteful practices (West, 1993, Fimbres, 1985).

Unfortunately, doing so did not end the problem.

Mexican fishing communities on the Gulf appear to have picked up where the Japanese were forced to leave off. For the past 50 years, the shrimp fishery of the upper Gulf has been one of the most important commercial fisheries in Mexico. In addition to the ports of the area (Puerto Peñasco, El Golfo de Santa Clara, and San Felipe), shrimp boats from fleets based farther to the south regularly trawl for shrimp in the upper Gulf but return their catches to their home ports such as Guaymas and Yavaros, Sonora (Findely and Nava, 1992).

The rapid growth of Puerto Peñasco serves as a measure of the commercial success gained from the upper Gulf. In 1941, there were 187 fisherman and railroad workers living in Puerto Peñasco (Monographia, 1992). In 1950, 800 men were employed in town and the general population stood at about 2,500 (Ives, 1989). By 1980, the population had grown to 17,666 (INEGI, 1983) and in 1990, the population was recorded at 26,141 (INEGI, 1991b.). That this rapid growth was fostered by fishing is indicated by the fact that as fishing productivity has fallen, unemployment in Puerto Peñasco has risen. Unemployment increased from 0.5 percent in 1980 to 2.89 percent in 1990 (SIUE, 1992).

As early as the 1980's, there were signs that the upper Gulf was overfished as shrimp production began to fall sharply. According to fisheries statistics provided by the state of Sonora, in the 1980-1981 fishing season 6,400 tons of shrimp were produced. By the 1990-91 season, that number had fallen to about 1,300 tons (Lowe, 1993). These figures are corroborated by those

available from the Development Plan of the Municipality of Puerto Peñasco, which indicate that there was an annual decrease in shrimp production of 13.8% between 1988 and 1991 (Turk-Boyer, 1992). At the peak of shrimp activity in the 1988-1989 season, 240 trawlers were officially permitted to operate out of Puerto Peñasco. In January of 1992, only 38 boats were active in that port (Turk-Boyer, 1992). Fisherman who had taken out loans because of the low shrimp harvests in 1989 and 1990 were unable to make their payments. Consequently, the banks and other financiers were unwilling to lend money and many boat owners were unable to make repairs for the 1991 season. In 1992, banks foreclosed on many of the owners with outstanding debts and seized their boats. By the beginning of 1993, only 40 boats had legal permits to shrimp. Turk-Boyer (1993b) notes that "This is in effect an 80% reduction in the shrimping activities from Puerto Peñasco and El Golfo de Santa Clara. The situation is similar in other ports of the northern Gulf." Another indication that the upper Gulf has been overexploited for shrimp is the fact that there has been a steady decrease in the average catch per area trawled over time. "For the same amount of effort, there are fewer returns today" (Turk-Boyer, 1992).

In addition to overfishing, researchers have suggested other possible causes of declining catches. These include:

(1) The reduced flow and increased salinity of water flowing into the northern Gulf from the Colorado River. Tapped by farmers and cities largely within the United States, most of the surface flow of the river to the Gulf is diverted long before it reaches the sea except during exceptionally wet years (Turk-Boyer, 1992; Turner, 1992, Alvarez-Borrego et al., 1973). The environmental

impacts to the ecosystem of the upper Gulf that these actions have had can only be guessed at.

- (2) The fact that the fishing season overlaps the shrimp breeding season.
- (3) Ineffective monitoring and enforcement of the closed season.
- (4) Excessive pollution in the bays and estuaries.
- (5) Possible adverse effects of the major climatic event known as El Niño.
- (6) The introduction of a new disease into shrimp populations (Moore, 1991).

The upper Gulf towns are not the only Mexican communities which have possibly overexploited shrimp. The industry is in danger of collapse throughout the nation. The consequences of such a collapse would extend far beyond local economies because shrimping is Mexico's most valuable fishery (Merino, 1987). The industry represents 25 percent of the value of all fish production in the country and it is the third most valuable export after oil and coffee (Merino, n.d.).

The ecological consequences of shrimping are also grim. In 1974, Mathews estimated that on the average the shrimp nets were passing over each square meter of the Mexican Pacific shrimp grounds about seven times per year. In the upper Gulf, the number is unknown but must be much higher (Alvarez-Borrogo, 1983). As discussed earlier, shrimp trawlers are not selective. Only 30 to 50% of the typical catch of a shrimper is utilized; the remainder is thrown overboard (Turk-Boyer, 1993b). Of the total catch, less than 5 percent is shrimp (Turk-Boyer and Ramirez, 1993, Turk-Boyer, 1993b, Turk-Boyer, 1992). Merino (1987) notes that marine organisms of lower economic value are underutilized by shrimp trawlers. Luch and Swartzlose (1985) estimate a potential capture of 10,000 tons of squid and 30,000 tons of

hake in the Gulf. The capture of juveniles of many species of fish by shrimp net may be a severe problem for many species, especially in the shallow waters of the upper Gulf, and the effect may be overlooked simply because there are no important fisheries for all of them. Many of these could be useful, but they may already be diminished as a resource (Alvarez-Borrego, 1983). "The conclusion is that this industry, driven by one highly-valued resource that represents less than 5% of the total catch, wastes a tremendous amount of biomass in the process" (Turk-Boyer, 1992, p.5).

B. Human History

1. Pre-Historic and Historic Native Americans

(a) First Inhabitants

A degree of controversy surrounds the question as to when the first human inhabitants arrived in the Pinacate region. There is ample evidence to support the theory that humans migrated to the North American continent about 12,000 to 10,000 B.C., when low sea levels opened the Aleutian land bridge from Asia. Archaeologists have documented the presence of Clovis spear points in the Sonoran Desert, supporting the notion that the first human habitation of the area occurred around 10,000 B.C. (Hartmann, 1989). These early inhabitants are known as the San Dieguito Complex; they occupied the entire region of the Southwest during this time (Hayden, publications and personal communications; cited by May, 1973). Archaeologists generally agree that this culture lasted until around 8,000 to 5,000 B.C., when the climate began to change from cool and moist to one that

was more similar to the hotter and drier climate that persists today (Hartmann, 1989).

Some archaeologists, however, maintain that the earliest migrations into the Americas took place 30,000 years ago or even earlier. Among them, Julian Hayden has used evidence gathered in the Pinacate region to support that theory: the environment there is particularly well-suited for archaeological research. Hayden (1976) states that "the Sierra Pinacate is unique among the deserts of North America in that all non-perishable remains of man's occupancy are preserved in direct association with the surface upon which they were deposited, undisturbed by erosion. This is as true of the earliest stone tools as it is of tin cans left by cowboys or campers."

Whether the first human inhabitants of the region arrived 12,000 or 30,000 years ago, the presence of the San Dieguito culture in the area is indicated not only by stone tools but also by impressions left upon the landscape. Within the Pinacate region, there still remains a network of trails between tinajas and between food-gathering camps which date from this period (Hayden; cited by May, 1973). Also in the vicinity of the tinajas are "sleeping circles," small enclosures of stones six to ten feet across bounded by rocks and boulders one to two courses high. In addition, intricate patterns on the desert floor which were formed by scraping off the desert pavement and by arranging stones in long, straight or wandering rows date from this period. Rock cairns, many of which have been destroyed by pot-hunters, are also scattered throughout the area (*ibid.*). This early culture came to an end as the cold, wet climate of the Pleistocene gave way to warmer and drier conditions.

Indians of the Amargosa Complex arrived from the California deserts to the north and west, penetrating south into Mexico 8,000 to 5,000 years ago (Hayden; cited by May, 1973). Hayden (1967, 1970) states that these peoples were the ancestors of the Pima-speaking peoples of present-day northern Mexico and southwestern United States, including the Pima and O'odham. Within the study region, it is likely that the early Amargosa exploited similar natural resources as had the San Dieguito: small and large game, seeds, roots and fruits (Hayden; cited by May, 1973). Among the new stone-working techniques and the new tool patterns introduced by the Amargosa were the metate and the mortar (*ibid.*). From the presence of these grinding stones at camp sites, it is clear that by about 1,500 B.C. there was a shift in the economy of hunters and gatherers to an increasing reliance on wild plants, particularly grasses (Rankin, 1992). Recent research in southeastern Arizona and in the Tucson Basin has uncovered storage sites containing corn that date to approximately A.D.150 (*ibid.*). Such finds indicate that where possible, native inhabitants were significantly shifting their culture from hunting and gathering to more sedentary farming.

(b) Hohokam civilization

Around A.D. 200, cultural influences from the advanced civilizations of central Mexico began to be introduced in the study region, especially in the northern and eastern portions near perennial rivers such as the Gila. In addition to corn (discussed above), pottery, cotton cloth woven from a loom, shell and turquoise jewelry, and an advanced system of irrigation all made their entrance into the region (Underhill, 1953). The culture associated with

this revolution is today known as the Hohokam and it is still uncertain just how it arrived in the region. Some archaeologists insist that the Hohokam migrated as a new people into the area from the south. Other scientists maintain that the Hohokam were the original Amargosans who adopted these new customs through trade with the south. However it originated, for approximately 1,000 years the Hohokam was the dominant culture of the region. They developed one of the world's largest prehistoric irrigation systems before the downfall of their civilization about 600 years ago. In addition, new evidence suggests that the Hohokam constructed a series of reservoirs that may have been capable of retaining water year-round, thereby allowing them to irrigate crops throughout the summer. Unlike other Hohokam irrigation canals which were constructed near permanent sources of water such as the Gila and Salt Rivers, these reservoirs were located away from any perennial streams. Similar in appearance to modern livestock tanks, Bayman (Volante, 1993) reports that Hohokam reservoirs were elliptical in shape with raised embankments and a depth of up to twenty feet. The remains of several of these reservoirs are located within the study area along Growler Wash.

The Hohokam culture came to a rather sudden end sometime between 1400 and 1450 (Hartmann, 1989). As with their arrival, the cause of their demise is uncertain. One theory holds that one or more social or environmental stresses forced the collapse of the intricate Hohokam civilization and that its descendents remain in the region today as modern Pima and Tohono O'odham Indians (Hartmann, 1989).

(c) Hia-Ced O'odham

The O'odham Indians live in the northern portions of the Sonoran Desert. Fontanna (1989, p. 11) estimates the present-day size of the aboriginal population at about 12,000 people or about one human being per two square miles. Within the O'odham nation, modern observers have counted at least nine separate dialect groups; there were probably more in times past.

The Hia-Ced O'odham (the "In the Sand People") historically inhabited the greater portion of study region from south of the Gila River to below the town of Caborca and from the lower Colorado river on the west to the Ajo mountains on the east, the present western boundary of the Tohono O'odham reservation (Hayden, 1970). Fontanna (1989, p. 40) estimates that between 250 and 300 people lived off this vast expanse of land. To the east lived the Tohono O'odham (the "desert dwellers") and along the rivers which flowed at the boundaries of the desert lived the Akimel O'odham (the "river people") (Burquez, et al., 1993). Hayden (1967) maintains that early in the migration of the ancient Amargosa people into the Sonoran desert, those that moved into the Pinacate region, the "Pinacateños" (also known as the Sobas and Sand Papagos (Nabhan, 1989, p. 510)), diverged from other Amargosa populations and remained isolated, perhaps because of the rigors imposed by the environment. As evidence, Hayden describes the unique nature of archaeological material found in the area, such as patterns of cleared desert pavement that form large figures of humans, snakes, and lizards (1967). He also reports the presence of piles of cremated animal bones (1985). In addition, Hayden (1967) notes the fact that the Pinacateños spoke a local dialect of the O'odham language. Childs (1954) reports that the Pinacateños

spoke with a "different brogue" to their speech when compared to other O'odham who called the Pinacateños "those who speak like Chinamen." Hayden (1967, 1970, 1972) theorizes that from 1,000 B.C. through the 19th century, the Pinacateños formed a single ethnic group which lived in isolation. He states that although they maintained contact with the Yuma Indians of the lower Colorado and Gila rivers, it appears that they had little contact with the Hohokam from the north, who traveled to the upper Gulf for shells, and even other O'odham, who traveled to the sea for salt. Apparently, the Pinacateños were unfriendly, if not downright hostile, to all outsiders, even other Hia-Ced. While the Pinacateños remained isolated in their desert mountain fastness, the other Hia-Ced O'odham populations (sometimes referred to as the Areneños) occupied the greater part of the remainder of the study region. Hayden (1967) states that they were considerably more open to contact with outsiders than their congeners in the Sierra Pinacates.

Unlike their Tohono O'odham relatives to the east where the more dependable rainfall afforded greater opportunities to farm and thereby remain in a single location for longer periods of time, it is likely that the Hia-Ced were by necessity more frequently nomadic. Hayden and other researchers insist that the Pinacateños were entirely nomadic, a position disputed by Nabhan et al. (1989). Nabhan claims that this distinction between the Pinacateños and other Hia-Ced is overstated, arguing that it "...is an arbitrary overclassification based on polarizing the traits of just two of the several informally organized bands" of Hia-Ced (pp. 519-520). Citing both written texts and transcriptions of oral histories, Nabhan contends that the Hia-Ced in

general may be characterized as a people who utilized a variety of habitats in a variety of fashions including run-off farming, plant gathering and hunting (p. 524). He reports that

... the movement of the [Hia-Ced] O'odham between various habitats should not imply that they were nomads with no seasonal pattern of established places of residence. In fact, several permanent villages and encampments are discussed [in oral histories] as being as ancient as Quitobaquito (p. 524).

The authors raise an interesting question when they wonder why the Hia-Ced did not remain most of the year near the most productive habitats such as the Sea of Cortez coastline, the Sonoyta River, or the Gila River (p. 517). Nabhan makes clear, however, "... that the Hia-Ced O'odham can at least claim historic usufruct rights to many sites within southwestern Arizona and northwestern Sonora" (p. 524).

The debate surrounding just how nomadic were the Hia-Ced holds more than academic consequences. As will be discussed below, proving that the Hia-Ced were permanent residents of the study area is vital to their claims as rightful landowners. While the debate continues, the reason for nomadism is quite clear. Charles Bowden (1977) writes:

Their constant coming and going reflects the area's hydrology and weather. No modern has ever chosen to disagree with the Sand Papago assessment. Structures identified as marks of civilization elsewhere here spell death. Build a house and it is a trial to survive while constructing it, lethal to linger afterwards. Dwell in fellowship with large numbers of other human beings and mass starvation greets the effort. Become enamored of possessions, and the simple transport of property guarantees a swift end to desert living. Humans in such an environment manage to leave little behind but footprints (p. 43).

As remarkable as their ability to survive in such an extreme environment is the oral tradition of the Hia-Ced. Inhabiting a homeland which forced its

residents to travel lightly, the Hia-Ced had few material goods to offer other Indians. Instead, they traded with their ultimate resource: their minds. Their experiences in surviving with so little water generated fantastic stories that were made into songs and dances which were prized by others (Bowden, 1977) and the Hia-Ced were considered to be powerful witches (Hayden, 1967).

2. European exploration

Beginning in the sixteenth century, Spanish explorers passed through the area, intent on discovering similar riches to those that had been recovered from the Incan and Mayan empires to the south. Not finding any, they focused their attention further north (where their luck wasn't any better) and the Pinacate region remained neglected. The latter part of the seventeenth century witnessed the arrival of the intrepid Jesuit, Father Kino, the "Apostle of the Pimas" (Ives, 1955). In addition to exploring much of the greater Sonoran area, Kino was the first non-Indian to thoroughly explore the Pinacate-Gran Desierto region and provide maps and detailed records of this area. In order to determine if Baja California was an island, he climbed the Pinacate summit in 1701. He saw that the peninsula was indeed attached, making a connection possible between the chain of missions in Baja California to those on the Santa Cruz River and northern Sonoran region (Ives, 1964).

