



**UNIVERSIDAD NACIONAL AUTÓNOMA DE MÉXICO  
PROGRAMA DE MAESTRÍA Y DOCTORADO EN GEOGRAFÍA  
CENTRO DE INVESTIGACIONES EN GEOGRAFÍA AMBIENTAL**

**COMMON POOL RESOURCE SYSTEM ASSESSMENT USING THE CRITICAL  
LIST OF VARIABLES FOR SUSTAINING THE COMMONS, LASSO, AND  
SPEARMAN'S CORRELATION IN THE MONARCH BUTTERFLY BIOSPHERE  
RESERVE**

**TESIS  
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DOCTORADO EN GEOGRAFÍA  
PRESENTA  
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**A common pool resource system assessment using the critical list of variables for sustaining the commons, LASSO and Spearman's correlation in the Monarch Butterfly Biosphere Reserve**

**Una evaluación del sistema de recursos comunes utilizando la lista crítica de variables para mantener los bienes comunes, LASSO y la correlación de Spearman en la Reserva de la Biosfera Mariposa Monarca**



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## **ABBREVIATIONS IN THESIS**

AN- Agrarian nuclei

CBNRM- Community-based natural resource management

CONAFOR- Comisión Nacional Forestal

CONANP- Comisión Nacional de Áreas Naturales Protegidas

CPR- Common pool resource

DPs- Design principles

FAO- Food and Agriculture Organization

GAPDES Monarca- Gestión Ambiental y Proyectos para el Desarrollo Sustentable Monarca

IC- Indigenous community

INEGI- Instituto Nacional de Estadística y Geografía

IUCN- International Union for the Conservation of Nature

MBBR- Monarch Butterfly Biosphere Reserve

NA- Núcleo agrario

PES- Payment for ecosystem services

PHINA- Padrón e Historial de Núcleos Agrarios

PROCEDE- Programa de Certificación de Derechos Ejidales

PROFAUNA- Protección de la Fauna Mexicana

PROFEPA- Procuraduría Federal de Protección al Ambiente

RAN- Registro Agrario Nacional

RBMM- Reserva biosfera de la Mariposa Monarca

SEMARNAT- Secretaría de Medio Ambiente y Recursos Naturales

SRC- Sistema de recursos comunes

UAEM- Universidad Autónoma del Estado de Morelos

UMSNH- Universidad Michoacana de San Nicolás de Hidalgo

UNAM- Universidad Nacional Autónoma de México

UNESCO- The United Nations Educational, Scientific and Cultural Organization

USFS- United States Forest Service

WWF- World Wildlife Federation

**Abbreviations for critical variables:**

ResSmSize- Resource system Small size

WDB1-Well defined resource boundaries

GrpSmSize- Group system Small Size

WDB2- Well defined group boundaries

ShdNorms- Shared Norms

PSE- Past successful experiences

AppropLeader- Appropriate leader

IGM- Interdependence of group members

HEHII- Heterogeneity of identity

Poverty- Low levels of poverty

Overlap- Overlap between user-group residential location and resource location

DepRes- High levels of dependence by group members on the resource system

Fairness- Fairness in allocation of benefits from common resources

LowDemand- Low levels of user demand

REU- Rules are simple and easy to understand

LDAMR- Locally devised access and management rules

EasyEnf- Ease of enforcement of rules

GradSanct- Graduates sanctions

ALCA- Availability of low cost adjudication

Accountability- Accountability of monitors and other officials to users

MRHRR- Match restrictions on harvest to regeneration of resource (RW, EO)

LCET- Low cost exclusionary technology

CGSNULA- Central governments should not undermine local authority

SESI- Supportive external sanctioning institutions

ALEA- Appropriate levels of external aid to compensate local users for conservation activities

NLAPEG- Nested levels of appropriation, provision, enforcement, governance

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## RESUMEN DE LA TESIS

Este estudio procura entender las influencias y suministrar sugerencias con respecto al manejo y al mantenimiento de la cobertura del bosque por medio de un análisis compuesto de varias partes que ha partido de una lista crítica de variables requeridas para el sostenimiento de los recursos comunes presentes en La Reserva de la Biosfera de la Mariposa Monarca (RBMM). Esta RBMM, abarca una superficie de aproximadamente 56,259 hectáreas, es una zona forestal protegida compleja, constituyendo la zona de invernación más grande para la mariposa Monarca (*Danaus plexippus*). El RBMM es un ejemplo de sistemas de manejo comunitario de recursos naturales, debido a que un gran porcentaje (80%) del área protegida está bajo alguna forma de manejo comunitario o colectivo. Es importante además examinar las áreas en las que este manejo ha logrado mantener una cobertura forestal densa ante las amenazas que existen actualmente como la tala hormiga, la degradación de los bosques y el cambio climático.

Después de una variada historia de explotación maderera y extracción de recursos que resultó en deforestación y degradación, se ha documentado una constante, aunque incremental, reducción en la pérdida de cobertura forestal a partir del establecimiento de la Reserva en 1986. Sin embargo, a pesar de las múltiples intervenciones que han ocurrido en la Reserva durante los últimos 40 años, todavía existen incoherencias significativas en las prácticas de manejo que resultan en inconsistencias en estrategias de manejo del bosque en la RBMM. Para evaluar y mitigar esta inconsistencia, es necesario el uso de parámetros y métricas sistemáticos que se respaldan por la teoría del manejo de recursos comunes. La lista crítica de variables para sostener a los recursos comunes (lista crítica) establece los parámetros para el análisis. Esta lista crítica ha sido el resultado de décadas de investigación de expertos en investigación del manejo de recursos comunes. Fue presentado por primera vez por Ostrom (1990) como principios de diseño (DP). Luego junto con Wade (1994), Baland y Plateau (1996) y Agrawal (2003) los cuales agregaron variables adicionales la lista crítica creció para incorporar más de 30 variables críticas al manejo sustentable de sistemas de recursos comunes.

Para esta investigación preliminar se eligieron cuatro núcleos agrarios (AN), basados en una historia de manejo eficiente. Para este estudio en particular el término «gestión eficiente» se define como  $< 0.03\%$  de pérdida de cubierta forestal por el periodo de 2006 a 2015 en las zonas de amortiguamiento y núcleo del RBMM. Los cuatro áreas de estudio de Carpinteros, San Francisco Curungueo, San Juan Zitácuaro y Nicolás Romero, ubicados en el municipio de Zitácuaro en el estado de Michoacán, México fueron elegidos como ejemplos de núcleos agrarios que han sostenido su cubierta forestal a lo largo de la década 2006 al 2015. El diseño de cuestionarios fue basado en los indicadores establecidos por los investigadores previamente mencionados con el uso de la lista crítica de variables para capturar información de las autoridades locales y miembros de la comunidad ayudaron a proporcionar valores para este análisis. Estos datos se computaron como valores normalizados para su uso en los análisis estadísticos y así permitir la comparación de los datos cualitativos con los datos cuantitativos.

El proceso de aplicación de estos métodos consiste en tres fases: evaluar la cobertura forestal, operacionalizar las variables, y el análisis estadístico. Primero, se hizo una evaluación del cambio de cubierta forestal del 2006 al 2015 para confirmar la tasa de cambio menor a  $0.03\%$  del 2006 al 2015. Para el cambio de la cobertura forestal el cálculo utilizó imágenes Landsat de Google Earth y polígonos en ArcGIS. Los mapas de cambio de cobertura fueron hechos en los dos periodos (2006 al 2010 y 2010 al 2015). En la segunda fase, se operacionalizaron las variables de la lista crítica. La lista crítica representa los parámetros analíticos. El propósito del análisis es determinar cuáles de estas variables ejercen influencia significativa sobre la variable dependiente, cambio de la cubierta forestal a lo largo de la década. En la tercera y última fase, se utilizaron dos análisis de regresiones multivariadas no paramétricos para analizar el grado en el cual se podría decir cuál de las variables predicen la variable dependiente.



