

**Common Property and
Traditional Ecological Knowledge:**

**Biodiversity Conservation in the
Sierra Tarahumara, Mexico**

Serge LaRochelle

Thesis submitted to the Faculty of Graduate Studies of the University of Manitoba in partial
fulfilment of the requirements of the degree of Master of Natural Resources Management

Natural Resources Institute
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**COMMON PROPERTY AND TRADITIONAL ECOLOGICAL KNOWLEDGE:
BIODIVERSITY CONSERVATION IN THE SIERRA TARAHUMARA, MEXICO**

BY

SERGE LAROCHELLE

**A Thesis/Practicum submitted to the Faculty of Graduate Studies of The University
of Manitoba in partial fulfillment of the requirements of the degree
of**

Master of Natural Resources Management

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Abstract

The Sierra Tarahumara, a range of deep canyons and high mountains of the Sierra Madre Occidental in northwestern Mexico, is home to important biological and cultural diversity. The Rarámuri who inhabit the Sierra Tarahumara have maintained for generations a subsistence relationship with the resource base, consisting of pine-oak forests intermixed with arable land. The common property arrangements that govern the relationship between humans and nature stem from a long history of Indigenous norms of land stewardship, combined with externally integrated decision-making structures for the management of natural resources. Property rights and the institutional arrangements that arise from the history in the area each have a role to play in decision-making regarding resource use, especially with the recent increase of development in the area. They are the subject of the first part of the thesis, which is the examination of social institutions to make decisions regarding the use of biodiversity in the Sierra Tarahumara.

The second part of the thesis presents results of ethnobotanical research undertaken in the community of Basíhuare, where Rarámuri harvesters have developed strategies that manipulate the landscape in a way that appears to conserve the biodiversity of the forest ecosystem, and specifically the variety of edible wild plants. The results shed light on the aspect of the Rarámuri worldview that respects the interconnected relationship between people and their forest environment. This forms the basis for the sustainable use of wild plants, reflected in the strategies of selective harvesting, domestication, and environmental modification. These land use management practices lead to the conservation of biodiversity by creating patchiness and renewing the plant cover on the land. These activities also provide the opportunity for harvesters to monitor the landscape and the plant resources found on the land, as well as present a setting for the communication and exchange of traditional ecological knowledge. However, these harvesting strategies are under stress because of increasing external pressures in the area. The key to the conservation of biodiversity in the Sierra Tarahumara is the continued practice, exchange and communication of traditional management strategies.

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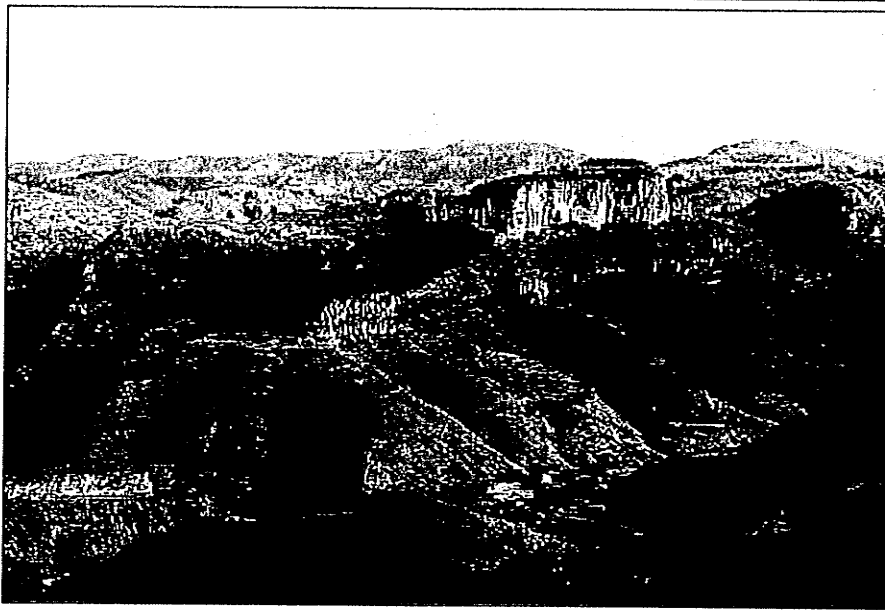
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Chapter 1 - Introduction

The Sierra Tarahumara is characterized by a tremendous diversity of flora and fauna, including a number of species found nowhere else in the world.

(Merrill 2000)



The Sierra Tarahumara is a region of deep valleys and high cliffs

Photo: S. LaRochelle



The community of Basihuare, nestled along the Basihuare arroyo

Photo: S. LaRochelle

1.1 Background

Biodiversity conservation is at the forefront of discussions surrounding the issue of sustainable development. In fact, the United Nations Convention on Biological Diversity has as its main goals the conservation of biological diversity, and the sustainable use of its components (Posey 1999; Gadgil et al. 2000; Kimmerer 2000). Biodiversity conservation is of interest because of the role it plays in providing ecological services that maintain the global life support system (Cairns 2002).

Among the growing practices in the conservation of biodiversity is to study how human intervention on the land and its resources influences the functioning of ecosystems (Heywood 1995). Cultural groups whose livelihoods are intrinsically linked to forest resources are often considered as they have developed methods to conserve the biological diversity of the ecosystems in which they live (Thompson and Langill 1999; Vandergeest and Rogge 1999; Chapeskie 2001). On a global scale, the bulk of forest diversity exists outside of protected areas, and outside the management authority of conservation projects and forestry departments.

The exploration of traditional non-timber forest products is gaining momentum as a research focus in the study of forest biodiversity conservation (Peters 1994; Turner 1999). Davidson-Hunt, Duchesne and Zasada (2001, p.5) suggest a broad definition of non-timber forest products as “those biological organisms, excluding timber, valued by humans for both consumptive and non-consumptive purposes, found in various forms of forested landscapes”. Ethnobotanical research on harvesting practices and strategies of non-timber forest products (NTFPs) has made specific contributions to the study of forest biodiversity (Martin 1995; Turner 1995; Boyd 1999). Strategies and practices for harvesting NTFPs comprise an important aspect of such research because they explore, for instance, the importance of using a diversity of resources to generate multifunctional landscapes (Gadgil et al. 1993; Anderson 1996; Posey 1999). An important component of NTFP study is the harvest strategies of cultural groups whose diets often comprise wild plants (Melchias 2001). The study of edible wild plants is increasingly important because approximately 100 kinds of plants provide the great majority of the world’s food, with only nine food crops

accounting for about 75 percent of global human dietary needs (FAO 2001). Hence, conserving the biodiversity of edible wild plants and relatives of crop species may become a significant factor when looking for a local solution to the continuing loss of diversity in food sources.

The management of forest areas is often maintained by collective choice decisions of local people who operate under a common property arrangement (Becker and León 2000; Klooster and Masera 2000; McKean 2000). Cultural groups have implemented a series of rules or social norms, constituting institutions to govern the management of forest resources (Becker and León 2000). Institutions in traditional resource management systems allow harvesters to coordinate activities, cooperate in tasks, and devise rules for social restraint (Davidson-Hunt and Berkes 2001). Such institutions seem to be successful when harvesters depend on a resource for a major portion of their livelihoods, and are interested in the sustainability of that resource (Ostrom et al. 1999).

It has been recognized that regions rich in biological diversity are usually inhabited by cultural groups who have managed to hold onto traditional ecological knowledge of their bioregions (Gadgil et al. 1993; Laird 1995; Posey 1999). These societies often depend on subsistence harvests of non-timber forest products for their livelihoods and have developed traditional knowledge, gained by generations of interactions with natural forested areas (Brookfield and Paddock 1994; Turner et al. 2000; Davidson-Hunt and Berkes 2001).

A cultural group whose members maintain traditional knowledge about the biodiversity of the landscape, and who have designed institutions for the management of natural resources is the Rarámuri of Chihuahua who inhabit the Sierra Tarahumara of northwestern Mexico (Salmón 1999). In this thesis, Rarámuri and *Latin* terms are given in *italics*; Spanish terms are presented in the first instance with single 'quotation' marks, and provided in a glossary at the end of this chapter.

1.2 Purpose and objectives of the research

The purpose of my research was to explore the Rarámuri social-ecological system to determine which factors may lead to the conservation of biodiversity in the Sierra Tarahumara. I undertook qualitative research in the community of Basíhuare, where I explored common property arrangements and traditional ecological knowledge of non-timber forest products. In order to guide the research process, the following specific objectives were determined:

1. Compile an overview of local and regional organizations that are involved in the maintenance of Rarámuri traditional ecological knowledge;
2. Determine common property rights and local-level institutions (norms and rules) pertaining to the use and management of non-timber forest products;
3. Explore traditional ecological knowledge regarding strategies to conserve the biodiversity of non-timber forest products, with a focus on edible wild plants;
4. Describe local processes and actors involved in the communication and exchange of traditional knowledge about edible wild plants.

These objectives have evolved since my research proposal, thanks to discussions in Basíhuare with the local research facilitator and the community leader. I refined these objectives with my thesis advisor during a visit to Winnipeg at the mid-point of the field research, and discussed these modifications with the research facilitator upon my return to the community.

My research was carried out in the context of the Project on Diversity in the Sierra Tarahumara, initiated by México-Norte, a regional non-governmental organization. The main objective of this project is to document and explore the linkages between biological, linguistic and cultural diversity in the Sierra Tarahumara (Merrill 2000).

1.3 The Sierra Tarahumara: important biological and cultural diversity

The Sierra Tarahumara, a major component of Mexico's northern Sierra Madre Occidental, is a region of high sierras and deep canyons, ranging in altitude from 200 meters to 3000 meters and extending for nearly 1000 kilometres from the United States border through the northern Mexican states of Chihuahua, Sonora, Durango, and Sinaloa. The World Wildlife Fund has designated the Sierra Madre Occidental as a Global 200 Ecoregion, defined as the world's major habitat types designated for conservation because these regions foster outstanding examples of biodiversity (WWF 2002). The Commission for Environmental Cooperation has identified the Sierra Madre as a priority ecoregion in the development of the group's long-term agenda for cooperation on a strategic and concerted approach to North American biodiversity conservation (CEC 2001). The Sierra Tarahumara is characterized by a tremendous diversity of tropical, subtropical, and temperate flora and fauna, including a number of species found nowhere else in the world (Merrill 2000). In fact, some 1900 plant species occur in the Sierra Tarahumara region (Bye 1995), 350 of which are used for food and medicine (Felger et al. 2001). Mexico's National Commission for the Knowledge and Use of Biodiversity has identified six areas within the Sierra Tarahumara as priority terrestrial regions, designated as areas of significant ecological integrity with the potential to be preserved (Arriaga et al. 2000).

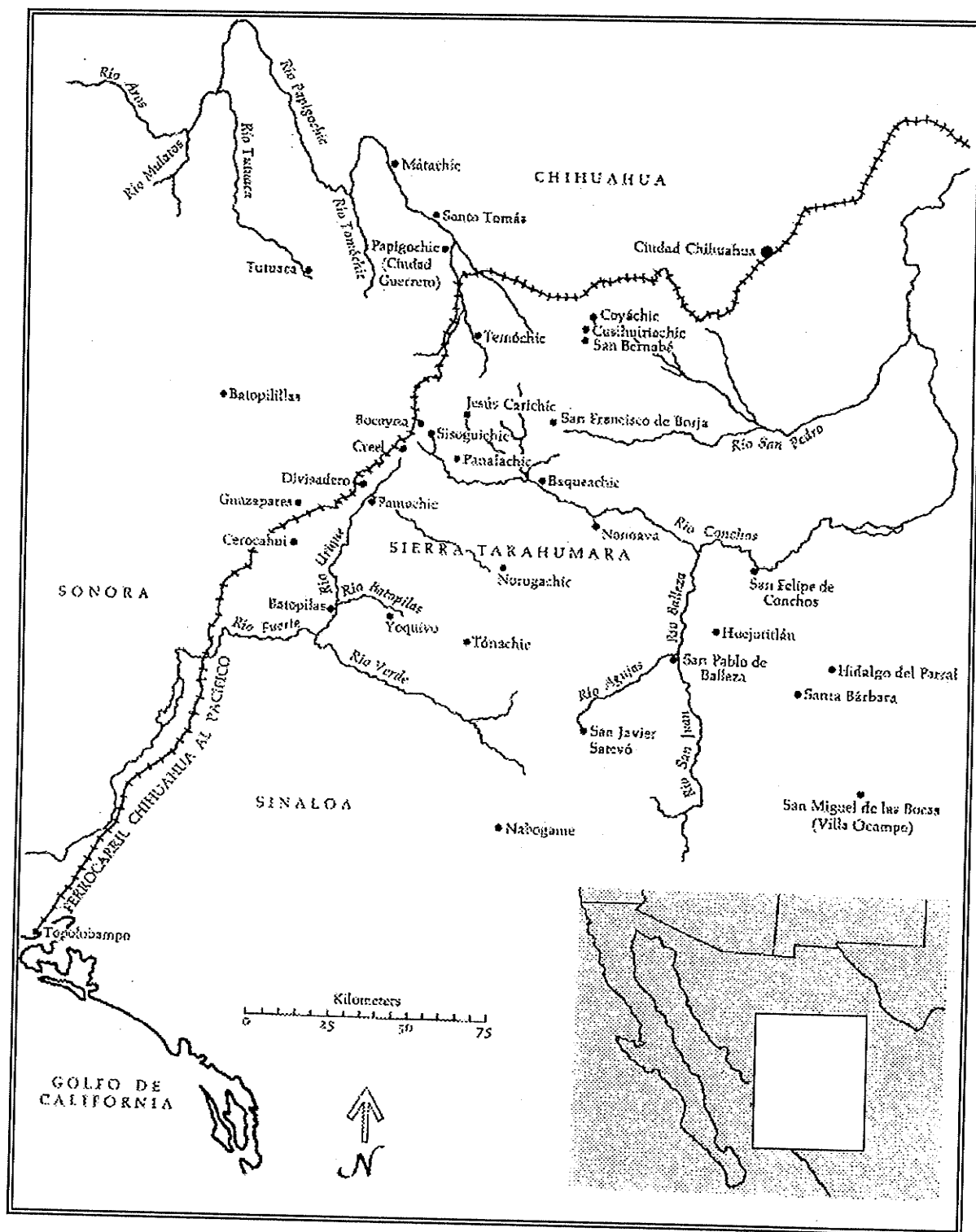
The Sierra Tarahumara is also an area of significant cultural diversity. Four Indigenous groups - the *Rarámuri* (Tarahumara), *Ódami* (Northern Tepehuan), *O'óba* (Mountain Pima), and *Warijío* (Guarijío) have their homelands there, and each of these societies has its own distinct language. With a total population of approximately 60,000 members (Merrill 2000), the *Rarámuri* are the dominant group in the Sierra Tarahumara, and one of the most significant groups of native peoples in Mexico. The *Rarámuri* people have a particular affinity to the forests and mountains of the Sierra Tarahumara, believing in the total interconnectedness and integration of all physical and spiritual life (Salmón 2000a). *Rarámuri* harvesters maintain a traditional subsistence relationship with the forest resource from which they view themselves as participants in the natural community. As such, the *Rarámuri* have developed over generations a knowledge base around the harvesting of

plant resources, and have used wild plants for centuries in a manner that has been described as sustainable (Bye 1995; Salmón 2000b).

The municipality of Guachochi, where my research project was carried out, is one of 67 municipalities in the state of Chihuahua. Guachochi has an overall population of 38 715, 66 percent (25 471) of which are Indigenous peoples, making it the second most populated municipality and the one with the highest percentage of Indigenous peoples in the state (INEGI 2001, p.424-431). The 'ejido' of Basíhuare, a subdivision of the Guachochi municipality, is representative of the percentage of Indigenous inhabitants living in the municipality. With a total of 305 registered 'ejidatarios', 80 percent of them are Indigenous people (Alvarez, Diemer and Stanford 1999).

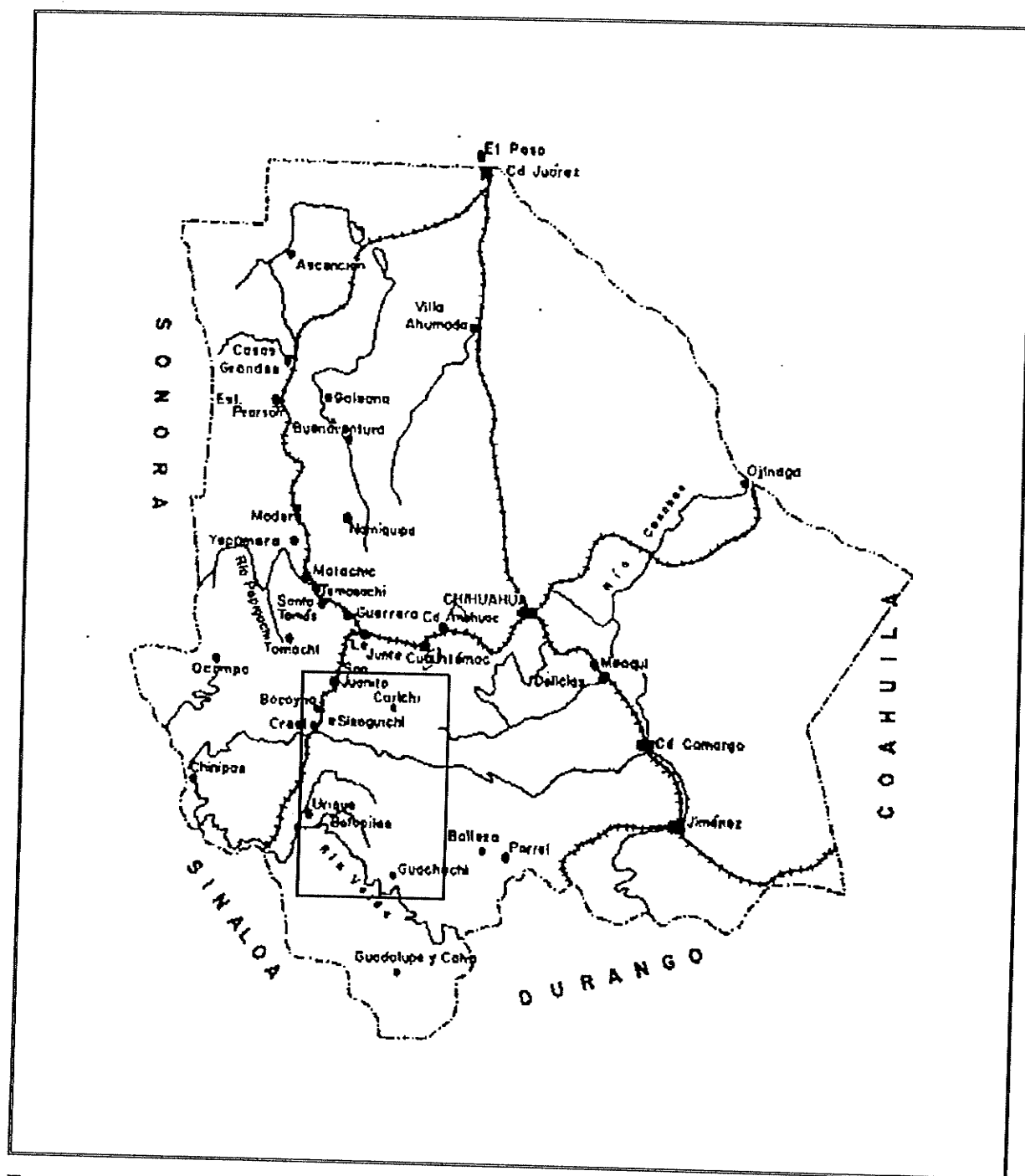
The recent history of 'Mestizo' (Spanish descendant) immigration to the Sierra Tarahumara, began with the 'Barranca del Cobre' (Copper Canyon) mineral exploration of the early 1900s (Zingg 2001). This was followed by commercial forest operations in the mid-twentieth century, bringing many changes in land and resource use in the area. A principal road through this area of the Sierra Tarahumara, paved in the 1990s, runs near the community of Basíhuare. The highway supports the increased flow of traffic from local residents and tourists travelling to and from Creel, an important commercial centre and a starting point for excursions throughout the Copper Canyon region. In effect, these changes integrate into the global economy what had been a relatively isolated region of Indigenous communities. Increased activity has impacted local ecological relations, and contributed to deforestation, soil erosion, and loss of understory plants (Felger et al. 2001). External demand for natural resources in the Sierra Tarahumara and the ensuing increase in trade has resulted in the loss of some traditional activities. There is concern that such changes are threatening traditional ecological knowledge, and the cultural integrity of the Rarámuri people (Merrill 2000). These recent developments, coupled with the predominately Indigenous population give Basíhuare a unique flavour for the study of community-based institutions and of traditional ecological knowledge. **Figures 1.1, 1.2 and 1.3** display maps of the area.

Figure 1.1 - Map of the Sierra Tarahumara



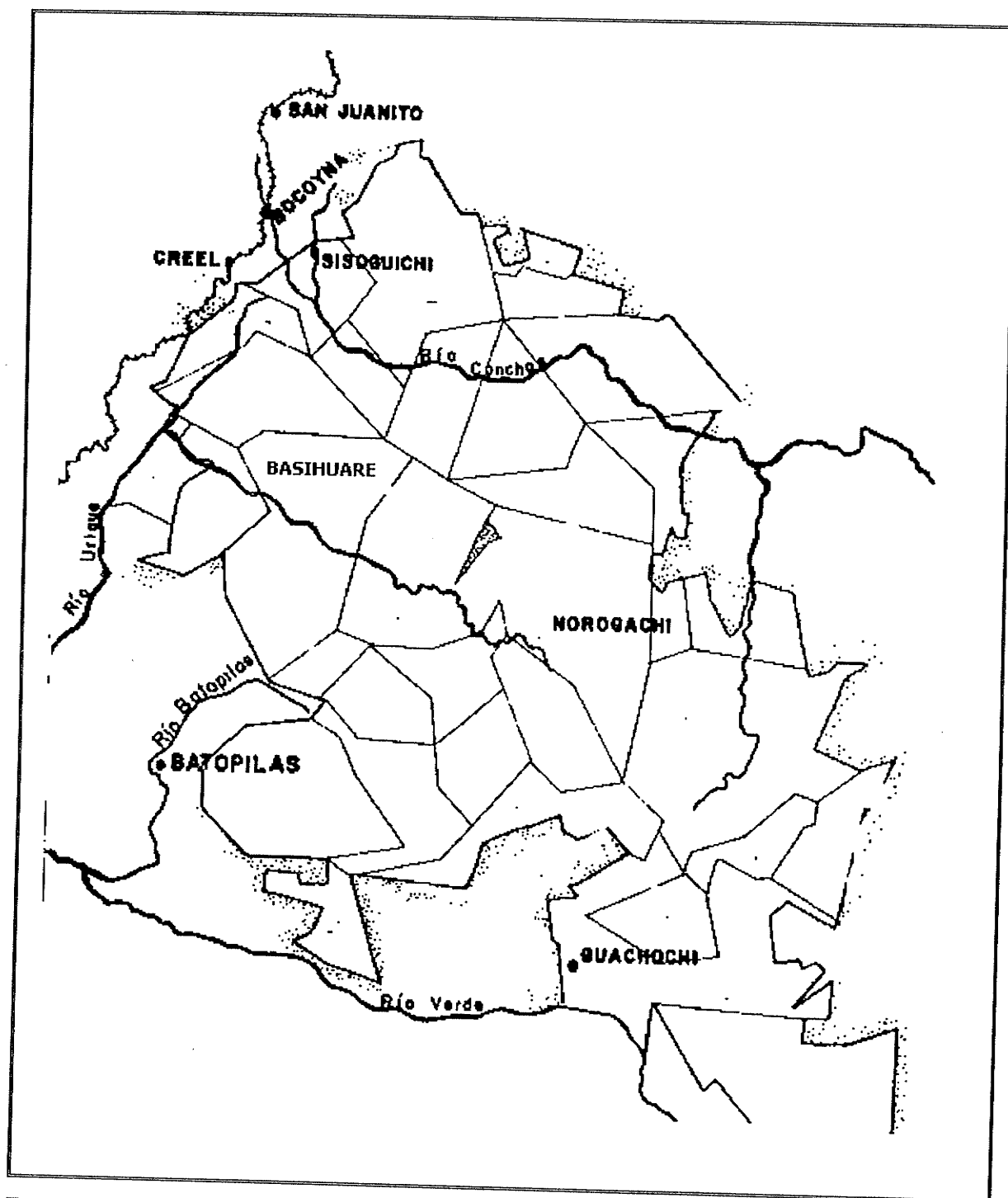
From Fontana and Schaefer (1979).