European exploration continued in the nineteenth century. One noteworthy individual was an ex-English naval officer, R.W.H. Hardy. Employed by a private company to explore the Gulf for sources of pearl and coral, he sailed near the present-day location of Puerto Peñasco in the

summer of 1826 and named the nearby promontory "Rocky Point." Commemorating a friend, he also named the bay south of the Pinacate "Adair Bay" (Hartmann, 1989).

Mexico gained independence from Spain in 1823 only to become engaged and defeated in war with the United States in 1848. Consequently, Mexico lost all of its territory north of the Gila River. The region south of the river did not become part of the United States until 1854 when that land was purchased by the United States in order to secure a suitable route for a New Orleans to San Diego railroad. The international border was thereby relocated to its present location through what is now known as the Gadsden Purchase. That boundary was first surveyed in 1892. The report filed by the surveying parties provided one of the first scientific descriptions of the topography and biology of the region (Report of the International Boundary Commission upon the survey and remarking of the boundary between the United States and Mexico west of the Rio Grande, 1891-1896; cited in Bryan, 1925).

The discovery of gold in California in 1849 encouraged hundreds of gold-seekers to travel across the western United States. Rather than follow the Gila River and risk confronting Apache Indians, many chose to take their chances on the old road from Caborca, Sonora, to Yuma, Arizona (Bryan, 1925, p. 415). They usually elected to do so in the summer, when the threat of attack by Indians was reduced (Barney, 1943). The 225-mile trail passed through the village of Sonoyta, then proceeded north of the Pinacate, near what is today the international border, and skirted the other smaller ranges in the area that held tinajas (natural water tanks). The lack of water and the fierceness of the Pinacateños who guarded the few sources of water and who

sometimes killed and robbed travellers led to the deaths of over 400 would-be miners (Barney, 1943). Lined with the graves of immigrants and the skeletons of livestock, the trail came to be known as "El Camino del Diablo," the Devil's Highway.

The Hia-Ced O'odham fared badly under increasing pressure from both Mexicans and Americans. In 1851, the Pinacateños were decimated by what is believed to be Yellow Fever (Lumholtz, 1912). In 1854, the Gadsden Purchase effectively cut in half the homelands of the Hia-Ced. The northern portion became part of the territory of New Mexico (the territory of Arizona came into being in 1863), and the southern portion remained within the Estado de Sonora. Some O'odham, possibly as many as half of them, remained as Mexican citizens (Fontanna, 1989, p. 69). In 1858, placer gold was discovered on the Gila River. As greater numbers of newcomers arrived in the area, the Hia-Ced, like the Tohono O'odham, were forced into more remote areas. The Pinacateños, considered invincible in their mountain hideaways, developed a reputation as a fierce breed who preyed on travellers of the Camino del Diablo. In the 1880's, the residents of Sonoyta organized a posse to rid the region of the Pinacateños. Lumholtz (1912) maintains that these forces drove the Pinacateños entirely into extinction. It seems more likely that the remaining Pinacateños assimilated into other Hia-Ced and Tohono O'odham communities both in Mexico and the United States to avoid further persecution. Nevertheless, the death of the final Pinacateño, the hermit Juan Carvajales, around around 1915 marked the end of at least 10,000 years of continuous inhabitation of the Pinacates by Native Americans (Hartmann, 1989, based on research by Hayden).

In the United States, the bulk of the O'odham lands, nearly 3,000,000 acres, were set aside in 1917, making the reservation the second largest after the Navajo. The southern O'odham began to migrate north; those who did not flee were slowly engulfed. William Langewiesche (1992) writes:

By 1900 the identifiable population in Sonora had shrunk to a thousand; today it is estimated at two hundred. The holdouts live in remote villages just south of the border, under threat from encroaching ranchers... The official count underestimates the strength of the O'odham in Mexico. It is based on a legalistic definition of the border, and on "pure race" concepts that do not necessarily reflect people's view of themselves. Many O'odham are still semi-nomadic. They live a few weeks here, a few weeks there, and do not let the border stand in their way... Crossing the border is illegal, but there are thirteen gates in the cattle fence, and they are left open...(p. 83).

Flores (cited by Nabhan et al., 1989, p. 509) maintains that between 1,150 and 1,300 people alive today claim to be Hia-Ced O'odham.

Although the Hia-Ced have been recognized by many (including the Tohono O'odham) as a distinct culture, their historic homelands have not been declared a reservation and they are excluded from many of the habitats which they formerly utilized and managed (Nabhan et al., 1989, p. 526). A number of sites within the study area are held to be sacred (see Burquez and Castillo, 1993) and Underhill (1979, 1953) reported that in the 1940's and '50's the O'odham continued to use the ancient system of trails through the region for salt pilgrimages to Adair Bay. (In his accounts of his exploration of the northwestern Sonoran Desert in 1909-1910, Lumholtz (1990, pp. 269-273) provides a fascinating description of the O'odham rituals surrounding the gathering of salt.)

Planning issue: Vandalism of cultural resources

Because of low precipitation and little development, archeological remains are well preserved in much of the study area. However, the interest in and demand for cultural artifacts from throughout the world has grown steadily and few areas are immune to the dangers of intentional and unintentional vandalism. The dangers of unregulated access to cultural sites within the study area is illustrated by the fate of Tinajas Altas, where Kino, de Anza and other explorers of the region watered and where countless '49ers died and were buried beneath graves of piles of stones. Located just outside the boundaries and protection of Cabeza Prieta Game Refuge, the tanks today are "a dusty maze of car tracks and turn-around spots where visitors have parked" (Hartmann, 1989, p. 188). The numerous graves that once marked the area have been largely destroyed. In addition, numerous sites significant to both the Tohono O'odham and Hia-Ced O'odham within the study area have been disturbed. At one time, many of the water holes in the study region were marked by heaps of bighorn sheep skulls which had been cremated by their human hunters in order to pacify the spirits of the dead (Hayden, 1985). Today, "...most of the cremation heaps have been scattered and trampled into the sands by cattle, horses, burros, cowboys, and tourists" (*ibid.*, p. 247). Of greater concern to the O'odham

...is the disappearance over the last half century of artifacts taken from I'thi Ki, the lava tube (an underground corridor formed by lava flow) that is the legendary emergence point of the O'odham after a great flood. It has remained among the most sacred sites of the O'odham, and yet few of the O'odham offerings left there over the centuries remain (Flores, et al., 1990).

Because of easy access provided by Mexican Highway 2, there is concern that American pot hunters may invade remote areas in the Gran Desierto and damage fragile archaeological sites beyond recovery.

Planning issue: Loss of Hia-Ced land rights

The historical presence of the Hia-Ced in the Pinacate and elsewhere in the Mexico portion of the study region is important to establish. Mexican law determines land rights based upon historic documentation of communities present in an area before the first written titles were granted. Despite the presence of such documents, the Mexican government has not approved petitions by the O'odham, maintaining the Hia-Ced are simply recent "intruders" from the United States (Flores, et al., 1990, p. 27). Without some legal means of land rights, the Hia-Ced will continue to be pushed aside by a federal government that encourages agricultural and ranching entrepreneurs to construct irrigation systems and thereby assume control over O'odham ancestral lands (Flores, et al., 1990, p. 29). Aside from the moral implications of a people forced from their homeland, the loss of a culture that had successfully sustained itself over many generations would be contrary to the goals of the 1984 Action Plan for Biosphere Reserves. Supported by UNESCO, the United Nations Environment Programme, the International Union for the Conservation of Nature, and the Food and Agriculture Organization, the Action Plan recommends that each biosphere reserve include "examples of harmonious landscapes resulting from traditional patterns of land use" and that local people "be considered as part of a biosphere reserve [and] encouraged to participate in its management" (UNESCO, 1984). While the

Hia-Ced currently play an active role in the management of Organ Pipe Cactus National Monument (as will be discussed below), such is not the case in Mexico. There are several reasons for allowing them to do so:

(1) In addition to hunting and gathering, the Pinacateños occasionally and the Hia-Ced probably more frequently practiced floodwater farming techniques in a few locations where local geology permitted. This method of farming, employed with great success by the Tohono O'odham, utilizes stormwater runoff, channeling the precipitation into flat, arable patches of flood plain. Although dependent on monsoon rains and therefore highly unpredictable in the study area, ethnobotanist Gary Nabhan (1985) reports that he witnessed one farming family just east of the Pinacate raise marketable crops of native corn, tepary beans, squash and melons near a wash which received only two rains over the course of the growing season. Lumholtz (1990, p. 162) described similar farming methods in the same area at the turn of the century. Nabhan (1985) maintains that floodwater farming was practiced at three sites in the Pinacate and that they are more arid than any other nonirrigated farming areas in the world. This form of agriculture stands in marked contrast to recent groundwater-based agricultural development on the edge of the Pinacate, which is highly subsidized by the Mexican government.

(2) Not only did the Hia-Ced sustain themselves, their agricultural practices may have actually increased biodiversity. Nabhan et al. (1982) compared habitat and biotic diversity at two similar oases in the study area:

Quitobaquito, which is located in Organ Pipe Cactus National Monument and where cultivation has not occurred for over 35 years, and Quitovac, Sonora, where O'odham families continue to practice traditional farming methods. The authors report that the farming methods practiced at the latter oasis created greater habitat opportunities than existed without regular human intervention at Quitobaquito, concluding that the "... diversification of habitats associated with native agriculture has had a beneficial effect on faunal species richness, due to edge effect phenomena, increased insect and seed availability" (p. 124).

(3) Traditional cultures contain a wealth of local ecological information. Nabhan (1990, p. 3) writes: "Diverse native flora are like unknown languages, and native cultures can translate those languages into understandable dialects. The knowledgeable cultures of the Sonoran Desert hold keys to open the doors to an incomparable treasure." He also notes (1992, p. 4) that "... there exists a detailed traditional phytogeography (the study of the origin and distribution of plants) among native peoples... One short-term scientific study of two or three years cannot determine whether a population is increasing or declining—but often the rural people can offer these observations because they have extensive knowledge of the historic changes in abundance and distribution of rare plants." Specifically as regards the study region, Nabhan, et al. (1989) conclude from oral histories of Hia Ced O'odham elders that more than 64 species of plants and 38 animals were utilized in nine distinct natural and anthropogenic habitats within the Pinacate region. Furthermore, in stark contrast to modern practices, Nabhan (1985) concludes

that there is little evidence that the O'odham subsistence activities overexploited any of these food resources, with the possible (and contestable) exception of bighorn sheep. He also notes that there is intriguing evidence that certain plant resources such as sandfood (Pholisma sonorae) may have actually diminished in number since O'Odham gathering has been suspended.

3. Present-Day Communities

The population within the study region is largely urban. At the present time, in the state of Sonora there are approximately three urban residents for every rural resident and urban growth rates far surpass rural growth rates (Vazquez, 1991). Practically no people live in the Pinacate, Gran Desierto or Adair Bay areas (Burquez and Castillo, 1993). The same may be said of the Arizona side of the study area. Only the town of Ajo has a substantial population of about 3,000.

(a) Ajo

According to historian Richard Dillon (1992), the copper town of Ajo is the oldest mining town in Arizona. The present name of the town is probably derived from the O'odham word for red paint, "au' auho." Long before Europeans arrived in the Sonoran Desert, the area's coppery soil was used by the tribe for ceremonial body painting (Martin, 1992). In the early 1700's, Jesuit friars mined the area for silver. Following the expulsion of the Jesuits from the Spanish New World in 1773, Mexicans took over the mines. Rumors flew from the mines of "planchas de plata"--slabs of pure native

silver. The mines were abandoned near the turn of the century, possibly as a result of Indian attacks (Dillon, 1992). In 1847, they were rediscovered by Tom Childs while searching for the famous lost Planchas de la Plata silver mine (Lesure, 1955). He found a series of open surface cuts and a 60-foot shaft complete with mesquite ladders and rawhide ore buckets (Dillon, 1992). Although Childs decided against developing the mine any further at that time, the Gadsden Purchase of 1854 brought more Americans and increased interest to the area. Several outfits operated the mines with varying degrees of success until 1906. In that year, John Greenway, Yale athlete and big-man-on-campus, Spanish-American War Rough Rider, and general manager of the Calumet and Arizona Mining Company of Bisbee, acquired Ajo's struggling New Cornelia copper mine (Dillon, 1992).

Under Greenway's direction, the boom times in Ajo were on. With the assistance of renowned mining engineer Louis D. Ricketts, Greenway developed a new leaching process using sulphuric acid and electrolysis. Copper could then be produced at a competitive price from low-grade ores, thus launching the practice of large scale open pit mining (Dillon, 1992). Unfortunately, the town of Old Ajo (and the site of the original O'odham village) stood over the proposed site of the pit and residents there steadfastly refused to relocate. Dillon reports that "a mysterious fire swept through [the town] and completely destroyed the place. New Cornelia forged ahead" (p. 33). Greenway also addressed one of Ajo's most persistent problems by developing a dependable water supply. (Water was so precious in town at the time that it was sold on the street by the bucketful (Bryan, 1925, p. 136).) He sunk wells seven miles north of Ajo at Childs Ranch and piped the water

into town (Dillon, 1992). By 1916, Greenway had completed the Tucson, Cornelia and Gila Bend Railroad, connecting Ajo with the Southern Pacific line. In that same year, he began plans for the new (and present) town of Ajo. Together with his wife, Isabella, who subsequently directed construction, they planned the new community around a downtown Spanish-style town square featuring a central park surrounded by retail shops, restaurants and a mission-style church (Ajo Chamber of Commerce). In 1921, Greenway sold out to the Phelps Dodge Corporation, which presently owns the mining operation (Dillon, 1992). In 1923, Greenway built for Isabella the Greenway Mansion which today overlooks Ajo. He died in 1926. (Not long after, Isabella moved to Tucson, became Arizona's first congresswoman and built the Arizona Inn.) In 1984, a bitter conflict between Phelps Dodge and the unions combined with falling copper prices to close the mine and, a year later, the smelter was shut down (Martin, 1992). The Spanish colonial town plaza is still owned by Phelps Dodge as are the utilities and a number of what were once company homes. The present population of the town stands at about 3,000 (Ajo Community profile).

(b) Puerto Peñasco

Puerto Peñasco and its immediate environs have had a long history of human occupation. The Hia-Ced O'odham utilized the coastal area for gathering shellfish. Piles of discarded shells still remain on the sand dunes of Adair Bay. Occupation by the Hia-Ced may date to 5,000 years ago or more (Hayden; cited by May, 1973). Other O'odham clans and the Hohokam also traveled to the area; the former for salt and the Hohokam for shells for

jewelry (Hayden, 1967, 1970). No permanent settlements were possible in the region because of the lack of freshwater.

The first Hispanic settlers began moving into the area around 1926, originating mainly from other fishing camps along the coast such as Puerto Lobo, Puerto Libertad, Bahia de Kino, and Guaymas. At the same time, the town began to gain a reputation as a tourist destination. Prohibition laws in the United States in the 1920's encouraged Americans Thomas Childs (the same Tom Childs who would later figure largely in the history of mining in Ajo) and John Stone to construct hotels and gambling casinos in the village during that period. Stone also constructed the first well in Puerto Peñasco; the community had previously depended on water trucked in from Sonoyta. In addition, Stone obtained the permission of the Mexican government to fly in American guests for vacations of fishing, hunting, gambling and, of course, drinking. However, according to historian Guillermo "Memo" Munro (1988), Stone raised the ire of local officials by refusing entrance to Mexican fishermen and in 1931 his license was revoked. In retaliation, Stone burned his hotel and dynamited the well, leaving the town once again without a local source of water. Residents had to again depend on water trucked in from Sonoyta. The dirt road from that town to Puerto Peñasco was occasionally flooded and frequently wiped out by blowing sands, making the twelve-hour drive through the desert a hazardous undertaking (KUAT, 1988). (In hindsight, it is likely that Stone's well was largely seasonal and only adequate for the very small population of the town at that time (Bodenchuck, 1993).)