Primero, se utilizaron las correlaciones de Spearman para determinar si, y en qué medida, cada variable independiente podría estar relacionada con el resultado de manejo eficiente. En segundo lugar, se aplicó una regresión de LASSO (operador de reducción y selección mínima absoluta), en la que se identifican las variables independientes que, en conjunto, explican los resultados para cada núcleo agrario. Ambos análisis utilizaron el software estadístico R. Se escogieron estos métodos de análisis porque el estudio se basa en una gran cantidad de variables con una pequeña muestra y estos métodos estadísticos no paramétricos son diseñados y en conjunto sirven para dar respuestas indicadas por la literatura.

Al final, se reportan los resultados del análisis estadístico y las conclusiones que siguen de esos resultados. Las correlaciones de Spearman mostraron que, en general, las variables explican mejor las ganancias que las pérdidas de cobertura forestal. La regresión LASSO también apoya la correlación, mostrando que tres variables (superposición, pequeño tamaño del recurso y dependencia en el recurso) aparecen consistentemente con una relación con ganancias de cobertura, y con valores positivos, que están de acuerdo con la teoría subyacente a la lista crítica. Algunos de los resultados fueron consistentes con la teoría, mientras que otros fueron inconsistentes con la teoría. El análisis de la correlación de Spearman mostró que cinco variables independientes tenían una fuerte correlación, dos positivas y tres negativas, con dos de las variables dependientes. Ambos períodos evaluados (2006 al 2010 y 2010 al 2015) mostraron aumentos generales en la cubierta forestal. Las otras categorías de cambio de cubierta forestal no mostraron ninguna correlación significativa con las variables independientes. Tres variables (superposición, tamaño pequeño del recurso y dependencia en el recurso) están asociadas consistentemente con ganancias forestales, y con valores positivos, que está en consonancia con la teoría. Al mismo tiempo, estas mismas tres variables están asociadas en una dirección negativa con la pérdida de bosque, que también sigue la teoría. La pobreza, que en teoría está asociada con un mayor riesgo de deforestación por necesidad de uso del recurso, no se indica como tal en los resultados de esta investigación. En cambio, en este caso la pobreza está positivamente relacionada con el aumento de la cubierta forestal probablemente como resultado a beneficios de monitoreo y estrategias anteriores. Por otra parte, la equidad (que se entiende como una condición importante para asegurar que las comunidades manejen bien los bosques) está positivamente relacionada con la pérdida de bosques, un resultado contra-intuitivo. Lo anterior se discute en detalle en el último capítulo con las implicaciones de los resultados y posibles explicaciones. Por último, se presentan sugerencias para mejorar los métodos para futuras investigaciones.

# CHAPTER 1: INTRODUCTION TO THE STUDY/ INTRODUCCIÓN AL ESTUDIO

## RESUMEN DEL CAPÍTULO

La necesidad de hacer más sistemático el análisis de los sistemas de recursos comunes (CPR) ha sido abundantemente documentada y su relevancia es cada vez más relevante a medida que el cambio climático mundial, la seguridad de los recursos básicos y las pérdidas de hábitat, crean una necesidad urgente de tener evaluaciones rápidas acerca de las condiciones resultando del manejo forestal, además de todos los otros recursos comunes. Ostrom (1990), en su obra seminal sobre los parámetros de CPR, encontró que había varios principios de diseño (DP) que eran pertinentes y significativos en todos los casos en diferentes áreas alrededor del mundo que son elementales para un manejo eficiente. Estos principios de diseño se convirtieron en variables consideradas como teóricamente pertinentes para todos los sistemas de CPR, sin embargo, algunos otros investigadores como Wade (1994) y Balland and Plateau (1996) consideraron que estaba incompleta y añadieron variables adicionales. Finalmente, Agrawal (2003) sintetizó todas los principios de diseño DP con las variables adicionales adicionando variables por su propio conocimiento, desarrollando una lista crítica de variables utilizada para sostener los recursos comunes en donde se ha aumentado de los 8 originales DP a 33 variables en total. Si bien hay muchas investigaciones de los sistemas de CPR, existe una falta de acuerdo en el contexto utilizado para los parámetros y métricas, a pesar de las cualidades teóricas específicas relacionadas con cada de los 33 variables, resultando en meta-análisis no suficientemente informativos por esas inconsistencias.

Este estudio busca explorar cuán informativa es la lista crítica de variables para sostener los recursos comunes y si puede ser utilizada en sistemas de CPR en áreas protegidas tanto por estudios de caso como parámetros para la comparación de casos, siendo los meta-análisis. El contexto para la lista crítica de variables se presenta como la base para la operacionalización de cada variable y el desarrollo de métricas para ayudar en la sistematización de su aplicación en la investigación de sistemas CPR en la RBMM. A través de este proceso, se crea un medio para medir y analizar la importancia estadística de las variables en cada caso en comparación con otros, cuantificando comparativamente los datos mixtos cuantitativos con cualitativos, con implicaciones para la totalidad de la RBMM y otros sistemas de CPR. Tres objetivos de investigación y una hipótesis de investigación forman la fundación de esta prueba inicial de las variables críticas las cuales se aplican como parámetros a cada uno de los cuatro (4) estudios de casos y para compararlos:

### **Objetivos**

1. Realizar un análisis de la importancia estadística para determinar qué variables muestran importancia con respecto al cambio de la cubierta forestal a lo largo del tiempo.
2. Recomendar parámetros operativos prácticos para los criterios utilizados en la lista crítica.
3. Proporcionar cuatro casos para la base de casos de CPR y su revisión.

### **Preguntas de la investigación:**

1. ¿Hay relaciones estadísticamente significativas entre las variables independientes y la variable dependiente?
2. ¿Es necesario el cumplimiento total de cada variable de la lista crítica para una gestión eficiente?

3. ¿Existen patrones en los datos que sugieran que la unidad de tenencia de la tierra tiene alguna influencia?

### **Breve resumen de la estructura capitular de la tesis**

En el Capítulo 1 se presenta el enfoque de la investigación y antecedentes. El Capítulo 2 proporciona los antecedentes respecto a la RBMM con más profundidad y un marco teórico para la investigación. El Capítulo 3 detalla los métodos de la revisión métricas, sitios de investigación con la operacionalización de las variables, la forma en que se dirigió a los mapas de cobertura forestal, y los análisis de LASSO y correlación Spearman's. El Capítulo 4 describe los núcleos agrarios en detalle lo que incluye los resultados de las entrevistas e investigación demográfica. En el Capítulo 5 se presenta y el análisis de cambio de cobertura forestal, los resultados los cuales salieron del análisis estadístico. Sigue en el Capítulo 6 una discusión de los resultados y las implicaciones, incluyendo un segmento respecto a sugerencias para seguir adelante con estos parámetros e implicaciones para investigaciones semejantes al futuro. Se termina la tesis con el capítulo 7.

## **INTRODUCTION**

### **RESEARCH PROBLEM**

The need for systematizing common pool resource (CPR) systems analysis has been well documented and becomes more and more pressing as global climate change, basic resource security and habitat loss create an urgent need for rapid, informative assessments of the efficiency of resource management (Hák et al. 2016, Agrawal 2003). While there is much research about CPR systems, there is a lack of agreement of parameters, making meta-analyses difficult and less informative than they could be with more systematic agreement (Barnett et al. 2016, Agrawal 2003). Ostrom was the pioneer in this effort to identify key variables, which she elaborates on in detail in her book "Governing the Commons: Evolution of Institutions for Collective Action (1990)."

Ostrom (1990) provided critical insight into common pool resource management and demonstrated through case studies how local managers make decisions with regard to resource use, conservation and allocation. In this work she outlines the theoretical framework based on case studies where governance and management have been both efficient and inefficient. She outlines the 8 design principles illustrated by long-enduring CPR institutions as well as the framework for analyzing institutional choice (Ostrom 1998, 2008). In fact, Ostrom worked for more than 20 years with CPR researchers to advance our understanding of CPR systems to enable sustainable and equitable management through case studies and comparing the commonalities and differences inherent in them (Damon et al. 2019, Ostrom & Nagendra 2006, Anderies et al. 2004, Agrawal & Ostrom 2004). In her seminal (1990) work on CPR parameters she found that there were specific design principles (DPs) that were pertinent and significant across cases in different areas around the globe. The DPs are: well defined resource boundaries, well defined group boundaries, locally devised access and management rules, ease in enforcement of rules, Graduated sanctions, availability of low cost adjudication, accountability of monitors to and other officials to users, match restriction on harvest to regeneration of resources, central governments should not undermine local authority, and nested levels of appropriation, provision, enforcement, and governance.