Figure 1.2 - Map of the state of Chihuahua and location of Figure 1.3



From Lartigue (1983)

Figure 1.3 - Map of the Basihuare ejido and vicinity.



From Lartigue (1983)

1.4 Limitations of the study

Interdisciplinary research often requires “thinking outside of the box” to link the various components that exist in a complex social-ecological system. This mode of research may lead to a cursory review of a number of issues, as opposed to a thorough understanding of a specific variable. Qualitative interdisciplinary research produces an overview of the issues that are deemed important in a natural resources management setting, and provides a series of conclusions to research objectives.

Although my research took an interdisciplinary approach, this thesis only provides a glimpse of the actual situation in the study area. The time period in which I completed the research was relatively short: four months of pre-study preparations; six months in the field; and one year of review, analysis, presentation and discussion of findings. Taking a holistic, interdisciplinary approach to fully understand and interpret the social-ecological system in the Sierra Tarahumara requires years of research with a team of individuals committed to the study. The area, like any other, is in constant change, affected by internal variations and external pressures. My thesis only provides a snapshot of the complex social institutions and expansive knowledge embodied in the Rarámuri culture.

Interdisciplinary research undertaken with an Indigenous community in a country where the working language is not my native tongue posed limitations to my research. These are just a few of the many that I encountered.

1. Communication with Rarámuri community members was limited due to cultural and linguistic differences.

Living and working within a different cultural context was exhilarating one moment, and confusing the next. This dichotomy of emotions was due in part to a language barrier, because most research activities were undertaken in Spanish. I especially had a difficult time interpreting local accents and colloquialisms, but within a month, my Spanish skills improved enough to speak comfortably with community members. Unfortunately, my knowledge of the Rarámuri language remained limited. Although most research participants understood and spoke Spanish, their knowledge of the language was also

limited. Thankfully, I developed a close relationship with the research facilitator, who proved to be a conscientious translator.

We decided that it was important to encourage research participants to share ideas and impressions in their own language. Some ideas were not fully developed because the facilitator would translate responses into Spanish, and the opportunity to delve deeper into the subject was limited. Plus, research findings went through a double translation ringer before washing onto the pages of this thesis – initial responses were translated from Rarámuri to Spanish, and research findings were transcribed from Spanish to English. The final product differs, I hope only slightly, from ideas initially conveyed by research participants.

2. Challenges arose in the development of trust and understanding with research participants due to the relatively short timeframe of the project.

The fact that I came from another place to ask questions about edible plants made my presence in the community somewhat of a novelty. Thanks to Iain Davidson-Hunt from the Natural Resources Institute, I was able to identify a research facilitator who had worked with outside researchers in the past. Despite a sense of reluctance at first from community members, working with a research facilitator made it possible to link up relatively quickly with individuals who were interested in the study, and who were willing to participate in research activities. His help made it possible to delve into issues that I would not have been able to discuss had I been conducting research on my own.

3. The selection of research participants was limited to a handful of people, which may have alienated some community members.

My research focused on providing an in-depth study with a few community members. As a result, research findings reflect the impressions and knowledge of only a segment of the population of Basíhuare. Even though the community is predominantly Rarámuri, Basíhuare has a complex interplay of individuals who hold varying religious and societal beliefs. As well, decisions relating to resource use often occur at the family level, with a priority placed on helping family members and community members with whom close ties

have been created. By working primarily with one research facilitator, the knowledge and opinions presented in my thesis are limited to mainly one kinship group. However, I did undertake triangulation activities in the final stages of my field research, to provide a wider breadth in the research findings. Nonetheless, the intent of the thesis is still not to generalize for the entire community, but to provide a glimpse of the social-ecological structure of the community of Basihuare.

1.5 Organization of the thesis

This section presents the organization of the thesis. The second chapter presents a review of literature pertaining to the main themes of the research, namely biological diversity, common property arrangements and traditional ecological knowledge. Chapter three provides an explanation of the partnership for participatory research that was established with the research community, followed by a description of specific research activities as they pertain to each of the four research objectives. The chapter finishes with an analysis of verification and feedback mechanisms employed during the field research, reflections on the research process and an explanation of my synthesis and analysis of research findings. The thesis then presents, discusses, summarizes and provides conclusions to research findings, relating to common-property rights and local institutions in the fourth chapter, and traditional ecological knowledge of edible wild plants in the fifth chapter. These chapters were written with the intention of submitting them as journal articles, and thus employ a slightly different writing style than the first three chapters. The sixth and final chapter provides overall conclusions to the study.

1.6 Glossary of key Spanish and Rarámuri terms

Dueño – landholder, or caretaker of a rancho

Ejido – formal community land tenure area set forth by post-revolution (1910) agrarian reforms

Ejidatario – registered member of an ejido

Mestizo – person with Spanish ancestry

Milpa – agricultural system or area for the production of crops

Owirúame – Rarámuri spiritual healer, with the role of curing plants, animals and humans

Pueblo – community, or town within an ejido

Quelites – edible plants consumed as vegetables or greens

Rancho – land with specific tenure rights where families reside, produce milpas and keep livestock

Siríame – Rarámuri traditional community leader

Tarahumara – Spanish interpretation of the Rarámuri title

Notes on representation of Rarámuri terms

1. Rarámuri is now a recognized term in Spanish and English, and thus is not italicized in the text.
2. According to the orthography of the Rarámuri language, the r and l are interchangeable; and the use of either letter varies among communities of the Sierra Tarahumara. For example, Rarámuri can also be spelled Ralámuli.
3. In the text, showing stress in Rarámuri terms follows the Spanish convention, by using an accent only when stress does not fall on the penultimate syllable. If stress falls on the penultimate syllable, an accent is not used.

Chapter 2 - Literature Review

2.1 Introduction

My research deals with the main themes of biological diversity, common property institutions and traditional ecological knowledge. In this chapter, I provide background to my research by reviewing the literature about these themes, and attempt to identify the role my study plays in filling gaps in previous research. The chapter begins with a definition of biological diversity and the role biodiversity plays in providing ecological services. The section on biological diversity follows with a look at the recent loss of biodiversity and the global response through the UN Convention on Biological Diversity (CBD). The chapter explores the importance of NTFPs in the study of biodiversity, put in the context of the current situation in Mexico and that nation's response to the CBD. I continue with a general review of common property institutions, and discuss how property rights and local institutions form a fundamental aspect of commons management, and what has been written on common property in the context of biological diversity. The literature review examines how traditional ecological knowledge contributes to the conservation of biological diversity. I discuss previous research about the communication and exchange of traditional ecological knowledge, and conclude with an examination of the challenges presented when researching traditional ecological knowledge.

2.2 Biological diversity

Biological diversity, or biodiversity, has been defined in many ways by many authors (Heywood 1995; DeLong 1996; Wilson 1997). One definition seems to capture the ideas presented by these authors: "the living creatures, including humans, which form a community in an ecosystem, interacting with one another and with the air, water, and soil around them" (UNEP 2000a, p.2). Biodiversity can be determined at the species level, by considering the wide variety of plants, animals and micro-organisms of an ecosystem, or at the genetic level, by viewing the differences in features that exist between similar species (Kimmins 1999). Species diversity can increase the productivity of ecosystems by creating more opportunities for energy flow and nutrient cycling (Costanza and Folke 1996). Not

only is the diversity of species important, but also how that diversity is organized to determine the overall health of ecosystems (Costanza and Folke 1996). As such, biodiversity can also be measured at the landscape level, in terms of, for example, the variety of ecosystems that exist on an entire continent. In fact, the diversity of life on earth has resulted from the diversity of species and the interactions that occur among them at the landscape level. The importance of studying biological diversity thus lies in the role it plays in the integrity and function of ecological systems.

Studying biodiversity is rendered even more important by recent reports estimating that although the loss of species has always occurred as a natural phenomenon, the pace of extinction has accelerated dramatically in recent years, with species disappearing at 50 to 100 times the natural rate (UNEP 2000a, p. 5). If the present rate of biodiversity loss continues, ecosystem productivity and integrity will be reduced, thereby shrinking nature's products and ecological services (UNEP 2000a; Cairns 2002). The reduction in biodiversity is a result of changes in traditional human attitudes of interconnectedness with nature, and growth in human populations and resource consumption (Canadian Forest Service 2000). Biodiversity loss is also associated with "mono-culturation" of production systems, exemplified by the World Bank's green revolution, which sought to replace multiple-species traditional agricultural practices with input-dependent single food crop production (Shiva 1993).

I became interested in the study of biodiversity in Mexico, because it is home to a rich diversity of biological resources (MNCF 2000). In fact, Mexico is listed as the fifth most biologically rich nation in the world (Castillo and Toledo 2000). The case of Mexico is interesting, because as in most parts of the world, the loss of biodiversity is a pressing problem, especially relating to diversity in forest ecosystems. In fact, Mexico's average annual deforestation rate between 1990 and 1995 was estimated at 510,000 hectares (Roper and Roberts 1999, p. 3). Paradoxically, the country is ranked fifth worldwide in terms of forest loss, caused primarily by forest fires, agricultural development and unsustainable forest operations (CEC 2002).

Studying biodiversity of forest ecosystems is important because they provide the most diverse sets of habitats for plants, animals and micro-organisms, and hold the vast majority of the world's terrestrial species (UNEP 2002). In fact, the protection of forest biodiversity is a major area of focus of the United Nations Convention on Biological Diversity, which is an attempt by the global community to respond to the ever-increasing loss of biodiversity.

At the 1992 Earth Summit, co-organized by the United Nations Environment Program, world leaders agreed on a comprehensive strategy for sustainable development, in which the needs of humans are met without compromising the health and viability of the world for future generations (WCED 1987). One of the key agreements to come out of the Earth Summit was the Convention on Biological Diversity (CBD). The Convention, adopted by governments from more than 175 countries, including Mexico, recognizes that the conservation of biological diversity is "a common concern for humankind" (UNEP 2000a, p. ii). The CBD encompasses three main goals: the conservation of biological diversity; the sustainable use of its components; and the fair and equitable sharing of the benefits from the use of genetic resources.

The convention has a role to play at the international and national policy level, entrusting nations to adopt their own measures for the conservation of biodiversity. For example, signatory nations must develop a legal framework and take the necessary administrative measures to adhere to the objectives outlined by the convention. In Mexico, the institution entrusted with the responsibility of implementing the CBD is the National Commission for the Knowledge and Use of Biodiversity (Comisión Nacional Para el Conocimiento y Uso de la Biodiversidad, or CONABIO). The Commission's goal is to co-ordinate conservation and research efforts designed to find sustainable uses for biological resources (CONABIO 1992). Although my research does not develop an analysis of the convention, I consider how it may be applicable to conserving the biodiversity of non-timber forest products in the Sierra Tarahumara.

Studying biodiversity in a forest ecosystem often focuses on the variety of tree species for the sustainable production of timber. However, forest biodiversity provides more than

trees; it offers an array of goods and services, including non-timber forest products, and ensures livelihood for hundreds of millions of people worldwide (UNEP 2002). The Food and Agriculture Organization (FAO) of the United Nations was one of the first international organizations to study the biodiversity of non-timber forest products (Davidson-Hunt et al. 2001). Since then, several other international agencies, for example the International Union for Conservation of Nature and the Biodiversity Support Program, along with Canadian organizations, such as the Canadian International Development Agency and the International Development Research Centre, have incorporated the study of NTFPs into program areas.

The study of non-timber forest products is also important at a local level, because forest biological diversity plays important social and cultural roles in the lives of many Indigenous communities (UNEP 2002). Cultural groups who maintain a subsistence relationship with forest ecosystems value more than just timber; they depend on the medicinal, spiritual and cultural attributes of forest products. It has been suggested, for instance, that several communities throughout the world have adopted subsistence harvesting practices of edible wild plants to overcome food scarcity (Begossi 1998; Ladio and Lozada 2000).

The Rarámuri of the Sierra Tarahumara are such a group who live in concert with their environment (Salmón 2000a). As Shiva (1993, p. 11) has suggested, "Monocultures are not just reducing the rich biological diversity. They are reducing the way diverse societies organize themselves politically". To study a region, which programs of the green revolution have not affected, may provide some insight into how traditional societies, such as the Rarámuri, potentially maintain an array of common property institutions that lead to the conservation of biodiversity.

2.3 Common property institutions

The study of community arrangements to learn from present and past common property regimes is being promoted in the conservation of biodiversity (Agrawal 1994; McKean

2000). Common property systems of resource management are of great importance in Mexico (Alcorn and Toledo 1998; Castillo and Toledo 2000), where several thousand communities manage up to 80 percent of Mexico's forested areas (Klooster 2000, p. 4). Under these common-property systems, communities "define and allocate individual and group rights to particular resources within the lands held by the community" (Alcorn and Toledo 1998, p.220). Such common pool resources are defined as "goods that can be kept from potential users only at great cost or with difficulty but that can be subtractable in consumption and can thus disappear" (McKean 2000, p. 28).

Property rights are one of the attributes of common property arrangements (Ostrom 1990; Oakerson 1992; Berkes and Folke 1998; McKean 2000). "Property Rights systems do not simply define and grant rights; rather they establish the rights and responsibilities of system participants" (Alcorn and Toledo 1998, p. 216). For instance, under common property regimes, a resource is held by identified users who regulate use and exclude others (Ostrom 1992; Berkes 1996). Some of the most sophisticated property rights arrangements are found in areas where systems have developed over a long period of time (Costanza and Folke 1996). If the people that live near forests lose the property rights related to the resource, they lose the incentive to manage these resources in a way that ensures long-term sustainability (McCay 2002).

As presented in the second objective of my research, I studied property rights in the Sierra Tarahumara, where the Rarámuri have been living for generations, to gather findings on the responsibilities that have generated relationships among community members, and provided incentives to manage the area sustainably. To do so, I considered the property rights that exist in a common property arrangement; operational level rights of access and withdrawal, such as selling the resource base; and collective choice rights, such as the management of the land, the exclusion of other potential users, and the right of alienation (Ostrom 1990; Schlager and Ostrom 1992; Ostrom and Schlager 1996). An example of alienation rights in Mexico was reported by Alcorn and Toledo (1998), who describe how families hold agricultural lands within commons and transfer property rights over these lands to descendants following inheritance practices. Ostrom and Schlager (1992) convey

the effect property rights have on incentives individuals face, the types of actions they take and the outcomes they hope to achieve on the land.

Local-level institutions are a mechanism to protect and regulate property rights and to maintain control over a valued resource base, which is a fundamental aspect of local users wanting to conserve the land (Gibson and Becker 2000). Much of the common-property literature emphasizes institutions as intervening factors that govern the use of natural resources by the society that depends on them (Berkes 1996). These rules focus on providing social regularity in a way that is observable and explainable by members of this society (Ostrom 1992). But, institutions are more than rules. They define what it means to be a community member, by providing the “major feature of the cultural cognitive and ecological realms within which acting and decision-making individuals and social groups are embedded” (McCay 2002, p. 362). Local institutions also afford an arena to discuss and make decisions regarding commons management, and provide a forum to resolve conflict (McCay 2002; Gibson and Becker 2000).

Many groups with long histories of forest use have a wealth of institutions upon which to draw in making locally based decisions (McKean 1995; Berkes and Folke 1998; Ostrom et al. 1999; Klooster and Masera 2000). These “rules for orderly use” (Berkes and Farvar 1998, p.10) are complex and embedded in cultural systems (Klooster 2000). As a result, local institutional arrangements are considered better than central government institutions at developing the capability to respond quickly when faced with environmental feedback or change (Berkes and Folke 1998).

To undertake research on common property institutions in the Sierra Tarahumara, I examined the participatory approaches to managing forest resources, as suggested by Varughese (2000). More specifically, it was important to identify if local level institutions were included in the planning and decision-making stages of forest management (Alvarez et al. 1999; Webb and Khursid 2000; Berkes 2002).

Another reason to focus on community-based institutions is in terms of enabling national or international priorities, (such as those set forth by the Convention on Biological Diversity),

which focus on local action for the conservation of biodiversity (Meredith 1997). In fact, “the conservation of cultures that have conserved biodiversity is the most effective means to protect the richness and variety of life” (Shiva 1993, p. 19). The value of common property arrangements for promoting biodiversity conservation is well recognized (Chapeskie 2001). Examples of commons institutions from several societies of the world show that these community-based arrangements are composed of certain attributes that lead to sustainable land management. As Ostrom et al. (1999, p.282) conclude, promoting “institutional diversity related to how diverse peoples cope with common property resources may be as important for our long-run survival as the protection of biological diversity”.

More specifically, forest common property systems offer an intriguing social context in which to seek examples of management systems that conserve biodiversity (Klooster and Masera 2000). But as McCay (2002) posits, further study is required to widely apply an institutional framework in the hopes of curbing the loss of biodiversity in forest ecosystems. My research provides examples of institutional arrangements in the Sierra Tarahumara to complement this field of study. My research on institutional arrangements is placed in the context of traditional ecological knowledge held by Rarámuri people, as outlined in the third objective, partly because local institutions tend to use traditional ecological knowledge for management (Berkes 2002).

2.4 Traditional ecological knowledge

A fundamental aspect of the UN Convention on Biological Diversity is the acknowledgement of the role played by Indigenous and local communities in the conservation and sustainable use of biological diversity. As outlined in Article 8 (j) of the Convention, signatory states agree to:

“... respect, preserve and maintain knowledge, innovations and practices of Indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity and promote their wider application with the approval and involvement of the holders of such knowledge” (UNEP 2000b, p. 2).

Several authors have provided definitions of traditional ecological knowledge (Hunn 1993; Ruddle 1994; Purcell 1998; Kimmerer 2000). The definition of traditional ecological knowledge that is best suited to consider biodiversity conservation was provided by Berkes (1999, p.8): “a cumulative body of knowledge, practice, and belief, evolving by adapting processes and handed down through generations by cultural transmission about the relationship of living beings (including humans) with one another and with their environment”. As outlined in this definition, traditional ecological knowledge ‘evolves by adapting processes’; and embraces the intrinsic ‘relationship of humans with their environment’. I discuss how traditional ecological knowledge of non-timber forest products offers an inherent relevance to the study of biodiversity.

In an ecological sense, biodiversity is important to the integrity of an ecosystem because it provides flexibility or adaptive capacity (Davidson-Hunt and Berkes 2001). It supplies the backbone to the theory of ecosystem resilience, which describes the complex and continuously changing state of ecosystems (Holling et al. 1995). According to Holling & Meffe (1996, p. 330), ecosystem resilience is measured by “the magnitude of disturbance that can be absorbed or accommodated before the system changes its structure by changing the variables and processes that control system behaviour”. In other words, resilience indicates the capacity of a system to handle disturbance, and the ability of the ecosystem to maintain integrity when faced with change. A knowledge system for assessing and conserving biodiversity must therefore contain these same resilient elements.

Traditional ecological knowledge is consistent with ecosystem resilience by perceiving the environment as a portfolio of resources, as in the case of New England Indigenous groups prior to the development of a colonial economy focused on commodities (Cronon 1983). In this case, the use of a portfolio of resources sustains a productive landscape and a high degree of biodiversity by maintaining a variety of adaptive uses for an ecosystem.

The Kayapó of the Middle Xingu Valley in Brazil provide examples of how adaptive methods of harvesting non-timber forest products according to ecosystem change have boosted forest biodiversity (Zimmerman et al. 2001). The Kayapó have developed a system of utilizing abandoned fields on the edge of semi-arid land to enhance the abundance of

plants and wildlife (Posey 1997). In these areas, the Kayapó simulate the formation of natural forest patches by intentional concentration of useful species into limited plots, based on knowledge of soil and plant characteristics (Posey 1997). The ensuing adaptive resource management model integrates agricultural cycles within forest management cycles.

Alcorn (1990) specified traditional Mesoamerican agroecological strategies based on traditional knowledge that enabled mechanisms of ecological resilience. These strategies include, among others, utilizing natural environmental variation and mixing domesticated crops with native species. These traditional agroforestry systems utilize ecological processes to increase food production by manipulating the landscape in order to enhance the productivity of plants (Kimmerer 2000). These methods of adaptive resource management, founded on traditional ecological knowledge, provide a solid foundation in the conservation of structural and species diversity (Brookfield and Padoch 1994).

Beyond affording adaptable strategies that embrace ecological resilience, traditional ecological knowledge is based on a worldview of humans interconnected with their environment, which sets forth applications for the conservation of biodiversity. Many traditional knowledge management systems stem from the premise that “there is no separation between the landscapes in which people live and play and those in which they work” (Davidson-Hunt and Berkes 2001, p.79). In western British Columbia, aboriginal peoples sustain the management of resources through traditional knowledge, which has formed an integral part of their belief system by stipulating “spiritual connections among humans, animals, plants and nature in general” (Turner et al. 2000, p.1279).

Most traditional ecological principles based on the relationship between humans and nature are largely concerned with experience, subsistence and survival (Slikkerveer 1999).

Turnbull (1988, cited in Follér 1999, p. 201) conveys the intrinsic ecological knowledge of the Pygmies of Congo, based on their relationship with the forest where they have lived for thousands of years: “they do not have to cut forests down to build plantations, for they know how to gather the wild fruits that grow in abundance there”. The Kayapó of Brazil

have produced by human manipulation and cultural interpretation of the forest what were once thought of as natural ecological systems (Posey 1997).