Meanwhile, Puerto Peñasco, the fishing village, grew rapidly. In 1941, completion of the railroad connected Puerto Peñasco with the towns of Sonoyta, Mexicali, and San Felipe in Baja Norte. Five years later, the highway between Sonoyta and Puerto Peñasco was also completed (Fimbres, 1985) followed shortly by the construction of a breakwater and a small harbor. Greater access and a vigorous economy increased migration into the area. Ives (1989) described Puerto Peñasco in 1950 as "...a modern city of hope on the western bastion of the arid and unproductive Sonoran Desert... Population growth is rapid, market demand for refrigerated fish exceeds the current supply, ship building and repair work is in demand, and conditions are improving rapidly" (p.129). This rapid rate of growth continued unabated until recently when declining catches forced many fishermen out of business. The present population stands at about 26,000 (INEGI, 1991b).

At the same time, tourism has increased tremendously. The early 1980's witnessed the "rediscovery" of Puerto Peñasco by Americans and the beginning of a tourist boom which continues today (KUAT, 1988). Estimates of the annual number of visitors range from 240,000 (Munro, 1988) to about 550,000 (SIUE, 1992). Tourism will be discussed in greater detail below.

(c) Sonoyta

The oldest community of those profiled in this report is probably the "ancient Papago oasis of Sonoydag" (Ives, 1955, p.201). Located on the banks of the only perennial stretch of the Sonoyta River, Ives (1941) noted that "there is no geologic or legendary evidence that the springs have ever gone dry" (p. 21). For that reason, it has probably been continuously inhabited by

man for as long as he has occupied this area and for as long as water has been in short supply. Ives estimated that the town has been inhabited between 2,000 and 4,000 years, first by Hohokam and subsequently by O'odham. He surmised that the village population was about 400 people. The first confirmed visit to the village by a European was that of Father Kino who, after travelling to the Colorado River, returned through the Gran Desierto and arrived in the little village that he named San Marcelo in 1698 (Ives, 1955). In his letter to Father Visitor, Kino described the settlement as "a post very suitable for a great settlement, because it has good pastures and rich lands, with their irrigation ditches, and with water..." (*ibid.*, p. 202). In later visits, Kino brought cattle and seed for wheat; by 1701, the people of Sonoyta were successfully raising both and a small church, San Marcello del Sonoytag, was established (*ibid.*). Fifty years later, the mission was destroyed and its only resident missionary, Father Ruhen, was killed during the Pima revolt.

The village remained largely in the backwaters of European exploration until the discovery of the California goldfields in 1849. As the only dependable source of water and forage for horses on the 225 mile Camino del Diablo, the village once again became an important supply point (see the section entitled "European Exploration" earlier in this chapter for more information). According to Ives (1955), over 500 would-be migrants died on the camino.

Changes in the local water table, possibly due to a large earthquake in 1887 (Hartmann, 1989), led to the abandonment of the old townsite in 1890 and its relocation to its present site, about 1 1/4 miles downstream (*ibid.*). The

population of the town was estimated 15,000 in 1988 (Brown, 1991); it is expected to increase to 35,000 by the year 2,000 (Hartmann, 1989).

(d) Lukeville

Lukeville is an unincorporated community, developed on private lands at the terminus of Arizona Highway 85 where it meets the international border. All land within the community is within Organ Pipe Cactus Monument except for the Customs and Immigrations Service. Present landowners are Customs and Immigration, Gringo Pass, Inc. (which operates the community's visitor facilities), one other private holder, and Organ Pipe Cactus Monument (National Park Service, 1978). The management objectives of the monument call for the eventual purchase of all private inholdings within the boundaries of the park. Approximately 60 acres of private land remain within the monument (*ibid.*).

(e) Other communities near the study area:

San Luis, AZ: population 6,200

San Luis Rio Colorado, Sonora: pop. ca. 250,00 (one of the fastest-growing cities in Mexico)

Yuma, AZ: population 55,000

C. Modern Activity in the Region

1. Resource Extraction

(a) Mining

Ajo

The town of Ajo was built by Phelps Dodge to house miners and their families. Mining provided an excellent livelihood for employees while it lasted. In 1980, the average Ajo household was more affluent than those in either Pima County or the state of Arizona (Western Pima County 2000, 1992). Dependent as it was on the copper industry, the town was hit hard by the closing of the mine in 1984. In 1980, an estimated sixty percent of all employed residents worked for the Phelps Dodge Corporation (Western Pima County 2000, 1992). After the mine closed, the number of employed persons as well as the overall population of the town decreased by approximately fifty percent. Today only 7.9 percent of the work force is employed in mining or agriculture, while almost 70 percent is employed in retail sales or services (Arizona Department of Commerce, 1991). The local 30-bed hospital closed in 1985 and today the nearest hospitals are in Phoenix and Tucson. Also in 1985, Phelps Dodge began selling off company-owned homes. It still owns and operates several of the town's utilities as well as the historic plaza and the buildings which surround it. At this time, the company's plans are to divest itself of its remaining property in town and restrict its interest to mining. It considers the mine to be temporarily closed (Western Pima County 2000, 1992). At the present time, approximately equal numbers of Ajo households have incomes of less than \$10,000, between \$10,000 and \$20,000, and between \$20,000 and \$40,000 (Bureau of the Census, 1990).

Other Mining Operations

Within the Pinacate region, there are several mining operations which extract volcanic cinders. According to Burquez and Castillo (1993, p. 126), the

cinders are largely exported to the United States. These same authors state that these operations have grown dramatically in the last ten years and that there are increasing animosities between the mine's owners, who live in Puerto Peñasco and Sonoyta, and the local residents and land owners. These mines are located for the most part on the north and northeastern sides of the volcanos, at the edges of the lava flows and relatively close to Mexico Highway 2. According to Burquez and Castillo (1993), the mines are degrading the biological and visual values of the landscape not only through the operations themselves, but also as a result of the network of roads which lead to them and into the surrounding areas.

In addition, Burquez and Castillo report that sand and gravel are extracted from the bed of the Sonoyta River near its junction with Highway 8. As is the case in the removal of volcanic cinders, this operation is generating ill will among the local residents. According to Burquez and Castillo, the mine's employees have destroyed fences and the operation has caused the river to flood its banks during storm events. The authors report that further animosity is generated by the fact that the owners of the sand and gravel operation are not local residents but live in Puerto Peñasco.

Finally, the U.S. mining company, Hecla, has begun a gold mining operation about eleven kilometers south of the afore-mentioned Quitovac farming oasis in the state of Sonora. In the last three years and with the assistance of the World Bank, Mexico has opened its doors to foreign mining companies. Near the international border in the state of Sonora, about 120 companies have filed applications for mining. If the the Quitovac mine is any indication, it appears that the Mexican government's environmental

standards are much less stringent than those in the U.S. Gary Nabhan (1994) states that Hecla's environmental report is inadequate and that local residents have not been fully informed of the possible consequences of the mine. There is concern that the large volumes of water necessary and the process of cyanide leaching will have detrimental effects on the local water table.

(b) Fishing

As was discussed earlier in this chapter, fishing was a very lucrative industry. However, without some form of control, it was carried on at an unsustainable rate. Today the consequences are similar to those of the played out mines of Ajo: a marine ecology that is probably extensively damaged and an industry that may never recover.

Planning issue: The liquidation of natural capital

The mining town of Ajo provides an excellent example of the costs and benefits of an economy based entirely on natural resource extraction. While the mine was functioning, local residents enjoyed a financially higher standard of living than did most southern Arizonans. However, in reality, the town had only half of an economy. The other half--reinvesting the profits of that industry back into the community-- occurred only marginally. While the community continues to enjoy some of the services and infrastructure remaining from the boom days, it has struggled to develop alternative economies since the closing of the mine. In addition, the local landscape will bear the scars of the open pits and the huge tailings piles that will remain for centuries if not eons. These eyesores would seem to

compromise the future of Ajo as a retirement community. An even less attractive future may yet unfold in Mexico where it appears that outside mining interests with no stake in the well-being of the local communities have secured control over what may prove to be a quite lucrative (estimates run as high as \$60 million) operation.

A similar theme runs through the history of fishing in the upper Gulf. Tremendous fortunes were made from fishing, especially from shrimp. However, the profits from fishing were not reinvested back into the community, but instead were directly enjoyed by the individual fishermen and their families (Hartmann and Hartmann, 1995). Consequently, today the fishing villages of the upper Gulf are struggling to deal with shifting economies.

2. Agriculture

(a) Farming

As discussed earlier in this chapter, the primary planning issue is the fact that Mexican government subsidies have led to a rapid increase in the number and efficiency of groundwater pumps. Consequently, the water table is dropping rapidly as indicated by the loss of native riparian vegetation and the downcutting of the Sonoyta river. Natural and human communities on both sides of the border may be affected.

(b) Grazing

Livestock grazing in the Mexican portion of the study area was discussed earlier in this chapter.

Livestock grazing on the U.S. side of the border has a long history, dating back to when the Spanish first came into the region. However, in recent years, it has decreased considerably, both because the lands were devoted to other purposes and because of market factors. Cattle were entirely removed from the Barry M. Goldwater Air Force Gunnery Range in 1941, from Organ Pipe Cactus National Monument in 1978, and from Cabeza Prieta National Wildlife Refuge in the early 1980's. Livestock grazing on the U.S. side of the border now occurs on Bureau of Land Management administered public lands within the study area, as well as on private and state-owned lands. The public lands are divided into grazing allotments of varying size and carrying capacity. All are cattle operations. Some have year-round operations along with what is termed ephemeral use, while others have only ephemeral use. Ephemeral use is grazing permitted during years of good winter rains, when livestock numbers can be increased to take advantage of more abundant forbs and annual grasses (Schumacher, 1993).

(c) Ejidos

Any discussion of agriculture in the study region must include the ejidos and the fact that they play a central role in the rural economy of Mexico. According to Brown (1991),

Ejidos were established as part of the agrarian land reforms which began in 1917 when the government initiated land redistribution programs to reduce large land holdings by individuals and to provide access to landownership for a larger number of people. Ejidos are similar in ownership to Indian trust lands in the United States. Lands are assigned to individuals and can be utilized, developed, and even passed on to family members but cannot be sold. The ejido is a miniature community with a group of people having adjacent land

assignments living in a central area sharing equipment and facilities. A formal organization exists for each ejido with elected officers to represent interests of the ejido in business, government programs, and political affairs. A centralized governmental structure exists to provide close control of crop production on all lands. This function is handled by the local office of SARH [Secretary of Agricultural and Hydrological Resources]... The majority of ejidos in Mexico are small in size, in the range of 2 hectares (ha). Ejidos in the Sonoyta Valley are somewhat larger, ranging from about 10 to 500 ha in size (p. 29).

Changes in the laws regarding land ownership of ejidos and the role of ejidos in the local economy will be discussed below.

3. Tourism and service industry

(a) Puerto Peñasco

As discussed earlier in this chapter, Puerto Peñasco has had a long and colorful history as a tourist destination. At the present time, visitors can choose from about sixteen hotels and motels, seven recreational vehicle (R.V.) parks, numerous rental homes, and several camping areas. The peak of the tourist season is spring. Unlike the winter season during which mostly retired Americans tend toward quiet and subdued activities, spring is marked by more of a party atmosphere. Warmer temperatures and the sea attract a larger and younger crowd during college vacations (Turk-Boyer, 1993).

Planning issues: The consequences of tourism in Puerto Peñasco

(i) The Present

Although visitor accommodations have generally stayed apace with the increased number of tourists, the town's water and sewer systems have not. During the peak tourist season, water is typically unavailable for up to two hours per day (Turk-Boyer, 1993). In addition, Puerto Peñasco relies on

water piped in from two wells located 20 and 50 kilometers outside of town in the Sonoyta River watershed (SIUE, 1992). When repairs are required to the pumps or pipelines, the town may be left without running water for several days (Turk-Boyer, 1993). In addition, the city's sewage treatment plant is located at a higher elevation than the densest urban and tourist areas along the coast. Consequently, sewage cannot flow to the plant from these areas and untreated wastewater is discharged directly into the sea (FONATUR, 1993), creating a hazard to both humans and wildlife.

Many tourist developments in and near Puerto Peñasco rely on concrete septic tanks. Because these developments frequently are near the water's edge where the water table is quite high, wastewater which leaks from the septic tanks can quickly move through sand into the saline groundwater and hence into the nearby sea (Cordova, 1993). Similar wastewater problems seem to have occurred in tourist developments on nearby Cabo La Cholla. Septic systems there were built on impervious granitic soils. As a result, wastewater is leaking into Cholla Bay and polluting the water (FONATUR, 1993). Oysters from the bay are therefore not suitable for human consumption (Turk-Boyer, 1993).

(ii) The Future

Puerto Peñasco is the home port of a substantial fishing fleet of approximately 240 vessels which historically depended on shrimp for the greater part of its catch. According to Rodolfo Irineo Flores, director of Development and Planning for Puerto Peñasco, 70 percent of the community's economy was based on shrimping and fishing (Hardie, 1993).

With the decline of the shrimp industry, the town is looking to tourism as a possible remedy. Sr. Filberto Alfaro Cázares, State Coordinator of Operations for Solidarity (Mexico's public works program), believes that as the nearest ocean beach to the cities of Tucson and Phoenix, Puerto Peñasco can be transformed into the "tourism center of the state of Sonora" (*ibid.*). The state is offering loans to fishermen and small businesses to encourage economic growth in the community. Loans have been made thus far to about 100 small businesses, ranging in purpose from remodeling and expanding existing stores and restaurants to starting aquaculture farms for cultivating oysters and shrimp (*ibid.*). City and state officials are also seeking outside national and international investors in order to further develop tourism (*ibid.*). Hoping to attract serious attention, the highway from Sonoyta to Puerto Peñasco was recently widened and work is currently underway on the Caborca-Puerto Peñasco highway. There are also plans to expand the local airport in order to accommodate flights from the United States (*ibid.*).

Central to these plans for a greatly expanded tourist industry are recent changes in land ownership which make investments attractive to foreign companies and individuals. Under the direction of former President Salinas, the federal government has radically shifted its policies regarding the administration of ejidos (collectively-owned communes, as discussed earlier). These changes in Mexico's Agrarian Reform Law are known collectively as Article 27. The bottom line for the Puerto Peñasco area is that it is now possible for members of ejidos to sell their properties to foreign investors for subsequent development. One of the new ways privatization of ejido lands is being facilitated is through FONATUR, Mexico's tourism development

agency. In the fall of 1992, a landmark agreement was reached authorizing the first U.S. company (Scottsdale's Realty Network, Inc.) to market tourism properties held by FONATUR, and to draw commissions from subsequent real estate deals. Although U.S. brokers have worked independently to market smaller projects in Mexico for years, this is the first time that FONATUR has embraced the concept of bold U.S. marketing with commissioned brokers to promote large-scale tourism development (Herr, 1992).

The prospects for tourism appear bright. As discussed earlier in this chapter, the 1980's witnessed the "rediscovery" of Puerto Peñasco by Americans and the beginning of a tourist boom which continues today (KUAT, 1988). Estimates of the annual number of visitors range from 240,000 (Munro, 1988), 254,500 (Turk-Boyer, 1992), to 546,287 (SIUE, 1992). Depending on subsequent development, FONATUR (1993), Mexico's tourism ministry, estimates that visitation may reach 1.2 to 1.7 million by the year 2000.

However, there is cause for concern, both in principle as well as practice. Lea (1988) describes international tourism in less developed countries as a highly "volatile industry":

There is no other international trading activity which involves such critical interplay among economic, political, environmental, and social elements as tourism.... The temporary presence of mainly white and relatively wealthy foreigners in tourist hotels, situated at scenic locations in some of the world's poorest countries, is a scenario fraught with risk and opportunity (p.2).

Britton (1980) reports that tourism may contribute little to "...indigenously defined economic and social development" of host countries. He maintains that proponents of tourism tend to exaggerate the economic benefits while

ignoring "...adverse social, political, cultural, and environmental impacts" (p. 241).