To further complicate matters, there are CPR systems embedded in protected area (PA) management scenarios that have a complicated mix of social and institutional factors. Ostrom and Nagendra (2006) review long-term studies pertaining to forest conservation under various tenure agreements in protected areas. They found that local managers (those actors that are directly interacting with the CPR system) are key in the successful management of protected forests and that their involvement in the rule-making and governance of the resource is imperative to it. They also found that, in spite of previous belief to the contrary, local managers had a vested

interest in aiding in these processes. This was supported by Brenner and Job (2006) who looked specifically at forest management in Mexico. As they note, participation has been a significant factor in management success (and failure) to a large degree in the Monarch Butterfly Biosphere Reserve (MBBR) in Mexico. The MBBR is a protected area that was established in 1986 and expanded in 2000 to its present size with 13,551.552 ha of core area and 42,707.498 ha of buffer area, a total of 56,259 ha. In 2007, it was designated a Biosphere Reserve by UNESCO, and in 2008 it made its way to the list of World Heritage sites.

This is a protected area where the largest burden of management falls on local managers. Inside the reserve area there are 72 ejidos, 13 indigenous communities, 22 small properties, one federal property and one state property according to the most recent IUCN (2017) report. This translates to approximately 82% of the reserve area being in the hands of local managers. While UNESCO provides the criteria to maintain the Heritage site status since 2008 and CONANP provides the reserve rules and influences related legislation directly, it is the local managers who must ensure the execution and enforcement of those rules. Local managers also have direct (and time built) knowledge regarding the practicality and effectiveness of those rules and laws, aside from the intimate knowledge of the function and needs of the CPR system itself.

While Ostrom's (1990) DPs have been argued as insufficient for explaining CPR system success/failure, it is not the final outcome of Ostrom's seminal work. Robert Wade (1994) added several variables to the list of enabling variables for sustaining the commons: Small resource system size, Small group size, Past successful experiences, Interdependence among group members, Overlap between user group and resource location, High levels of dependence by group members on resource system, and Low cost exclusionary technology. Baland and Plateau (1996) added the following variables: Heterogeneity of endowments and homogeneity of identity and interests, Fairness in allocation of benefits from common pool resources, Rules re simple and easy to understand, Supportive external sanctioning agencies, and Appropriate level of external aid to compensate local managers for conservation activities. The literature shows that many CPR researchers focused on the DPs and some of the subsequent aggregated variables aforementioned, though rarely as a group; So, while there is agreement on the pertinence of the DPs, they do not enable theoretical advancement nor fully effective strategic interventions (Gari et al. 2017). This is in spite of the fact that Agrawal (2003) consolidated the theoretical variables that have demonstrated impact on CPR cases across the globe. Agrawal (2003) synthesized research by three other seasoned CPR researchers-- Ostrom (1990), Wade (1994), Baland and Plateau (1996)-- and added his own contributions: Low levels of mobility of the resource, Possibility of storage of benefits from the resource, Predictability of the resource, Gradual change in levels of demand, Time for adaptation to new technologies related to the commons, Low levels of articulation with external markets, and Gradual change in articulation with external markets. This resulted in the critical list of variables for sustaining the commons (Chapter 2 Table 2.1). This reasonable and ample basis for systematizing case-study and meta-analyses already exists and has been underutilized. This assessment is based on the calls by CPR researchers to produce systematic analysis of case studies that provides a template for meta-analyses that allow for consistency among cases and flexibility to account for circumstantial nuances that goes beyond Ostrom's original DPs (Gari et al. 2017, Baggio et al. 2016, Frischmann et al. 2014, Agrawal 2003).

This study seeks to explore how informative the critical list of variables for sustaining the commons is and whether it can be used in protected area CPR systems, both on a case-by-case basis. Context for the critical list of variables is presented as the basis for operationalizing each variable and developing systematic metrics to aid in the systematization of their application in CPR research. In this way, the information from the base of case studies can be easily compared to determine local (and perhaps eventually, larger) patterns imperative in effective management strategy interventions. This exploration will be statistical and will look at how the independent

variables in the critical list influence the outcome measured using the dependent variable of forest cover change over time.

## RESEARCH OBJECTIVES

A. To carry out a case study of common pool management using the critical list of variables for sustaining the commons, as developed by Ostrom and related researchers.

B. To suggest practical operational metrics for variables to operationalize the critical list

C. To perform a rapid statistical analysis to determine which of the variables on the critical list appear to influence forest cover change over time

## RESEARCH QUESTIONS

1. Are there statistically significant relationships between the independent variables and the dependent variable?
2. Is full compliance for each variable in the critical list necessary for efficient management?
3. Are there any patterns in the data that suggest that the land tenure unit has any influence?

## BRIEF THESIS CHAPTER OVERVIEW

Chapter 1 is the introduction to the problem statement and very general overview (above). Chapter 2 provides a more in depth background of the MBBR and conceptual framework for the research. Chapter 3 details the metric review, survey sites and variable operationalization. Chapter 4 contains a detailed description of the study sites. Chapter 5 is the Results section, which presents the results from the statistical analysis of the significance of the critical variables and rapid forest cover change analysis. Then a discussion of the results and the implications for them is provided in the Chapter 6 Discussion portion of the thesis, including a segment about suggestions for moving forward with these parameters and the implications of the results for future research. Chapter 7 presents the conclusions for the thesis.

# CHAPTER 2: CONCEPTUAL FRAMEWORK/MARCO CONCEPTUAL

## RESUMEN DEL CAPÍTULO

La Reserva de la Biosfera Mariposa Monarca (RBMM) es un ejemplo interesante de manejo comunitario de recursos naturales, ya que un gran porcentaje (80%) del área protegida está bajo alguna forma de manejo comunitario o colectivo. Ha habido una historia mixta entre conflictos y compatibilidad entre las prácticas reglamentarias y las de manejo, lo que ha dado lugar a inconsistencias en la eficiencia de manejo a pesar de las reglas que rigen la reserva. En 2007, fue designada Reserva de la Biosfera de la Mariposa Monarca en el marco del programa de la UNESCO, y en 2008 fue nombrado Patrimonio Mundial. El marco regulatorio existente para la Reserva está encabezado por el gobierno federal Mexicano e involucra a los gobiernos estatales de Michoacán y México a través de varias organizaciones gubernamentales. Sin embargo, a pesar de la presencia de instituciones externas y apoyo de grandes ONG todos los autores mencionan el manejo ineficiente como causa directa de la disminución de la presencia de la Monarca y de la calidad de la cobertura forestal, con la tala hormiga como resultado. Sin embargo, desde la expansión de la RBMM en 2000 ha habido una tendencia al aumento de la cubierta forestal, en general, aunque hay zonas donde hay pérdidas aún. Hay una gran cantidad de evidencias de que los factores sociales tienen mayor impacto en la sostenibilidad, la recuperación y la conservación. Sin embargo, no está claro cuáles de ellos impactan mayormente. Los actores locales son el vínculo más cercano al recurso, disponibles a las agencias gubernamentales, los gerentes, los responsables políticos y los investigadores. Como tal, es importante escucharlos con respecto a los procesos y percepciones. Se utiliza como parámetros la lista crítica de variables para sostener los bienes comunes (la lista crítica) para explicar cómo varía la dinámica del manejo forestal en la Reserva según las variables establecidas y cómo impactan la cobertura forestal. La lista crítica está basada en décadas de investigación de eminentes expertos en sistemas de recursos comunes. La lista completa de se encuentra en el Capítulo 3, Métodos. En este capítulo, los cuatro NA se presentan con los detalles demográficos basados en la lista crítica. También se presentan cuadros con los resultados de la operacionalización y la metricalización de cada variable. Los análisis y mapas de cambio de la cobertura forestal se presentan al final de cada sección y los resultados de cada una también se discuten en detalle. Se examinaron dos comunidades indígenas (CI) y dos ejidos. Hay varias similitudes y algunas diferencias entre estos dos tipos de asentamientos. Ambos tienen sistemas de manejo de recursos en los que tanto los miembros certificados como los no certificados pueden acceder a los recursos naturales para su consumo y sustento, aunque sólo los miembros certificados tienen derechos formales sobre la tierra y su uso. La toma de decisiones se realiza a través de una Asamblea que consiste exclusivamente en miembros certificados y existe un organismo central llamado el Comisariado, que consiste en tres miembros: el Comisario, el Secretario y el Tesorero. Más allá de éstos, hay otras similitudes y diferencias que se exploran en mayor detalle. Para todas las diferencias, es evidente que los cuatro casos tienen mucho en común. En general, los gestores locales han demostrado eficiencia en el manejo de bosque, como lo demuestra el cambio positivo de la cobertura forestal de 2006 a 2015 para todos los AN, discutido en detalle en el capítulo 4.