In the Sierra Tarahumara, the Rarámuri cultural concept of *Iwigara* explains the human connection with the land as a kincentric relationship in which all the natural elements of an ecosystem including humans are related (Salmón 2000a). A fundamental component of Rarámuri knowledge resides in the perception of the bioregion in northwestern Mexico as a relative who must be nurtured. Their dependence on non-timber forest products, built on understanding ecological processes, has inspired them to incorporate sustainable harvesting strategies into agroecological practices.

In his study of the Rarámuri in the Sierra Tarahumara, Salmón (2000b) identified the following management strategies:

- transplanting natural edible greens to corn and bean fields – ensures that greens become more abundant through the cultivation and irrigation that occurs alongside agricultural fields;
- using digging sticks to harvest wild onions, often selecting only the larger bulbs – disturbs the ground and leaves smaller bulbs behind to encourage further growth;
- creating controlled fires in the understory of oak groves – stunts the growth of new trees, resulting in higher yields of acorn and fruit-producing shrubs.

Human intervention has wide reaching implications, for instance placing importance on those species that provide sustenance. However, the Rarámuri worldview of humans interconnected with nature has led to the development of these management practices in a manner that appears to conserve the biodiversity of the forest (Salmón 1999). My research builds on these methods, identifying practices in the community of Basíhuare.

Traditional ecological knowledge, with its foundations built on the ability to adapt to fluctuations in natural ecosystems, the long standing accumulation of knowledge from identifiable ecosystems, and the human influence on the environment, affords a framework to study biological diversity. Examining traditional knowledge is not only important in terms of biological diversity, but also in terms of how that knowledge is conveyed to

younger generations, given the loss of traditional ecological knowledge that is being felt in many societies around the world.

A vast number of aboriginal peoples no longer rely on traditional knowledge because they have been educated away from their own culture and traditions. This concern intensifies when one considers that the wealth of ecological knowledge that has been passed down over generations resides in native languages, many of which are nearly extinct (Kimmerer 2000). This situation exists in the Sierra Tarahumara, where the Rarámuri are seeing their livelihoods under threat. Rapid change is endangering traditional knowledge, the languages used to communicate this knowledge, and the cultural traditions that embody this knowledge (Merrill 2000).

In many societies, the introduction of a new dominant cultural lifestyle has resulted in the loss of knowledge regarding the management of wild plants (Schultes and von Reis 1995; Ladio and Lozada 2000). A study in a rural Mexican village revealed that non-native school-age children identified and knew the uses of 37 plants, compared to Otomi children who were able to do the same for some 138 plants (Icamina 1997). "Just as important as it is to conserve biodiversity, it is as urgent to conserve the diversity of local cultures and the Indigenous knowledge that they hold" (Gadgil et al. 1993, p. 156).

Relatively few studies have been conducted on the communication of traditional ecological knowledge among people of different generations living in the same community. Ethnobotanical research has been undertaken to provide insight into the level of knowledge held by young Indigenous peoples. Nabhan (2000a) concludes that traditional ecological knowledge about relationships between plants and animals is being lost among O'odham children who live in the U.S. Sonoran Desert. Gadgil et al. (2000) report a decline among the younger generation in the level of knowledge relating to plant species in several states of India. Osemeobo (2001) painted a slightly different picture, positing that the majority of youth who participated in his research in five Nigerian states retained some level of traditional knowledge of medicinal plants. Even fewer studies have provided an understanding of the role experiential learning, through activities lived on the land, plays in

the communication of traditional knowledge to younger generations (Ruddle 1993; Ohmagari and Berkes 1997).

What seems to be missing from the literature is research on the loss of traditional ecological knowledge, especially in terms of learning and exchanging knowledge in a natural resources management context. As outlined in the fourth objective, my research attempts to add to this body of literature, not by quantifying the knowledge held by community members, but rather by identifying the processes that make the exchange of knowledge possible, and gathering impressions held by community members on the importance of maintaining mechanisms that preserve traditional knowledge.

To achieve these objectives, I set forth a research methodology, which attempted to study the social institutions and traditional ecological knowledge shaping the conservation of biodiversity in the community of Basíhuare. A focus on traditional knowledge posed some serious challenges, especially in terms of respecting the rights of those who hold this knowledge.

It has been said that knowledge is often removed from its spiritual foundation, from Indigenous worldviews and the values, morals and the relationships that give it meaning (RAFI 2000). By focusing on resource management approaches of local knowledge, the full extent of the importance of traditional ecological knowledge is respected (Simpson 2000). As such, I focused the research on practical applications of traditional ecological knowledge, such as harvesting strategies of edible wild plants, while still paying attention to the Rarámuri worldview.

Maintaining respect for the integrity of Indigenous peoples can be jeopardized by researchers who place the focus on knowledge itself, and not on the holders of this knowledge. Thus, "traditional ecological knowledge is given power, and not aboriginal people" (Proctor 2000, p. 160). When knowledge becomes the focus of attention to better understand a resource management issue, it is liable to be conceived as a commodity suitable for consumerism. While there may be some immediate gain for community participants, in the long run, rendering traditional ecological knowledge into a commodity

poses threats to the erosion of cultures (Kimmerer 2000). "Instead of concentrating on knowledge which has been turned into a commodity, we need to concentrate on a dialogue that focuses on empowering people" (Proctor 2000, p.162).

Given the strong focus on the study of traditional ecological knowledge, I tried to take these concerns into account when undertaking research activities, such as using a participatory research approach to set a dialogue in motion.

Chapter 3 - Research Methodology

“Qualitative research is an inquiry process of understanding a social or human problem, based on building a complex, holistic picture, formed with words, reporting detailed views of informants, and conducted in a natural setting”.

(Creswell 1994, pp. 1-2)



The research facilitator helped to identify participants for transect walks

Photo: F. Hébert



Semi-structured interviews were conducted with community members in Basíhuare

Photo: S. LaRochelle



Interdisciplinary research requires thinking outside of the box; perception is everything

Photo: S. LaRochelle

3.1 Introduction

Working within the realm of qualitative research, I lived in the community of Basíhuare and led discussions with a number of community members. As Marshall and Rossman (1989) have suggested, my role as researcher was to immerse myself into everyday life and to interact with community members to seek their perspectives on the social-ecological system in the Sierra Tarahumara.

To conduct research in the predominately Indigenous community of Basíhuare, it was important to design a research project that was participatory in nature, with the community becoming a partner in the cooperative process of knowledge exchange and creation, rather than merely being the object of research (Martin 1995; Berkes 1999; Cunningham 2001). The need to understand local perceptions of the social-ecological system, coupled with the importance of involving local research participants in the design of the research process, invited the use of a Participatory Rural Appraisal approach.

3.2 Participatory rural appraisal: community involvement in research

Participatory Rural Appraisal (PRA) is a research process for Indigenous knowledge gathering that is appropriate for learning about rural life and conditions with rural people (Chambers 1994). PRA is based on the philosophy of people's participation, which respects the following principles (Mukharjee 1993):

1. Any traditional knowledge and experience should be respected;
2. Indigenous people have a storehouse of traditional knowledge and experience which can be of great use;
3. People are capable of undertaking research projects, whether as a community, a group, a household or as individuals.

The first step in my research was to present the objectives which I had generated for my research proposal at a weekly community meeting. Permission to undertake the research was granted by the community, after which I wrote a letter of agreement and presented it to the community leader. This letter outlined project objectives and provided details related to compensation for research participants and the community. An informal partnership was then forged between the local traditional leader, the secondary school (Secundaria Técnica Intercultural Cruz Rarámuri), a regional NGO (México-Norte), and myself.

Further consultation with members of the partnership helped to identify edible plants as a focus for the research on non-timber forest products and aided in the agreement on a methodology that would integrate the needs of the community into the research process. For instance, I discussed with the school director and the community leader how research findings could be incorporated into teaching materials for the secondary school, a need identified by parents during the development of the school's mandate. Knowing that research findings would provide teaching materials for youth of the community motivated research participants to share heartfelt experiences of the land and its resources.

Because my research had a focus on traditional ecological knowledge of non-timber forest products, many of the research activities respected the principles of ethnobotanical research methodology, which refers to the study of interactions between people and plants (Martin 1995). Ethnobotanical research methodology is useful not only to develop a list of plant names and their uses, but also to understand local knowledge of the ecosystem and the interactions among system elements (Martin 1995; Nabhan 2000b; Cunningham 2001).

Working with a community member who would act as research "facilitator" would help me become familiar with the peculiarities of the local culture and help set up working relationships with research participants. The research facilitator agreed to work with me because he was interested in the study and he was available to work on the project throughout the field season. He held knowledge of research methodology, through his earlier research facilitation experience with Iain Davidson-Hunt, who was completing a portion of his PhD thesis research when I arrived in Basíhuare.

The Participatory Rural Appraisal approach provides community members with the opportunity to participate in decision-making relating to the design and execution of the research project (McArthur 1994). In the case of my research, the research facilitator helped to make decisions in the field on specific research activities in consultation with participants.

Table 3.1 provides a listing of research activities undertaken during the six-month field season, which was divided into two phases, the first from May to August 2001, and the second from September to November 2001. Activities are presented in relation to research objectives, with a description of the results achieved and the time frame in which they were conducted.

3.3 Regional organizational overview

The rationale behind building an organizational snapshot was to gather an initial impression of activities undertaken by groups involved in the conservation of NTFPs and the preservation of traditional ecological knowledge in the Sierra Tarahumara. This work provided both a contact list of potential research participants, and a description of principal activities undertaken by these groups. To complete a regional organizational framework, I conducted semi-structured interviews to ascertain local NGO perspectives on what is required to preserve traditional ecological knowledge. I undertook semi-structured interviews with a representative from four non-governmental organizations, and with an official from two government agencies who work with Indigenous communities in the Sierra Tarahumara (**Table 3.2 and 3.3**).

Table 3.1 - Research activities, corresponding results, and timeframe of activities.

Methods	Corresponding Objective	Results	Time Frame
Semi-Structured Interview	1 – Organizational overview	Snapshot of organizations that work with Rarámuri communities	May to October
	2 –Property rights and local institutions	Land use rights and local rules	September & October
	3 – Knowledge of edible plants	Harvesting and conservation methods	July to October
	4 – Exchange of knowledge	Impressions from community members on traditional knowledge	October & November
Transect Walk	3 – Knowledge of edible plants	Ethnobotanical data set and photographic samples	June & July
Participant Observation	2 – Property rights and local institutions	General understanding of land use practices and decision-making mechanisms	June & July
	3 – Knowledge of edible plants	Harvesting strategies and landscape descriptions	June & July
Specimen Collection	3 – Knowledge of edible plants	Identification of scientific names for edible plants	September
Field Excursion	4 – Exchange of knowledge	Videotape harvesting methods with students	June & September
Focus Group	4 – Exchange of knowledge	Impressions from youth on importance of traditional knowledge	November
Secondary Literature Review	2 – Property rights and local institutions	Local institutional framework, worldview on norms and beliefs	September to November

Table 3.2 - Non-governmental organizations that work in the Sierra Tarahumara.

Group Name and Location	Organizational Objectives and Programs
México-Norte Red de Investigación y Educación, A.C. <i>Chihuahua City</i>	<p>The main focus of this group is to coordinate research efforts with international partners and support the efforts of residents of the Sierra Tarahumara to resolve social, cultural, and economic problems.</p> <p>México-Norte projects provide community capacity building by involving local members in the design and implementation of research activities.</p> <p>The group is in the process of establishing a resource centre to house research results from international projects and provide learning opportunities for Rarámuri wishing to undertake their own research.</p>
MITYTAC Mujeres Indígenas Tepehuanes y Tarahumaras, A.C. <i>Chihuahua City</i>	<p>This group of women is interested in capacity building in terms of technical and administrative skills to tackle socio-cultural concerns facing Indigenous communities in the Sierra Tarahumara.</p> <p>MITYTAC facilitates community-based projects to increase the political power of Indigenous people, to conserve the environment and to provide gender equality in decision-making.</p> <p>The group has worked on programs involving the commercialization of handcrafted artwork, the building of educational and judicial capacity to value non-timber forest products, and the promotion of Indigenous culture among youth.</p>
COSYDDHAC Comisión de Solidaridad y Defensa de Los Derechos Humanos, A.C. <i>Chihuahua City</i>	<p>The main objective of this group is to protect the rights of Indigenous groups in the Sierra Tarahumara.</p> <p>COSYDDHAC coordinates a "mobile school" to discuss issues related to the management of natural resources, such as the use and conservation of medicinal plants and agroforestry techniques.</p> <p>The group has recently requested that a biophysical inventory of the Sierra Tarahumara be conducted, with a focus on the entire watershed, and has presented a petition to the Commission for Environmental Cooperation with regards to Mexico's commitment to protecting Indigenous rights under the UN Convention on Biological Diversity.</p>
Kosemi <i>Guachochi</i>	<p><i>Kosemi</i> is the Rarámuri term for creatures that keep the 'arroyos' clear of large debris to maintain water flow and prevent flooding. These tiny people play the important role of helping all those who live in the Sierra Tarahumara. This is the mandate of Kosemi.</p> <p>The group's objective is to unite participants of individual projects and form a cohesive group to ensure the overall sustainability of these projects.</p> <p>One of the members hosts a radio show, offering cultural programming in Rarámuri, and a daily message board so people can send a verbal memo to isolated communities throughout the Sierra Tarahumara.</p>

Table 3.3 - Government agencies that work with communities in the Sierra Tarahumara.

Group Name and Location	Organizational Objectives and Programs
CET Coordinación Estatal de la Tarahumara <i>Chihuahua City</i>	<p>The fundamental objective of this state government agency is to fund projects that provide what appear to be basic living requirements for Rarámuri communities, such as adding tin roofs and water collection systems to houses.</p> <p>CET acts as a storehouse of information for development projects, undertaken by various NGOs and government agencies in the Sierra Tarahumara. Project coordinators are currently developing a database to identify gaps in terms of communities where no help has previously been provided, and to fund future development projects in these areas.</p>
INI Instituto Nacional Indigenista <i>Chihuahua City</i>	<p>The mission of this federal agency is to guide government policy to promote and defend Indigenous culture and social organizations. Their vision is to develop action-oriented programming to establish a new working relationship between government agencies and Indigenous communities.</p> <p>INI provides funding for the planning and implementation of projects that deal with infrastructure development and cultural promotion. Such projects include workshops dealing with traditional medicine and intellectual property rights, the production of traditional crafts, events featuring traditional music and protection of forested areas.</p>

Semi-structured interviews entail “having a mental or written checklist, but being open-ended and following upon the unexpected” (Chambers 1994, p. 959). I used a snowball sampling technique, where interviewees were invited to provide information on other groups or individuals interested in discussing issues about preserving traditional ecological knowledge. Guiding questions for semi-structured interviews helped to inquire about organizational operations, and to discuss the groups’ activities and impressions related to traditional knowledge (Table 3.4).

Table 3.4 - Guiding questions for NGO semi-structured interviews.

English	'Español'
What is the organizational structure of your group?	'¿Puede describir la estructura de su grupo?'
What are the goals and objectives of your organization?	'¿Cuales son las metas y los objetivos de su organización?'
What are the main activities currently undertaken by your group?	'¿Puede explicar las actividades que se realizan actualmente?'
How can Indigenous groups benefit from your activities?	'¿Cómo los indígenas pueden beneficiar de las actividades de su grupo?'
What does the term traditional knowledge mean to you?	'¿Que entiende usted del termino "conocimientos tradicionales"?''
What do you believe is the biggest threat facing traditional knowledge?	'¿Que crea es la amenaza más importante para las conocimientos indígenas?'
What is the best way to protect and promote traditional knowledge?	'¿Que piensa es una manera de proteger los conocimientos indígenas?'
How does your group assist in the protection of traditional knowledge?	'¿Cómo su grupo puede apoyar a la protección de estos conocimientos?'

3.4 Property rights and local institutions

Collecting information on property rights was defined as a research objective at the end of the first phase of the field season, and incorporated into research activities for the second phase of the research. I assisted at many of the weekly community meetings, in part to set-up research activities for the coming week, and also to observe the proceedings of the meeting and to inquire about discussion topics from the research facilitator, and from other community members. A number of research techniques were employed to gather information on this second objective, including participant observation, semi-structured interviews and a secondary review of literature.

With the help of the facilitator, we devised a semi-structured interview framework to inquire about the property rights identified by Ostrom and Schlager (1996): access; withdrawal, including the ability to sell goods from the land; management; exclusion of other potential users; and alienation, including bequeathing and selling the land. We

conducted interviews with six research participants from Basíhuare in September and October.

Throughout my field research, I would travel to Chihuahua City (approximately once a month) to check email messages and conduct interviews with groups and agencies located there. For the purposes of the second objective, I conducted interviews with officials from the natural resources ministry (Secretario del Medio Ambiente y de los Recursos Naturales, or SEMARNAT) to inquire about the incorporation of traditional land uses into forest management plans.

In Chihuahua City, I consulted documentation regarding land use rights and previous anthropological research on the cultural aspects of the Rarámuri at the Universidad Autónoma de Chihuahua (UACH) and the Escuela Nacional de Antropología e Historia (ENAH). I also reviewed government documents, including copies of forest management plans and Mexican agrarian and forest law books.

3.5 Traditional knowledge of edible wild plants

With help from the research facilitator, stories, beliefs and explanations related to edible wild plants were shared by research participants from the community through activities such as transect walks, participant observation, and semi-structured interviews. The research facilitator selected participants because of their kinship or friendship ties, and because they showed an interest in the study.

Transect walks were undertaken with the Rarámuri research facilitator and with five research participants on average three times a week for six weeks throughout June and July. In total, we went on eighteen outings to conduct transect walks. The collection of photographic samples of edible plants was conducted through transect walks, which is an efficient way to identify and reflect upon some key features of local land-use (McArthur 1994).

The study did not focus on a specific eco-unit area, but rather took a holistic look at the local watershed area. The first set of transect walks were undertaken while trekking to selected controlled burning sites, identified by Iain Davidson-Hunt as site plots to conduct vegetation surveys for his research. Additional transect walk locations were chosen in relation to the participants' knowledge of specific edible wild plant habitat. We also conducted transect walks in the vicinity of 'ranchos' (living places) to identify plants that occur near agricultural fields or streams. Some areas were revisited in the fall to capture on film certain plant species when these were in bloom. These walks provided the opportunity to photograph and identify a total of 27 wild plant species. Although more exist, these were found in the specified areas and where known by the research participants.

Conducting transect walks provided the opportunity to become familiar with the resources and physical surroundings of the Basíhuare region, and to observe the interactions between Rarámuri harvesters and the landscape. I observed and noted first hand research participant experience with land use and resource management involving edible plants. Participant observation became an ongoing process in the first phase of the research, undertaken primarily with the five research participants who had participated in the transect walks and their families. I recorded descriptive notes rather freely, trying to keep in mind the following categories, as suggested by Creswell (1994) – the physical setting where a particular plant was harvested; reflective notes, like certain impressions or feelings from research participants about the place; and information related to when and where the observation took place.

On several occasions, I carried a digital video camera to record in Spanish and Rarámuri explanations from research participants regarding the harvest and preparation of various edible wild plants. I also recorded a conversation between the facilitator and one of the research participants on the use of fire to increase the quantity and quality of arable land for crop production. I conducted an interview with the *Owirúame*, who explained his role as spiritual healer of the community and his role in caring for wild plants.

As a final component of transect walks, we gathered additional data on wild plants, including local names, the ideal time of year to collect plants, a description of their habitat,

and techniques to prepare plants for consumption. This basic information was gathered before the month of October, when plants that occurred naturally were still abundant, and before participants would begin harvesting their crops of maize.

Findings for habitat and uses were based on emic categories, providing for the ability to “draw impressions from the way people perceive things through their own eyes and classify objects in their own language” (Martin 1995, p. 11). For instance, participants identified ideal habitat features according to local descriptions of forest types, and indicated locations by their culturally significant name. The setting for gathering results thus reflected local knowledge and traditions about place names and plant uses.

During the phase of collecting information relating to wild plants, it became apparent that some fundamental characteristics would have to be added to the research process. For example, participants would differentiate plants that held the same name by describing the use for each. At least two different types of *sipeke* (*Bidens*, *spp.*) existed in the area, the first is consumed as a vegetable; the second is used to dye wool. As such, we began noting local uses for each of the identified plants. In other cases, participants referred to habitat or time of bloom to make a distinction between similar plant varieties.

With the help of a botany student from the Universidad Autónoma de Chihuahua (UACH), we collected samples of several edible plants to later identify their scientific names. We collected samples in the month of September, when many plants were in bloom, making species identification easier, from locations where research participants had originally identified these plants. However, because we had limited access to plant pressing equipment, we did not collect samples of plants that are more difficult to press, such as those in the Cactaceae and Agavaceae families, nor did we collect plants that could not be found at that time. Plant samples were brought to UACH, where the student identified their scientific names with the help of faculty members.

To gain a better understanding of norms related to the management of the identified edible wild plants, we conducted semi-structured interviews to probe further on issues relating to harvesting strategies, using the inquiry framework listed in **Table 3.5**. With the help of the

research facilitator, we conducted these interviews with three of the five original participants, as well as with three new participants.

Table 3.5 - Framework for semi-structured interviews about harvest practices.

Areas of Inquiry	Sample Questions
Means of monitoring and harvesting plants	<p>What methods do you use to identify the readiness of the plant for harvest? What aspects of a plant's structure do you look for?</p> <p>Is the harvest of specific plants always done at this time of the year? If it is harvested more than once a year, when is that done?</p> <p>What signs do you look for to assess the plant's health? How does the health of the plant affect the potential for harvesting, in terms of quality or quantity?</p>
Ways in which people know where plants are located	<p>What physical landscape features are identified when selecting the proper harvesting area? Do you have a special name for this area?</p> <p>Does the harvest area change from season to season? If so, is there a pattern for this change?</p> <p>Do several species co-exist in this area? Is there a sequence for harvesting these products?</p>
Harvesting practices that conserve plant species	<p>Do you harvest more than one plant species from one specific area? Are these harvested at the same time or at different times of the year?</p> <p>How do harvesting techniques affect the well being of the plant and of the surrounding species?</p>

The collection of findings related to traditional knowledge of edible plant harvesting practices provided a background to explore the communication and exchange of knowledge, identified as the fourth objective of my research.

3.6 Communication and exchange of knowledge

Research activities relating to the fourth objective were undertaken primarily with students from the Secundaria Técnica Intercultural Cruz Rarámuri, which was a key partner for the project because it is the only secondary school in the State of Chihuahua to offer an intercultural education program.

In order to gain an initial appreciation for the learning opportunities available in the Basíhuare area, I spent time with students and teachers of the secondary school. In June, I participated in two field excursions with 35 students from the secondary school. On the first excursion, we visited a research plot set up by Iain Davidson-Hunt, where I demonstrated methods to conduct vegetation surveys and transect walks. Students recorded vegetation found on the site and later compiled digital tables to synthesize these findings (**Appendix 1**). The second excursion provided the opportunity to accompany one of the research participants and record digital video images of several edible plants and descriptions of how to prepare them.