More specific to the study area, there is concern regarding the type and quality of development that is now occurring in Puerto Peñasco. Central to this issue is the fact that Mexico does not have a comprehensive, integrated coastal zone management program and will not have one in the near future (Merino, 1987). If individual states are interested in initiating their own coastal zone management program, they have to implement it on their own (Clark, 1989). Rapid coastal development is taking place in several coastal states in Mexico, and the need for a comprehensive approach is apparent (Valdes-Casillas, 1989; Marshall, T. 1993). One of the dangers to the local community of proceeding with unplanned coastal development lies in the possible economic consequences. If Puerto Peñasco is developed as an international resort, the resulting economy might be similar to those resulting from natural resource extraction: an economy driven by outside interests providing minimal returns. There are several possible underlying causes:

(1) The very nature of tourism is one that is by definition dependent on the economic well-being of outsiders. The greater the dependency of the local economy on tourism, the more susceptible that community is to outside forces. It should also be recognized that no matter how much the tourism industry grows, it will probably remain a seasonal business. Summer temperatures which average over 100 degrees F are simply too uncomfortable for the majority of travelers.

(2) At the present time, tourist development in the Puerto Peñasco area provides little economic return. Most development there typically consists of privately-owned vacation homes that are located on narrow lots arranged in linear fashion parallel to the water's edge on the beaches outside of town. Planning authorities recognize that development of this sort compromises the quality of the beach by restricting access to the water (SIUE, 1992). They also realize that aside from the sale of land and construction costs, development of this type contributes little to the economy of the community (Joseph, 1992; SIUE, 1992). They are proposing greater investment in hotels, condominiums, and recreational facilities that would create permanent jobs for local residents (SIUE, 1992). However, at this time there seems to be little incentive to change the way in which development is proceeding. As the fishing industry has declined and as tourist development continues to expand from Puerto Peñasco, beach-front property becomes more valuable. Local fishing communes (ejidos) find that an easy way to generate income is to sell their land as is now permitted by Article 27 (Turk-Boyer, 1993).

(3) By selling their land and failing to reinvest in the community, fishermen may find themselves outside the benefits of a tourist boom. In addition, there are currently nine developments in process (all former ejidos) that are located near local estuaries and there is at least one proposal to create a marina at Estero Morua (Turk-Boyer, 1992). Estuaries are extremely susceptible to disturbance and are completely destroyed by the dredging necessary for creating a marina (*ibid.*) They are also among the most productive marine

environments. Larval fishes find nourishment there and, at the same time, are themselves freer of competition than they would be offshore. It is estimated that over 70 percent of all commercially valuable marine fishes rely on estuarine areas during at least part of their lives (Amos, 1980). The local estuaries appear to be no exception. Despite the absence of freshwater, the area's estuaries are rich in organic matter provided by halophytes and they serve as nursery grounds for many commercial and non-commercial species of fish, molluscs, and birds (Turk-Boyer, 1992). If development continues to proceed as it has thus far, it would appear that the biological productivity of the Upper Gulf would be significantly compromised. Fishing as a viable economic industry would suffer accordingly. Local economies would become more dependent on tourism.

(4) Instead of aiding locally-owned small businesses that are dependent on tourism, a boom in tourism may actually financially endanger them. The primary cause for this threat is the fact that Mexico's banks were privatized in 1991-1992. The new owners of the banks have been reluctant to approve loans to small businesses which typically offer small rates of return and have high risks (Lazaroff, 1993). Therefore, small businesses in Mexico are frequently less able to obtain funds for starting up or for expansion. Another danger to small businesses is the fact that in 1986, Mexico joined the General Agreement of Trade and Tariffs, a world trade body now comprising 108 members. A condition of membership was to reduce import tariffs. Consequently, foreign-made products that previously were not widely available began to appear in Mexican stores. Small businesses in Mexico now

find themselves competing with U.S. and Mexican big-name chains (such as fast-food restaurants and department stores) that can offer better prices through volume discounts (Lazaroff, 1993). Such a scenario is possible if Puerto Peñasco begins to attract serious national and international interest.

(5) Another consequence of growing tourism was provided earlier in this text: future problems due to the lack of freshwater in the region. Increased human development such as a proposed golf course will require additional water. Pumping more groundwater from the Sonoyta watershed will not only generate human conflicts of interest between tourist-dependent industries and farmers but also affect sources of water for wildlife. Perennial springs in the area are rare. How they will be affected as the water table is lowered remains uncertain.

On the positive side of tourist development, there are indications that a growing number of tourists are attracted to areas because of the natural resources of these areas (Boo, 1991). While the economic incentives to maintain sanitary beaches are obvious, perhaps less apparent are the benefits gained by restricting development in some areas. Local estuaries, for example, are valuable not only as sites for marinas but also for observing wildlife, such as migrating birds. Economic studies performed in southern Arizona indicate that bird watchers contribute up to ten percent to the gross economy of Santa Cruz county (Leones, 1992). Such studies demonstrate the real economic potential for preserving natural areas. The opportunities for tourism based on enjoying natural resources is substantial in an area with so

little modern human development. Activities such as observing wildlife, sea kayaking (which is currently enjoyed on the east coast of Baja), and multi-day tours of the Pinacate and Gran Desierto are possible.

(b) Ajo

Like Puerto Peñasco, the community of Ajo has witnessed a dramatic shift in the way in which residents gain employment. With the closing of the Phelps Dodge copper mine in 1985, more than half the town's employed residents were laid off and moved away from Ajo (WPC 2000, 1992). The population has recovered from a low of 1,600 following the mine's closing to a population of about 3,000 at the present time.

Tourism is offsetting some of the losses incurred by the shutdown of the mine. One immediate benefit to tourism that the mine's closing provided was the return of clear air. Smoke from the smelter and dust from the mining operation in general used to cloud the horizon at least as far south as the Pinacate region (May, 1973). The mine's closing also left a huge inventory of low-cost company-owned housing which Phelps Dodge began selling off in 1985. Another holdover from mining days is the large number of facilities and services offered for a town of its size. Finally, town officials point to Ajo's climate and its adjacency to public lands and Mexico as attractive to tourists.

Ajo does seem to be attracting increasing numbers of retirees. Sales of company homes to retired people from outside the community has grown from forty percent in 1985 to ninety percent in 1992 (WPC 2000,1992). After one year of a national campaign aimed at the active retirement population,

the town had a surge of new residents and a net gain of 76 mostly service jobs (Herr, 1992b). Employment figures reflect the shifting local economy. In 1990, seventy-seven percent of all employed people were involved in retail business or in construction and real estate. Only eight percent were employed in mining (WPC 2000,1992). As Jack Garchow, county constable and member of the Community Council, states, "There isn't any huge industry here now, other than gray hair" (Herr, 1992b).

4. Maquiladoras

At this time, the only town near the study region in which export-based manufacturing (or maquiladoras) is becoming economically important is that of San Luis Rio Colorado in which 13 maquiladoras are located (Vazquez Ruiz, 1991). That same town is also planning on constructing a large industrial park (Burquez and Castillo, 1993). City officials are apparently interested in increasing the industrial bases of both Sonoyta (Burquez and Castillo, 1993) and Puerto Peñasco (SIUE, 1992). The fact that Highway 8 is being expanded may aid in this development.

Planning issue: Indications of change in the regional economy

Within the state of Sonora as a whole, it appears that trade in manufactured goods have replaced agriculture and fishing as the primary state export, climbing from less than 10% of total exports in 1986 to 80% in 1988. (Ford Motor Co. held the largest share (39%) of Sonoran exports in 1987.) At about the same time, fishing, which represented nearly 45% of exports in 1985 fell to 5% in 1988. These changes also appear to be reflected in

the state of Sonora's economy. As reported by the state, "industry", which includes manufacturing, has grown from 11% of the state's economy in 1960 to over 30% in 1986. (Of that share of the state's economy, manufacturing represents about 40%, construction 33%, and mining 25%.) At the same time, "agriculture and fishing" have dropped from 35% of the state's economy in 1960 to 15% in 1986. It is interesting to note that the "service sector" (including professional and unskilled workers) has changed relatively little over the same time period, earning approximately 50 to 60% of the state's economy (Estado de Sonora, 1992).

As noted above, the economy of Ajo has also changed dramatically since the closing of the mine.

5. Transportation

The oldest network of overland communication in the study region is the system of trails left by the original human inhabitants of the area. Many of these trails are still visible within the Pinacate region and in the vicinity of some of the tinajas (see Hayden, Hartmann). The Camino del Diablo, which ran from Caborca through Sonoyta to Yuma (as was discussed earlier in Chapter 3), was probably originally a Native American trail. This trail/road, which roughly parallels the modern international border, continued to act as a thoroughfare of the region well into the age of the automobile. Today the pathway is designated as a Backcountry Byway within the United States.

The growth of Puerto Peñasco in the 1940's and '50's and the fact that townspeople relied on water from Sonoyta would seem to indicate that Mexico 8 was the first road to be used in the area on a regular basis. According

to Ives (1989), the two-lane highway was paved in 1946. It was expanded to four lanes in the winter of 1993-94.

Arizona State Highway 85 connects Ajo with Lukeville and was also paved in 1946. The southern terminus of Arizona Highway 85 marks the Lukeville, Arizona/Sonoyta, Sonora, international border crossing. The border crossing here is the only major crossing for approximately 420 kilometers (250 miles) between Nogales to the east and San Luis to the west. The highway is of particular interest because it bisects Organ Pipe Cactus National Monument, effectively dividing the monument in two.

Planning issue: Consequences of increased traffic

The consequences of highway traffic to the monument's wildlife are unknown. Evening traffic on Highway 85 is clearly visible from both the campground and park headquarters, thereby diminishing one of Organ Pipe's attributes: its excellent location for star-gazing (Brown, 1991). Because the border crossing at Lukeville/Sonoyta is closed between midnight and 6:00 AM, traffic at night is fairly light (*ibid.*) and impacts to wildlife and human visitors might be less than expected. There is interest in making the Lukeville/Sonoyta crossing a twenty-four hour crossing. Doing so would facilitate the delivery of (and therefore the market for) agricultural products from Sonoyta. It could also increase international commercial traffic through the town of Ajo. Unfortunately, doing so could also increase impacts to both wildlife (much of which is nocturnal in the area) and humans.

In terms of vehicular traffic, the most important highway in the region is Mexico 2. The sole connecting highway between Baja California and the

mainland, it replaced an older road that paralleled parts of the still more ancient Camino del Diablo (Hartmann, 1989). The Sonoyta-San Luis Rio Colorado stretch was completed in 1956 and it allowed relatively easy access to the north and west sides of the Pinacate and to Tinajas de los Papagos.

Hayden (1967), for one, was grateful for the easier approach:

The Mexican woodcutters from San Luis who immediately began to search the arroyos in the lava flows for ironwood and mesquite laid down an ever-widening network of truck tracks, many of which followed Indian trails. Utilization of the new highway and the side tracks, then, made possible short-term archaeological survey trips into the lavas, for which formerly weeks of arduous labor would have been required. All credit must be given to the woodcutters who have, with their dilapidated trucks, with a barrel of water, a sack of frijoles, and an abiding faith in God, laid down tracks where no sensible person would have driven an army truck (p.335).

Unfortunately, easier access afforded by the highway allowed for resources of the area to be overexploited. As noted earlier, large mesquite and ironwood trees are becoming increasingly rare in the study region. Desert bighorn sheep are rarely sighted within the Pinacate, in part because of poaching, and stonecutters harvest slabs of basalt for facing buildings (Hartmann, 1989). In addition, similar to State Highway 85, the thoroughfare itself is an environmental liability. The fact that a major highway essentially divides the U.S. protected areas from those in Mexico undoubtedly has consequences for some species of migrating wildlife. Unlike Highway 85, traffic on Mexico 2 does not diminish at night. During the evening, a steady stream of traffic can be observed from the national monument as it moves west of Sonoyta on the highway. Many of the vehicles are large tractor-trailers which, in addition to making substantial noise, are completely outlined with running lights

(Brown, n.d.). These environmental liabilities will probably increase in the future as traffic on Mexico 2 is expected to grow. A four-lane highway between Tijuana and Mexicali was projected to be completed by 1994 (Mexicali is only 50 miles from San Luis Rio Colorado and Yuma). In addition, the Mexican government plans to expand Highway 2 from two-lanes to a four-lane toll road between Santa Ana (in central Sonora) and San Luis Rio Colorado by 1997 (Mead, et al., 1993).

The North American Free Trade Agreement will obviously have implications for the network of highways of both countries. Both Arizona and Sonora will stand to benefit as increased commerce between the United States and Mexico is directed through these two states. The two border states will gain revenue and jobs created by cross-country trade such as warehousing, distribution, packaging, processing, customs brokering and freight forwarding. There are several possible trade corridors from Canada through the United States into Mexico that are currently being proposed by various states and agencies. At this point, it is too soon to predict what the consequences will be to the Western Sonoran Desert Border Region but it seems likely that Mexico 2 will play a large role. The other highways will also increase in importance if a coastal highway from Puerto Peñasco to Guaymas now under consideration is completed.

In addition to the system of interstates, there is a railroad in the Mexican portion of the study region running from San Felipe and Mexicali, through Puerto Peñasco and on south to Caborca.

6. Smuggling

Those same qualities that make the Western Sonoran Desert Border Area attractive to conservationists also interest parties pursuing less legal activities. The remote emptiness of the region and the long international border make smuggling any commodity into the U.S. attractive. William Langewiesche (1992) reports that because marijuana is bulky and therefore somewhat difficult to conceal, it goes around official ports of entry as it is passed through the Sonoran Desert. It is smuggled in pickups or on the shoulders of a string of backpackers who may walk their 100-pound loads fifty miles north of the border, hiding them near state highways. Langewiesche maintains that on the O'odham reservation where unemployment is high, smuggling may constitute the most common occupation among the O'odham. It would seem unreasonable to assume that such activity is limited to the reservation. Hartmann (1989) reports that the 1970's and '80's saw a proliferation in the number of dirt airstrips laid out in the flatter areas of desert pavement in the vicinity of the Pinacates. In rural border communities particularly in northern Sonora, the lawless conditions created by the drug smuggling have encouraged cattle rustling and a general atmosphere of fear among residents (Langewiesche, 1992). What affects these activities will have on the Pinacates remains to be seen. Hartmann (1989) reports that a friend who frequents the Pinacate no longer drives in the area at night for fear of meeting with well-armed smugglers. There are indications that the U.S. Border Patrol will construct a road that parallels the international boundary in order to better police the border.

D. Public Land Management

1. United States

(a) Organ Pipe Cactus National Monument

Named for an indigenous species of giant cactus (Semairocereus thurberi), Organ Pipe Cactus National Monument (OPCNM) was established for its rich diversity of desert plants not found elsewhere in the United States. Its unique fauna notwithstanding, writer Tom Miller maintains that the park was at least partly the result of its unique location: state legislators wanted a paved road to the border to allow for easy access to Mexico and inexpensive liquor. Designated in 1937, the monument today stretches about 30 miles along the international border and comprises an area of about 300,000 acres. It is managed by the National Park Service. From 1699 until 1975, cattle were grazed in the area which resulted in visible erosion and floral species composition changes (Risser and Cornelison, 1979). Mining, excluded from the monument at the time of its designation, was allowed to return in 1941 because of the war. It was again excluded in 1978 (Hartmann, 1989). In 1976, OPCNM was proclaimed an International Biosphere Reserve as an outstanding example of the Sonoran Desert ecosystem under the United Nations Educational, Scientific and Cultural Organization's (UNESCO) "Man and the Biosphere" (MAB) program. In 1978, 312,600 of the monument's 330,689 acres were designated as wilderness.