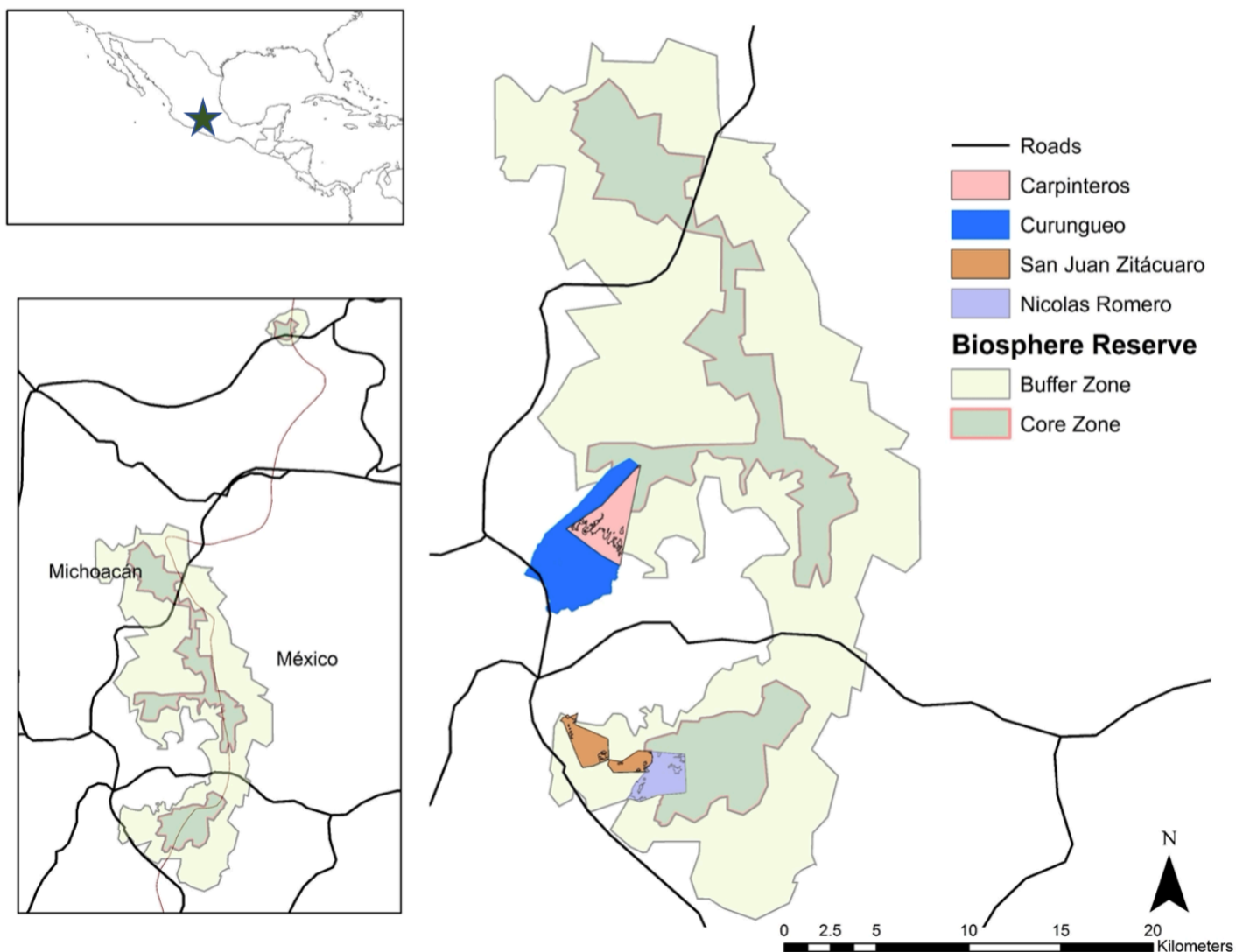
## CONTEXT OF THE RESEARCH PROBLEM

### INTRODUCTION

In the Monarch Butterfly Biosphere Reserve (MBBR), local managers (that is to say the communities whose territory is incorporated in the Reserve) are directly involved in the management of the protected area forest and in land-use strategies within their territorial boundaries. While the State and Federal government regulate the terms of the general protection of the MBBR forest, it is the local managers who face the daily socio-political and economic livelihood pressures which often drive deforestation and degradation. The difficulties the communities face are exacerbated by the fact that the establishment and expansion of the reserve greatly limit their freedom of action. In this section, an overview is given of the interventions that have been made over the last 40 years with a view to protecting the habitat of the Monarch Butterfly.

### BRIEF HISTORY/OVERVIEW OF THE MONARCH BUTTERFLY BIOSPHERE RESERVE

In 1986, 16,100 ha of the MBBR were designated as a protected area by Presidential decree, and in 2000 the Biosphere Reserve was expanded to its present size with 13,552 ha of core area and 42,708 ha of buffer area, a total of 56,259 ha. Then in 2007, it was designated a Biosphere Reserve under the UNESCO program, and in 2008 it made its way to the World Heritage list. The Monarch Butterfly Biosphere Reserve is located in the Mexican trans-volcanic mountain range between the states of Mexico and Michoacán with an altitude between 2,000 m and 3,640 m (Map 2.1). The vegetation of the reserve has a wide biodiversity with a high level of endemism.



Map 2.1. Map of the Monarch Butterfly Biosphere Reserve with AN color coded as listed in the legend.

The National Commission for Natural Protected Areas (CONANP) manages the Monarch Butterfly Biosphere Reserve under the Ministry of the Environment and Natural Resources (SEMARNAT). Individuals, private companies and local communities (both ejidos and indigenous communities) own the land inside the reserve. Overwintering butterflies have been found to be very sensitive to anthropogenic disturbances. However, during the last quarter of the 20th century the largest tract of this habitat was reduced by four-fifths and fragmented into islands of thinned woodland as a result of logging and agriculture. The wildlife in this habitat becomes more susceptible to disease, rain and frost as a result. The butterflies' overwintering sites are thus still under threat even though the reserve is part of the Conservation International Hotspot, WWF Global 200 Ecoregion, is a BirdLife-designated Endemic Bird Area and a UNESCO Biosphere Reserve.

Furthermore, a program designed in 2001 by CONANP manages the MBBR through the Monarch Commission. The program goals are to provide sustainable development, wildlife management, public use, research and monitoring, and control legal requirements for operation. This management plan has divided the reserve in two zones: (1) a core zone of 32,740.902 ha where no logging is allowed, and (2) a buffer zone. The buffer zone is itself divided into sub-zones for different activities: an agro-ecosystem zone (9,602.789 ha), a special use sub-zone (66,665 ha), a public use sub-zone (259.601 ha) and human settlement sub-zone (37,541 ha). In the buffer zone controlled logging is allowed via permits (Quesada et al. 2007).

However, protecting the reserve has been a challenge due to different pressures and the lack of effective law-enforcement. Between 1971 and 2005 3,995 ha of the forest were degraded despite the efforts of the local communities and the authorities (Brower et al. 2002). According to the study, this loss of trees within the forest was mainly due to illegal logging and illegally exceeded logging quotas. To mitigate this, over a million dollars was donated to the Monarch Fund to promote conservation (9,089 ha in the core zone) and to support 31 ejidos, communities and small properties between 2001 and 2004 (Monarch Fund 2005). In addition, some ejidos and communities have received payment for environmental services (PES) compensation for ceasing all logging and the National Institute of Ecology created a pilot project to promote non-timber forest product management (personal communication). Furthermore, a great deal of research has been conducted in the area, as evidenced by the bibliography associated with this thesis, among others. A monitoring plan has been designed to keep a record of butterflies numbers, ecology, forest cover, immigration, ecotourism impact, logging and the socio-economic status of the people within the reserve (Quesada et al. 2007).