These excursions with students led to the preparation of an educational CD-ROM that provided a geo-referenced and locally based multi-media resource for the secondary school. The CD-ROM integrated digital video images and audio clips recorded by the students along with those I obtained from research participants. The videotapes were transcribed and translated by one of the schoolteachers, and were eventually integrated onto the CD-ROM, along with photos of plants and places I had taken from the field. These files were compiled onto the CD-ROM, linking text, photos and video to points on a map identified by students during field excursions. These activities helped to create a certain level of comfort between the students and myself, which set the tone for focus group discussions.

Morgan (1988, p. 25) describes how “self-contained focus group” discussions can be used as a stand-alone research activity to gather participants’ experiences and perspectives. I established areas of inquiry for the focus group discussions with a teacher and the director of the school, by revisiting initial research findings obtained from observation and semi-

structured interviews regarding edible plant use (please see **Table 3.6**). I conducted focus group discussions with two groups of six students from the secondary school. These provided the opportunity to discuss edible plant use and management in a group setting and gather youth perspectives regarding the importance of current and future use of these plants.

Table 3.6 - Guiding questions for focus group sessions with students.

English	'Español'
Are there certain plants that you prefer? Why?	'¿Hay plantas que les gustan mas? Porque?'
Do you know how to collect and prepare edible wild plants?	'¿Saben como buscar / preparar las plantas comestibles?'
What is one thing you can learn at home from your parents or siblings about edible plants?	'¿Que seria una cosa que pueden aprender en la casa (por ejemplo de sus padres o hermanos) sobre las plantas silvestres?'
What is one thing you can learn at school from your teachers or friends about edible plants?	'¿Que seria una cosa que pueden aprender en la escuela (de los maestros o de sus amigos de clases) sobre las plantas silvestres?'
Do you think you can learn less, more or the same in the school than you can at home?	'¿Piensen que pueden aprender menos, mas, o lo mismo de lo que están aprendido en la escuela sobre las plantas comestibles?'
Do you think you will use more or less edible plants that your parents or teachers? Why?	'¿Van a usar menos, mas o lo mismo que sus padres o maestros? Porque?'
Do you think it is important to continue using edible plants?	'¿Es importante de consumir las plantas comestibles silvestres?'
Do you think it is important to know how to collect and prepare edible wild plants?	'¿Piensan que es importante que saben como buscar y preparar las plantas silvestres?'

Aside from research activities with the school, I conducted semi-structured interviews on knowledge exchange mechanisms active in the community with five research participants who had participated in earlier activities. The objective of these interviews was to gain impressions on the status of knowledge about the conservation of edible wild plants, and the importance of communicating this knowledge to future generations. Discussion focused on identifying the network of individuals and institutions that are involved in the communication of knowledge, and to describe local perceptions on the viability of

preserving knowledge for future generations given recent developments in the area. I conducted interviews using the query areas and sample questions listed in **Table 3.7**.

Table 3.7 - Framework for interviews about the exchange of knowledge.

Areas of Inquiry	Sample Questions
Ways to learn about plant harvesting techniques	How did you learn to identify different plant species? Who did you learn this information from? Who taught you these harvesting techniques? How old were you when you learned them? How do the seasonal changes form a part of the learning process?
Means to exchange traditional knowledge of edible plants	Do children participate in harvesting activities? At what age do they begin learning? What are the evolutionary stages in the learning process? How long does it take to become a 'good' harvester? Is proper harvesting a gift – a natural talent, or is it learned with experience and the growth of knowledge?
Changes in methods of acquiring knowledge about harvesting techniques	Is there community input into your own harvesting technique? Is there a ranking order to the exchange of knowledge (e.g. age or status)? What similarities or differences exist between the knowledge exchange between you and your parents, and between you and your children? How do the ways you learned to exchange or communicate knowledge resemble or differ from how your children are learning?

3.7 Verification and feedback

The iterative nature of the participatory research provided regular feedback from the research facilitator and participants, providing a forum to crosscheck information and fine-tune further research inquiry. Much of this process occurred throughout the fieldwork; for instance, when I learned of a harvesting technique, I would discuss this knowledge with the research facilitator, and would bring it up with another research participant the following day; or when I asked questions about property rights, I would try to base it on information provided by an earlier participant, but tailor it to the current situation.

Research findings were discussed during a research planning conference held in October in the neighbouring community of Norogachi. México-Norte coordinated a conference to reunite traditional government representatives and international scholars who were already conducting research or were interested in studying ecological and cultural issues in the Sierra Tarahumara. The three-day conference brought together representatives from seven Rarámuri communities to discuss issues of interest to the represented communities. Conference attendees discussed issues such as water quality, eco-tourism and traditional knowledge preservation, and shared ideas and impressions on current and potential research activities.

The conference provided me with the opportunity to gain a better understanding of what issues were important to neighbouring Rarámuri communities, and to discuss preliminary research findings with academics from a wide range of disciplines. Discussions we had on traditional knowledge provided additional support for the importance of examining harvesting practices of edible wild plants in Basíhuare. Discussing local resource management concerns responded to the objective of exchanging information and perspectives between scholars and local residents, set forth by the México-Norte Project on Diversity in the Sierra Tarahumara.

In November, the timber extraction season began. The facilitator took a job supervising forest cutting operations at this juncture, and I thought research activities would be temporarily delayed. However, I decided to discuss research findings and verify the original set of data about traditional uses and harvesting methods of edible wild plant practices, which I undertook individually with five participants who had earlier participated in semi-structured interviews.

Until this point, apart from the youth from the school, all research participants were men because of the fact that the research facilitator was male, and because local customs would have made it awkward for me to be spending time with a woman of the community. Discussions I had with the research facilitator and the school director led to the agreement that it was vital to gather impressions from women, because they participate in the harvest

of edible plants and, more importantly, play the principle role in preparing them for consumption.

As a result, I undertook verification activities with three women from the community on separate occasions. Because of Rarámuri cultural dynamics, I asked one of the female teachers, with whom I had previously worked to translate text for the academic CD-ROM, to help facilitate the verification exercise. She was instrumental in finding research participants who were interested in helping with the study. As a result of this work, I was also able to undertake semi-structured interviews on exchange of knowledge with two of the three women, again with the help of the schoolteacher.

I began the verification of plant names and uses by placing an album containing photos of previously identified plants before the participant, and I encouraged them to identify the plant, talk about its uses, including how they were prepared for consumption, and explain when it was best used and where it was most commonly found. Photographs were an adequate means of identifying plant varieties, because participants could recognize specific visual indicators, such as appearance of the leaf or colour of the flower. These features were captured in most of the photographs. However, some characteristics could not be used for verifications, such as a coarse stem, or a sweet smelling flower.

Participants began to offer information freely whenever a page containing a new series of photos was shown. Simply going through the existing list would have been monotonous work, and would have been of little interest to the participant who may simply have ended up confirming or denying the information as it was presented. I thought it was important to provide the participant with the opportunity to give additional information, by describing, for example, a plant use that had not yet been identified. In this way, the verification process was participatory as it provided the opportunity to collect additional information as well as to verify existing data.

In cases of contradictory information, I asked the participant about his or her knowledge of the already recorded information. For example, I would ask whether a specific plant was collected during winter months, as had been originally stated by a research participant. My

question would sometimes spark a memory of the occurrence, or a denial of this knowledge. Nonetheless, I noted these contradictory responses, because although all participants lived in Basíhuare, some grew up in neighbouring communities, which might have explained variations in knowledge.

The verification process ensured that names were accurately spelled, uses and harvest times were correctly identified, and preparation methods were properly described. This was important because I presented the final table of results, along with copies of the photographs, to the secondary school director, who wanted to develop them into course material. This table is given in **Appendix 2**. Along with the findings gathered during this process, Iain Davidson-Hunt and I sent to the director of the school a copy of the CD-ROM, which we completed after having returned to Canada.

Table 3.8 provides a list of research participants and the activities in which they took part. The table helps to provide examples of when participants partook in more than one activity, and provides the total number of people who participated in the research. It is important to note that most research activities were undertaken with the help of the research facilitator (Chema), and with the assistance of the female teacher (Rufina) for research activities undertaken with women.

Table 3.8 - Research activities and participants for each study objective.

Research Objective	Activity	Participants
1 – Organizational overview	Semi-Structured Interview	Reps from 4 NGOs - México-Norte, MITYTAC, COSYDDHAC, Kosemi Reps from 2 government agencies - CET, INI
2 –Property rights and local institutions	Semi-Structured Interview	2 reps from government agency - SEMARNAT 6 male participants - Manuel, Lerma, Tonio, Isidro, Guadalupe, Martin
	Secondary Literature Review	SEMARNAT, ENAH, UACH
3 – Knowledge and harvest strategies	Transect Walk	5 male participants - Manuel, Lerma, Tonio, Moreno, Chonel
	Participant Observation	5 male participants - Manuel, Lerma, Tonio, Moreno, Chonel
	Semi-Structured Interview	6 male participants - Manuel, Lerma, Tonio, Isidro, Guadalupe, Felipe 2 female participants - Esposa, Petra
	Sample Collection	UACH Student (Elivy)
	Verification of Plant Names and Uses	5 male participants - Manuel, Lerma, Tonio, Isidro, Guadalupe 3 female participants - Esposa, Petra, Matiana
4 – Exchange of knowledge	Field Excursion	2 trips with 35 students each
	Focus Group	2 groups with 6 Students in each: Group 1 (4 men, 2 women) - Gaetano, Valentin, Jesus, Teodolph, Rosalia, Ofaelia Group 2 (6 men) - Elmer, Carlos, Cesar, Manuel, Arnold, Carlos
	Semi-Structured Interview	5 male participants - Manuel, Isidro, Guadalupe, Felipe, Martin 2 female participants - Esposa, Petra

3.8 Reflections on the field research process

Working in-depth with a research facilitator and with community members to clarify objectives and elaborate a research process, I attempted to respect three principles of participatory research (Fortmann 2001).

1. Joint ownership of the research project where local users and researchers are equal partners in developing research questions and methods.

Although I drafted initial ideas on research questions and methods, the research facilitator and participants were involved in the elaboration and fine-tuning of research methods.

2. Mutual accountability, so that researchers and resource users are accountable to each other regarding the above agreed upon research process;

Participants understood the objectives, knew who was participating in the research and seemed confident that research findings would be presented to the local school. I trusted that if a research activity required some fine-tuning, that they would be free to say so; in turn, I trust that I could confide in them if I felt I needed to do the same.

3. The process counts as much as the research results, as such, researchers and local users understand each other's knowledge and analytical framework.

On this point, my attempt at participatory research has failed. In fact, I did not discuss with the research facilitator, nor the participants, at least not directly, the theoretical concepts in which my research was grounded (PRA, traditional ecological knowledge, Institutions, etc.). I doubt however, that participants would have felt any differently about the research, or would have conveyed opinions, ideas and stories other than those presented in this thesis had we discussed these issues.

Furthermore, I have not submitted the synthesis and analysis of research findings to the community. I have sent the technical report to the director of México-Norte, and plan to do the same with my thesis. However, to adequately present these ideas to the

community, I would have to translate them into Spanish, and return to the community to discuss my thesis with the research facilitator and participants, and the director of the school.

3.9 Synthesis and analysis of findings

Verified findings were translated into English from records I had kept in two journals, two notebooks, and two ringed workbooks, and incorporated into a technical report that I presented to the Canadian International Development Agency (CIDA), who funded a major portion of the field research. CIDA had suggested that methods be presented as they related to research objectives; I decided to keep this format for the thesis.

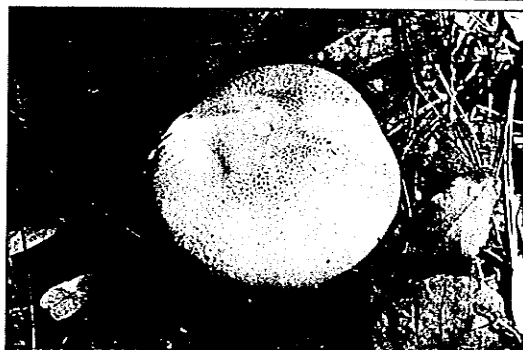
Working from the technical report, I categorized similar findings into subheadings within three main research areas: property rights, local institutions and traditional ecological knowledge. These I jotted down on a third ringed workbook, which I transferred to Microsoft Word regularly. This is the only software package I used to deliver my thesis.

To give order to these subheadings and make some sense of the findings, I decided to select an analytical framework from existing literature for each of the three themes. I had already identified the Ostrom and Schlager (1992) paper, which provided some context for the analysis of property rights; Gibson and Becker (2000) provided a framework to consider property rights in relation to local institutions. Chapter four of my thesis presents the result of the synthesis and analysis of findings related to these two themes. In terms of traditional ecological knowledge, the Turner et al. (2000) model, even though it applies to another part of the world, encompassed many of the subheadings that I devised from my findings. The model provided a way to present and discuss traditional ecological knowledge of edible wild plants in the Sierra Tarahumara. The outcome of the synthesis of findings related to traditional ecological knowledge is presented in chapter five.

Chapter 4 - Common Property Rights and Local Institutions

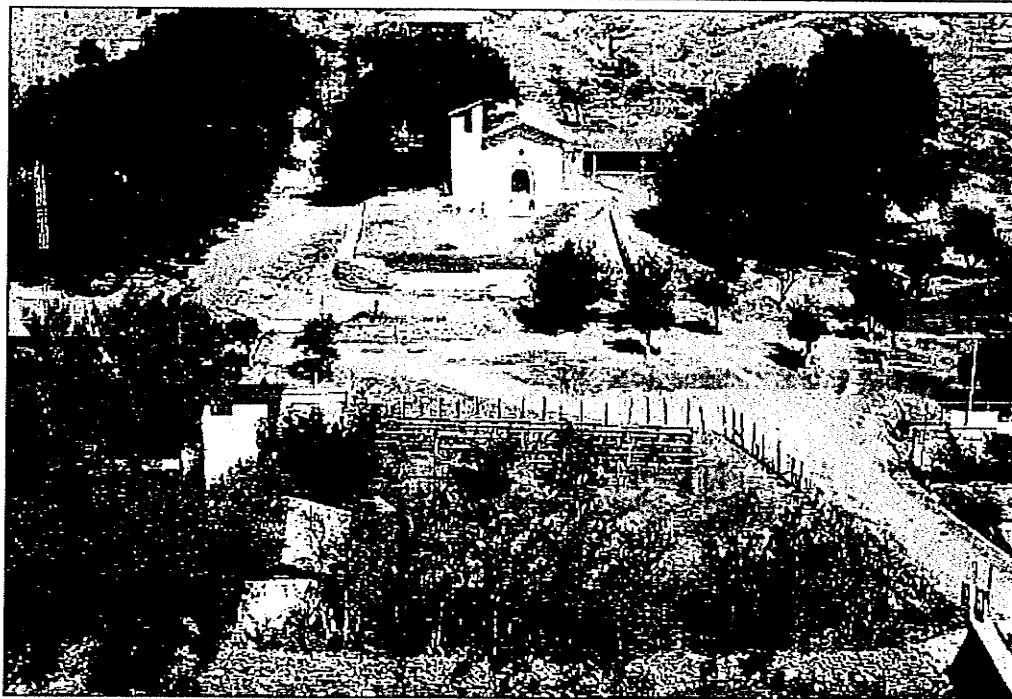
“Wild plants form a part of us. They give us the energy and the nutrients to live. In return, we help to conserve the plants by using them in a way that ensures their survival”.

Rarámuri harvester and representative of Kosemi



Rarámuri harvesters identified over twenty edible wild plants, including oregano (left), and a variety of mushrooms

Photos: S. LaRochelle



A blend of traditional and official institutions play a role in decision-making regarding the use and management of natural resources

Photo: S. LaRochelle

4.1 Introduction

The opening statement of this chapter, expressed by a Basíhuare research participant, depicts what Salmón (2000b) referred to as the Rarámuri relationship to the Sierra Tarahumara in which all physical and spiritual life is interconnected. This relationship is reflected in the many ways Rarámuri community members value the forests of the Sierra Tarahumara. The non-timber forest products that occur there form a part of the regular subsistence regime of Rarámuri families. During my stay, I observed community members harvesting edible greens, roots and fruit from the forest commons. They also harvested plants for medicinal purposes, including the root of *Chuchupate* (*Ligusticum porteri*), which the research facilitator explained can be used “to cure nearly anything”, and was earlier reported as having several curative properties (Bye 1986). Local residents in Basíhuare also value timber products, such as oak and pine trees that dominate Tarahumara forests. My neighbours used logs from nearby tress to build homes, and coppiced oak trees and collected fallen timber to be used as fuelwood.

The Rarámuri in Basíhuare value their resource base, which, according to Gibson and Becker (2000), is the first indication that a successful common property management arrangement exists in that community. The authors explain that two other requirements must exist in a common property arrangement: effective property rights, and recognized and respected local-level institutions, in order for successful decisions to be made regarding commons resource management. My research findings offer examples of these two components as they relate specifically to non-timber forest products in Basíhuare.

Before I present these findings, I begin the chapter with a brief history of Mexican land tenure as it pertains to the ‘ejido’ system. I then present findings from discussions with research participants relating to five common property rights – access, withdrawal, management, exclusion and alienation, as identified by Schlager and Ostrom (1992), and discuss what they represent in terms of commons management. I then examine local-level institutions, the third requirement for successful commons management, which are comprised of a blend of traditional norms and beliefs for sustainable resource use and ejido rules. These institutions are governed by a traditional governance system, in conjunction

with an ejido government structure. I discuss how interaction among these various decision-making mechanisms, although ambiguous, provides local rule enforcement and conflict resolution over resource use issues, and may provide the necessary institutional framework to manage increasing external forces at play in the area.

4.2 History of the 'ejido' land tenure system

Mexico has a lengthy history of shifting land-use rights (Table 4.1). The ejido land structure was formed as a result of agrarian reforms that emerged from the 1910 Mexican revolution, which was driven by peasant and Indigenous uprisings (Sanderson 1984; Randall 1996). These agrarian reforms led to the adoption in 1917 of Article 27 of the Mexican constitution, which institutionalized the reorganization of property by restoring lands to Indigenous communities (Kiernan and Freese 1997; Alcorn and Toledo 1998). Peasants and Indigenous communities were officially recognized as 'dueños', or caretakers, of the land, but ownership remained in the hands of the federal government.

In 1992, the Mexican federal congress, led by President Carlos Salinas de Gortari, adopted changes to Article 27, effecting modifications to Mexican agrarian law. The main reason for the reform was to attract private interests in preparation for the liberalization of trade relations with the United States and Canada, under the North American Free Trade Agreement (Ibarra Mendivil 1996; COSYDDHAC 1999). Changes to agrarian law represent an end to the redistribution of land to Indigenous groups in exchange for security over land tenure (Randall 1996). As a result, communities are considered legal owners of communal lands, have the ability to sell or rent property within ejido lands, and can cooperate with private enterprises to extract resources (DeWalt and Rees 1994).

Table 4.1 - Significant events in Mexican history and their effects on land tenure.

Time Period	Event	Significant outcomes
Pre 1910	Period prior to the Mexican Revolution	<ul style="list-style-type: none"> • Elimination of communal property rights, sustained from Spanish colonization of the 16th and 17th centuries • Government declares that all lands without official title become state property • Oppression of Indigenous and peasant rights, leading to the 1910 Mexican Revolution
1917	Adoption of Article 27 of the Mexican Constitution	<ul style="list-style-type: none"> • Lands restored to 'campesinos' and Indigenous groups • State maintains ownership over land use • Control of resources transferred to communities and commons protected • Commons can not be sold or transferred
1992	Reforms to Article 27, in light of NAFTA	<ul style="list-style-type: none"> • Implementation of changes to the agrarian law • Communities become owners of the commons - security of land tenure is insured • Communities permitted to sell held property and establish joint-ventures with outside groups

Compiled from Sanderson (1984), Sheridan (1988), Randall (1996), Kiernan and Freeze (1997) and Alcorn and Toledo (1998).

Recent changes to Article 27 of the Mexican constitution also brought revisions to the 'Ley Forestal' (Forest Law). As posited by Wexler and Bray (1996, p. 239), Mexican forest law calls for "the conservation, protection, and restoration of forest resources and their biodiversity, the protection of watersheds, the sustainable management of timber and non timber forest products, the generation of employment in the forest sector, and the promotion of a forest culture". Like the recent changes to Mexican agrarian law, modifications to the forest law have reformed tenure rights, transforming ejido members from dueños to proprietors (Randall 1996).

In the Sierra Tarahumara, this extensive history has complicated the examination of property rights. Landholders with whom I spoke in Basíhuare considered themselves as caregivers of the land, and not necessarily owners of property. As a result, the concept of property reflects accounts from González et al. (1994), who reported that Rarámuri place emphasis on possession of plants found on the land and of goods produced on the land, and not of the property itself. When examining property rights in Basíhuare, the research facilitator and I decided to focus on the products derived from the land, such as non-timber forest products.

4.3 Common property rights in Basíhuare

The current common property rights arrangement in Basíhuare appears to have evolved over time from a combination of traditional and externally influenced systems. In fact, Alcorn and Toledo (1998) suggest that under the ejido system, the local community, and not the national government, allocates and enforces rights to resources within the boundaries of the community.

These resources are found both on ‘ranchos’ and in ‘areas comunales’. Ranchos are designated by Article 76 (p. 20) of Mexican agrarian law as “parcelled land which ejidatarios have the right to develop”, where individuals and their families build homes, create ‘milpas’ for crop production, and craft wooden structures to enclose livestock. Ranchos are usually located near streams and water sources so inhabitants can obtain water for washing, cooking and drinking. Communal lands, on the other hand, are for the general use of the community and, according to Article 73 (p. 19) of agrarian law, are “designated to support the economic well being of the community”. In Basíhuare, forested areas cover most of the commons, with a section consisting of pastureland along waterways and on mountain plateaus. Although Mexican agrarian law delimits general rights associated with these land use areas, I did not ask research participants to make a distinction between *de facto* and *de jure* when discussing property rights. As a result, research findings do not distinguish rights that are secured by traditional norms (*de facto*) from those that are written in law (*de jure*).

In this section, I present findings related to operational level property rights of access and withdrawal, along with collective choice rights of management, exclusion and alienation (please see **Table 4.2**). I explain these five property rights, as defined by Schlager and Ostrom (1992), and provide illustrations of resource use as applicable to each property right, for both rancho and communal areas of the Basihuare ejido.

Table 4.2 - Property rights in Basihuare related to resources on ranchos and commons.