OPCNM has made some noteworthy progress with respect to incorporating the goals of the MAB program. In 1986, the monument launched the Sensitive Ecosystems Program, a long-term program of inventory, monitoring, and research for lands both within and adjacent to the park. As part of this program, monument managers have developed a

geographic information system in cooperation with adjacent land managers. More recently, managers have initiated studies in coordination with Mexican scientists that documented the overdraft of groundwater reserves by Mexican farmers and that strengthened the scientific basis for restructuring practices to reduce water use. In addition, OPCNM programs have pioneered attempts at including the O'odham in cultural resource management and interpretation of biosphere reserves. Tribal members have been closely involved in archaeological surveys. Spiritually significant objects earlier taken into museum collections from the monument have recently been returned to their origins, repatriated in O'odham ceremonies on the land with the full cooperation of the monument management. Tohono O'odham also have free access to burial sites in OPCNM, and continue to honor Day of the Dead ceremonies there (Flores, et al., 1990).

(b) Cabeza Prieta National Wildlife Refuge

In 1939, the Cabeza Prieta Wildlife National Refuge was established to protect the dwindling numbers of desert bighorn sheep and pronghorn antelope. Running along the international border for approximately 55 miles, it is managed by the United States Fish and Wildlife Service. Permits required for entry into the refuge help regulate visitation and ensure that natural and cultural resources within are not degraded. However, the neighboring Barry Goldwater Range includes airspace over much of the refuge and there is some concern that low-flying aircraft and the use of live ordinance near the refuge has a deleterious effect on the bighorn sheep (Williams, 1993, p. 77).

(c) Barry Goldwater Range

The Barry Goldwater Range (BGR) was established in 1941 and contains approximately 2.8 million acres (4,186 square miles) of land and air space, making it the second largest land-based military range in the United States. The land does not "belong" to the Air Force, but military operations are the priority use of the area (Kline, 1992). Management authority for military operations lie with the Air Force, but the Marine Corps use the western half of the range (Kline, n.d.). The Bureau of Land Management (BLM) administers the lands, natural resources, and non-military uses in both the Western and Eastern Sections.

The major use of the BGR established by law is military use and training. According to Kline (n.d.), the Goldwater Range is the premier U.S. training range for aerial warfare tactics. Much of the range is undisturbed, due in part to the fact that livestock grazing, mining, oil and gas drilling, and off-road driving are prohibited by law as incompatible with military use. The dropping of bombs and aerial gunnery are done in specified areas which comprise a total of less than 10 percent of the total range (Kline, n.d.). However, a University of Arizona report concluded in 1986 that the protective aspects of military use for the Range environment have become strained as the cumulative impacts from expanding military and nonmilitary uses have taken their toll on the area's natural and cultural resources" (School of Renewable Natural Resources, 1986, p. 1-1). Recognition of these environmental threats led to the formulation of the "Luke Air Force Range Natural Resources Management Cooperative Agreement" (NMRCA)

between the U.S. Air Force, the U.S. Navy Marine Corps, the U.S. Fish and Wildlife Service, the Bureau of Land Management, and the State of Arizona Game and Fish Department. The primary objective of the agreement is education of both military and non-military users. In addition, the BLM designated three Areas of Critical Concern within the range: the Tinajas Mountains, the Mohawk Mountains and Sand Dunes, and the Gran Desierto Sand Dunes.

2. Mexico:

(a) The Pinacate and Gran Desierto del Altar Biosphere Reserve

The Pinacate area was first designated as a protected area in 1979 under the administration of the Subsecretary of Forestry and Fauna, a department of the Secretaría de Agricultura y Recursos Hidráulicos (Ministry of Agriculture and Water Resources, known as SARH). However, this area didn't incorporate areas of special geological interest such as some of the craters nor areas of ecological importance (Burquez and Castillo, 1993). In 1984, the Secretaría de Desarrollo Urbano y Ecología (SEDUE; today the agency is entitled Secretaría de Desarrollo Social, SEDESOL) agreed to collaborate with SARH in protecting the Pinacate area. In that year, the Pinacate was declared an "ecological reserve." However, funds for adequate management were not made available (Hartmann, 1989).

In the late 1980's, the Centro Ecológico was formed. Under the direction of the state of Sonora government, the organization developed into the primary moving force for conservation in the state. As a result of its activities (and due largely to the political power of the individuals involved),

the Pinacate region was designated as one of fourteen sites within the state as deserving of protection. Unlike most conservation projects in Mexico which are the responsibility of the federal agencies SARH AND SEDESOL, Centro Ecológico (a state agency) has continued to play a key role in devising management guidelines for the area.

In 1993, the region was declared a Biosphere Reserve by then-President Salinas. The biosphere reserve boundaries were dictated by three factors: (1) The incorporation of outstanding geologic formations; (2) The conservation of maximum biodiversity; (3) Avoiding private and ejido landholdings (Burquez and Castillo, 1993, p. 48). Because of this last factor, the reserve has two distinct core areas. The larger of these is the Sierra El Pinacate y Bahía Adair zone. The second core zone is the Sierra El Rosario, an isolated range of granitic peaks in the dunes of the Gran Desierto, selected for its endemic flora that represents twenty percent of all the dune flora (Burquez and Castillo, 1993). The managing agency responsible for this and all of Mexico's biosphere reserves is SEDESOL.

(b) The Upper Gulf

The Upper Gulf of California Biosphere Reserve incorporates about 940,000 hectares, of which approximately 400,000 acres (including the Colorado River delta) comprise the core zone. Within the buffer zone, local fishermen will have a three-year grace period in which to find alternative fishing methods that are less harmful to the environment, according to Rodolfo Irineo Flores, director of planning and development for Puerto Peñasco (Hardie, 1993b). During that time, gillnets with openings greater than

4 inches will be prohibited. After that period, gillnets will be completely prohibited from the buffer zone.

When combined with the Pinacate/Gran Desierto reserve, the two areas incorporate over 4 million acres. Together with the Organ Pipe Cactus National Monument and Cabeza Prieta National Wildlife Refuge, more than 5 million acres will be encompassed, making it the largest protected ecological zone in the world (Hardie, 1993c).

Planning Issue: Fragmented authority

Although much of the study area is under some form of environmental protection, there is no unified or overarching strategy for coordinating resource management. Rather, there exists an historical lack of coordination among U.S. land managers and little international collaboration. This is in part owing to communication barriers (such as language, inadequate phone and mail systems, distance), the very real and physical border fence, sovereignty issues, differences in international law, inadequate agency budgets, and competing agency mandates. These man-made and legal impediments have led to a piecemeal approach to resource conservation and, hence, to fragmentation of the ecosystems. Ecosystems have suffered as a result, with long term genetic and demographic consequences already being seen locally in the rarest species (Suzan et al., 1994; Nabhan et al., 1994; Wilco et al., 1986). A recent survey (Camp et al., 1994) notes that "interagency management on the U.S. side of the border is sufficient to meet the long-term needs only for the Sonoran pronghorn and desert bighorn."

CHAPTER IV

Success Stories: Case Histories of Sustainable Development in Action

Introduction

As described in Chapter II, sustainable development can only succeed if three areas of concern are addressed: economy, ecology and culture. Within these broad areas of concern, several means of implementation were discussed such as citizen participation, ecosystem management and traditional land uses. If regional planning can address these concerns, it would appear that the goals of the Man and the Biosphere program would also be served.

In the following section, I describe case studies where one or more of the steps necessary for holistic planning and sustainable development were taken. As yet, I have not discovered an example of holistic planning which addresses all three areas of concern.

A. The Mapimí Biosphere Reserve: incorporating cultural and economic concerns

The Mapimí Biosphere Reserve was created in 1977 and is located in the Chihuahuan Desert where the three Mexican states of Durango, Chihuahua, and Coahuila meet. It was created in order to gain protection for the Bolsón tortoise, a species endangered as a result of excessive hunting and habitat alteration. A research station and 20 hectares (ha) that were donated by a local property owner form the nucleus of the protected area, but the surrounding lands of over 120,000 ha are considered to be part of the

biosphere reserve. Those lands are entirely within the boundaries of privately owned ranches and ejidos. Therefore, at this time there is no core area from which human activity is entirely excluded, only a buffer zone of which 99.9 percent is owned or controlled by local residents. The existence of the Mapimí Reserve is thus dependent on local people's recognition of the reserve and their continued cooperation with the reserve's policies (Kaus, 1993,). There are several lessons to be gained from this relationship.

From an economic point of view, the ranchers benefit from the presence of the reserve in that they believe that the reserve acts as an ally in maintaining control over their livelihoods. Kaus (1992) notes that as a group, the ranchers are politically weak against the threats of government expropriation, private land takeovers, squatters, or trespassers. By allying themselves with the reserve, locals believe that they benefit from the recognition Mapimí receives from state, federal, and international agencies. However, this allegiance is limited. While residents have been instrumental in decreasing the poaching of tortoises and deer, many will not respect restrictions on shooting coyotes or other livestock predators. The ranchers do not perceive their cooperation as a shared vision of long-term preservation of the desert and its natural resources. Rather, their cooperation is seen as security in maintaining their grazing rights and the ability to use the natural resources more productively (*ibid.*).

From a cultural point of view, the fact that the Mapimí reserve is located almost wholly within the boundaries of private landholdings has made the reserve managers acutely aware of the need for good relations with local residents:

[Managers] walk a fine line between the goal of improving resource management in the region and the need for continued acceptance by the local people.... [The] policy of the reserve has been to put the researchers and local people in situations where an exchange of information can take place, whether by employment, projects of mutual interest, visiting, or fiestas.

Kaus notes that a formal management plan has never been established.

Instead,

... the reserve's managers rely on good public relations at the individual rather than the institutional level. The general rule given to the researchers is one of courtesy: to stop, talk, and listen to the local people (Kaus, 1993, p. 404).

From the perspectives of the local ranchers, Kaus notes that they cooperate with the reserve policies because of the personal friendships which many of them have formed with researchers and managers. The ranchers view these relationships very seriously as social contracts "... and the concept of sticking to one's word (locally referred to as being "*muy hombre*"--very manly) holds more weight than a legal edict in the area" (Kaus, 1992, p. 386). Thus, the success or failure of the reserve rests on establishing personal (and culturally appropriate) relationships between reserve managers and researchers and local residents.

Furthermore, outreach programs in the Mapimí Reserve have met with greater success when performed in a culturally-sensitive manner. Kaus (1992) reports that local residents suggested that the emphasis of educational programs should be aimed at the children.

The residents say that the children teach their parents new ideas and concepts best. The parents are interested in what the children are doing and are pleased when that information validates their own cooperation with the Reserve's policies (p. 401).

Although the success or failure of the reserve rests on the cooperation of the local residents, Kaus (1992) notes that they have not actively participated in the formulation of management plans or research projects. He notes that residents are too intimidated to speak up in traditional park management meetings such as seminars or workshops. The reserve managers maintain that they attempt to address this problem by hosting fiestas and through personal contact. However, this solution only encourages the participation of the immediate communities and, with respect to fiestas, only the men within those communities--women are not allowed to attend functions at which alcohol is served.

B. The International Sonoran Desert Alliance: citizen participation

In 1988, Carlos Nagel, President of Friends of PRONATURA (PRONATURA is a Mexican conservation organization; Friends of PRONATURA is its U.S. counterpart), and members of the Sonora-Arizona Commission sponsored a symposium on the Pinacate. Held in Hermosillo, Sonora, researchers, community members, and members of nongovernment organizations (NGO's) shared their knowledge about the area and views regarding how best to protect it. Also present were members of the O'odham nation. The occasion marked the first at which the O'odham had been asked to participate and present their views and perspectives on the region in general and on the Pinacate in particular (Laird, et al., 1996).

A second forum, held in Ajo, Arizona, in the fall of 1992 attracted more than 200 participants from throughout the region and from all walks of life. The enthusiasm generated by the forum led that same year to the formation

of the International Sonoran Desert Alliance (ISDA), a tri-cultural coalition of individuals from the three regional nations. In January, 1994, a twelve member governing board consisting of four residents each from Mexico, the U.S. and the Tohono O'odham nation were elected to office. The board serves to guide the Alliance whose membership and monthly meetings are open to all residents of the region. (Public officials are not members of the Alliance, but serve in an advisory capacity.) The stated concerns of ISDA are:

- Consensus building and information sharing about ecologically sound economic development and shaping public policy to better serve a region divided by an international border.
- Developing a framework for cooperation among the protected areas in the biosphere reserves on both sides of the border.
- Expanding the scope of the biosphere reserve program to include environmental education and go beyond traditional scientific studies to addressing a broad spectrum of regional needs and concerns (ISDA, 1995).

Since its founding, ISDA has grown into a network of residents, government agency representatives, business and community leaders, and NGO members. Issues addressed to date include meeting regional transportation needs, exploring the potential for establishing dual citizenship for the O'odham, pressing for greater control over the illegal importation of saguaro ribs and seeking easier access for donations and health care assistance to Mexican communities.

In addition, several projects initiated by ISDA are now underway, including the development of a binational and tricultural environmental education curriculum. Geared to elementary school children in Ajo, Sonoyta, and the Tohono O'odham nation, the program is the first bilingual environmental education curriculum developed about the Sonoran Desert and its people. ISDA has also initiated a program involving high school youth in community beautification, recycling, and tree planting. Finally, ISDA has commissioned a regional profile which describes the economic, ecological, and cultural attributes of the region. The profile is to be published in both Spanish and English and to be made available to residents of the area in order to foster informed debate regarding regional planning (Laird, et al., 1996).

As discussed in Chapter II, sustainable development in general and the Man and the Biosphere program in particular call for the incorporation of citizen participation. As an example of citizen participation, Smith, et al. (1996) note that the

International Sonoran Desert Alliance offers a forum for building a common understanding of the ecosystem and for resolving conflicts associated with the management and development of resources. By encouraging communication among people who have traditionally not spoken with each other, ISDA is building recognition of the biosphere reserve as a meaningful concept of practical value in their lives (p. 42).

The authors attribute the success of ISDA to the following factors:

- Biosphere reserve managers are willing to join as partners with ISDA in promoting the biosphere reserve program without taking a lead role.

- ISDA grew out of a private, mostly local, initiative which has succeeded in building self-confidence and self-reliance among its members.
- ISDA was able to build a regional identity and develop a common understanding of and support for the biosphere reserve program.
- A well-established scientific database was developed which has supported a number of projects outside the protected areas of the biosphere reserve.
- The leadership and initiative provided by Organ Pipe National Monument (OPNM) Superintendent Harold Smith. Prior to the creation of ISDA, Smith was committed to integrating biosphere reserve concepts into planning, research, public education, and management on both sides of the border. He was also instrumental in securing funding from the U.S. Congress in order to support ongoing efforts by ISDA (p. 43).

With respect to the future of ISDA and its role in the biosphere reserve, continued financial support remains a critical constraint. In addition, more active participation by governmental agencies (with the exception of the long-involved OPNM) in program planning and management is required (*ibid.*, p. 42).

C. The Southern Appalachian Man and the Biosphere Cooperative Program: addressing fragmented regional management

The Southern Appalachian Biosphere Reserve (SAMBR) encompasses a series of mountain ranges in six states--the highland portions of northern Georgia, northeastern Alabama, western South Carolina, eastern Tennessee, western North Carolina, and southwestern Virginia--an area of 247,028

hectares. The region contains a variety of national and state parks, recreational and wildlife areas, national and state forests, experimental forests, lands administered by the Tennessee Valley Authority (TVA), and Cherokee Indian lands. About a third of the land in the region is owned by federal and state agencies (Hinote, et al., 1995).

SAMBR was formed largely in response to a growing urban population. Poorly planned land development had led to region-wide degradation of natural resources such as air and water quality, fragmentation of wildlife habitat, and invasion by exotic species. Based on recommendations in 1986 by the U.S. Man and the Biosphere (U.S. MAB) program, the National Park Service's Southeast Regional Director agreed that a MAB approach should be used in the Southern Appalachians. Baker stressed the need to begin a process of identifying regional issues and developing objectives and strategies to address those issues on a scale reaching beyond park boundaries, indicating that "...these efforts should draw their strength from interagency cooperation aimed at achieving common goals--an ecosystem approach which should be discussed with leaders in the area" (Hinote, 1992). The MAB program could lead to systematic cooperation on a regional scale rather than continuing to address regional planning issues through separate agency "outreach" programs.