Alternare is a non-government organization which is working with the local communities in capacity building concerning how to manage the natural resources within the reserve and maximize and encourage sustainable practices (Conservation in North America 2010). Other national non-government organizations include: A.C. Biocenosis, Mexican Fund for the Conservation of Nature (FMCN), TELMEX Foundation, Sierra Environmental Group's Bell AC, Alas Man and Conservation (HALCON) AC, Papalotzin AC, Protection of Fauna Mexicana AC, Royal Mail (PROFAUNA), and Gestión Ambiental y Proyectos para el Desarrollo Sustentable Monarca (GAPDES Monarca).

A large component that has been missing in the conservation of the Monarch Reserve is research and education. The incorporation of local universities is ideal to promote research on the reserve and to serve as a source of information to help educate all of the stakeholders involved. The Universidad Nacional Autónoma de México (UNAM) and La Universidad Michoacana de San Nicolás de Hidalgo (UMSNH) have both served as important sources of information gathering. Several other academic institutions are also involved, both locally and internationally. Those include but are not limited to: Institute of Geography (UNAM-CIGA), Smithsonian Institution, Sweet Briar College, State Autonomous University of Mexico (UAEM), University of Guadalajara,



University of Kansas, University of Florida and University of Minnesota. However, there has not yet been an effort to unify the reserve in terms of community involvement and systematizing of resource-benefit distribution and information dissemination.

## REGULATORY FRAMEWORK OF THE RESERVE

The existing regulatory framework for the Reserve is headed by the Mexican Federal government through several government organizations: The Procuraduría Federal de Protección al Ambiente (PROFEPA, Michoacán and Mexico Delegations), CONANP, SEMARNAT and CONAFOR. The ejidos and communities in the Reserve are also affected by the Programa de Certificación de Derechos Ejidales (PROCEDE), a governmental program dedicated to regulating land tenure within ejidos and indigenous communities, although participation in this is not mandatory. Management within the Biosphere Reserve is currently based on a management plan created in 2001 and it was evaluated in 2006 by CONANP. The management plan evaluation included an assessment of what had been occurring in the buffer zones as well as the core areas of the reserve (Lopez-Garcia 2012).

According to the UN World Conservation Monitoring Center and CONANP, the management structure of the Reserve is as follows: There is a total of 130 people from six organizations that work in the Reserve-- nine from CONANP, including the Director, two sub-directors and six department heads, for Biodiversity, Development, Forest Management, Operations, Education and Communications. There are eight Michoacán state forest police, 95 federal police, ten from GOES (Michoacán), four officers from the Mexico State forest Service (CONAFOR) and four federal environmental protection attorneys. Continual training for employees in conservation and management is conducted by government organizations, universities and NGOs, among others.

Ejidos, indigenous communities, private companies and individuals are the titleholders of the Reserve land and the Estate, which is jointly managed by CONANP and the states of Michoacán and Mexico and is coordinated under the Ministry of the Environment and Natural Resources. Ejidos and indigenous communities are land tenure units designated by the Mexican federal government in which rights holders may work the land for agricultural purposes. The distinctions are several but can be generalized in the following way: ejidos were established first in 1917 (Article 27 in the Mexican Constitution) where the certificate holders had exclusive rights to parcels within the established ejido boundaries, while Indigenous Communities are communal land that all certificate holders work and were part of agrarian land reform in 1992 (Barcenas Chavez 2000). The mountains still separate different indigenous groups, which include P'urhépecha, Mazahua, and Otomi people speaking mainly Mazahua (INEGI 2010), though a few speak other native languages in the area.

The present population living within the buffer zones is well over 100,000 people in over 100 agrarian nuclei and 55 villages outside these communally managed territories. The small town of Angangueo (~10,000 inhabitants) in the buffer zone is surrounded by farming villages, which also cluster between the central and southern core reserves and at the south end of the Reserve. The population of the surrounding towns was approximately 382,298 in 2017. The area around the reserves was still mined for minerals and logged by state-run companies into the 1990s and this has begun again in the early 21st century. The area is poor but butterfly tourism has contributed notably to the local economy, as is evident in the budget discussed in greater detail below.

Tourist activity is centered around the four main butterfly sanctuaries (Sierra Chincua, El Rosario, Cerro Pelón, Piedra Herrada), all of which offer campsites and campfire sites, food services (formal and informal), shops, guided tours, signage, mountain bike paths, horse riding and restrooms (UNESCO 2008). El Rosario and Sierra Chincua (the most well-known) also have interpretive centers, playgrounds and hostels or lodges. External tourist access is by the highway that runs through Zitácuaro, the largest city proximal to the Reserve, where there is also

a range of accommodation and other services. Surrounding communities on the travel route are also involved in tourism whether for day trips, brief stops or less formal lodging.

Total annual visitation increased by almost 5 times from 30,000 in 1986-7 to 132,486 in 2005-6 (UNESCO 2008) and shows a general trend of increase yearly for a total of 2.8 million people from 1986-2016 (UNESCO 2017). This exponential increase makes improved controls and monitoring even more necessary. Tourists bring in revenue beneficial to the area. However, the revenue is not controlled or organized in any way and varies widely from vendor to vendor and community to community. Tourists and tours are also not organized in any way and the communities are often at the mercy of tours and tourists arriving without notice. There is also very limited quality control of facilities and products, which can be negative for tourist experience and expectations. Tourism during the peak butterfly season (approximately the months of December through February) is a major source of income, but there is a serious need of a well-designed and well-implemented regional tourist protocol to minimize opportunistic and inequitable exploitation, and to maximize the income potential for the individual communities and reserve as a whole. This is the weakest area of the management plan and where the controls must be implemented fairly and consistently based on access, available resources and eco-friendly entrepreneurship to ensure abstinence from illegal forest use activities and unity in support of the local stakeholders, the forest and the Monarch butterfly.

## STATE, FEDERAL AND INTERACTIONAL MANAGEMENT REGULATIONS

Management regulations have resulted in a rather 'mixed bag' of benefits and conflicts ever since the designation of the Reserve in 1987. Although the area is protected, land tenure in the reserve is the same as it was before it was made a protected area in 1987 and again in 2001 when it was internationally recognized (Brenner 2009). Government protection limited the use of forest resources but without granting compensation or economic alternatives for the rural cooperatives (ejidos), communities and private owners that own them (Barkin 2003, Brenner 2009). The saw mills that were set up before the designation of the reserve to provide immediate returns and easy markets for timber were opposed by some local communities who see communal resources being usurped for private benefit (UNESCO 2008) and logging quotas have been greatly and illegally exceeded (personal communication). Enforcement of the law was difficult before 2011 due to limited internal resources and poor government support (Brenner 2009).

There are provisions for livelihood and sustainable development and wildlife management activities of the local population. There are also provisions for public use, monitoring and research, as well as for the operational and legal requirements for resource extraction. To contribute to conservation of the area's natural resources (and with the intention of improving the livelihood potential of the local people), the National Institute of Ecology created a pilot project for management of the non-timber forest products in the Reserve by inventorying them, assessing their vulnerability and exploring the options for their commercialization. The Federal government has established programs for Monarch butterfly protection in nine other states. Monitoring is mostly focused on ecological indicators like number of individuals (butterflies), colony size and migrations, forest area and quality, physical impacts of tourism, microclimate, global climatic effects. The social-economic conditions of the local people is included but as a general overview and not a case-by-case analysis. However, it is important to mention the involvement in research, capacity building and support by institutions like the National Autonomous University of Mexico (UNAM) and their contribution to the understanding of the problems and possible solutions inside the reserve.