Property Rights ¹		Illustration of relevant use rights	
		Ranchos	Commons
Operational	Access <i>Entering a defined area for non-substantive benefits</i>	Using paths along waterways and through milpas	Walking in forests and through pastureland
	Withdrawal <i>Obtaining products of the resource area</i>	Harvesting edible wild plants for domestic or commercial use	Selling large quantities of plants (with the permission of the community)
Collective choice	Management <i>Regulating use patterns and transforming the resource</i>	Family agroecological practices	Selective burning, or <i>kumerachi</i> , for the cultivation of beans
	Exclusion <i>Ability to exclude other potential users</i>	Exclusion of other users to harvest rancho products	Limiting the harvest of medicinal plants to ejidatarios
	Alienation <i>Transferring management or exclusion rights</i>	Transferring land by traditional bequeathing practices	Selling of ejido land under recent agrarian reform (with the permission of the community)

¹ Property rights categories as defined by Schlager and Ostrom (1992)

Operational level rights of access and withdrawal relate to actions of individuals that affect the state of the land (Schlager and Ostrom 1992). Access is defined as “the right to enter a defined physical area and enjoy non-substantive benefits” (Ostrom and Schlager 1996, p.131). Whether someone lives in the ejido, or resides outside of the ejido boundaries, they

have the right to access rancho and commons areas in the Basíhuare ejido. As a result, community members have the right to traverse areas to travel from one rancho to the next.

Withdrawal rights permit a landholder to “obtain products from a resource” (Ostrom and Schlager 1996, p. 131). Members of the ejido, or ‘ejidatarios’, have the right to withdraw products from the forest and pastureland of the commons by paying a yearly ‘impuesto’ (tax), valued at \$10 Canadian in 2001. The research facilitator explained that by paying this tax, “an ejidatario has the right to collect edible and medicinal plants, to collect fuelwood, and to use pastureland for livestock”.

Selling products derived from the resource is an illustration of the right of withdrawal (Schlager and Ostrom 1996). Products originating from ranchos can be sold in any quantity, without special permission from the community. Ejidatarios also have the right to sell products from communal areas. In this case however, permission from the community is required to sell large quantities of resources. Although one local harvester thought he needed a permit from the ministry of natural resources to harvest large quantities of plants for commercial use, further consultation with ministry officials confirmed that, in fact, a special permit was not required. Herein lies one example where the distinction between de facto and de jure rights is unclear.

Collective choice rights of management, exclusion and alienation, shown in **Table 4.2**, are important because they provide community members with the authority to devise future operational-level property rights (Schlager and Ostrom 1992). Management rights provide the ability to “regulate internal use patterns and transform the resource by making improvements” (Ostrom and Schlager 1996, p. 131). Management rights give ejidatarios the permission to develop a rancho on an unclaimed area of the commons, provided the community has given consent. For example, a research participant and his spouse, who were both born in the ejido, moved close to the ‘pueblo’ of Basíhuare approximately 10 years ago. The pueblo of Basíhuare is characteristic of most pueblos in the Sierra Tarahumara, which is designated by Article 63 (p. 17) of Mexican agrarian law as “an area for human settlement, including the development of community life for the ejido”. As described by Brouzes (1980, p.26), a pueblo consists of “a ‘templo’ (church), a school,

ejido offices, a scattering of homes, and a store from which one can purchase basic provisions". Basíhuare pueblo also has an elementary and a secondary school, a state-run store, and a modern medical clinic. The research participant explained that he and his family moved to Basíhuare to "benefit from increased work opportunities and to be closer to the medical clinic".

Another research participant moved from his family's rancho to the pueblo of Rejogochi, located in a valley where the land is of relatively better quality and the growing season is longer. He moved to this new location to "make it easier to receive and provide help in terms of raising our children and to share the work in the fields with other community members".

Exclusion provides the right to "determine who will have an access right, and how that right may be transferred" (Ostrom and Schlager 1996, p. 132). The right to exclude refers to limiting the use of resource areas to specific rights holders (Schlager and Ostrom 1992). In Rarámuri culture, inhabitants of ranchos become the proprietors of the goods they produce on milpas (González et al. 1994). Goods harvested from milpas are considered the property of the dueño, and the land user has the right to exclude others from these fields.

At the ejido level, residents of Basíhuare have the right to exclude non-ejidatarios from the commons. But some exceptions are made; specifically related to resources that are harvested for traditional ceremonies. For example, during 'Semana Santa' (Holy Week), many festival goers play a type of 'flauta' (flute), crafted from a specific variety of cane. The cane is only found within certain areas of the Sierra Tarahumara, including in 'barrancas' (canyons) of the Basíhuare ejido. Due to the extensive use of these flutes throughout the week's activities, the resources required to craft the instrument are widely sought. As one research participant explained: "People come from all areas to harvest the cane to make the flauta that they use during Semana Santa". There did not appear to be formal measures to delimit the allowable time frame for this activity, possibly because the cane appeared only to be harvested at that time of the year.

Alienation is the third collective choice right, and deals with the transfer of management and exclusion rights (Ostrom and Schlager 1996). In Basíhuare, landholders can transfer stewardship over ranchos through the right to bequeath land to children or relatives.

Although Ostrom and Schlager do not include the ability to bequeath in their definition of alienation rights, traditional inheritance practices are discussed here because of their cultural significance with regards to the maintenance of ranchos. Because land users are not proprietors of the ranchos, inheritance does not represent a transfer of land entitlement, but rather a transfer of the responsibilities as caretakers of the land.

Discussion with research participants seem to indicate that the inheritor of a rancho is most likely to be the son or daughter (in union with his or her spouse when applicable), who is most apt and willing to take on the responsibilities of caring for the rancho. An example of the right to bequeath land was given by a research participant, who inherited a rancho from his grandfather: "I was interested and able to take on the responsibilities of the land, so I am now the caretaker of the rancho". Another research participant lived on the rancho that was once cared for by his grandfather. As he stated: "this land is where my mother was born. My family and I kept the land because we are accustomed to living here and we wanted to continue caring for this land".

4.4 Discussion of property rights toward managing the commons

In their examination of property rights, Schlager and Ostrom (1992, p. 256) conclude that the existence of the five property rights in a commons setting constitutes a situation of "ownership". My research findings seem to indicate that the bundle of rights that exist in Basíhuare give ejidatarios this same status of ownership over the land. According to the authors, collective choice rights of management, exclusion and alienation provide specific advantages to owners.

Management rights in Basíhuare have regulated the use of the commons, as exemplified by controlled burning sites, known locally as *kumerachi*, used primarily for the cultivation of beans. The yearly impuesto that provides access to the commons gives an ejidatario the

right to produce a *kumerachi*. The dueño of the *kumerachi* remains the caretaker for that year, and crops harvested on the site become the property of this individual. As such, the dueño can sell goods cultivated on the *kumerachi* and can exclude others from harvesting products from the area. The following year, the land on the *kumerachi* is no longer used for cultivation, and therefore becomes available to anyone in the community who wishes to harvest products from the area. This system appears to provide equitable access to the commons, by allowing ejidatarios to harvest resources and to maintain traditional practices on the land.

The right of exclusion is important because it provides incentives for land users to make decisions on who can and cannot access the land and harvest the resources that occur there (Schlager and Ostrom 1992). In Basíhuare, monitoring the land in terms of outsiders harvesting resources is problematic. Although Mexican agrarian law delimits the spatial configuration of an ejido, boundaries between pueblos, ranchos and communal areas in Basíhuare are not clearly marked. In fact, during my field research I heard of a few occurrences where non-ejidatarios entered the ejido to collect firewood or harvest medicinal plants, such as *chuchupate*. The identity of the offenders was not known, nor was it sought; thus punitive actions were not taken.

Monitoring the land, based on exclusionary rights, will become important in the case where traditional products are sold to outside markets. At the moment, ejidatarios rarely exchange goods among themselves, and very few individuals sell products to outside buyers. However, current harvesting practices by outside users may already cause undue stress to certain types of plants, such as the cane used to craft flutes for Semana Santa celebrations. Increased tourism during the festive season may create a demand for arts and crafts. Furthermore, Felger and Dahl (1994) concluded that there is a potential for the creation of cottage industries based on the sustainable harvest of non-timber forest products. Increased harvesting of resources related with increased demand would place additional pressure on the survival of wild species.

Alienation rights are important in terms of producing incentives to make long-term investments of resources, because land "owners" can capture the benefit of these resources

for themselves and their offspring (Schlager and Ostrom 1992). In Basíhuare, the bequeathing of ranchos means that the resources found there will be used sustainably, in order to provide healthy lands for future generations. An individual in Basíhuare who has lived on his rancho for approximately 45 years provides a good example of this conclusion. "My family moved here when I was a child because the soil is good; this is where we used to let our goats graze. But when we moved here there were no milpas". He has since inherited the land from his father and developed extensive milpa areas. His children have married, have had children, and have built their own homes and developed additional milpas on the rancho. The entire family, from grandfather to granddaughter, appear to maintain a largely subsistence existence from the right to transfer access and withdrawal rights associated with the rancho.

The notion of ownership seems to apply in terms of the property rights on ranchos. But when it comes to the forests or pastureland commons of the ejido, that distinction is not clear. The idea of alienating land outside of ranchos is relatively new, as is the ability to sell commons land. Historically, communal lands were not subject to inheritance practices, because communal lands were held in the hands of the federal government. However, as a result of changes made to the agrarian law in 1992, ejidatarios now have the right to transfer titles to commons with the authorization of the community. These changes did not appear to have become local knowledge, as at least one participant confirmed that land from communal areas could not be sold.

The repercussions or opportunities associated with recent changes to Mexican agrarian law remain unclear. They have brought about instruments to form new social organizations for the regulation of land use (Randall 1996). But the potential disruption to traditional institutions may lead to negative ecological and social impacts (Toledo and Alcorn 1998). What is clear, however, is that property rights can only be ensured with the local institutional rules or norms to protect these rights, actors to monitor and enforce these rules, and mechanisms for the resolution of conflict.

4.5 Local-level institutions: a blend of traditional and external influences

Gibson and Becker (2000) identified local institutional control over resources as the third requirement for a successful commons management regime. Institutions have been described as culturally embedded beliefs that develop norms of actions or activities on the landscape (Klooster 2000; McCay 2002). Institutions for decision-making and rules over resource use in the Sierra Tarahumara are based on the Rarámuri traditional norm of community sharing, known locally as *Korima*. These institutions have been affected by external rule-making systems, from colonial influences of 17th century missionaries (Merrill 1988) to impacts of the 1910 Mexican revolution. **Table 4.3** lists the local-level institutions in Basíhuare, consisting of an array of traditional customs and ejido rules, played out by actors who maintain specific roles, and who access a series of mechanisms to provide a discussion forum for decision-making and conflict resolution.

Table 4.3 - Local-level institutions in Basíhuare.

Origin	Norms and rules	Representative body	Discussion forum
Traditional governance	<i>Korima</i>	<i>Siriame</i> and Capitanes	Sunday community meeting
Ejido government	Ejido internal rules	Comisariado Ejidal	Asamblea ejidal meeting

At the basis of the community institutional structure resides a traditional belief system known locally as *Korima* – the need and desire to share. Sharing occurs between members of the immediate family and extends to all members of the community. As I observed during my stay in Basíhuare, sharing happens on a daily basis. Community members would often welcome a guest into his or her home, whether the visitor was a close relative or a distant neighbour. The dueño of the welcoming rancho would offer what he or she had on hand, from a glass of ‘pinole’ (maize beverage) to a complete meal. As Brouzes (1980) observed, the offering and accepting of food is at the heart of *Korima*.

Sharing is also an important part of community livelihood activities, most importantly when working in the fields. Community work to produce crops on milpas forms a reciprocal assistance network (Alcorn and Toledo 1998). This system means that family members and neighbours who participate in community work receive help when it comes time to harvest their own crops. In recognition of their commitment to this community spirit, those who share in the work to seed and harvest crops also receive compensation for their work in the form of maize by-products (Vatant 1990). To formalize the *Korima* principle, the dueño will prepare and share 'tesgüino', a fermented maize beverage. A research participant in Basíhuare explained that: "food and tesgüino is prepared for everyone, so we can listen to the *Owirúame* speak of how the Creator wants us to share with others". The *Owirúame* is the community's spiritual healer, and is said to be in contact with the Rarámuri spiritual world by grasping a metaphysical understanding of the natural world (González et al. 1994). The *Owirúame* in Basíhuare explained his role this way: "I conduct a 'curación' ceremony that protects maize and milpas, so that no harm will come to them, for example when hail falls heavily. I also cure humans and crops from ailments and disease brought on by wrong-doing spirits". The *Owirúame* embodies the meaning of *Korima* by sharing the word of the Creator, and relating norms for community partnership.

The emphasis on sharing within kinship groups and with close community members is at the heart of decision-making on resource use. These decisions are first made at the immediate family level, and are based on the *Korima* sharing principle. As such, the relationship that exists in a Rarámuri family is based on interdependence for survival, whereby mother, father and child share the work to prepare meals, maintain crops, and harvest plants. Decisions on the stewardship of resources stems from within this immediate family unit, and forms the nucleus for making decisions at the community level. In this way, the community forms the basis for the Rarámuri governance system.

Representing the community within the traditional governance structure are a number of players, each with a variety of roles and functions, all operating within the same parameters of maintaining internal order in the community and making decisions regarding the management of resources. **Figure 4.1** portrays the structure of the Rarámuri traditional governance body, which emerged from Spanish colonial governments and Catholic

missionaries of the 17th century, who wished to organize the internal affairs of local communities (Merrill 1988). The main vehicle for the function of the traditional governance body is the Sunday meeting, where community members discuss and make decisions regarding land use issues.

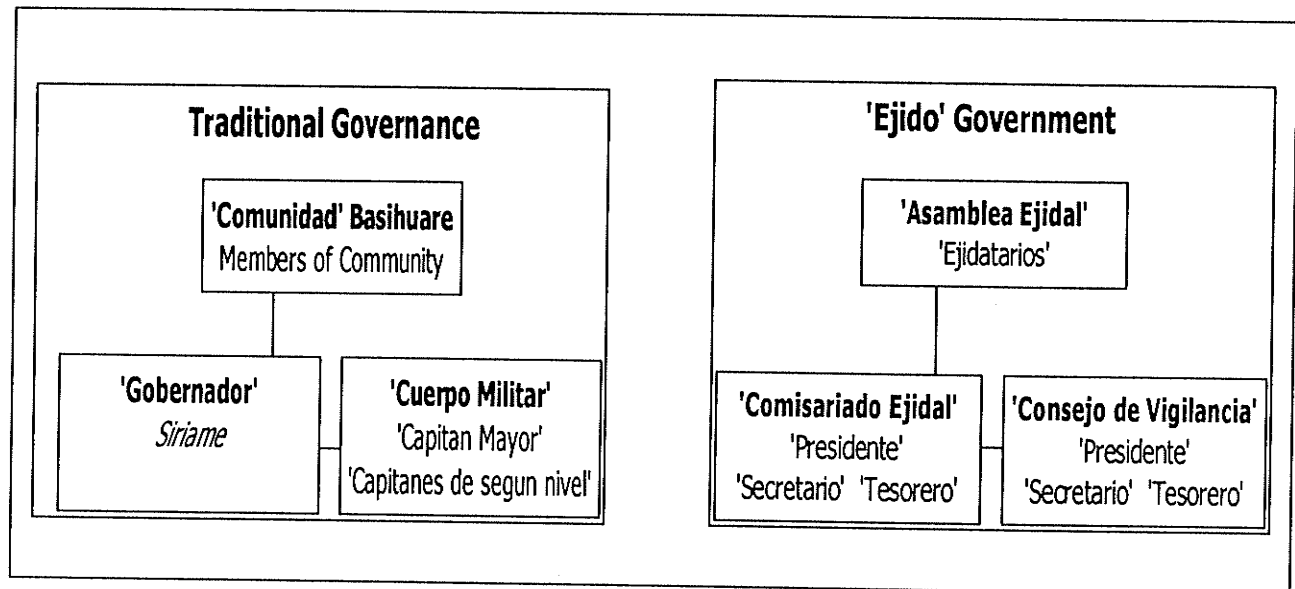


Figure 4.1 - Traditional and official government structures in Basíhuare.

Adapted from COSYDDHAC (1999), with information from González et al. (1994), Alcorn and Toledo (1998) and (INEGI 1999).

The *Sirame* or 'Gobernador', the Rarámuri community traditional governance leader and chief justice of the pueblo, leads weekly meetings. The *Sirame* lives in the 'ejido' and plays the role of principal guardian of Rarámuri cultural and moral values. The *Sirame* also makes decisions in terms of local employment opportunities, including the work related to forest operations, and represents the community at regional events. He is elected by the community for a 3-year term and is accountable to those who live within ejido boundaries. In fact, the ejido delimitations in Basíhuare seem to correspond with the expanse of the area within which the *Sirame* governs, as the community members who attended the Sunday community meetings all lived within ejido boundaries.

Community meetings are followed by the celebration of mass, which is a blend of catholic and Indigenous traditions, where the *Sirame* pronounces a *nawésare* (sermon), and where

the 'cuerpo militar', the other officiating body in the traditional governance system, consisting of the *Siriame*'s 'Capitanes', play a role in protecting Rarámuri customs and traditions (Merrill 1988).

The revolutionary agrarian reforms of 1917 established formal government structures and created a political body within Indigenous communities to formally liaise with municipal and state governments (Merrill 1988; González et al. 1994). The national government is represented locally by the ejido government structure, depicted in **Figure 4.1**. The *asamblea ejidal* (general assembly) encompasses 'Mestizo' (Spanish descendants) and Rarámuri heads of households who have become registered *ejidatarios*.

The *asamblea ejidal* is governed by the 'comisariado ejidal' (communal delegation), comprised of a 'presidente', a 'secretario' and a 'tesorero'. Members of the *comisariado ejidal* reside in the ejido and are elected to a three-year term (INEGI 1999). The *comisariado ejidal* is the official representative body to the state government and is charged with overseeing administrative functions of the ejido as they pertain to the rules outlined in Mexican agrarian law (Alcorn and Toledo 1998). In Basíhuare, the president of the *comisariado* is charged with overseeing forest operations, and acts as liaison with representatives from forest companies and officials from the ministry of natural resources.

The 'consejo de vigilancia' (oversight committee) is the other officiating body of the ejido government. Its composition is identical to that of the *comisariado ejidal* - a president, a secretary and a treasurer. The oversight committee is responsible for administering legal matters of the *comisariado ejidal*, including overseeing accounts and ensuring local enforcement with regards to forest operations (González et al. 1994).

Meetings of the general assembly are attended by *ejidatarios* and are the officially recognized medium for the discussion of topics relating to ejido land use and forest issues. *Asamblea ejidal* meetings provide the opportunity for a community member to become an *ejidatario*, by submitting a motion that is accepted with a majority vote. To qualify as a candidate, the individual must have been born in the ejido, must have reached the age of majority (18), and must still reside within ejido boundaries. The candidate must also show

an interest in working the land where they reside, and demonstrate a sense of responsibility toward cultivating fields or raising livestock.

Meetings of the general assembly must occur once every six months according to Article 24 of the Basíhuare ejido internal rules. These rules were adopted by the Basíhuare asamblea ejidal in 1996 and deal with commons management issues. **Box 4.1** lists the main areas of concern governed by ejido rules.

Ejido rules are recognized by municipal and state governments and appear to be respected by community members. The rules recognize the traditional governance system, as depicted by Article 7, which stipulates that conflicts at the community level are to be resolved in accordance with traditional customs. Furthermore, ejido rules specify, under Article 51, that since the ejido membership is primarily made up of Indigenous people, those who disrupt a traditional ceremony can be charged a fine by the asamblea ejidal. This is but one example of enforcement mechanisms available to community members through local institutions.

Box 4.1 - Items governed by ejido rules

Item I - General provisions

Item II - Ejidatarios

Chapter 1 – Ejidatario rights and obligations

Chapter 2 – Becoming an ejidatario

Chapter 3 – Loss of ejidal rights

Item III - Ejido authority

Chapter 1 – The asamblea

Chapter 2 – Asamblea operations

Chapter 3 – Comisariado ejidal

Chapter 4 - Consejo de vigilancia

Chapter 5 – Elections

Chapter 6 – Changing ejido authority

Item IV - New residents

Item V - Ejidal land

Chapter 1 – Use of land and water

Chapter 2 – Lands with specific uses

Item VI - Communal pastures

Item VII - Cultural rights

4.6 Provisions for rule enforcement and conflict resolution

McCay (2002) relates the importance to commons management of having a deliberative forum to share information and air conflicts about the commons. In Basíhuare, the

enforcement of local norms and rules and the resolution of conflict are conducted through both traditional governance and 'ejido' government mechanisms. For example, there is no formal limit to the amount of plants or fuelwood an ejidatario is allowed to collect, nor is there a maximum amount of livestock one is permitted to keep on communal lands.

General resource use is respected through the informal norms embodied in the *Korima* worldview of using only what is needed, and sharing the remaining resources with the rest of the community.

If these norms are abused, the traditional governance system offers rule enforcement and conflict resolution through discussion at Sunday community meetings. The issue is brought forth by the *Siriamo* and discussed at the meeting. If the accused is charged, his right to access and manage the land can be revoked. During my field research, a situation of overuse occurred involving a neighbour of the ejido who was given special permission by the community to use the commons as pastureland. Community members had perceived that the neighbour was keeping an excessive number of cattle in grazing lands, and thus had abused his right to use the commons. This issue was discussed through the mechanism of an informal hearing at a weekly community meeting and resolved with the individual agreeing to reduce the amount of pastureland used by his livestock. This hearing occurred near the end of my research and thus I do not know whether the accused followed through with the agreement.

If this individual did not change his ways, the community had recourse to discussion at the next meeting of the *asamblea ejidal*. The research facilitator described how infringement of internal ejido rules could be discussed at these meetings, and enforcement is maintained through the offices of the *comisariado* and the *vigilancia* committee. For example, if this ejidatario refuses to comply with the community's wishes, the *asamblea ejidal* can declare that punitive action be taken against the guilty party, such as the confiscation of livestock. The facilitator explained that the ejidal system also provides the mechanism of applying a fine if an ejidatario acts irresponsibly on the land, such as over harvesting plants. Meetings of the *asamblea ejidal* thus provide the venue for infractions to be brought forth to the *comisariado* for discussion and eventual resolution, with the possible recourse of enforcement by the *vigilancia*.

4.7 Discussion of institutions in making locally-based decisions

How does cooperation between traditional governance and ejido authorities in Basíhuare play out in terms of commons decision-making, given the ambiguous nature of the relationship between these two governing bodies? The situation is unclear, and my research does not provide an adequate answer to this question. González et al. (1994) reported that there appears to be miscommunication between the two governance systems, caused perhaps by a lack of trust in Mestizo leaders, who often dominate the ejido structure, and by divergent interests on the part of both cultures. In Basíhuare, the traditional governance system appears to be more prominent than the ejido government when making decisions regarding resource use. For instance, the Sunday meeting is the Rarámuri cultural engine, driving discussions of everyday concerns related to the management of the commons. Community meetings occur on a weekly basis, whereas *asamblea ejidal* meetings happen only once every six months, and thus appear to play a more active role. Furthermore, the official government structure seems to deal more with management of the forest commons in relation to the state government vis-à-vis forest timber operations, and less with daily harvesting activities.