In 1988 Southern Appalachia was officially designated a multi-unit biosphere reserve, thereby becoming the first regional MAB reserve in the U.S. Three units were designated: (1) Great Smoky Mountains National Park, administered by the National Park Service; (2) the Coweeta Hydrologic Laboratory, administered by the USDA Forest Service; and (3) the Oak Ridge

National Environmental Research Park, administered by a private contractor for the U.S. Department of Energy. Since 1988 two additional management units have been added: Mount Mitchell State Park, administered by the State of North Carolina; and Grandfather Mountain, North Carolina, administered by the Grandfather Mountain Corporation with guidance from the Nature Conservancy. Later that same year, seven federal agencies and bureaus signed an "Interagency and Cooperative Agreement for the Establishment and Operation of the Southern Appalachian Man and the Biosphere Cooperative." Other federal agencies are considering membership as are the five states who have not already joined (the State of Georgia has already signed) (*ibid.*).

The SAMAB program is made up of two organizational entities: the SAMAB Cooperative, consisting of federal and state agencies who have signed the Interagency Agreement and their participating organizational representatives; and the SAMAB Foundation, a nonprofit organization made up of university, corporation, local governments, and private organizational representatives. A secretariat coordinates the work of both the Cooperative and the Foundation, each of which is responsible for developing their own program of work and priorities that are consistent with the objectives of the participating agencies and institutions and the MAB mission. Although initial funding for the program is supplied by the participating federal agencies, long-term funding is expected to be through the nonprofit SAMAB Foundation which will enable the private sector and other institutions to be more directly involved (Hinote, 1992).

SAMAB benefits each of the units in the SABR by providing a cooperative institutional structure for planning and carrying out projects that support resource management. The SAMAB umbrella enables participants to share ownership of large scale projects that require coordinated action. These projects often go beyond the capability of individual participants. Projects include multi-agency and multi-state initiatives to monitor air quality, monitoring of ecological changes in regional forests, educational programs to encourage the reintroduction of the endangered Red Wolf, and coordinating efforts to encourage sustainable development strategies for local communities with tourist-based economies. In addition, SAMAB plays a growing role in disseminating scientific and technical information to users and is becoming a significant source environmental education materials for the region's schools (Hinote, et al., 1995).

Despite its success in providing the aegis for cooperation among agencies, institutions, and organizations, local managers have had to support SAMAB from their own budgets. Regional and national agency administrators have continued to remain reluctant to commit time or funds to SAMAB's efforts. Such reluctance is indicative of how difficult it is for public agencies with legislated mandates to commit to holistic planning practices.

D. The Rincon Institute at Saguaro National Monument: reconciling development and natural resource protection

Saguaro National Monument was created in 1933 to preserve and protect the exceptional diversity of plant life, such as the saguaro cactus. In

recent decades, the city of Tucson has grown to the very boundaries of the monument. Continued piecemeal subdivision and unplanned development of lands adjacent to the monument raised concerns about the monument's ecological and scenic integrity. National Park Service officials concluded that "...planned development with significant environmental protection measures would be preferable to incremental piecemeal development, even if the planned development had higher overall residential density" (Propst, et al., 1991a, p. 30).

An opportunity for such planning arose with the proposed development of a resort-oriented community on the Rocking K Ranch. Encompassing 6,000 acres and sharing a five-mile boundary with the monument, the ranch was of a sufficient scale to play a key role in maintaining biological diversity in the monument through the protection of integrated corridors for undisturbed wildlife movement (*ibid.*). In addition, the developer recognized that the natural and scenic resources in and adjacent to the ranch would be a prime contributor to profitability (Propst, et al., 1991b). Consequently, the Park Service, county officials, and local as well as national environmentalists worked with the developer to produce a site plan that would protect critical wildlife habitat and restore degraded riparian areas throughout the ranch. The development plan set aside over one half of the total area as protected open space in a system of integrated wildlife corridors, which are keyed to riparian habitat. The plan also provides public access to the monument as well as the creation of public trails within the development (*ibid.*).

However, park officials and consultants determined that a land use plan, regardless of good intentions, would prove insufficient to ensure that long-term commitments to environmental standards not be overlooked by the developer after the ranch was fully developed. Nor did they think that local land use regulations and traditional private controls like deed restrictions would prove adequate. A mechanism for ensuring long-term stewardship of the area was needed. In cooperation with the developer, the Park Service, county officials, local environmentalists and others, an independent, nonprofit organization was created: the Rincon Institute (Propst, et al., 1991b). The Institute's main functions include:

- Scientific research and monitoring for ecological restoration and wildlife conservation.
- Environmental education programs for contractors, residents, school children, employees and guests in the Rocking K Ranch and other communities in the Rincon Valley.
- Management of designated natural open space for wildlife, science, education and outdoor recreation.
- Professional advice to lessen the impacts of development in the Rincon Valley (Gregg, 1993).

Of particular interest is the fact that the activities of the Rincon Institute are funded by the development process itself. The developer has provided start-up funds; deed restrictions binding on future landowners generate long-term funding. These restrictions require various fees--

including nightly hotel-room fees, residential and commercial occupancy fees, real-estate transfer fees and monthly homeowners fees (ibid.). Bed fees from the first proposed resort hotel could generate approximately \$50,000 per year for the institute. When fully built out, Rocking K could generate annual fees for the Rincon Institute on the order of several hundred thousand dollars (Propst, et al., 1991b).

The Rincon Institute's use of deed restrictions is an innovative means to generate long-term funding of conservation activities. In addition, the fact that the institute evolved as a result of cooperation between public and private land owners means that dedicated funds will be used to the advantage of both: sensitive lands will be protected and the marketability of private development will be promoted.

CHAPTER V

Planning for Sustainable Development: Recommendations of Non-Governmental Organizations Familiar with the Region

Introduction

In an attempt to gain greater insight into management issues in the study region and in particular those of Mexico, I conducted interviews with individuals who are currently involved with planning and conservation efforts in the area. In addition, each of my interviewees is or was a professional or voluntary member of a non-governmental organization (NGO). My interview process was largely an informal and heuristic one in which I explored various areas of interest according to the experiences and expertise of the interviewee. In all of these interviews, the basic theme was that of sustainable development—how can it best be achieved, what are its greatest hindrances. In addition, I specifically questioned the importance of citizen participation to sustainable development. I interviewed Wendy Laird, former executive director of the International Sonoran Desert Alliance (ISDA) (ISDA was described in detail in Chapter IV) (January 5, 1997); Carlos Nagel, a community development consultant who has devoted considerable time and effort to the ISDA process and who describes himself as "a citizen of the region in the context of the Man and the Biosphere" (January 9, 1997); Susan Anderson and Serge Dedina, both of The Nature Conservancy, a non-profit natural resource agency which has extensive operations throughout the United States and Latin America (January 15, 1997); Peg Boyar, co-director of the Intercultural Center for the Study of Deserts and Oceans (CEDO), an

environmental organization which has been based in Puerto Peñasco for the past seventeen years (January 20, 1997); and Lorraine Eiler, former President of ISDA's board of directors and a member of the Hia-Ced O'odham nation (February 22, 1997).

As might be expected, for the most part each person spoke from his or her experience and gave recommendations based on those experiences. Despite the broad range of personal histories, however, a number of common themes emerged:

A. Defining Organizational Goals

While everybody that I interviewed supports the idea of sustainable development, that term is a vague and poorly defined one, as I discussed in Chapter II. Sustainability means different things to different people and organizations. (In fact, many of the interviewees objected to the very term "sustainable development," preferring terms such as "sustainable use" or "sustainable lifestyles.") In order to recognize and organize the planning issues of a region that relate to sustainable development, an individual or organization must decide which facet of sustainability it wishes to address. Dedina states that an organizing philosophy "... becomes a way of focusing and being successful in working on a small level. Because if you stand in the middle of the desert and look around you, your brain fizzles out... [The scale] becomes paralyzing." The goals that an organization carries will determine its strategy in trying to achieve sustainability.

For example, TNC approaches sustainability from a natural resource point of view. Therefore, Dedina notes, TNC focuses "... on protected area

management because that is a tool to enhance environmental protection and provide the long-term protection for the natural resources." On the other hand, ISDA takes an approach that focuses on community development. Nagel states that "sustainable use is permeated with quality of life." Laird notes that dealing with quality of life issues, especially in the initial stages, is a more compelling means of initiating sustainable development in rural communities. Boyer also approaches sustainability from a community point of view, though for CEDO the basic strategy is one of educating the community. She notes that including communities in planning is "... very difficult to implement... when you're dealing with people with a variety of backgrounds and they don't all have the same information and the same values."

B. Public Participation

As I discussed above, virtually all of the parties I interviewed advocate sustainability as a planning goal. They also maintain that local communities lie at the heart of sustainability: in order for sustainable development to successfully occur, local communities have to want it. For this to happen, the interviewees say, communities have to be involved at some level in the decision-making process; ie., public participation in the planning process must occur. However, the manner in which planning organizations incorporate public participation into the planning process depends on the philosophy and specific goals of that agency.

For example, as I stated earlier The Nature Conservancy (TNC) defines sustainable development within a conservation context. Their

primary goal is to reduce threats to a given nature reserve. They do so by first identifying those threats and then identifying the specific communities that are responsible for those threats. It is these specific communities with which TNC becomes involved. Anderson summarizes TNC's strategy as follows:

The goal is to reduce the threats to the reserve and to build support among local constituencies. So you have to be strategic because you are never going to have enough money, you are never going to have enough time about how you do that. So you may not do that in every community. You may only do it in the community that is most important, the community that has the most political power or the community that is currently the biggest threat to the reserve. You have to be clear. There are lots of sustainable development programs. But if its one that is focused on the reserve, the goal is to reduce the threats to the reserve. Your primary goal is not to have more income into these communities for sustainable development--you use that as a tool.

TNC's objective in dealing with local communities is to compel them to act in a manner that doesn't compromise the ecology of the reserve. They do so by helping these communities realize that the ecological health of the reserve is in the best interests of the community. Anderson notes:

People have to want the reserve there. They have to see a value in the reserve and they have to be engaged in the process of decision-making regarding the reserve. There are a couple of things that are critical in being able to do that: (1) Communication with the reserve direction and a sense that their suggestions are being employed. A clear process for how decisions are made and what their role is in the decision-making process: public participation... (2) Detailing the benefits of the reserve [to the community] and the communities being healthy themselves. You have to have healthy communities if they are going to participate--their own decision-making processes within the communities, their own sources of income, their own quality of life have to be stable if they are going to be participating in the reserve.

Therefore, the primary goal for TNC is not sustainable community development programs per se, but an ecologically sound reserve. In part,

however, the best way to achieve that end is sustainable community development: look to the needs of local residents that are impacting that reserve, build a "committed constituency in the reserve" (Anderson), and develop programs that help the community while protecting the reserve.

One of the tools used by TNC to develop sustainable communities is public participation. Anderson states that TNC has employed various means of public participation. Recently, the organization has been organizing community leaders and residents into a "technical advisory committee." One of these committees might include "... the presidente of the municipio, ... a representative of the local ranchers union, or a key farmer who has been trying some of the sustainable development techniques for a couple of years and is now a promoter in his community." Anderson notes that with a local committee established, there will be more legitimacy [in the eyes of the community] because you'll have the key leaders from different communities on that committee." Anderson also notes that in Mexico the greatest obstacles for implementing this kind of participation have originated with the federal government, despite the fact that these committees are mandated by that government. Anderson says that federal officials are reluctant to relinquish control, that they aren't sure they want "... to give non-federal employees a voice in how decisions are made." She also states that in order for this approach to succeed, it is essential that the Mexican government get involved. Without it, no real action will take place:

If it is lip service, people will know about that. You know, if we say that we are going to have the committee but we really can't do anything, you really won't have any influence in what is going on, people will know about that--that just sort of adds to the cynicism.

What we have to do is get beyond lip service to real functioning communication between stakeholders and reserve direction.

On a more positive note, Anderson notes that Mexicans may actually be better at public participation than Americans because of the fact that in Mexico, people often reside within park boundaries and managers have been reluctant to restrict their activities:

In Mexico, most people working on the reserves are very careful about restricting the activities of the people living within the boundaries because they need that constituency... In the Pinacate, [the reserve managers] did a study of overgrazing. They didn't start by telling ranchers that they had to cut back on grazing. They did the study first so that they can tell what the appropriate amount of grazing is and then they can take that information back to the ranchers and try to come to solutions jointly.

The Nature Conservancy defines sustainability within a conservation context. It uses public participation with a specific goal in mind: to address specific threats to a nature reserve. Public participation, therefore, is one means to an end.

The International Sonoran Desert Alliance (ISDA), on the other hand, defines sustainability within a human community context. Sustainable development is defined as improving the overall quality of life. Therefore, ISDA focuses on the identification of community values that, if acted upon, can improve the quality of life. Laird says that this approach makes sense in rural communities especially in Mexico where basic needs are often lacking and concerns regarding natural resources are usually secondary. "A lot of times what they care about is health, their kids, education, some things that may not necessarily be conservation-oriented but can have a conservation

component." In ISDA's approach, public participation becomes a forum for the identification of community values and the role of the planner is that of a mediator: "Planners play the role of getting community members to express values, to see the common threads among the values of different parties and to prioritize those values." With respect to public participation within the study region, ISDA came into being following a 1994 regional conference organized by the Sonoran Institute, a Tucson-based, non-profit organization. From the outset, a concerted effort was made by the Sonoran Institute to include all three regional cultures in the meetings. Laird notes that they had to fight a strong cultural bias regarding the United States on the part of the Mexican participants:

Although there were monthly meetings following the Ajo conference, Mexican participants did not really buy into the idea of equal participation until after the ISDA board of directors was established in which all three cultures were represented. Until then, Mexicans viewed the Alliance as more of an American organization. Today that is not the case. In fact, the current president of the board is from Mexicali. Now there is equal participation on the board by all three cultures. And there has been a definite cultural shift in the relationships between board members.

The Sonoran Institute also had to work to create a tri-cultural organization that was relatively free of any sort of hierarchy. Laird recalls:

At the first meeting in Sonoyta, in Mexican tradition, the organizers placed a table up on a dais at the head of the room with banners for the officials to talk down to the audience. We had to change the tables to a square on the floor so that everybody was equal at the same table—they got that and that became a real symbol of how we wanted the Alliance to operate and approach public meetings.

Regarding culturally-based differences in the behavior of participants at the meetings, Laird notes that despite the fact that ISDA has been meeting over

the past three years, the O'odham have continued to remain largely uncommunicative:

[T]hey are still mostly quiet observers of the process, [although] there are some individuals that are a little more vocal. Especially in meetings of mixed cultures, they traditionally listen more than they speak. They are active listeners: if you ask them one on one, they have distinct opinions. But they don't tend to be vocal in meetings. At their own meetings, where they are the organizers, they are different so it is definitely an intercultural thing. But it is still important for them to be participants in meetings--listening is participating too. In addition, working in small groups and/or one-on-one seems to work.

Laird also notes that

... the Alliance acts as a glue and means of informing between [O'odham] communities. There is such an incredible communication network that is not telephone-based. Because people are so isolated from each other, they tend to go into town a lot... So there is an incredibly rapid information network.

Over time, ISDA has led to the successful development of a number of small projects. Puerto Peñasco, for example,

... submitted a proposal to build a sanitary dump--the existing one was unlined and on fire more often than not, the town had a tremendous problem with flies and sanitary issues. Through ISDA, Puerto Peñasco successfully submitted a proposal to the North American Development Bank for funding to redo the city dump and start a recycling program. They called the shots for the entire effort and they were required to include community participation (Laird).