These efforts were not terribly successful as they were approached with a top-down mentality and did not take many pertinent factors such as local capacity, market access, practicality, etc. into account (Van der Meer 2007,

Brenner & Job 2006, Martin 2001, Barkin 2003, Chapela & Barkin 1995). The major ecological and socio-political threat was illegal logging until 2009, as it was double what has been suggested as appropriate (and what is legally permitted). This fragmented the forest and over-thinned the trees, making regeneration difficult (UNESCO 2008). Uncontrolled tree-removal also diminishes water supplies to local villagers and is blamed for local climate change over the last 20 years (see section on deforestation and degradation below). It is known that much of this activity is driven by agents from outside, including criminal gangs, though often with collusion from some community members (personal communication in the field). However, other threats to the forest clearly have their roots in the local population, such as uncontrolled access to forest resources and clearing for agriculture, tree-cutting for fuelwood, uncontrolled burns set during agricultural clearance and diversion of water supplies. In addition there are natural problems such as disease and infestations, and the unorganized tourism activities combined with inadequate law enforcement exacerbate the problem.

## INTERNATIONAL INTERVENTION

The United States Forest Service (USFS), has been working since 1993 with managers in the Monarch Reserve along with various partners in the region to build management capacity, to provide guidance to communities for resource management, and to conserve natural resources focused mostly in the highly protected core zone. Staff from the Willamette National Forest (and other units) have provided capacity building and consultations to the Reserve on various topics such as forest inventory, GPS/GIS utilization, and design and maintenance of trails, etc. (USFS.gov website). Through a partnership with the Monarch Model Forest in Canada, partners developed proposals to help the Model Forest with recreation management, landscape ecology, small-scale wood product development and marketing, and community incentive programs. Local communities adjacent to the Monarch Butterfly sanctuaries were provided with workshops and project participants worked to reforest lands using native tree species. This was approached with the long-term goal of establishing alternative sites for extracting wood. Apart from reforestation, the Model Forest and its partners have worked on recreation and ecotourism as a basis for such programs in Mexico.

According to WWF (2006), the Monarch Butterfly Conservation Fund bought up core zone logging permits, financed forest conservation and supported sustainable economic activities in core zone communities. With the intention of fixing some of the damage after the expansion of the Reserve, 1440 hectares in the core area of the reserve were reforested in 2006. Between 2001 and 2004 over a million dollars was assigned by the Monarch Fund which was established by a donor from the U.S.A., the Federal and both state governments, WWF, the Mexican Fund for the Conservation of Nature, experts and local representatives. Also according to WWF (2006), the money designated by the Fund was used to support the participating 31 ejidos, indigenous communities and small properties, and to promote the conservation of 9,089 hectares in the five Reserve core areas. Participating communities have received payments for ecosystem services (PES) for non-extracted wood and forest areas that have been conserved.

There has been a history of both conflict and compatibility between existing regulatory and management practices. Critics have suggested that one of the places where the government went very wrong in the implementation of the management and designation of the protected area was that they were operating from a preservationist mentality rather than a cooperative conservation mentality-- which lead to resentment and resistance to the new policies by the local people (Melo 2002). The policies restricted access to traditional resources thus changing the livelihood system of the communities and ejidos in the reserve and unwittingly encouraging immigration due to industrial logging, which was already present and allowed to continue through permits and concessions (Brenner 2009). This created a focus on timber resources which conflicted greatly with the traditional local livelihood system and even with tourism in the area as logging caused significant

deforestation, particularly during the years 2001-2006 (WWF Informe 2006). Between 1971 and 2005, 3,995 hectares of forest were degraded despite the efforts of authorities and the local communities. In 2015, 11 ha of core area owned by the State of Michoacán known to be a preferred overwintering site for the butterfly were clear-cut following a previous decline in illegal logging in the reserve. According to Flores-Martines et al. (2019) who looked at forest cover loss from 2012 to 2018, forest loss peaked from 2015 to 2017 due to climatic factors (large storms) and illegal logging peaked from 2013 to 2015.

## RATES OF DEFORESTATION AND DEGRADATION IN THE MONARCH BUTTERFLY BIOSPHERE RESERVE

One of the difficulties that might have been hindering efforts for improved management is that data on rates of deforestation and degradation in the Monarch Butterfly Biosphere Reserve, as cited in a range of publications, are inconsistent and at times contradictory. While it is to be expected that rates of loss change over time, there are conflicting estimates even for similar periods. This may in part be the result of different methodologies used (e.g. different remote sensing platforms, area measurements in ha vs. geometric parameterization) and estimations for limited sections of the reserve instead of the reserve as a whole. For example, Brower and Ardis (2013) point out that the methods used to determine rates of deforestation, degradation and the impact of illegal logging are “incomplete and misleading” as they are only measuring visible deforestation in the core area (which is only ¼ of the total protected area). Others, like López-García et al. (2014) only measure other limited areas of the reserve or those who focused on specific human settlements.

A further complication is that many authors do not distinguish clearly between deforestation and degradation. Usually aerial estimates are used using remote sensing, with a view to depicting past trends and large areas. This, in spite of the fact that the common categories used to measure forest cover could very well have taken both deforestation and degradation into account. Four papers specifically differentiate between the two are Brower et al. 2002 for the period 1971-1999, López-García (2012) for the period of 2003-2009, Vidal (2013) for the period 2001-2012 and Flores-Martinez et al. (2019) for the period of 2012 to 2019.

In the following section I review available articles that refer to rates of deforestation and degradation and forest cover change data. The range of estimates will be discussed to explain these variations as far as possible.

### 1971 TO 1999/2003

The majority of the literature published before 2011 relies on data collected before 2006 (primarily data from 1971-1999 and some more recent studies to 2003). This data shows that degradation and deforestation (disturbance as broken down by forest cover quality categories) are severe in many places (see Figure 2.1) in the Monarch Butterfly Biosphere Reserve in spite of the 1986 and 2000 decrees establishing Reserve area, core and buffer zones, and acceptable activities determined for each. The studies published after 2011 rely mainly on data between 2001-2009 (except for Vidal et al. 2014 that analyzed data from 2001-2012); and the data reported by Brower et al. 2002 is still considered in some cases. Estimates range from 12.7% to 44% for deforestation while for degradation ranges from 31% to 44%. Only Brower et al. 2002 looked at the total area of the reserve before 2011 (42,020 ha). The others concentrate on particular areas of the reserve or focus on the core zone.