On the other hand, the *comisariado presidente* did appear to play a prominent role in local decision-making in Basíhuare. He lived in the pueblo and was usually present at Sunday community meetings during my field research. As well, issues relating to official government matters were often discussed along with local matters at the weekly meetings. In one instance, the *comisariado* president distributed government support payments at the weekly meeting.

Perhaps another way to approach this question is to consider local perceptions of the ejido government structure, by exploring whether community members identify themselves as *ejidatarios*. Brouzes (1980) observed that for an Indigenous person in the Sierra Tarahumara, being an *ejidatario* means thinking in an administrative version of their place, incorporating the political limits of the ejido, and adopting land use rules based on Mexican agrarian law. Brouzes (1980) concluded that only a portion of the population in the study area of her research was aware of ejido rules and geographical boundaries. In Basíhuare,

when research participants discussed issues surrounding property rights, or related concerns about state or federal government assistance, they appeared to consider themselves as members of the ejido. Aside from discussions about official state matters, community members did not refer to the term ejidatario during regular conversations about resource use.

Implicit here is that there have been multiple interpretations of the role of the ejido government in relation to the community decision-making structures of the Sunday meeting. As in earlier examples of confusion between de jure and de facto rights, these become juxtaposed and create considerable ambiguity when determining which level of government is most prominent. What remains to be seen is whether the traditional governance system will continue to maintain its familiar aspect, and to provide the opportunity for community-based discussion and decision-making, in the face of an increasingly dominant Mestizo population and escalating pressure from external forces. These forces, such as the agrarian reforms of the Mexican revolution, have already had an affect on traditional land use systems by affording jurisdiction over resources to the cultural group that controls the ejido decision-making structure, which in most cases is the Mestizo community (González et al. 1994).

To a certain extent, this does not appear to be the situation in Basíhuare, where families base their harvesting decisions on the *Korima* sharing principle, and community members bring forward their concerns regarding local resource use at a weekly meeting where respect is granted to the offices of a traditional governance system. But on a different scale, it becomes apparent that commons forest management, specifically in terms of forest timber operations, are made away from the local institutional setting.

According to Mexican Forest Law, members of an ejido must develop a forest management plan if they wish to undertake timber operations. Forest management plans require the authorization from a majority of ejidatarios, including signatures and fingerprints, but are not discussed at the weekly community meetings. In fact, a forest management plan for the Basíhuare ejido was approved in 2001, but did not appear to make it to the agenda of the weekly meetings. The community has, in effect, experienced difficulties in maintaining

control over their forest resources because these management plans are developed, approved and implemented by representatives of the federal ministry of natural resources. Forest technicians use scientific terms that are foreign to many community members to discuss biological inventory, to proscribe extraction and reforestation techniques, and to regulate means of protecting and conserving natural habitat (COSYDDHAC 1999). Furthermore, current forest management plans emphasize timber production and pay lip service to sustainable forestry practices by dismissing traditional land use practices, such as selective burning, and harvesting non-timber forest products. If these traditional systems continue to be thwarted by externally imposed systems, the situation in Basíhuare may very well reflect the ejido government structure as described by González et al. (1994.), which is indicative of the intolerance toward Indigenous political systems on the part of official government representatives.

Only if changes occur at the policy level, in which forest ministry officials begin implementing sustainable forestry management principles that integrate traditional land use practices, will institutions continue to be effective in making decisions at the community level. Non-government organizations also have a role to play in protecting Indigenous rights by making sure government representatives respect traditional institutional arrangements. COSYDDHAC and Kosemi are two groups that I identified when composing the regional institutional framework (please see **Table 3.2**), which may have a role to play in affecting policy change. Their role, as explained by a member of the Kosemi group, is "not to represent these Indigenous groups, but to facilitate a dialogue between governing forces and traditional leaders and community members". In this way, decisions over land management will remain in the hands of the community.

4.8 Summary and conclusions

The Rarámuri see the land and the non-timber forest products that occur there as a valued part of their livelihoods. The bundle of "ownership" property rights in Basíhuare seems to provide the basis for a community-based approach of maintaining the value placed on the local resource. The ownership arrangement, despite being unclear and imperfect, provides

the ability to make decisions specific to the needs of the community by excluding outside users and transferring management rights over the resource base.

The blend of traditional and externally influenced institutions in Basíhuare plays a role to ensure the protection of common property rights. For example, *Korima*, the need and desire to share, builds equity and forms the foundation for the informal rule of using only what is needed. The principle of sharing not only applies to what is found on ranchos, but also to what is available in the forest, including non-timber forest products. Perhaps then, sharing assumes an understanding of the subtractive features of the commons, and the implications of the "Tragedy of the Commons" (Hardin 1968), and leads to the sustainable use of resources. Sharing also applies to the sense of identity and belonging, in terms of valuing a shared history and harbouring some expectation of a shared future. These characteristics are critical to the development of trust and reciprocity, essential to the building of cooperative relationships (Ostrom et al. 1999). Sharing is built into the *Korima* framework, which represents the "social motivation" to act for the good of the community (Klooster 2000), and shapes traditional institutions that safeguard the ownership property rights that currently exist in Basíhuare.

Through adherence to *Korima*, the Rarámuri of Basíhuare maintain a community profile, as presented by Singleton and Taylor (1992), of "a set of people with some shared beliefs and preferences, beyond those constituting their collective action problem, with a more-or less stable set of members, who expect to continue interacting with one another for some time to come and whose relations are direct and multiplex" (cited in Klooster 2000, p. 315). The complex institutional setting in Basíhuare, with the ambiguous relationship between traditional governance and ejido government systems, certainly represents challenges to commons management. However, complexity and struggle can be a driving force for the maintenance of institutions, and can provide the right tools to deal with growing influences from outside pressure (Klooster 2000).

Struggle in the Sierra Tarahumara is fuelled not only by the growing Mestizo population, the potential for increased tourism, and the possible commercialization of non-timber forest products, but also by the challenge over maintenance of forest management decisions.

These forces create the need to adequately monitor forest resources according to traditional beliefs, and to integrate rules about the proper use of these resources into forest management plans. Ultimately, the establishment of enforcement mechanisms to monitor and legitimize traditional harvesting practices would help protect the cultural identity and political power of the community (McCay 2002).

With local decision-making and conflict resolution mechanisms, and with the support of local non-governmental organizations who can create the necessary dialogue between the community and ministry officials to establish proper management and enforcement plans, I believe the community of Basíhuare can maintain its solid institutional arrangement and bring to bear the right tools to navigate them through these challenges. With evidence of community members valuing the resource base and respecting existing property rights, criteria of a successful commons management scenario (Gibson and Becker 2000), it is even more realistic to think that the Rarámuri will set forth the local institutions to manage the non-timber forest products found on the commons of Basíhuare.

Chapter 5 - Rarámuri Traditional Ecological Knowledge of Edible Wild Plants

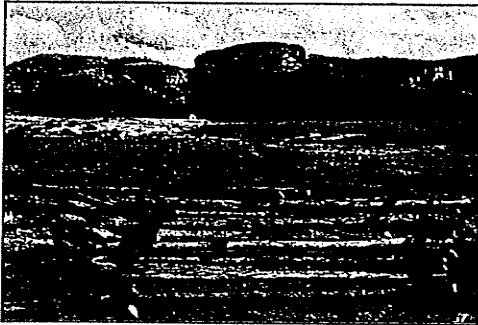
“Edible plants form an important part of our diet, so our children are learning which are and which are not edible, how and when to collect them, and how to prepare them”.

Rarámuri elder from Basihuare



Selective harvesting *ila* (*Opuntia* spp.) ensures seed dispersal and protects plant stocks

Photo: S. LaRochelle



Livestock are kept in *corrales*, fertilizing the soil to seed and transplant wild plants

Photo: S. LaRochelle



Kumerachi: oak trees are cut and burned for the cultivation of beans

Photo: S. LaRochelle

5.1 Introduction

The Rarámuri people maintain livelihood activities that include the harvesting of edible wild plants (Bye 1995; Salmón 2000a). A survey commissioned by the National Public Health Institute of Mexico reported that 91 Rarámuri women from 51 communities in the municipality of Guachochi identified wild plants such as 'quelites' (edible greens) as an important source of nutrition especially for young children (Monárrez Espino and Martínez Salgado 1996). Several cultivated and wild species of *Amaranthus* are used not only in the Sierra Tarahumara region, but also throughout Mexico for their high nutritional value (Wesche-Ebeling et al. 1995).

Basíhuare is one community within the Sierra Tarahumara where edible plants constitute a portion of the usual dietary regime. Qualitative field observations indicated that edible wild plants are commonly harvested and consumed throughout the year. The availability of edible wild plants changed with the seasons; for example, they were consumed as a secondary source of food in spring when household stocks of maize are low. Conversations with community members, men, women and youth, confirmed that wild plants are important as a source of regular nutrition. For example, the research facilitator explained that he and his family consume *kujubi* (*cosmos* sp.) because "it grows close to our home, it adds variety to our diet, and it is quicker to cook than 'frijoles' (beans)". He explained that needing less fuelwood to maintain a fire in the stove requires using fewer resources from the forest, and lessens the workload in terms of cutting and hauling wood.

Research participants identified over 20 wild species of edible plants and described techniques to prepare these plants for consumption. **Table 5.1** lists the edible wild plants identified during research in Basíhuare, and summarizes which parts are consumed and how they are prepared. Only those plants for which voucher specimens were collected are identified at the species level. Plants identified to genus were identified using reports from Bye et al. (1987), Mares Trias (1982), and Pennington (1963).

Table 5.1 - Edible wild plants and preparation methods in Basihuare.

Rarámuri Name	Common English and Latin Names	Plant Part and Preparation Method
<i>Amáwali</i>	Wild dahlia <i>Dahlia sp.</i> , Asteraceae	Root: skin is removed & eaten raw or mixed with chilies in a salsa
<i>Basoli</i>	Amaranth <i>Amaranthus hybridus</i> , Amaranthaceae	Leaves and shoot: new plant boiled, pounded & fried with onions
<i>Chawí</i>	- <i>Agave sp.</i> , Agavaceae	Heart: cooked in earth-pit oven & pounded; juice mixed into <i>tesguino</i>
<i>Cibóa</i>	Wild onion <i>Allium rizomatum</i> , Liliaceae	Stalk: new, steamed or mixed with water Bulb: mature, boiled or fried
<i>Ilá</i>	Prickly pear <i>Opuntia sp.</i> , Cactaceae	Pads: new, spines removed & boiled, served with onions & tomatoes Fruit: mature, eaten raw
<i>Kóchi'nakara</i>	Milkweed <i>Asclepia latifolia</i> , Asclepiadaceae	Leaves and shoots: new, boiled
<i>Kotó</i>	Amaranth <i>Amaranthus sp.</i> , Amaranthaceae	Leaves and shoots: new, boiled & fried with onions & tomatoes
<i>Kuichala</i>	Manzanilla <i>Arctostaphylos sp.</i> , Ericaceae	Fruit: new, raw or mature, mixed with water
<i>Kujúbi</i>	Cosmos <i>Cosmos sp.</i> , Asteraceae	Leaves and shoots: boiled or mixed with water
<i>Mekuásare</i>	Wild mustard <i>Brassica sp.</i> , Brassicaceae	Leaves and shoots: new, boiled
<i>Mesagoli</i>	Century plant <i>Agave sp.</i> , Agavaceae	Heart: baked in earth-pit oven and eaten, or pounded & mixed with <i>tesguino</i> Stalk: new, skin removed & baked
<i>Napá</i>	Oregano <i>Moranda citriodora</i> , Lamiaceae	Leaves and shoot: new, boiled or dried & mixed into soups
<i>Okowí Chupikare</i>	Mushroom -	All: fried
<i>Okowí Ripomi</i>	White water mushroom -	Cap, minus skin and stem: fried
<i>Okowí Sawaróame</i>	Yellow mushroom -	Cap, minus stem: fried
<i>Okowí Sitakame</i>	Water mushroom -	Cap, minus stem: fried
<i>Rolokochi</i>	Plantain <i>Plantago purshii</i> , Plantaginaceae	Leaves and stem: new, boiled & mixed with onions
<i>Salabí</i>	- <i>Prionosciadium sp.</i> , Apiaceae	Root: after stem has dried, baked
<i>Sipeke</i>	- <i>Bidens sp.</i> , Asteraceae	Leaves and shoots: new, boiled
<i>Sowinali</i>	- <i>Eryngium heterophyllum</i> , Apiaceae	Leaves: new, boiled
<i>Tomati</i>	Husk tomato <i>Physallis wrightii</i> , Solanaceae	Fruit: mature, raw or boiled & served in salsa
<i>Uli</i>	Wild grape <i>Vitis arizonica</i> , Vitaceae	Fruit: mature, raw

The traditional ecological knowledge related to these plants was examined according to the framework of Turner et al. (2000). The framework categorizes traditional ecological knowledge within three broad themes: philosophy and worldview, practices and strategies for sustainable living, and communication and exchange of knowledge (Figure 5.1).

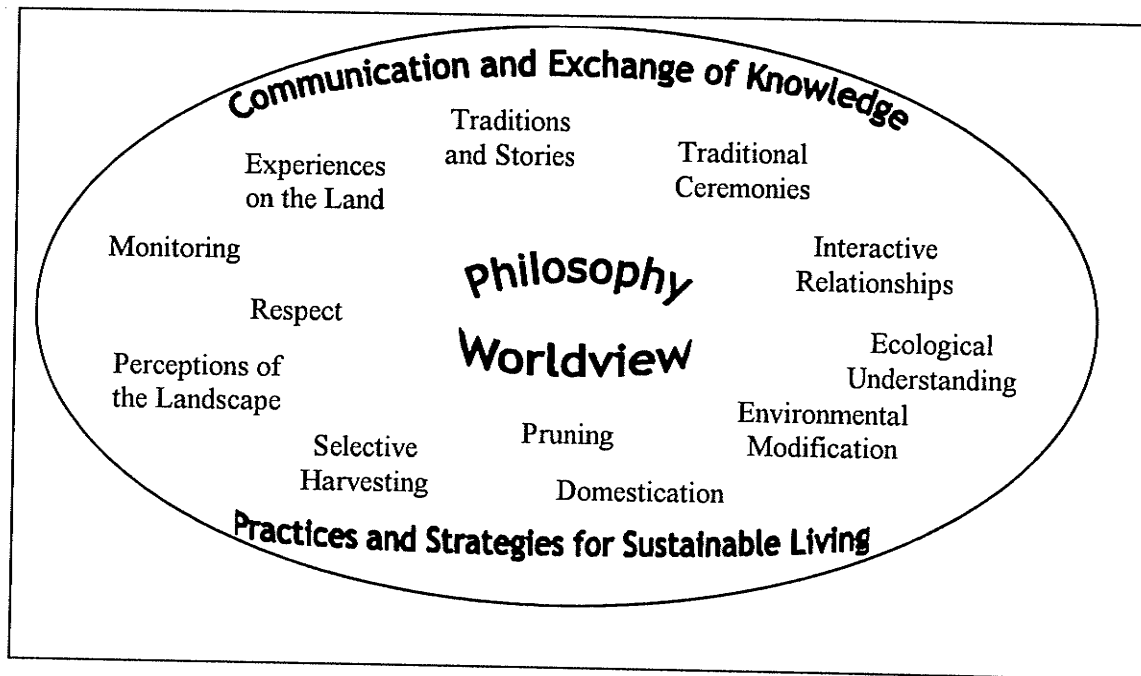


Figure 5.1 - Components of traditional ecological knowledge in the Sierra Tarahumara. Adapted from Turner et al. (2000).

The framework provides an indication of the holistic nature of traditional ecological knowledge. Although the framework was fashioned from experiences with several aboriginal communities of British Columbia, it appears to be applicable to the Rarámuri of the Sierra Tarahumara, mainly in how the broad themes are inextricably linked. The different elements within each theme are interrelated, and thus affect one another regardless of where they appear in the framework. For instance, worldview shapes perception of the landscape, and thus fosters the understanding of ecological processes and the implementation of harvesting strategies. The results of constant observation of the landscape, or monitoring, are fed into traditions and stories.

This chapter presents Rarámuri knowledge of edible wild plants and discusses research results as they pertain to the components of the adapted Turner et al. (2000) model within each of the main themes. Discussion continues about the status of traditional ecological knowledge in Basíhuare, in light of the relatively recent changes that have occurred in the region.

5.2 Philosophy and worldview

Philosophy and worldview themes of the Turner et al. (2000) model comprise several components that may be applicable in the Sierra Tarahumara, including respect and interactive relationships, traditional ceremonies, perceptions of the landscape, and understanding ecological processes. These are discussed from research findings in Basíhuare as they relate to the management of edible wild plants.

Rarámuri worldview recognizes a kinship between humans and nature, such that natural resources are respected and cherished as providers of life and energy. As Salmón (2000b, p. 193) suggests, “their knowledge of foods and medicinal plants embodies their relationship and, therefore, their model of self-identification with their place and their manner of using what nature has offered”. The Rarámuri philosophy of humans interconnected with nature seemed to form the underlying principle of sustainable resource use in the community of Basíhuare. Harvest related decisions are thus made through interactive relationships with family and community members, as well as with the natural world.

The Rarámuri relationship between humans and nature is embodied in traditional customs and ceremonies. An example of how elements of the natural world are considered as kin to humans is the ‘curación’ (curing) ceremony, conducted by the *Owirúame* (spiritual healer). The ceremony is designed to ask the Creator to protect livestock and crops from disease, pestilence and drought (Merrill 1988). The applicability of the curación ceremony to edible wild plants is not clear. The *Owirúame* in Basíhuare explained that plants that occur naturally are not incorporated into the ceremony. Even though plants from the forest are not free from threats such as drought, they did not require a special curing ceremony.

However, further discussion with a research participant revealed that the curación might indeed incorporate wild plants. During the curing ceremony, the *Owirúame* would motion a sprig of *chuchupate* (*Ligusticum porteri*) toward crops and livestock, and raise the plant to the sky. By performing this gesture, the spiritual healer was recognizing the physical and biological surroundings. Acknowledging the natural environment during the curing ceremony may not mean that the *Owirúame* was requesting the protection of wild plants, but he was showing a sign of respect for the strength and interconnectedness of the natural world.

In the Sierra Tarahumara, Rarámuri place names are the product of culturally transmitted knowledge and relate to the natural environment, often describing physical traits of an area or referring to a natural event that occurs there (Brouzes 1980). For example, *Basíhuare* is the name of the place where “the mountain face resembles a woven belt”, and *Rawárachi* is the place where “certain birds build their nests among the manzanilla trees”. Rarámuri also identify places according to the resources found there, such as *Akichi*, where “two streams meet” and provide a source of water for washing and cooking; or *Rowhárare*, an area where “oak trees are found”.

In *Rarámuri* culture, places are not named after people who have made contributions to the area, nor are they named to honour forefathers. In fact, Burgess (1987, p. 83) recorded a conversation with a *Rarámuri* in the Sierra Tarahumara, during which the individual participant related that “God is owner of all the land, and we have no right to name land after ourselves, as if we owned it”. Meaning in place names is drawn from the relationship between humans and the natural environment, and from a keen insight into natural processes on the land.

The Rarámuri understanding of ecological processes fosters decision-making strategies that differ from those used by government resource managers. In Basíhuare, harvesters did not use maps or calculate maximum yields; nor did they consult a plan when harvesting edible plants. They made decisions based on a culturally embedded understanding of the relationships that exist in the local ecosystem. For example, members of the community did not hold formal meetings to decide when to seed frijoles. The decision depended on the

commencement of the rainy season, and was based specifically on the emergence of the flower of a certain variety of *ilá* (*Opuntia* sp., prickly pear).

Harvesting practices were also often based on detailed natural history and an understanding of when certain wild species were ready to be harvested. For example, *okowí sawaróame* mushroom reaches its maximum size in about 24 hours and only survives for approximately five days. The research facilitator explained that this species of fungus is best consumed fresh, within two to three days of sprouting. To benefit from its flavour and nutritional value, harvesters knew when and where the mushroom would appear. The relationship between humans and nature, along with perceptions of the landscape and insight into ecological processes leads to a number of practices specifically related to the harvest of edible wild plants.

5.3 Practices and strategies for sustainable living

The second theme in the traditional ecological knowledge framework presented by Turner et al. (2000) is practices and strategies for sustainable living. Beyond understanding ecological processes, Rarámuri harvesters are aware that human intervention can affect the health of local flora. Thus, strategies and practices have developed over generations of interactions with the land to harvest edible plants in a way that appears to be sustainable (Merrill 2000; Salmón 2000a). **Table 5.2** lists edible plant harvesting strategies practiced in Basíhuare under four headings: selective harvesting, pruning, domestication, and environmental modification.

Table 5.2 - Food types and harvesting strategies of edible wild plants in Basíhuare.
Please see Table 5.1 for common English and Latin names of plant species.

Type of food	Rarámuri plant names	Harvesting Strategies			
		Selective harvesting	Pruning	Domestication (seeding or transplanting)	Environmental modification
Fruits & berries	<i>Napó, Kuichala, Ulúbisi</i>	√	√		
	<i>Tomati</i>	√			√
	<i>Uli</i>	√			
Mushrooms	<i>Okowí (Sitakame, Sawaróame)</i>	√			
'Quelites' (Green leaves & shoots)	<i>Basolí, Mekuásare</i>	√		√	
	<i>Kóchi 'nakara, Kotó, Kujúbi, Napá, Rolokochi Sowinari</i>	√			
	<i>Sipeke, Cibóa</i>	√			√
Perennials (heart & stem)	<i>Ilá, Mesagoli</i>	√	√	√	
	<i>Chawí</i>	√			
Perennials (roots)	<i>Amáwali</i>	√		√	
	<i>Cusali, Salabí</i>	√			
	<i>Cibóa</i>	√			√

Rarámuri harvesters did not articulate selective harvesting in terms of quantitative goals or harvest allowances. When asked about how much can be harvested, most research participants responded that the optimal quantity relates to what is truly needed. In the case of the perennial *ilá*, the research facilitator explained that harvesting too many 'pencas' (pads) would most likely adversely affect the health of the plant. Results of participant observation indicated that harvesters, in fact, collected only what can be consumed. Young pencas were the most desirable portion of the plant because of their tenderness and taste, so harvesters tended to collect only the pads and left the stock, or the meristem, intact. It is known that: "as long as plants maintain meristematic tissues and have the capacity to

absorb sufficient nutrients and water, they can reproduce vegetatively and maintain individuals and populations even with a certain level of harvesting” (John Zasada, cited in Turner 2001, p. 68).

In the case of *amáwali* (wild dahlia), it was important to leave the meristem intact for the creation of future bulbs. A research participant explained the importance of replanting some of the propagules, defined as “portions of the underground parts that contain active meristematic tissues and hence have the ability to regenerate” (Turner 2001, p. 68). The research participant likened this practice to the harvesting of potatoes, where a spud is left in the ground to allow for the development of a new stock of ‘camotes’ (potatoes).