Laird notes that the public participation process is not a unique or new one:

This process has worked in small communities throughout the U.S. and in Guatemala and Mexico. You give people the opportunity to identify their needs and the training and funding to act on those values and you get results... Eventually the communities take over the process.

Laird also notes several potential pitfalls:

[One] problem is in communities where you get so many different opinions regarding what the 'thing' is. If you just focus on those then your divisions start. We were lucky because it was such a novel idea for an isolated area and we came in without an agenda, just about quality of life... We also benefitted by the fact that we didn't focus on Ajo, where there is a strong resentment against federal agencies. The coalition is so wide that we could reduce the power of [Phelps Dodge] voices.

Finally, Laird notes how critical timing can be for organizations like ISDA and how strong a part personalities can play, especially in the early stages of organizing. When it came time for Laird to step down as executive director, her replacement (who had been selected by ISDA's board of directors) proved to be a disaster in that she had a strong personal agenda, one that was at odds with the self-directed philosophy of the ISDA process. However, because ISDA was still relatively new, the organization lacked a strong enough sense of itself to control the new director. Eventually, the person was fired. Laird says that "... because the process is based on relationships, the choices made regarding personnel are critical... It took two years for the Alliance to recover from that move."

C. Long-term commitments/ Building relationships

Virtually all of the interviewees emphasized that a long-term commitment is necessary for sustainable development to occur. Because planners and managers are actively working with people in the local community, a level of trust must be established. This trust has to be built between both outside professionals and the community and as well as between the local community residents who take part in the planning process.

Laird notes that building trust is particularly important in small communities, where "sides and factions" are certain to already exist. For example, Peg Boyer recalls that several years ago Puerto Peñasco was near a general riot when PAN lost a hotly contested mayoral election to a PRI candidate (PRI is the ruling political party in Mexico). An indication of how completely the town had been torn apart is provided by the fact that the two candidates were from the same family. While the political situation in Puerto Peñasco has improved considerably since then, Boyer notes that similar impasses persist in many other northern Mexican towns such as San Felipe, which is located within the study area north of Puerto Peñasco. Boyer notes that these types of situations are often exacerbated by the fact that typically there are few professionals in these communities. Therefore, local elected officials are "... not necessarily trained, capable people" and personalities can play a large role in any public process. She states that some of the success that Puerto Peñasco has enjoyed in public participation may be due to the fact that the two most recently elected mayors have been the most professional that Boyer has seen in her seventeen years in the community. She maintains that their efforts have had a ripple effect. When the community held public meetings in order to plan for a sanitary landfill,

... the advisory council actually invited all of the other political parties to participate in the process. And one of the first questions that [these parties] had was, 'Why did you invite us to this meeting?' Ortencia, the woman who was coordinating the whole thing, said, 'Because you're a member of our community, you're interested in our community and we want you to be involved.' That was unheard of, in fact they were really tooting that in the [ISDA] process... as an example. I think somebody said that democracy started in Puerto Peñasco (laughing).

Carlos Nagel maintains that a part of achieving sustainability lies in "how we relate to each other:"

We need to integrate so that we begin to work together in a win-win situation which is very simplistic and very difficult to achieve. But when we begin collaborating,... we go back to the essential process of democracy where people in a community assume responsibility for their community despite their differences, where diversity becomes an added value rather than a reason for divisiveness.

Nagel states that this collaboration can be achieved through public participation and is based on listening and understanding:

You honor every one of the participants. Listening and honoring people's positions, even when they are very angry, provides two things: (1) By listening, you may learn something; (2) The person who is talking gets to hear themselves and they may even modify their behavior. But the minute that you resist and say, "Oh that's a stupid idea", people get locked in and the more that they get locked in, the less likely they are to let go of anything. And so there is no room for any kind of negotiation, there's no room for any kind of balance. The mechanism by which [collaboration] is accomplished is to truly sit down and listen to each other.

As might be imagined, Nagel notes that such a process defies rigid scheduling:

A planner isn't going to be able to come in with a strict time line. What he needs to do is to implement a process whereby there is a continuing dialogue between community members with the goal of establishing a quality of life. This dialogue should be an ongoing process... This kind of thing can happen in any culture. [With respect to ISDA] and the Tohono O'odham, the process has taken six years. But you cannot put a time frame around this process. We are so compulsive about time frames. We tend to push situations instead of allowing a certain synchronicity. The events that happen happen because they are ready to happen and certain individuals are ready to step forward. So you have to allow for synchronicity.

Nagel also notes that when it works, public participation as a means of planning can be very successful and is largely impervious to outside manipulation:

When you have this kind of process, it is very unlikely that you will have people against it. And if you do have people who are against it, the constituency is so large and organized that they have the confidence to exclude recent interlopers. It's not an administrator saying that, it's a local community. Nobody is in control--it's the group that exercises the control. People are owners of the process. And that is where commitment and the democratic process is. You're it.

Lorraine Eiler notes that the personal relationships built during the ISDA participation process are at times as important as the formal work undertaken:

Most of the people that work for BLM, Fish and Wildlife, Organ Pipe [National Monument], even the communities in Mexico see us [the ISDA Board of Directors] every month. Most of these meetings where we discuss issues, everybody works together to address these issues. And then we go out to eat and have social get-togethers. So you see them on a monthly basis. And we share a lot of rides because we have meetings all over the place. Like I'll share a ride with the people from BLM here [in Phoenix] to go to Ajo, or San Luis, or Puerto Peñasco and we do a lot of talking. And... you start talking about personal things-- I have so many kids and I grew up here and that kind of stuff. So it got to the point where we knew each other very well. So with the association and the sharing, we've been able to build up a rapport. So now we're on a first-name basis. We call each other if we have concerns.

For TNC, relationships revolve around the nature reserve. As Anderson stated above, communication with the reserve direction is essential in order for local residents to want the reserve. Therefore, reserve managers need to be present:

In order to establish trust between managers and locals, the main thing is that you have to be there. Most of those [community development]

programs that come from Mexico City, no one ever shows up or they show up and leave again. What you need to do is be there day in and day out. And where we've had success is where there is staff on site and the staff sees the community and they see the same faces. Once they've been there a couple of years, they may have some legitimacy (Anderson).

By maintaining a presence in the local community and establishing a relationship based on trust, reserve personnel can gain that "committed constituency" that Anderson argues is so vital to the ecological health of nature reserves. Maintaining a local presence also allows park personnel an opportunity to begin to understand the underlying powers in the community, a necessary component in any process that relies on close cooperation and support. Anderson states that many of TNC's failures can be attributed to ignoring or not understanding the local political hierarchy. In his current work in the Upper Gulf of California, Serge Dedina notes:

[T]here is a power structure... in how the communities organize themselves that is really invisible. It takes a long time to understand the dynamics of those communities... It took my wife and I two or three months of just watching and keeping our mouths shut... to get past the level of what they tell you to what really goes on.

Anderson also stated earlier that the key to healthy reserves is healthy local communities. Both she and Dedina note that protecting the reserve often means acting on the behalf of the community in order to ensure the health and improved quality of life for local residents. By doing so, managers also help to ensure a positive relationship with the community. Dedina notes that what is often needed is a sort of ombudsman who can act on behalf of local residents:

In Mexico, you have a one party state. And you have two levels: you have a political level and you have a technical or administrative level. [The two] should be separated. But what a government resource agency

wants to do, which might be good at a resource management level and community level, might conflict with the political goals of the ruling party. That's when you have a conflict or a threat--in Mexico you have a *choké*. For example, in the biosphere where I worked there is whale-watching. And you have these three communities and only locals are given permits to do whale-watching, which is really good because that means you have 10 to 15 less people fishing in the winter--it takes pressure off resources. Actually, in theory it's a really good example of sustainable development because they don't damage the whales, they're a small group of people, they're all locals and they're all fishermen. However, at the time those permits are granted, political interests might intervene and say, 'Hold it! I've got a friend who needs a permit.' So the guys at the lagoon, who have no power, no telephones, nothing, are going, 'What happened to my permit?' And they see a guy from town who's got the seasonal permit to go whale-watching. So you don't solve the problem... [T]here are a lot of internal things that happen that subvert the process. You have to start small and someone has to be there in the community. For example, the year that I was there one local fisherman who had worked as a guide longer than anyone else--some twenty years. He had assisted scientific communities, he had given a paper at a scientific conference. This guy didn't get a permit... A lot of it is a function of someone being there, finding out what is going on in the community, and being able to articulate those concerns either in Mexico City or at the state level. It doesn't have to be somebody who has any political pull but has the ability to articulate their concerns. The really important thing is being able to navigate the system... At times the system really does work if you know how to use it and if you are persistent. Of course, it doesn't always work that way. In Mexico, they have a saying that the big fish eats the little fish, but you constantly have to keep trying.

Anderson confirmed this characterization of reserve manager as ombudsman, one who can act on behalf of the community to help establish and maintain sustainability:

[W]hat we've seen in some of the older reserves in southern Mexico is that the reserve director knows the department of infant nutrition and [the director] can say, 'I'll give you a ride up the mountain if you want to give this stuff to the local community.' There are a lot of federal programs in Mexico, but they don't make it out to the most marginal communities. And reserves are usually near the most marginal communities, the places where people were given land last because it is

out in the middle of nowhere. And a lot of what we've seen is that [reserve personnel] can manipulate the system to get the guy who does children's vaccinations or to find out about whatever new program is happening in Mexico City that can help your community. [He can] try to weave the connections to bring those resources out to the site. And sometimes it's just offering a ride to the person from the capitol city or the state capitol who is interested but, of course, doesn't have any money or equipment to get out there.

Anderson hints at one of the difficulties in establishing an on-site presence in Mexico's reserves: they are often in very remote locales. In his work in Baja, Mexico, Dedina notes that

... getting people in the field in Mexico in really isolated areas is not easy--its not easy to live there. I lived in this really isolated area for five months. It takes a lot of energy and commitment to be there with no water, no electricity, you have to go thirty miles on a bad road to get food. It's a lot of commitment. So you're expecting these people not only to have commitment and energy but you can't expect them to get paid--they have no resources. They are depending on locals. Where I was working, the reserve people were actually depending on locals for help.

Dedina notes that working in the field in Mexico has its political disadvantages as well:

... [M]oving away from the office [is difficult] because the office is power and once you are disconnected from the office and the administrative center, you lose power... That's really hard for people in administrative or resource agencies to deal with because that's their key to moving forward.

Despite the difficulties, Anderson and Dedina note that more and more reserve personnel are moving into the field, including Juan Carlos Berrera, head of the Upper Gulf Biosphere Reserve who will be moving to Golfo de Santa Clara. Anderson also noted that in some cases, such moves are made possible in part with funds provided by TNC.

D. Education

Because sustainable development depends on the participation and support of local communities, educating local residents is obviously of importance. Anderson and Dedina of TNC recall that in early in the MAB process in the Upper Gulf, there were no funds with which to inform and educate Mexican communities regarding the reserve. "So the communities had all these wild ideas of what was going to happen from this reserve because no one had gone out to talk to them and in Mexico in a vacuum you assume the worst... They thought that the biosphere meant that they were going to put a big dome over it. Because that's a biosphere, right?"

Peg Boyer of CEDO notes that it is very difficult to implement a public participation process when one is dealing with people with a variety of backgrounds and values. Therefore, the basic premise from which CEDO operates is that of addressing the need for education. She argues that "most of these communities don't know enough. They just don't know enough about natural resources, about natural systems, about what is being done in their own community. They just don't know it." She maintains that "letting people know what is happening in their community,... not in a real environmentally preaching sort of way but in a scientific sort of way,... evolves people." In Puerto Peñasco, for example, Boyer states that residents began to realize the consequences of dumping trash and waste into nearby estuaries following presentations on the subject by CEDO. The estuaries are being developed for oyster cultivation for export to the United States. Contamination of the estuary could threaten that industry. Boyer says that as

a result of CEDO's educational efforts, residents began to see the connections between their actions and their quality of life. She says that providing environmental information and presenting possible alternatives encourages residents to take action and become part of a solution. Boyer has also addressed environmental issues by means of the Puerto Peñasco school system. She says that such an approach is highly effective:

... [K]ids listen to other kids. And I get them to talk to their parents about it--some of these parents are fishermen--to let them know that catching vaquita and totoaba and turtles is not good for the environment. [The kids] are educators to their parents big-time. That is a major benefit of doing these programs in the schools because then it all comes back to the parents.

To illustrate the effectiveness of CEDO's work, Boyer compares current attitudes and community development efforts in Puerto Peñasco, where CEDO has focused most of its work, with those of San Felipe, another fishing community located in the Upper Gulf. She notes that in Puerto Peñasco, fishermen have been willing to contribute to a management plan for the Upper Gulf MAB reserve and compromise their immediate livelihoods for longer-term interests. In part, they were willing to do so because they were scared by the fishing crisis--"they saw that they could lose all their shrimp." However, Boyer argues, it was also because that ground had been prepared before the crisis: "... it was rhetoric that they had been hearing over the years in terms of having to balance the whole thing. So they weren't an ignorant community." In contrast, San Felipe "... has been particularly difficult to get behind the biosphere reserve." Boyer notes that

... there has been no environmental education in the schools. In Puerto Peñasco, we've been working in the schools for seven or eight years now so the generation that is out there today is very different

from what was out there ten years ago. In San Felipe, that is not the case. We've done stuff in the last couple of years so there is more of a consciousness, but its mainly rape and do whatever they want to the environment.

Boyer concludes by stating:

You have to have people in the community who care about the community. And that is where education comes in--how do you expect people in the community to care about the community if they don't know anything about it? So that is our goal--to give people a sense of place and pride, give them a sense of where they live so that they can be proud of it and want to participate.

E. Starting with Small Projects

As discussed earlier in this section, sustainability is a vague term. In applying it to community development, most of the interviewees stated that it is best to start talking about values and real projects and not about sustainable development per se.

When describing how a reserve manager might help a local community towards sustainability, Dedina earlier in this chapter described the need to start small: just helping a single individual receive his whale-watching permit is an important step towards reducing pressure on the reserve and maintaining a healthy community. Boyer states that "defining sustainable development in a vacuum is a little hard to do for the average citizen." She argues that initiating a discussion regarding real projects and discussing them in terms of sustainability is more meaningful for local residents:

I think that it is much easier to start the process with something tangible, because then people know what you are talking about. They know the results. And [when] you actually apply for the money [to

build the project], people understand that very clearly... Money is the most tangible thing: everything gets down to money.

As described earlier, Laird notes that small communities are often divided into "sides and factions" long before an outside planner arrives. She argues that in order to build "... a base of trust both between themselves and you, as an outsider," it is better to work with communities on both short- and long-term projects. By taking a multi-project approach, she says, "... you can build relationships that will get you through the more troubling issues in which conflicts will be greater." With respect to ISDA, Laird believes that acting on what local residents felt was important generated greater enthusiasm among local communities to participate in the planning process. Eiler argues that projects that specifically involve children are the most successful in reaching locals who are reluctant to participate, such as the O'odham.

F. Importance of NGO's

Perhaps not surprisingly, each of the persons that I spoke with noted that non-governmental organizations (NGO's) are an essential part of any sustainable development planning effort (each of my interviewees is or was a professional or voluntary member of a NGO). Apparently, the North American Development Bank agrees with that assessment. In its efforts to encourage sustainable development in the international border region, it has mandated through its review committee that projects include public participation in the planning process and that NGO's serve in a supervisory capacity during that process. And apparently the bank feels that in Puerto Peñasco at least, public participation is working: it recently loaned that

community \$1.5 million in order to construct a sanitary landfill (Boyer). Both ISDA and CEDO played key roles during the participation process.