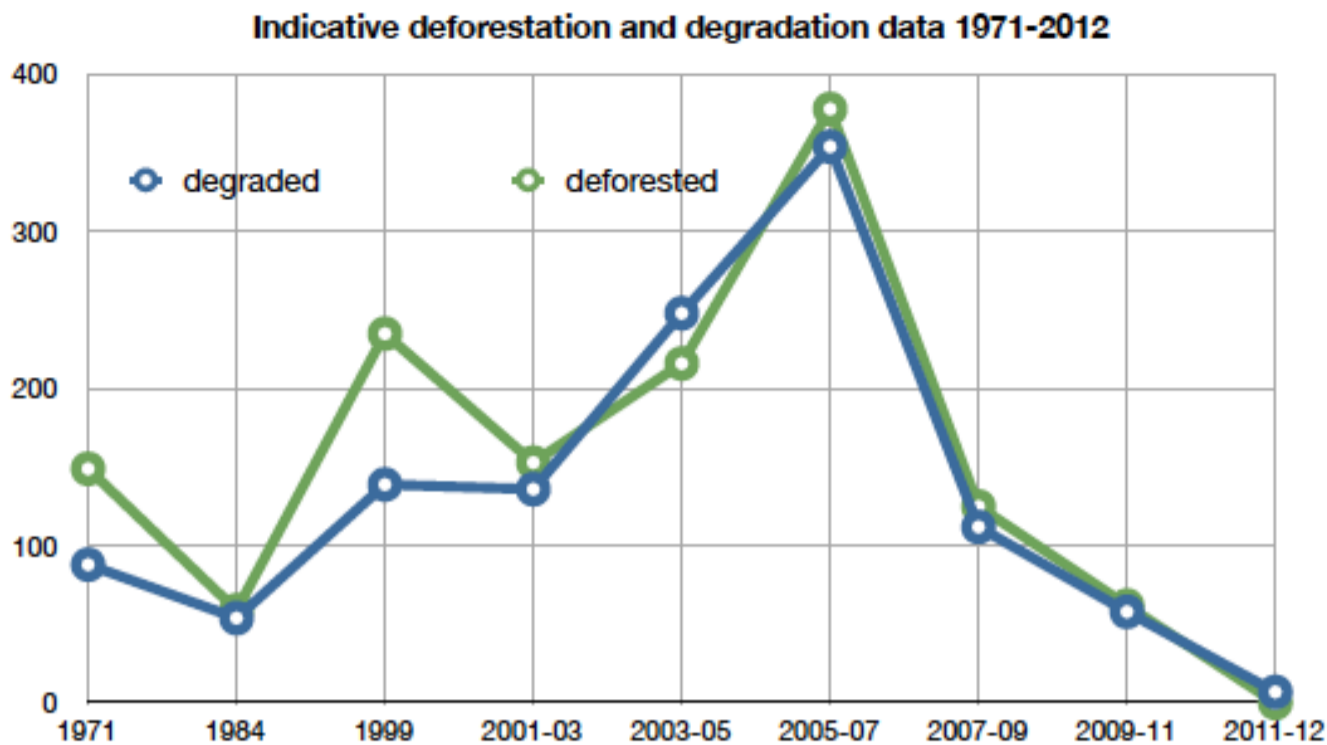


Figure 2.1. Forest quality data in hectares from 1971-2012, taken from data reported by Brower et al. 2002 and Vidal et al. 2013. The annual rates data from 1971-1999 takes into account the entire reserve area prior to the 2000 expansion, while the data from 2001-2012 takes only the core zone into account.

In a study conducted in 2011 by Navarrete et al., comparing dense forest in agrarian nuclei (AN) with and without forest management programs across the entire reserve from 1993-2006, no significant differences in change rates in terms of deforestation and degradation were statistically observed. Disturbance (as a separate category from degradation), however, was an issue in both. The FAO defines degradation as the reduction of the capacity of a forest to provide goods and services, while a disturbance is a distinct event that disrupts the ecosystem function. According to Navarrete et al. (2011), the disturbance in managed forests appears to be due to the clearing methods recommended by the forest management plans through SEMARNAT and/or CONANP, with a contingency for social distribution of the forestry benefits (e.g. PES). In the same study, they found that in forests without authorized management, disturbance was due to illegal logging, which resulted in inequitable distribution of benefits and uncontrolled, organized illegal loggers. This being the case, it is imperative to seek out the critical variables key to sustainable management in the cases where management is more efficient so that these variables can be promoted in all cases to improve local forest management plans. What was clear was that where the local managers are well organized, there is a strong defense against the organized illegal activities.

## CAUSES OF FOREST COVER CHANGE IN THIS PERIOD

There are several causes cited for deforestation during this period that were quite consistent among researchers. A direct cause was determined to be illegal logging. Consistent but slightly less stressed were indirect causes like marginalization, population growth, land tenure issues and generally poor PA management (focused mainly on lack of law enforcement and monitoring). Illegal logging was considered in large part the result of a lack of law enforcement and economic incentives that allowed for extraction of other forest products (NTFPs for example) or activities that were not associated with timber production, for example, aquaculture. Unsustainable logging practices were also cited associated with both legal and illegal logging. As for the indirect causes, the socio-economic and political issues (marginalization and land tenure) seemed to fall under the 'generally poor management' category as significant contributors to poor management and population growth was based on census numbers over the time period investigated.

## 1999/2003 TO 2014

There is general agreement that deforestation and degradation rates were less in this period than in the previous one (see Figure 2.1), although there are small inconsistencies among researchers regarding whether this is associated with the 2000 decree to expand the reserve and limitations to the accuracy of degradation figures determined by remote sensing.

The data that Lopez-Garcia (2012) published is somewhat confusing as he appears to vacillate on the recovery rates between 2009-2011 as the data suggests that there is an increase in forest cover change as the area of change increases as well as the total change in total between 2003 to 2009. However, the data he reported supports that there has been an increase in overall forest recovery particularly in areas left to recuperate naturally and those that were reforested (though he does admit that this needs to be evaluated, particularly for 2003). His overall assessment is that logging ceased in the established protected areas (with a few communities that are still maintaining unsustainable practices, as in Crescencio Morales) and that land-use has changed nominally since the 2000 expansion decree, both having a positive impact on forest recovery.

Vidal et al. (2014) indicate a similar trend and also report that logging ceased in the core zone. However they report that it occurred by 2012, while they report (contrary to López-García 2012) that there was still large-scale illegal logging until 2009. They state that small-scale logging (subsistence) is still very much a problem and call it a “growing concern” as it has affected a quarter of the total forest affected “and thus has severely affected the core zones.” They also cite extreme weather events that may or may not be related to human generated climate change. They cite degradation as a continuing and severe problem in both the buffer and core zones.

Taylor (2013) states that while deforestation is in decline, the forest condition is less than optimal for maintaining ecosystem services, which would imply that degradation is still a significant problem. The WWF Monarch Butterfly report (2014) maintains that there has been a 43% decrease in the total forest land occupied by Monarchs which (among other things) is a due to “scarce and deteriorated forests, the direct result of illegal logging.”

## SOME EXPLANATION FOR THE CHANGE

Lopez-Garcia et al. (2014) state that a combination of anthropogenic and extreme weather causes resulted in landslides in 2010 which were classified as significant land-cover change and they provide a statistic of an annual deforestation rate of 0.97% over the last 38 years. While this number could indicate that towards the end of the almost four decades the rate has slowed, the clear implication in accordance with their published data is that deforestation continues. Vidal et al. (2014) state that in their research analyzing deforestation rates from 2001 to 2012 it was only in 2012 that they found a total cessation of deforestation and degradation as a result of illegal logging. They also signal Crescencio Morales and Francisco Serrato as particularly problematic areas that show degradation and deforestation as a result of unsustainable practices that negatively impact the statistics for the whole of the reserve but that there is an overall decline in deforestation and degradation rates. UNESCO's 2011 report also cites illegal logging as a problem; although they mention that there has been a 90% reduction in illegal logging (in comparison to previous years).

Several researchers mention economic incentives as a means to shift away from illegal activities (particularly logging) and cite PES as an effective means to do so (Ardis 2013, Navarrete et al. 2011). The researchers that mention PES all agree that it has been a good incentive for conservation. Diversification and multiple-use scenarios were mentioned as supportive means for conservation as well. However, Brower and Ardis (2013) still consider illegal logging in the protected area a problem and do not discuss the possible reasons for it.

In spite of a successful cessation of illegal logging (Lopez-Garcia 2012) and recovery of forest cover since 2012 (Vidal et al. 2013), WWF, Brower et al. 2012, and MBF continue to cite illegal logging as significant contributors to deforestation and degradation, inhibiting regeneration and limiting the area occupied by the Monarchs considerably and incrementally, particularly since the turn of the century (WWF 2014 and Brower and Ardis 2013).

All authors mention poor management as a direct cause of the decline of the Monarch's presence and forest cover quality. Specifically, a number of papers recommend better and more consistent monitoring of federal and local forest management practices including pest/disease control, better enforcement of existing extraction regulations, diversification of livelihood activities (e.g. aquaculture, NTFPs) and economic incentives for conservation (e.g. PES). They also state that more sustainable practices in all activities inside the reserve are necessary, however, few are specific as to what that would mean. Vidal et al. 2013 mention the urgent need for better coordination between and among actors on all scales but particularly the larger institutions involved in determining management strategies.

## 2012 TO 2018

Flores-Martinez et al (2019) address forest cover change in the reserve and report that there was still a downward trend in deforestation during the period 2012 to 2018, though degradation was still a significant issue. They assert that climate-related factors caused the greatest impact on the forest cover change in the core zone. They also report that illegal logging resulted in moderate forest cover change from 2012 to 2018, but peaked from 2013 to 2015. Large-scale illegal logging decreased after 2015 in the reserve, according to their research. Ant-logging resulted in relatively low forest cover loss from 2012 to 2018, although it peaked from 2015 to 2017. While deforestation trends are low, it was worrisome to see that degradation is still a significant problem.