Selective harvesting strategies also apply to annuals. One example is *basoli* (*Amaranthus spp.*), a ‘quelite’ that is collected in its entirety, and consumed before flowering. Similar instances of amaranth consumption were witnessed by Vieyra-Odilon and Vibrans (2001) in the valley of Toluca, Mexico. Amaranth is consumed when it is new, because “in initial stages, the plant generates large quantities of succulent green matter” (Mapes et al. 1997, p. 303). Research participants elaborated that for all annuals, it is important to leave some plants intact to allow for future seed-generation. “The seeds are consumed by livestock or birds and deposited by the passing of feces in pastureland and along trails and waterways. Seeds that are deposited in riparian areas will be transported to other locations when water levels rise. The wind will also play a factor in future propagation by blowing seeds to areas where they will fall and germinate”. A harvester explained that by allowing these natural processes to act on a natural seed stock left behind, plants would propagate naturally and replenish themselves.

The stalk, which contains the inflorescence, of *mesagoli* (*Agave sp.*, century plant) is used as a supplementary food source. Research participants described that the stalk is harvested before the plant flowers in early spring, so it can be consumed while still tender. Community members harvested the stalk of the century plant for another reason – to extend the life of the plant. The research facilitator explained that “if the stalk were not cut, the juice of the plant would concentrate on producing fruit, denying the heart and roots of

essential nutrients and effectively killing the plant within one year. If its energies are not focused on reproduction, the plant can live longer”.

The practice of pruning the stalk is undertaken to prolong the life of the plant itself. Bye and Linares (2000, p. 60) describe how collecting the stalk maintains the *Agave* population because the stalk is “too dense and close to the mother plant to guarantee survival and dispersal”. This practice also maintains the plant in the developmental state, to grow vegetatively, instead of switching to the mechanism that puts the plant’s energy into reproduction. By allowing the plant to survive, the heart expands and provides more substance when it is finally consumed. Thus, pruning the *mesagoli* plant serves a dual purpose – to provide a source of food for immediate consumption, and to extend the life of the plant for future use.

Domestication practices, such as fertilization, seeding and transplanting, were also observed in Basíhuare. The Convention on Biological Diversity includes the domestication and cultivation of wild species in its definition of *in situ* conservation (Melchias 2001). The Rarámuri in Basíhuare have adopted domestication practices for a number of edible wild plants in naturally fertilized areas ('milpas'), grown along with cultivated crops such as maize and beans.

Milpas are maize growing systems used in many parts of Mexico (Alcorn and Toledo 1998). In Basíhuare, milpas are fertilized by keeping livestock overnight in ‘corales’ (enclosures), positioned on a section of the field and shifted on a rotational system. A research participant explains: “We leave goats for 16 nights in corales at which point the ground becomes fertilized. We repeat this process until we have fertilized the soil throughout the entire milpa area. Then we work the soil and seed edible plants”. According to the research participant, the fertilized soil can remain nutrient-rich for up to five years on flat surfaces, and two years on slopes or hillsides.

Wild edible plants are either seeded or transplanted in these fertilized areas. The seeds of *mekuásare* (*Brassica spp.*) of the Mustard family (Brassicaceae) are collected in the fall and sown in fertilized milpas during the rainy season and occasionally in late summer or

early fall. The same research participant explained: “you do not have to bury the seeds because they are small enough that the rain will wash them into the soil”. He described that when the ground moisture level is high, the seeds can begin to germinate in as little as five days. *Mekuásare* plants can be also dried and preserved for use at a later date, such as in the spring, when maize stocks are low and fresh edible greens have not yet emerged.

Seeding selected species of edible greens alongside wild varieties provides a condition that fosters genetic exchange and promotes the cross-fertilization between domesticated and wild plants (Cotton 1996). In Basíhuare, those species of the *Brassica* genus that are seeded in milpas cross-fertilize with other varieties of *Brassica* found in the area. Similar findings are reported regarding the cultivation of wild varieties of the *Brassica* genus in the Sierra Tarahumara (Bye 1979). The practice of domesticating wild species locally builds ecologically resilient strains of these species adapted to local environmental conditions (Nabhan 1997).

Wild plants may also be transplanted in fertilized areas within milpas. Research participants identified *mesagoli* (*Agave sp.*, century plant) and *ilá* (*Opuntia sp.*, prickly pear) as two widely used plants that are propagated in this way. The heart and root structure of *mesagoli* is transplanted when it is young, to an area with good quality soil. The research facilitator explained that the ideal area to transplant *mesagoli* is “free of stones, so that the roots will penetrate deeper and anchor the plant”. He went on to explain that *ilá* is transplanted by simply cutting a penca in half and placing it into good-quality, well-moistened soil.

Bye and Linares (2000, p. 60) reported how the process of transplanting vegetative propagules form a part of traditional agroecosystems in various areas of Mexico, and that selectively transplanting locally-recognized *Agave* species has resulted in the “diversification of folk cultivars”.

Environmental modification is another agroecological practice in Basíhuare that fosters the diversity of *Agave* species. Previous research in the Sierra Tarahumara (Bye 1976; Salmón 2000a) had identified a number of Rarámuri practices of environmental modification that

create habitats in which certain types of plant species can prosper. In the Basíhuare region, such agroecological practices include selective burning and soil disturbance.

Selective burning produces an area known locally as *kumerachi*, and is used regularly as part of traditional agroecological practices (Davidson-Hunt 2003). Oak trees are selectively cut and burned on mountain plateaus to produce nutrition-rich soil in which mostly beans are cultivated. An area is used only for one year, after which time oak and understory vegetation are allowed to regenerate naturally. On the Basíhuare landscape, oak forests were in different stages of succession as a result of selective burning, from recently burned patches to those that had not been disturbed for decades. The effect of these practices is to create a mosaic of oak forest patches of different ages, favouring the growth of a diversity of plants, some of them utilized as a food source.

Participant observation research included a visit to a *kumerachi* site that had been burned approximately seven years earlier, and where little vegetative regeneration was visible, with the exception of a considerable amount of *mesagoli*. Goats had been allowed to graze on the site and had consumed most of the vegetation, except for *mesagoli*, a plant they do not consume. Because oak had not regenerated on this site, the area had become more exposed to sunlight. This provided adequate habitat for certain species of edible plants, such as *mesagoli*, which thrive in sunny, nutrient-rich environments. The practice of selective burning, combined with livestock grazing on the *kumerachi* site, had the effect of increasing the amount of sunlight reaching the soil, and thus producing an area suitable for the growth of edible wild plants.

The other agroecological practice observed in Basíhuare was land disturbance on milpas, promoting the growth of certain edible wild species. One such species of edible greens, *sipeke* (*Bidens spp.*), is believed to have originated from the forest. It now prospers on land that has been disturbed by agricultural activity. "If this land was not cultivated, it is probable that *sipeke* would not flourish here", stated a local agroecologist. The disturbance of landscape also promotes the growth of *tomati* (*Physallis wrightii*), a husk tomato used to make salsa, which was only found near milpas in Basíhuare.

Disturbance is important in general: it produces a mosaic of patches on the landscape and creates a variety of habitats that are capable of sustaining a diversity of plant species (Cotton 1996; Altieri 2000). As such, Rarámuri agroecological practices may ensure the regeneration of edible plants, both the semi-domesticated varieties in agricultural fields and the wild ones in forested areas. As the above examples indicate, Rarámuri practices may be undertaken with the practical objective of maintaining and augmenting the productivity of the land, but their ultimate effect is the conservation of edible plant stocks and of biodiversity in general.

5.4 Communication and exchange of knowledge

Ruddle and Chesterfield (1977) described the sequences in the transfer of traditional ecological knowledge. First, there is familiarization and observation by the learner. This is followed by putting knowledge into practice, at first with assistance, then on one's own, culminating with sharing of learned experiences with others. As observed with the Rarámuri, the transfer of traditional knowledge is more than a unidirectional flow of information on harvesting practices from elder to youth. The communication of knowledge between generations is executed in a dynamic and interpretive way and involves mutual learning. In Basíhuare, experiencing the landscape by monitoring forest resources plays a role in the communication and exchange of knowledge, which is the third theme in the Turner et al. (2000) framework.

In Rarámuri culture, monitoring does not occur in a formal setting, but rather as an element of daily activities, such as gathering goats, collecting fuelwood, or harvesting plants. Research participants noted that to monitor the state of edible plants, people must harvest and use them. They are likely to lose knowledge and to stop monitoring the landscape of edible plants if they are not using their knowledge.

If a certain plant is no longer harvested, then its abundance is not likely to be monitored, and associated knowledge may be lost. For example, local harvesters knew of several varieties of *ilá* that existed in Basíhuare, four of which were edible. However, the fifth

caused headaches if consumed. There was also local knowledge that these plants had rich nutritional value and prevented diabetes; supported by research findings (González Ferrera 1998). There were a number of mushroom species in the area, some of which were edible and some poisonous. If the use of these plants were discontinued, local knowledge about the benefits and risks of consuming them might be threatened.

This specific knowledge of edible wild plants in the Sierra Tarahumara has developed through generations of sharing traditions and stories, manifested by the passing of knowledge from 'ancianos' (elders) to youth. A person's knowledge begins to grow from an early stage in a child's development and expands through time. As explained by an elder: "the knowledge required to recognize and prepare wild plants is learned little by little over a lifetime". The research facilitator, a man in his late thirties, acknowledged that he does not yet hold complete knowledge of edible plants available in the area. As such, the facilitator was expanding his own personal knowledge base throughout research activities with community elders, discovering locations or new ways of using already known plant species, and finding out about entirely new species of plants. A local research participant compared the process of gaining knowledge of edible plants to learning a language: "Learning begins when you are a baby, when it progresses from mumbling a few words to being able to read and write, and becoming familiar with the language. In fact, learning continues until the day you die."

Young community members also gain an understanding of edible plants and their habitat by experiencing life on the landscape. The exchange of knowledge was achieved by youth accompanying siblings, parents or grandparents on harvesting journeys or to collect fuelwood or herd goats. These activities provided youth with the opportunity to watch an adult gathering edible plants, to learn how and where to collect them, and to eventually undertake these harvesting activities on their own. A female elder of the community explained the process of acquiring knowledge related to edible wild plants in the following way: "Children will first learn by watching their parents and hearing them speak of the plants. They will then watch them search and harvest the plants. The parents will also teach them which can or cannot be used, and show them how to prepare the foods. Finally they will begin identifying and collecting their own."

Youth learn from their experiences on the land, and rely on those living there to understand the landscape and range of harvesting areas. During field research, the facilitator harvested *okowi sawaróame*, a commonly used supplementary food item from an area he first encountered as a child where he had often herded goats. The facilitator explained that he now collects mushrooms from this area with his son, who is learning the proper time and place to find them. Knowledge about conditions and locations of specific habitat was gained and preserved by experiencing the landscape and exchanging ecological knowledge over a lifetime.

5.5 The status of traditional ecological knowledge

Traditional knowledge in Basíhuare is exchanged and communicated largely through practices on the land. By gathering impressions from research participants through individual and group discussions, it was possible to assess whether plants are deemed important, now and in the future. If plants continue to be harvested, then strategies associated with conserving the biodiversity of the landscape will also continue.

Traditional knowledge associated with edible wild plants seems to live on because of the continued importance of using them. A research participant related that it was important for his children to learn about plants, as he did from his parents when he was young; if his children were in need of nourishment, knowing about edible plants would allow them to simply walk through the forest and harvest them. A young man from the community indicated that his children would know which plants to harvest because they will observe him and their mother preparing edible plants.

Discussions with local secondary school students participating in the project confirmed that they learned how to identify, collect and prepare edible plants from their parents or grandparents. Several students identified a variety of quelites as a specific type of wild plant they used most commonly, and explained their habitat and how to prepare them for consumption. One youth described conservation practices for quelites, such as seeding and transplanting. Another student explained that it was important to harvest wild plants, “so

we do not forget which ones are edible, and which should not be consumed". When asked which edible plants they preferred, every student in one discussion group agreed that their favourite were *napó*, the fruit of the *ila* plant. Students found it important to continue harvesting, preparing, and consuming edible plants because "they are natural and available here; they are nutritious; and you do not have to buy them!"

This statement may, in effect, refer to the recent changes that have occurred in the Basíhuare region, which have affected the communication of traditional knowledge regarding edible wild plants. Development in the area has enhanced trade, resulting in the increased availability of commercially produced food. A research participant explained that people could now purchase necessary provisions from the local store, or from the multitude of grocery stores in Creel. As a consequence, store bought foods are replacing wild foods, especially those plants that require more time and effort to harvest. A research participant explained that *salabí* (*Prionosciadium* sp.) is used less frequently today than it was a generation ago when almost everyone in the community knew how to use the plant. From conversations with other community members, the amount of available *salabí* was unknown because it was rarely harvested and informal monitoring of the plant was not undertaken. As such, adults and youth were not consuming some edible wild plants, and as one participant explained, "the trend is bound to persist".

Access to outside employment plays a role in this continuing trend. Many community members in Basíhuare leave the area for months at a time to work in large agricultural complexes located outside the Sierra Tarahumara. Although outside employment has provided cash income to purchase foods, it creates a social dislocation whereby the community shifts from subsistence strategies to dependence on wage work (Nash 1994). This change clearly threatens the continued harvesting of wild plants and the monitoring of resources on the land.

The outcome of these changes is felt also in terms of the possible negative effects of store-bought foods. The availability of commercially prepared foods has provided a wider variety of products in Basíhuare, but has also increased the amount of artificially preserved foods consumed by community members. A research participant explained that buying

preserved items in cans meant that the community is losing out on the nutritional value of wild plants. "Food in cans is contaminated because it is processed and older, thus it is less nutritious. For example *tomati* (*Physallis wrightii*), which has been harvested from a naturally fertilized field, is better than tomatoes from a can". These changes threaten the knowledge associated with harvesting practices that appear to promote biodiversity, and disrupt the exchange of knowledge accomplished through monitoring the landscape. The local secondary school may offer a solution in terms of protecting and communicating this knowledge.

The Secundaria Técnica Intercultural Cruz Rarámuri offers a three-year intercultural secondary education program, unique to the state of Chihuahua. The school holds a fundamental teaching strategy that deals with caring for Mother Nature. The curriculum attempts to incorporate activities that teach students how to interact with one another, with their community, and with their local natural environment. The school's strategy was developed with the assistance of community members. Meetings were held with a total of 200 community members from several villages in the ejido, where people discussed many important issues, including the role of ancianos in the formal education system. Results were discussed at a Sunday meeting in Basíhuare, where community members agreed that a secondary school should incorporate research and in-class activities that included local people. For instance, the final exam for the chemistry course asked why the source of usable water was diminishing, and what could be done to improve the situation. Practical activities were also undertaken, like a herbarium that was constructed in class, and brought home so students could monitor the development of the seeds with their family.

Research participants expressed mixed feelings on the impacts of learning in a formal education system. Some agreed that children could learn traditional knowledge in a school setting, such as which plants are used and how they are harvested. The secondary school's emphasis on integrating local community members beyond classroom activities seems to confirm the school's ability to complement experiences on the land. In fact, students' impressions of community research activities were that they provided the opportunity to get out of the classroom and to learn about new plants.

An elder of the community explained that "children should learn to read and write, and to be able to do this, they should attend school. Parents should be caring for livestock, and taking care of some of their children's responsibilities so they can go to school".

Undertaking these responsibilities represented an added benefit to parents, by allowing them more opportunity to be on the land. For example, when the research facilitator's children returned to school in the fall, he assumed some of his children's chores. The facilitator explained that these activities would reduce his availability for research work, but that it allowed him to spend more time harvesting wild plants, and subsequently, to walk about the land and monitor the state of the resource. However, his children were missing an opportunity to experience activities on the land

One research participant explained that the knowledge about collecting seeds of edible wild plants was threatened, because school curricula did not teach students to understand the interaction between humans and their environment. As he stated, "when schools first arrived to the Sierra Tarahumara, everything that was related to Rarámuri culture was forgotten, and everything that needed to be taught came from books; these things are memorized without learning them in practice". (Much literature exists on the effects of the Mexican formal education system on Indigenous cultures, but is not discussed as it is beyond the scope of my research).

According to this research participant, the lack of knowledge about wild plants will lead to the demise of Rarámuri culture. As he explained, "youth are losing their identity, because many youth no longer believe in their culture". The apparent loss of cultural value among youth has motivated this same individual to lead workshops with school children, under the auspices of the Kosemi group. These workshops are given in Rarámuri and are designed to create discussion among youth on their perceptions of Mestizo culture, and to encourage youth to appreciate their own culture through dance and song. The basis of his work stems in part from the recent surge in the consumption of commercially prepared food items, and the ensuing threat to traditional knowledge.

The school program may very well succeed in teaching knowledge of harvesting edible wild plants. This success depends on including community members in field excursions,

incorporating cultural workshops that help to value traditional customs and practices, and maintaining a healthy relationship between elders and schoolteachers. In-class activities that focus on traditional harvesting practices, such as collecting wild plants and preparing them for meals that are served at the school, may also help to bridge the gap between formal and traditional learning.

5.6 Summary and conclusions

Communication and exchange of knowledge about edible wild plants is important for the maintenance of the local worldview in which humans and nature are interconnected, and these relations are guided by ethical and ecological principles. For instance, the naming of places by Rarámuri is a product of culturally transmitted knowledge of the landscape. Understanding the landscape, and recognizing names derived from physical and biological attributes of that place, are important components of knowing where to find and how to maintain habitat for edible wild plants. Furthermore, the Rarámuri who live in Basíhuare rely on their ecological understanding and insight to make harvesting decisions. Ecosystem dynamics, not only in regard to seasonal variations, but also of interactions between system elements, are key to making decisions, as noted in the section on environmental modification.

The exchange of knowledge is important for the maintenance of practices and strategies for the sustainable use of resources, specifically as they relate to the harvesting and management of edible wild plants. Strategies for managing edible plants, such as selective harvesting, domestication and environmental modification, provide an array of management options necessary for the conservation of biodiversity. For instance, traditional use of fire renews the plant cover and creates a mosaic of landscape patches. This probably leads to biological diversity at the species and landscape levels, through the creation of patches of habitat at different stages of succession (Berkes et al. 2000).

In terms of livelihood strategies, “not putting all dietary eggs in one basket” by harvesting wild plants ensures a variety of food sources, and provides a back-up resource when stocks

of maize are low. As pointed out by Cronon (1983) in the historical ecology of New England, this strategy is not unlike the financial practice of investing in a diversified portfolio, which involves a number of holdings to provide a safer, more stable return. In agroecological terms, this may lead to missing out on quick cash incomes from commodities, but helps to absorb perturbations, such as devastation of disease or drought (Berkes et al. 2000). These combined effects seem to indicate that the harvesting and management of edible wild plant species practiced by Rarámuri people in Basíhuare plays a role in supporting a resilient social - ecological system by maintain a biologically diverse landscape and a reliable diet comprised of various food sources.

Rarámuri culture and traditional education have a number of characteristics that support the acquisition and exchange of environmental knowledge. Youth are provided with the freedom to act at a very early age; with the assurance that their independent thought and experiences will provide the knowledge they need to survive. In this way, youth begin to understand their surroundings and develop techniques for monitoring the landscape. Monitoring begins with watching over the state of individual species and extends to understanding habitat and landscape. While searching for wild plants, harvesters not only watch for the health of individual plant species, they also monitor the state of the forest. Monitoring thus plays a part in the Rarámuri role as stewards of the land, and provides the opportunity for the communication and exchange of knowledge.

Exchanging knowledge requires that youth accompany elders on the land so they can begin harvesting plants. When a research participant was asked directly about the key to caring for the forest environment, his response was to teach children about the importance of using natural resources properly and in a way that provides for future generations. As youth from the local school confirmed, there are three ways to maintain knowledge about which plants can be harvested and how to prepare them: "by living in the 'campo' (on the land); by continuing to search and collect wild plants; and by teaching our own children knowledge about edible wild plants".

What makes knowledge traditional, as described by Berkes (1999), is the fact that it has been handed down over the generations, based on interactions with the environment.

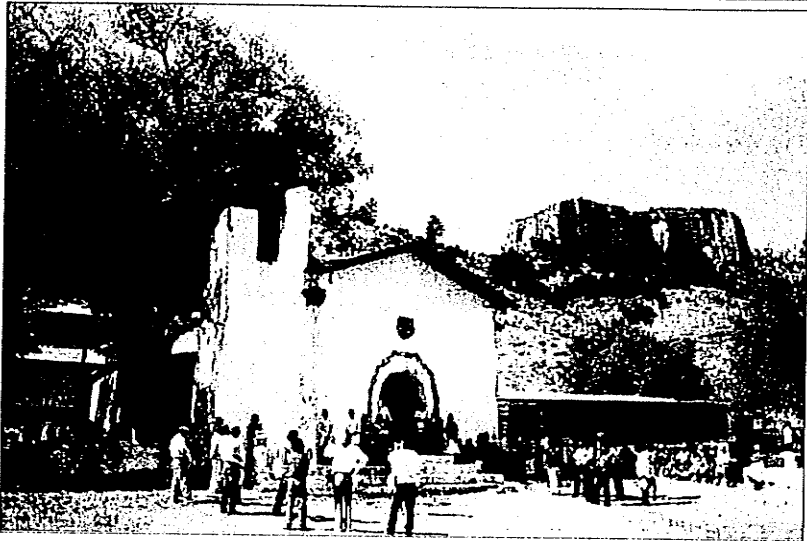
Traditional knowledge develops by personal observation along with teachings from ancianos and community members. It requires a forum in which the exchange of knowledge can continue. The sharing of 'cuentos' (stories) by ancianos is important not only in the information that is being delivered but also in the cultural context that it provides. Communication with elders and the *Owirúame* teaches the importance of maintaining an interactive and interconnected relationship with the land and its resources.

Recent developments in the Sierra Tarahumara, and specifically in the community of Basíhuare, have had impacts on the use of edible wild plants. Increased trade has resulted in factory-processed food replacing wild foods, meaning that harder to find plant species are rarely harvested, monitoring of these species is not occurring, and the knowledge associated with the harvest and management of these plants is being lost. Youth can overcome some of these challenges by experiencing the landscape with elders and by participating in customs that place strong cultural and ecological value on the forest. Although the formal school system may hinder the amount of time children spend on the land, it too can foster the development of traditional knowledge, through field excursions and research activities with community members. These activities provide the opportunity to consult with harvesters, to observe traditional practices, and to remain in contact with nature. Coupled with continued harvesting practices as part of local subsistence activities, the exchange of traditional ecological knowledge related to edible wild plants will continue to develop.

Seemingly isolated regions inhabited by a majority of Indigenous peoples who are perceived to be unconnected to global markets, like the Rarámuri of the Sierra Tarahumara, are, in fact, feeling the socially disruptive effects of globalization. To mitigate these effects, studies on the conservation of biodiversity must include a concern for local uses of the landscape and human issues such as food security (Zerner 2000). Furthermore, state officials can resort to measures outlined in the Convention on Biological Diversity, which clearly emphasizes the protection of Indigenous knowledge. If the Convention is properly implemented by the signatory government of Mexico, then the Rarámuri, who respect a worldview in which people monitor and harvest a portfolio of forest resources, will continue to conserve the biodiversity in the Sierra Tarahumara.