As noted earlier in this chapter, the Sonoran Institute was (and continues to be) instrumental in establishing and supporting the ISDA organization. Laird notes that early in the ISDA process, the Sonoran Institute acted to secure funds in order to develop projects that communities had elected to undertake. In effect, the Institute served as a liaison between communities and sources of funding. She describes the process:

In order to ask for funding for a project, communities had to submit a proposal. Many had never done a proposal before, so that was a learning process in itself. The proposal stipulated a time line: what you are going to accomplish, who you are going to be working with, and so on... And we just dribbled the money out much like a consultant as each deadline was met. In a couple of cases, [the project organizers] accomplished a lot more sooner so they got funding quicker because it was based on accomplishments rather than on a time basis. And in some cases they didn't get stuff accomplished for various reasons, so we just delayed the payment--we worked with people.

Laird notes that working with people on an individual basis is one of the strengths of NGO's and she says that the MAB process encourages such individualism. Most government agencies, says Laird, are restricted by mandates which make it impossible for them to take an individual approach. Another advantage that NGO's have over government agencies is that the former can administer funds much more quickly than can the latter. She states that for new planning projects, such an approach makes sense. It is also one, she says, that the communities can eventually take over.

Like Laird, Nagel also states that the MAB process provides a framework for meaningful leadership by NGO's. He attributes at least part of ISDA's success to working "outside of the system:"

We had the freedom to do the things and not be constrained by an agenda that was written by an institutional framework. We did what we needed to do. We did it because of our convictions, not because there was a grant. We did it despite the absence of money.

Nagel also argues that while the Sonoran Institute and ISDA worked outside of the system of public agencies, they didn't challenge that system. In fact,

... the system became very supportive of what we did. What we are seeing now is administrators are very eager to participate in the process: (1) They can come and meet with people one-on-one instead of being pinned in their little towers defending themselves from the public. People can see them as human beings. (2) They also get a lot of information from the community because they are establishing this relationship; they are not isolated.

Anderson states that TNC has played a central role in the protection of reserves by making funds available for reserve staff:

Through TNC's Parks in Peril program, we have supported reserve staff on seven sites--we have paid for staff salaries to be out on site. We have a committed group that is willing to take management responsibility and they're working with the local communities. And what's happened in the last year is that the federal government has taken all of the people who have worked in the Parks in Peril program and hired them as reserve directors.

Anderson also states that TNC is responsible in part for the creation of the Pinacate and the Upper Gulf reserves by providing Centro Ecologico with funding for research. She further notes that

... the person with Centro that had been most interested in the Gulf of California had been Juan Carlos Barrerra who's now the federal reserve director for the Upper Gulf. Carlos Castillo, who wrote the management plan, has been working in the Pinacate for eight years and is now the reserve director for the Pinacate.

Finally, Dedina notes that if regional planning is going to succeed and if NGO's are going to play an integral role in that planning, then there must be more coordination:

If we are concerned with the Sea of Cortez as a whole, you can't just have people in the Upper Gulf talking to each other, which isn't happening either. You need to have the people in the Upper Gulf talk to the people in the Lower Gulf to figure out what are the larger priorities, what are the ways of focusing on those issues, and what are the ways of moving forward. And that is something that hasn't happened.

CHAPTER VI

Synthesis and Conclusion

A. The Research Question

In Chapter III, I described the outstanding natural attributes for which the Man and the Biosphere (MAB) reserves in the lower Sonoran Desert were created. In that chapter, I also described some of the outstanding threats to these attributes. In this chapter, I propose to answer the question, How can the natural attributes of the region's MAB reserves be protected in an effective manner?

In attempting to answer this question, I first outline a basic theoretical framework necessary to accomplish these goals. I then translate this theory into a proposed institutional framework.

B. Theoretical Framework

In Chapters II and III, I discussed and demonstrated the fact that human development and the ecologies of protected nature reserves are inseparable. Consequently, I concluded that park planning should incorporate human development; that is, it should be holistic in its approach. In addition, I concluded that at the heart of holistic planning lies the sustainable development of local communities. In Chapter IV, I discussed examples of applied sustainable development and in Chapter V, I discussed some of the necessary components of planning for sustainability.

Throughout this paper, I have emphasized the fact that sustainable development is a poorly understood term, one that has greater meaning

given a specific context. At this point, I propose such a context and definition. With respect to the biosphere reserves in the lower Sonoran Desert, sustainable development is defined as development that does not threaten the natural attributes for which the reserves were established. In addition, based on the information presented in the preceding four chapters, I propose that sustainable development is achieved by means of addressing the needs of both natural and human communities. Therefore, in order to address the goals of the MAB reserve program, the first step should be the identification of the needs of the two types of communities.

1. Natural Communities

With respect to natural communities, needs can be identified by means of a planning process which identifies desired natural attributes, threats to those attributes, and a strategy for protection and management. This process is identified in several natural resource planning methodologies such as Fabos, 1979, Lang, 1986, Marsh, 1983, The Nature Conservancy, 1996 and Westman, 1985. This approach can be generally described as follows:

(a) Define the goals

The identification of goals will dictate the direction of all subsequent efforts. Regarding the lower Sonoran Desert reserves, I suggest that these goals focus on the specific reasons for which the reserves were created. Goals should be set early in order to direct the planning process, provide a framework with which to measure progress, and yet remain flexible and adaptable to incoming information.

(b) Collect information

The establishment of goals will naturally suggest directions that research should take. Such research should include both ecological and human context information. With respect to the latter, the objective is that of understanding the economic, political and cultural forces which influence land use in the region. Chapter III in this text is an attempt to compile such a database.

(c) Analyze information

Identify, evaluate, and rank threats and sources of threats to natural attributes.

(d) Create strategies

Devise strategies in order to attain the goals defined earlier.

(e) Outline actions

Provides an outline of how conservation strategies will be implemented. This step should include breaking larger projects into smaller, more manageable units as well as identifying the personnel, equipment and funds that will be required. It should also provide information on how progress will be measured.

(f) Provide feedback

Progress should be monitored during the course of implementing a strategy. Progress should be measured for both long- and short-term goals.

2. Human Communities

As has been stated repeatedly in this paper, the ecological health of protected reserves cannot be safeguarded outside of a human context.

Although the reserves were created for the protection of specific natural resources, to suggest that strategies for the protection of these resources can be devised without including local residents in the planning process is to ignore the evidence that this text has presented. Therefore, the identification of strategies for implementing natural resource management goals should take place within a discussion of the needs of the local human communities. This approach is consistent with the objectives of the MAB reserve program.

My research suggests that one method for identifying and incorporating human needs is that of public participation in the planning process. The success that the International Sonoran Desert Alliance (ISDA) has had suggests that their model might be a good one. As described in Chapters IV and V, theirs is a tri-cultural, democratic, community-driven process that is based on the identification of shared community values. The role of a planner in this process is to help identify and incorporate those values into planning goals. It should be emphasized that public participation and goal-setting should precede any agency planning. Planners should avoid using the participation process as a means to simply legitimize policy decisions already made by more powerful interest

As might be predicted, the crux of the holistic planning process lies in the integration of natural and human community needs. In order to achieve this integration, local residents need to realize that the protection of the reserve is in their best interests. As Susan Anderson stated in Chapter IV: "people have to want the reserve there." In order to achieve that goal, several themes may be drawn from Chapters IV and V:

(a) Trust

In order for reserve planners to integrate natural processes and human development, the latter frequently must be compromised over the short-term in order to guarantee long-term community and ecological health. If local residents are to relinquish immediate rewards for the promise of a better future, they must trust reserve personnel. This trust can only be established if residents believe that reserve planners and managers consider the long-term interests of the community to be important. Therefore, reserve planners and managers need to work toward the overall improvement of the community, even if those efforts do not seem to have a direct conservation application. In addition, reserve personnel need to maintain a presence within the community and establish relationships with local residents—they need to become a part of the local communities. Finally, reserve planners need to establish real functioning communication between communities and reserve direction.

(b) Local Politics

Planners must understand the political hierarchies that are present in the community. They need to know the history of relationships and who are the community leaders, both obvious and hidden.

(c) Education

A successful public participation process is one that identifies community values. If local residents are to care about the outstanding natural attributes of their region, then these attributes must be made apparent. Conversely, if local residents are to recognize the threats that their activities (as well as those of others) pose to the reserve, then those threats must also be clearly

illustrated. Alternative actions that will reduce or terminate resource stresses should be presented as well as a means of implementing these alternative actions. In addition, successful examples of sustainable development within the region (or in similar environments) should be widely advertised. Finally, and perhaps most importantly, environmental education programs should be developed for community children.

C. Institutional Framework

Having presented the theoretical concepts behind a planning process, I now turn to the institutional framework with which to carry out the planning process.

1. International Sonoran Desert Man and the Biosphere Reserve

I propose that the three MAB reserves (Organ Pipe National Monument, the Pinacate and the Upper Gulf) join into a single planning unit, perhaps known as the International Sonoran Desert Man and the Biosphere (ISMAB) Reserve. A review of the environmental and socio-cultural issues reveals that both human and natural communities within the region are closely connected, despite the presence of the international border. Therefore, planning should proceed accordingly.

2. ISMAB Foundation

Using the Southern Appalachian MAB reserve described in Chapter IV as a model, the foundation should act as a coordinating body for researchers, academics and members of non-governmental organizations. Its role should

be to serve as educators for the local communities. Specifically, it should address the following issues:

(a) Environmental education

Efforts in this area should build on the successful examples of the Intercultural Center for the Study of Deserts and Oceans (CEDO) (described in Chapter V) and ISDA (Chapter IV).

(b) Coordination of research and monitoring

As was discussed in Chapter II, the MAB concept emphasizes both basic and applied research. In addition, one of the primary goals of the MAB program is to demonstrate through the application of sustainable development the value of protected areas to the surrounding region. Therefore, research efforts in the reserve should in part focus on demonstrating sustainable development. However, merely investigating sustainability is insufficient. Researchers also need to make the local application of his/her research a priority. Based on his studies of the Mapimí Reserve (Chapter IV), Kaus (1994) makes several suggestions for implementing research, some of which are consistent with themes discussed in this text and are described below:

- Researchers should participate in the activities of local people (rather than vice versa as is more often the case). This participation could be as simple as sharing a meal or installing a fence. By doing so, researchers build on the trust that (hopefully) has already been established between local residents and MAB management. In addition, by becoming more involved in local

community life, researchers might gain insight into the social and physical realities that could prevent or aid the application of their work.

- Researchers should be required to distribute information about their activities to local residents. This presentation might take the form of annual workshops. These workshops would not necessarily be directed towards local participation, but presented as a simple courtesy in acknowledgement of the residents' expertise concerning their local environment and their acceptance of the reserve.
- A revolving fund for small research/resident partnership projects should be established in order to address resource management issues. For example, on local ranch operations these projects might include improvement of water catchments, water-systems, pasture rotation systems, improved cattle breeding stock, demonstration/experimental sites, and pasture reseeded. Similar partnerships could be devised for other regional resources.
- A shared, uniform database should be developed in order to use existing and newly acquired data efficiently. At the present time, there is no coordination between researchers and each focuses on his/her special interest (Kunzmann, 1993). One model for data coordination is the Sonoran Conservation Data Center. Established by Centro Ecologico and the Nature Conservancy, the center is a repository for information regarding critical areas in Sonora with high biological diversity and high potential for natural resource development (Ocaña, 1993b).

(c) Public perceptions of the regional economy

A necessary first step in any sort of public planning for future development is an evaluation of what a population "does for a living." Although I described the current economies of regional communities in Chapter III, equally important to a planning process directed by public participation is how residents perceive the importance of the various industries that make up those economies. For example, in the western U.S. a common perception is that service industries are composed of "making hamburgers or shining shoes" and are therefore less important than extractive industries (Rasker, 1992). In the communities proximate to the MAB reserves, extractive-type industries had a relatively short and costly lifespan. Is it the general perception on both sides of the border that "one good factory will provide more jobs than the entire tourist industry" (Langewiesche, 1992)? Keeping in mind the recent approval of NAFTA, such perceptions may be hard to discount, especially in Sonora where poverty is so pervasive. A recent study by the University of Arizona's Udall Center notes that while only 31% of Arizonans would accept higher levels of pollution as a tradeoff for jobs and economic development, 64% of Sonorans polled would (Rothstein, 1996). As illustrated in Chapter III, development on one side of the border will effect the quality of life on the other. Is it possible to lead development of local communities in directions that maintain or increase the high qualities of life that currently attract tourists and retirees? Doing so would seem to be an important component in implementing sustainable development.

3. ISDA

Described in Chapters IV and V, this organization is successfully initiating public participation among all three cultures on both sides of the international border. In addition, it is attracting the attention of public agency personnel who are utilizing it as a means of gathering information and free publicity. In its role with ISMAB, ISDA's continued purpose should be to provide a forum for the identification of community values and the implementation of those values in plans and projects. Ideally, local ISDA chapters should be formed in each community, allowing the ISDA Board of Directors to coordinate with these local chapters in devising both local as well as regional planning goals.

4. ISMAB Cooperative

Similar to the cooperative formed in the Southern Appalachian MAB reserve described in Chapter IV, this organization should be composed of public agencies from both sides of the border. The cooperative should act to coordinate implementation of planning goals on public lands outside of the reserve boundaries.

5. ISMAB Coordinating Committee

Ultimate responsibility for the implementation of planning goals will reside in the coordinating committee. Composed of representatives from local communities as well as members of governmental and non-governmental organizations, the committee will act to acquire funds from outside sources. (Perhaps these funds could ultimately be derived from development within the region, as is the case in the Rocking K development

described in Chapter IV.) In a manner similar to that in which the North American Development Bank loaned money to Puerto Peñasco for the construction of a sanitary landfill, the committee will review proposed community projects for sustainability and public participation and award funds to local communities which meet these standards. The coordinating committee will essentially act as a bank for sustainable development. Ideally, the committee would act as a clearinghouse for a portion of all government funds that are currently directed to the communities of the region.

D. Conclusions

In this paper, I have sought to demonstrate the need for holistic planning in order to address the long-term conservation of protected reserves. I have also attempted to demonstrate that holistic planning ultimately depends on public participation in the reserve planning process in order to succeed. Despite the lack of a historical precedent, the time would appear to be ripe for the greater application of such an approach:

- As discussed in Chapter III, traditional means have failed in the past to balance economic development with environmental protection and little coordination exists across a maze of public and private jurisdictions. Much of the study region is currently undergoing considerable economic change as older extractive industries such as fishing and mining are giving way to tourism and service industries. In times of change and uncertainty, residents are naturally more concerned about their future and will be more eager to play an active role in regional planning.

- The political climate in Mexico seems to be shifting as opposition parties are mounting greater challenges to established political networks. Changes in national politics may encourage local groups to become more active in local politics. In politically uncertain times, a planning process with a broad base of public support would be taken seriously by all parties concerned with the area.
- The recent passage of NAFTA will certainly have an effect on economies on both sides of the border. At a minimum, infrastructure for transportation and storage will need to be coordinated on an international level. Such coordination will require planning, thereby offering an avenue for citizen participation.
- In 1994, the U.S. Congress legislated \$300,000 to ISDA, indicating that its efforts are being taken quite seriously.
- In the U.S., recent actions concerning public gambling on Arizona's Indian reservations seem to have confirmed greater Native American autonomy. Such trends may encourage the O'odham toward greater self-determination and greater participation in regional efforts.
- Federal management agencies in the U.S. by law must incorporate citizen participation into planning and management processes.
- The U.S. military must reapply in 2002 for renewal of its use of the Goldwater Bombing Range. A well-organized congress of local residents could play a key role in how the military continues to use the area.

Of course, public participation alone will not guarantee the protection of the reserves' outstanding natural attributes. In the end, the long-term survival of both human and natural communities depends on the values of

that human community. A community that values itself and its natural surroundings is more likely to want its children and grandchildren to live where it does. The community is more apt to take the long view. Conversely, a community that does not value local assets or fails to acknowledge its values will have few incentives to resist the degradation and loss of those assets. Ultimately, the success or failure of holistic planning rests on local residents.

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