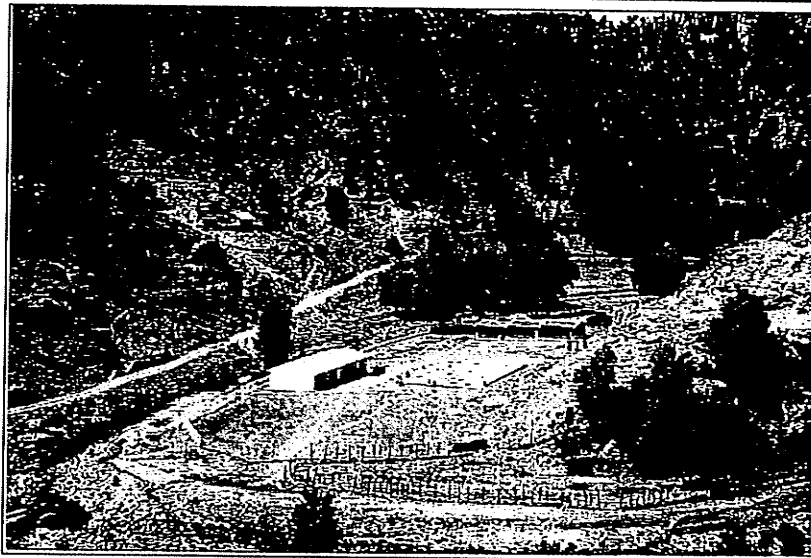
Chapter 6 - Conclusions and final reflections

How do common property institutions and traditional ecological knowledge lead to the conservation of biodiversity in the Sierra Tarahumara?



Sunday meetings in Basíhuare offer the opportunity to discuss and resolve conflicts over the use of biodiversity

Photo: S. LaRochelle



The Basíhuare secondary school offers an experiential learning program for the exchange of traditional knowledge

Photo: S. LaRochelle

My thesis is the result of living with Rarámuri of the community of Basíhuare, in the Sierra Tarahumara of Mexico, accompanying local harvesters on treks to places where the diversity of life sustains the worldview of humans as kin to nature. My research experience provided the opportunity to live among people who understand and respect an interconnection with their natural environment, and who hold traditional ecological knowledge that has proven effective in adapting to and fostering biological diversity.

The purpose of my study was to gain an understanding of how the interactions between social and ecological systems have led to community-based decisions that conserve the biodiversity of non-timber forest products in the Sierra Tarahumara. Research objectives helped to examine a number of themes, discussed through key research results presented in the fourth and fifth chapters of the thesis. In this chapter, I discuss the main results of these themes, to shed some light on the dynamic social-ecological system at play in the community of Basíhuare.

6.1 Edible wild plants: a valued resource

My thesis focused on edible wild plants to provide a context to the study of the social-ecological setting in the community of Basíhuare. This is a direct outcome of discussions with community members who identified these non-timber forest products as an essential part of the subsistence relationship with their local ecosystem. In just two months of research activities, community members identified over 20 species of plants that are harvested and consumed. Edible plants are a part of a family of resources that are considered valuable. Members of the community also described the curative abilities for some of these plants, along with others that were encountered during transect walks. They described habitats for these plants, gave their names, and described how to prepare them for consumption. This knowledge indicates an intricate understanding of these plants, gained by generations of interaction with the landscape. Their worldview that respects these resources as kin to humans generates the impetus to protect the commons area that provides habitat for these plants. A series of property rights are in place to do just that.

6.2 Common property rights enable “ownership” of the land

Community members who participated in the study seemed to understand and respect the bundle of property rights when making decisions on how to use the resources that are found in the forests, pasturelands and fields of the Basíhuare ejido. Non-timber forest products provided a suitable case study focus. It permitted the examination of property rights using examples of specific products, and switched attention from the land base as a focus of study to one in which resources are at the heart of making decisions, which is true to Rarámuri cultural beliefs and norms.

These rights are most important as they provide access to lands that hold valued resources and allow the harvesting of these resources as a part of subsistence activities. They also ensure the right to manage the land in order to modify the landscape in such a way as to protect it for future generations. The exclusion of other users makes it possible to monitor the land, and to provide mechanisms for the upkeep and maintenance of the resource base. Finally, the right to transfer these rights, in a way that respects traditional inheritance practices, affords the sustainable use of the products found on the land for future generations.

6.3 Local-level institutions to make decisions and resolve conflict

Social instruments regulating the use of forest resources were identified as important contributors to decision-making on the commons resource. In the Sierra Tarahumara, there exists a long history of cross-scale actors involved in the management of the commons, from Indigenous communities to Christian missionaries, Mestizo landholders and Mexican policy makers.

Local institutional actors, a blend of traditional governance and ejido government form a community-based structure for the protection of property rights. These systems present the opportunity to discuss issues relating to wild plant use and to resolve conflict when rights are abused and rules or norms are not respected.

My original intent was to explain the linkages between local institutions and regional organizations, and to describe how the relationship among these actors leads to decisions regarding the use and conservation of non-timber forest products in the study area of Basíhuare. What became apparent within the first few weeks of my research was that the community seemed to operate without the assistance of non-governmental organizations or government agencies. Several NGOs and government agencies are involved in the wider Sierra Tarahumara region, and have coordinated programs in Basíhuare in the past. In fact, steps are now being taken to implement programs in the distant future. For example, México-Norte is in discussion with Basíhuare community members to undertake future research on cultural and ecological survival.

At the heart of this institutional decision-making framework is the Rarámuri cultural sharing notion of *Korima*. What is important in the *Korima* model is the opportunity to represent social institutions as an embedded component of traditional ecological knowledge.

6.4 Kinship relationship of sharing with others and the natural world

Korima, the need and desire to share, is rooted in food, as it is the most immediate and accessible source of gifts. Community members perceive this same gift from nature, which shares its naturally occurring instances of plants. Plants are considered like kin to people in Rarámuri culture, and as such, they form a part of the community. So much so that ecological understanding appears to be internalized, and places are named based on the physical and natural features of these areas.

Sharing means making sure community members have access to these resources and areas, and can benefit from the energy and life they provide. In this way, *Korima* sets a precedent in decision-making by placing a priority on using only what is needed and sharing with family and community members. These norms support the development of practises and strategies for sustainable living. As an example, selective harvesting is driven by the community knowledge that the protection of plant stocks is important. The *Korima* concept

is embodied in these selective harvesting practices, as community members only use what is needed. As a result, wild plants are used sustainably, to allow enough for everyone in the community. The *Korima* institution in this case is intrinsically embedded into traditional ecological knowledge, embodied in harvesting strategies specifically related to edible wild plants.

6.5 Edible wild plant harvest strategies

Traditional ecological knowledge developed through Rarámuri intervention on the land and its resources appears to conserve the biodiversity of the ecosystem. Pruning *agave* plants leads to a more abundant final harvest, and aids in the dispersal of seeds. Collecting seeds of quelites and transplanting perennials creates a relationship between domesticated and wild varieties of species, potentially increasing the adaptive capacities of these edible foods. Selective burning practices and soil disturbance renew the plant cover and create a mosaic of landscape patches, creating a diversity of habitats to sustain a variety of plant species. These activities permit the monitoring of the forest and its resources, respecting the Rarámuri role as stewards of land, and fostering the exchange of traditional knowledge to younger generations.

6.6 Communication and exchange of traditional knowledge

Rarámuri knowledge exchange is an intrinsic part of childhood learning, and sets the stage for a life of adaptation and experimentation on the landscape. Offering opportunities for local youth to undertake these activities with community members outside of the family unit expands the realm of learning for the students of the local secondary school. The school experience builds value and respect among local youth for their culture, by integrating activities that maintain the recognition of traditional ecological knowledge in the conservation of biodiversity. These experiences are complemented by the work of one Kosemi member, who offers cultural workshops that combine music and dance with teachings of the Earth and the Creator to strengthen the value of Rarámuri culture.

The intercultural educational framework of the school serves as a model for other schools in the Sierra Tarahumara, to strengthen the local worldview of humans interconnected with nature. The school creates opportunities to learn harvesting practices experienced on the landscape that lead to strategies for sustaining livelihoods, and incorporates orally-based and locally driven teaching materials into the curriculum.

6.7 Challenges facing Basíhuare community members

The Rarámuri of Basíhuare are facing increasing pressure from a globalizing economy, confronted by a foreign culture that has a different understanding of what constitutes a basic need. Although they hold knowledge of their environment, and have developed social norms relating to the management of resources found in the area, they must lead a battle to maintain control over land use, and achieve decision-making power that is respected by policy makers. The struggle exists in terms of an ever-growing Mestizo culture of consumption, dependent on international trade to sustain their livelihood. Struggle is manifested by the recent migration to large cities of Rarámuri, who move to these areas, either temporarily or permanently, to gain employment. There, they become immersed in the Mestizo culture, often not speaking their language, forgetting their own cultural customs, and adopting ways that reflect the growing foreign culture.

6.8 Next steps to confront challenges

The key to the conservation of biodiversity in the Sierra Tarahumara depends not only on continued access, harvesting and monitoring by Rarámuri harvesters, but on respecting the decisions and vision of those who embrace and develop traditional ecological knowledge. A wider reaching program, perhaps with the assistance of NGOs and government agencies, could build capacity through cultural workshops. These should become a regular part of the Sierra Tarahumara educational system. Interactions between the director of the school and outside agencies and NGOs to ensure funding for these projects is one example of the kinds

of linkages that might be pursued, in order to increase the relevance of work conducted by these groups toward the preservation of traditional knowledge.

Communication of knowledge can also apply to the promotion of the Rarámuri culture within the larger Mexican community, to teach respect and trust for Indigenous people by explaining and helping Mestizos to understand the Indigenous worldview. Decision makers have much to learn from Indigenous groups and could use their help, just as much as Rarámuri youth need to understand traditional knowledge and value their own culture. Communication and exchange of knowledge transcends cultures, whereby cultural groups learn from each other and help one another. So the objective of the Kosemi cultural workshops, for example, is not only to help the Rarámuri community, but also to bring assistance to the Mestizos. After all, it is the Rarámuri culture that has helped to maintain the biological diversity for generations in the Sierra Tarahumara.

A new level of understanding of the Rarámuri worldview could have wide reaching implications for decisions made on the land; within the forestry sector, for example, where the focus is on maximizing yields to produce timber and fibre for economic benefits. A newfound respect for traditional uses of non-timber forest products based on Rarámuri cultural components of the interconnectedness of humans with nature, and the use of plants for subsistence foods, medicines and ceremonies, would provide a holistic approach to the conservation of biodiversity in the Sierra Tarahumara.

Another example of how the two cultures might better interact is in the work undertaken by the Mexican Biodiversity Commission. One of the main objectives of this government agency is to build an inventory of biological species found in Mexico, and to develop research and knowledge on the conservation of these species. By working in a participatory nature with the peoples of the Sierra Tarahumara, the commission's objective could be reached in a way which respects the needs of the community to maintain a connection to their land, and which provides insight into the value of biological diversity in the Sierra Tarahumara. This could be achieved by devising a database built on traditional ecological knowledge of culturally and nutritionally relevant species and of ways to conserve these species naturally on the land. Research undertaken by local community members and

secondary school students could foster the same objectives of the Kosemi program – to regenerate the forests as a valued component of the Rarámuri culture, and to inspire confidence among youth in their cultural traditions and worldview, while supporting the efforts of the federal government, and, as such, the Mestizo population, to conserve the biodiversity in the Sierra Tarahumara.

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Appendix 1 – Student results from transect walk

Nombre	Uso	Parte	Preparación	Lugar En Que Se Dan	Tamaño	Color
Nopal	Es una planta que sirve de alimento	Todo	Lo cosen y después lo guisan para comerlo y lo pueden preparar con otro alimento como por ejemplo frijoles y huevo	Se dan en los faldeos y en otras partes.	Uno a 2 m de alto y se extiende n de 3 a 4 de ancho.	verde y el fruto que da o sea las tunas son guindas
Manzanilla	Sirve como té para el cansancio	En marzo empiezan a florecer y en mayo se dan y en junio se maduran.	Se prepara con agua y azúcar en forma de té.	Se da en los cerros y en otras partes.	De 2 a 3m de altura y se extiende n de 1 a 2m de ancho.	La manzanilla es verde pero cuando ya tiene frutos son color amarillento.
Encino	Sirve como uso en el hogar y para hacer artesanías	Se encuentra n durante todo el tiempo.	Nada mas se corta y se hace leña.	Se da en los cerros donde hay buena tierra y humedad.	altura 5 m.	Es color verde amarillento
Pino	Sirve para fabricar muebles	Se encuentra n durante todo el año pero hay una época en que se le caen las hojas.	Se corta y después se los llevan a las fabricas.	Se da en todo tipo de bosque.	Mide mas a menos de altura 8 a 12 m.	Es verde
Magüey	sirve para curar erijas y para curar las anginas para fabricar sogas	Hay todo el año hasta que se secan.	También se corta y luego se hacen las sogas	Se da en los faldees y donde hay poca humedad.	De 1 a 1.5m de altura y de ancho 1 metro	Esta planta es color verde
Encino B.	Para hacer mangos de hacha.	Se encuentra todo el año.	Nada mas se corta y se cepilla	Se da en donde hay tierra buena y mucha humedad.	De 10a 11 metros de altura y de ancho 3 metros.	Esta planta es color verde y el tallo es blanco

Nombre	Uso	Parte	Preparación	Lugar En Que Se Dan	Tamaño	Color
Táscate	Sirve para curar la tos para hacer postes y artesanías	Esta planta la alomas durante todo el año.	Se corta en ramitas después se pone a coser y después se endulza	Se da en donde quiera nomás que haya humedad.	De 5 a 6 metros de alto y de ancho 2a 3 metros	Es verde y el tallo es café
Madroño	Sirve para tallar madera para hacer varias artesanías como por ejemplo bateas	Se da todo el año hasta que muere.	Se corta el fruto y se come	Se da donde hay buena tierra y mucha humedad.	De 5 a 6 metros de altura y de ancho 3 metros	Es color rojizo
Biznagas	Sirve como alimento quitándole las espinas.	Esta planta también la encontramos durante todo el año.	Se le quitan las espinas y se le sacan las bolitas y se comen, hay otras que se come todo.	Se dan donde hay laja.	De 10 a 11 cm de alto y de ancho cm	Es color verde las flores que dan son medias rosas.
Encino Chico	Sirve como alimento para animales	Se encuentra en todo el año	Se corta y se le da a los animales.	Se da donde hay húmeda	De 5 a 6 m de altura y de ancho 4 metros.	Es color blanco con verde
Diente De León	Sirve para dolor de muelas	Se encuentra todo el año.	Se corta se cose y se toma	Se da donde hay humedad	De 5 a cm de alto y de ancho cm.	Es color verde

Appendix 2 – Plant list presented to the school

Nombre Rarámuri	Partes y como se usan	Tiempo de la cosecha	Lugar en que se encuentra	Nº de foto
Amáwali	Raíz: cuando esta macizo; se le quita la cáscara, luego se muele con chile para comerselo así crudo como salsa.	Nov. a Feb. después de la flor (Jul. y Ago.- roja o amarilla)	Zona de encino Laderas de cerros	5-35, 36
Anachi /ki	Raíz: se machaca y se toma con agua caliente para purga y para inducir vomito o se coce, se muele y se toma con agua para la bilis.	Oct. a Ene. después de la flor (Ago.- amarilla)	Bosque de encino Laderas con piedras En llanos	11-14 11-17 11-18
Basagori (1)	Raíz: (en forma de bolito) se machaca y se pone crudo sobre heridas.	Sep. a Ene. después de la flor (Ago.- amarilla)	Bosque de encino y de manzanilla Con humedad y calor	6-1, 2 9-24 12-17
Basagori (2)	Raíz: se machaca y se mezcla en agua limpia para usar como purga	Sep. a Feb. después de la flor (Ago. y Sep. - amarilla)	Bosque de encino y de manzanilla Con humedad y calor	6-8 9-23
Cibóa (Chu'iribi)	Tallo: se cocina y se come o se mezcla con agua para tomarlo, cuando la planta esta tierna.	May. a Jul. antes de la flor (Ago. - blanca)	Bosque de encino y de manzanilla Con humedad y calor	5-33, 34 12-8, 9
Kóchi ná'cara	Tallo: el jugo se pone directamente sobre las heridas para desinfectar o desinflamar o se tome en té para dolor del estomago.	Jun. y Jul. antes de la flor (Ago. - blanca)	Bosque de encino y de pino En barrancas	12-12 13-8
Kujúbi (Kujúbare)	Hoja y tallo: se cocina en agua y se come o se toma con pinole o esquite; se usa entre 2 semanas y un mes después de su nacimiento.	Ultimo de Jun. antes de la flor (Ago. - blanca)	Milpas o en tierras de cultivo Cerca de arroyos	9-18 9-20, 21 9-22
Machima	Todo: se toma en té para diarrea o cuando tiene granos en la boca.	Sep. y Oct. después de la flor (Ago. - blanca)	Bosque de encino y de manzanilla Laderas de cerros	7-3,4, 5 11-21
Matari/ki	Raíz: se pone en remojo por una noche y se toma en té para tos y fiebre o para dolor reumático y muscular.	Oct. a Ene. después de la flor (Sep.- blanca)	Bosque de encino y de manzanilla Laderas con humedad	11-12 11-13 11-15
Mesagoli (Meke) Beyusa	Corazón: se cocina enterrado por tres días y se come, o se machaca y el jugo se mezcla con Tesguino. Flor: se pone a cocer en agua con una pizca de cal, se escurre y se guisa.	Dic. a Feb. May. a Jul. - amarilla	Bosque de encino y de manzanilla Laderas con sol	12-3 a 6 V4-41 y V4-46

Nombre Rarámuri	Partes y como se usan	Tiempo de la cosecha	Lugar en que se encuentra	Nº de foto
Mesagoli (Meke)	Tallo: cuándo esta tierno; se tatema sin cascara entre las brazos y se come.	Abr. y May.	Bosque de encino y de manzanilla Laderas con sol	V4-48 y V4-54
Mochogá (1)	Hoja y tallo: se toma en té para dolor del pecho o para la diarrea.	Sep. a Dic.	Bosque de encino y de manzanilla Entre piedras con sol y en barrancas	6-11, 12
Mochogá (2)	Hoja y el tallo: se toma en té para limpiar infecciones de la matriz después de haber tenido su bebe, para disminuir el nivel del flujo durante menstruación, y como anticonceptivo.	Ago. a Nov. cuando la hoja esta más verde	Bosque de encino y de manzanilla Ladera de cerros y entre piedras	5-1, 2
Ritébo'ára	Todo: se mezcla con Cola de caballo y Chikuá y se tome en té para limpiar el riñón y las vías urinarias o para el dolor del pecho o tos, o se machaca y se pone crudo sobre granitos.	No importa la planta nunca se seca	Bosque de encino Sobre piedras, rocas y en barrancas	10-17 10-18
Ritúnili	Raíz: se machaca y se pone crudo para desinfectar heridas o para dolor de muelas o se mezcla con agua y se usa para bañarse cuando tiene gripa.	Sep. a Nov. con flor (morada)	Bosque de encino Bosque de manzanilla	10-19 13-3
Rochá wa'sira	Hoja, capullo y raíz: se machaca crudos y se ponen sobre picotas, heridas o quemaduras para desinfectarlas. Tallo y flor: mismo uso	Sep. y Oct. después de la flor Jul. y Ago. (azul)	Bosque de encino En laderas con sol En orillas de tierras de cultivo	7-1, 2 11-23
Rorí ná'cara	Raíz: se machaca cruda y se mezcla con agua y se toma para inducir el vómito o para diarrea o cuando se duele el cuerpo (tiene gripa).	Sep. y Oct. después de la flor (Ago.- blanca)	Bosque de encino y de manzanilla y de pino Laderas de cerros	6-10 12-11 10-22?
Rotonili (1) o Rotonale	Raíz: se machaca cruda y se mezcla con agua limpia para desinfectar picaduras de animales ponzoñosos o se pone con trapa para dolor del cinturón y se mezcla en Tesgüino para hacerlo mas picoso.	Sep. y Oct. con flor - blanca	Bosque de encino y de manzanilla y de pino En tierras de cultivo	10-0, 1 13-9
Rotonili (2) o Rotonale	Raíz: se machaca cruda y se mezcla con agua limpio para desinfectar picaduras de animales ponzoñosos.	Sep. y Oct. con flor - blanca	Bosque de encino y de manzanilla En tierras de cultivo	9-25 10-2 6-16, 17

Nombre Rarámuri	Partes y como se usan	Tiempo de la cosecha	Lugar en que se encuentra	Nº de foto
Rotonili (3) o Rotonale	Raíz: se machaca cruda y se mezcla con agua limpio para desinfectar picaduras de animales ponzoñosos o se pone directamente con trapa para dolor del cinturón.	Sep. y Oct. con flor - morada	Bosque de encino y de manzanilla En tierras de cultivo	10-4, 5
Rotonili (4) o Rotonale	Todo: se toma en té para diarrea o se machaca y se cocina en poco y se pone en los orejas para matar a las carapatas.	No importa Flor en Ago. - blanca	Bosque de encino y de manzanilla y de pino	11-25 12-1
Rurubésali (1) (o Rurubisi)	Tallo y hoja: se machaca secando y se tome en té para problemas de orinar o dolor de la vejiga.	Oct. y Nov. después de la flor (Jul. y Ago. - roja)	Bosque de encino y de manzanilla Barrancas	6-3, 4, 5
Rurubésali (2)	Tallo y hoja: se tome en té para reumatismo o dolor del estomago.	Mayo a Jun. antes de la flor (Ago. a Nov. - roja)	Bosque de encino	11-22
Sipe/ke a'káame	Todo: se toma en té para dolor del estomago.	Sep. y Oct. con la flor - amarilla	Bosque de encino y de manzanilla Tierra de cultiva o llanos con milpas	11-5, 6
Kujúbi	Todo: se toma en té para la diarrea.	Sept. y Oct. con la flor - amarillo	Bosque de encino y de manzanilla	11-24
Sopépari	Raíz: se machaca y se mezcla con tierra para matar a los pescados.	Bosque de encino y de pino, con humedad en laderas	Ene a Mayo (Flor Ago. y Sep. - amarilla)	6-6, 7, 9 10-20 12-7
Sowinari (o So'iwale)	Flor y parte del capullo: se cocina en agua para sacar el jugo y la mezcla se aplica a los ojos para limpiar infecciones.	Oct. cuando hay flor - blanca	Bosque de encino Bosque de manzanilla En llanos	12-13 a 12-15
Umi/ki	Raíz: se machaca y cocina en agua para limpiar áreas afectado para granitos o sarampiones.	Nov. a Feb. (Flor en Jul. y Ago. - amarilla)	Bosque de encino y de manzanilla En barrancas	5-14 13-0