Demonstrating the influence of climate change and significantly diminished illegal logging (both large and small scale) diverged somewhat from what was reported for the period of 1977 to 2012, as climate change was not highlighted during that period as much as illegal logging. There was some overlap between Vidal et al (2014) and Flores-Martinez et al. (2019), though the general trends held for both. However, with diminished illegal logging, the effects of climate change become more apparent along with the impact of severe weather events like the storm that devastated Monarch populations and felled a significant number of trees, damaging other vegetation in the reserve and impacting Monarch habitat and feeding grounds in March of 2016. In fact, Brower et al. (2017) discuss the impact of climate change on the reserve and a caution that interventions include climate change mitigation. Both Flores-Martinez et al (2019) and Brower et al. (2017) concur on the need to ensure mitigation strategies for rapid response to climate change impacts on the forest and the animals that live there. In fact, Carbajal-Navarro et al. (2019), Agrawal (2019) and others join in agreement and make suggestions as to the inclusion of monitoring of forest cover change and multilateral cooperation to ensure the longevity of not only the Monarch Butterfly Biosphere Reserve but of the Monarch itself, highlighting the importance of the species as an indicator of the environmental health all along the migratory route.

## POSSIBLE REASONS FOR THE VARIATIONS IN ESTIMATES WITHIN PERIODS

There are several areas of inconsistency in reported data. Some are more evident than others. In some cases, it is notable in the reported data and in others it is more subtle, embedded in the materials and methods that were applied to the studies. First, there is a major inconsistency in the area to which the figure refers. Several of the papers refer to the reserve as a whole while others focus on specific areas—some inside the core zone and others in particular human settlements. There seems to be no systematized approach in reporting the statistics on

deforestation and degradation, either. And none of the articles that discuss localized rates compare those local statistics with what is occurring in the greater reserve area. This comparison would be useful particularly within the overall context of management in the reserve and whether the downward deforestation and degradation trends in the later period are universal or are the result of successful efforts in a limited number of human settlements. Those papers that do discuss specific areas where deforestation and degradation are taking place either do not give statistics for overall rates or use only the 1971-2003 data (with a general focus on data from 1971-1999). There are several possible reasons for these inconsistencies. With regard to the areas measured there are a number of reasons that researchers might choose smaller areas: access, safety, time limitations, funding limitations, available information, etc. There may also be a bias towards the core area since it is the area established as the most important for butterfly survival and is the area most important for maintaining strictly natural processes and ecosystem services, where all human activities are strictly limited (IUCN guidelines 2008).

Second, there is a possible source of inconsistency in the use of different remote sensing platforms as they have changed considerably over the last several decades—from lens quality, pixel size and correction for atmospheric conditions to analysis software. This could have a significant impact on the reported results over time as observable details have increased over time. There is also the issue of how resampling algorithms are selected and how they affect the radiometric integrity of the data (Lunetta et al. 1991).

Finally, there is also an inconsistency particular to degradation data as remote sensing is not precise with regards to the various degrees of degradation. Aerial photography is not accurate in revealing the details that signal degrees of degradation considered in the low impact categories (Miller 2006). The percentages or geometrics are based on ‘visible’ changes in remote sensing systems. Deforestation is directly observable, so the deforestation data is likely more reliable. Recent efforts by CIGA-UNAM to assess degradation using photo-images taken from drones and counting the cut stumps appears to be a promising new method (Skutsch citing Ramirez, personal communication, 2014).

A question could be raised, however, as to whether it really matters that estimates of loss rates are so inconsistent, because in spite of these inconsistencies, the general trends are probably valid and are widely accepted as such. It could be argued that spending more resources on getting ‘better data’ just avoids the real issue, which is how to tackle the drivers of these losses. Nevertheless, there appears to be a need for better monitoring and measurement particularly of degradation, as this is as significant a threat to habitat conservation and ecosystem function as deforestation and is in many ways more subtle and menacing. Being aware of the extent of degradation and investigating its causes for mitigation purposes is imperative.

## SOME CONCLUSIONS ON THE LITERATURE REVIEW

Different authors have suggested various solutions to the problems that have been facing the Monarch Butterfly Biosphere Reserve, most of which center around assessment and monitoring of the suspected drivers of deforestation. The rapid appraisal forest cover assessment presented in this study is a useful tool in monitoring forest cover to inform forestry strategies like reforestation, controlled logging and management area foci. As well, it is a useful tool for monitoring climate change impacts on degradation, species composition and reforestation-intervention forest cover rates. It has been consistently noted that better management is key in resolving deforestation and degradation issues. Certainly, management is the general category under which all activities, investigations and interventions fall. There are many levels and aspects of area management that must be organized and synchronized to ensure the sustainability goal is met. This goal is not solely of benefit to the global patrimony or the Monarch butterfly, but also of the local and national economy and the general well being of the people who live in the area—an area known for overexploitation and marginalization. This research project is just



one such attempt to systemize the approach to understand efficient management, through with the use of the critical list of enabling variables for sustaining the commons, as developed by Agrawal (2003), explained briefly below and in more detail in chapter 3, along with a statistical analysis to see which enabling variables are most influential and how the variables are related to inform management interventions and current assessments.

## WHAT IS EFFICIENT MANAGEMENT?

This thesis has, as its central concept, the notion of 'efficient forest management' rather than the more usual 'sustainable forest management'. This is because sustainable forest management is such a broad term, with a broad definition that is difficult to quantify. The FAO, for example, adopted the following definition for sustainable forest management: "The stewardship and use of forests and forest lands in a way and at a rate that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfill, now and in the future, relevant ecological, economic and social functions, at local, national, and global levels, and that does not cause damage to other ecosystems." While this is an ideal set of conditions to which few would offer opposition, the fact is that it is impossible to measure makes it impractical for operationalizing. Because of this, a working-definition was determined for the purposes of this study, based on the Global Forest Resource Assessment. Looking at forest cover change trends for North America, the total land cover change in forest areas was 0.01% (FAO 2016), while in the Monarch Butterfly Biosphere Reserve the figures vary in different locations in the reserve (see earlier section on forest cover change and references to core and buffer zone). The figures of forest cover change trends used in this study come from the Fondo Monarca in conjunction with WWF, who stated that the rate of forest cover change was 0.03% and has been in a steady decline since 2008, though they refer to the core zone exclusively (Fondo Monarca 2016, Vidal et al. 2013). This study takes into account the whole Monarch Reserve area and so, for the purposes of this study, 'efficient' forest management was measured as any increase of dense forest cover or maintenance of a rate of  $< 0.03\%$  negative forest cover change, from 2006 to 2015.

Local managers frequently have a vested interest in the resource (as noted by common pool resource researchers and evidenced by variables present in the critical list of variables for sustaining the commons in the following section) and compete with powerful external pressures. This is also evident in the Monarch Butterfly Biosphere Reserve as all the residents that live on or near the reserve have demonstrated an interest and an investment in its care. In order to encourage and maintain efficient management, it is imperative to develop a systematic yet tailored approach to look at the established variables associated with external pressures, the internal idiosyncrasies and the situational and different ways the various levels of governance exert influence on management. The focal variables have been established by CPR researchers and a revision of them is necessary in order to determine focal points for strategizing and maintaining cohesive dialogue among the different actors in order to ensure both sustainable and efficient management. It is with these ideas in mind that this research study was developed. There is compelling evidence in common pool research that it is in fact the nuances and idiosyncrasies that are ultimately key in the management success of common pool resources (Baggio et al. 2016, Barnett et al. 2016). Thus, when diagnosing and/or planning interventions the first step is to determine what those are with respect to the general traits and correct for the situational nuances that can impact the outcome in spite of the systemic similarities. In this way the approach can be systematized (critical list) while the situational details are taken into account (operationalizing) in order to create a picture using the parameters, which acts as the operational universe. The next is how those parameters translate into categories and indicators that influence management. From there it is possible to determine to what degree the variables influence management and finally how to maximize the influential elements. To this purpose, four ANs were chosen that present the local characteristics stated in the literature as important for success. Successful cases have greater potential to give specific insight into what is most important and what can be further strengthened in order to improve long-term

management (stability and resilience). The expectation is that the case studies may speak to areas of focus in less efficient or inefficient cases in the reserve and point to a method that could be useful in other CPR scenarios.

## CRITICAL LIST OF VARIABLES: BACKGROUND AND MODIFICATIONS

The critical list of variables for sustaining the commons is the result of decades of work by researchers such as Wade (1994) and Baland and Plateau (1996) that was first presented by Ostrom (1990) as design principles, though since Agrawal (2003) discusses the sustainable use of the commons, “no studies of common pool resources develop their research design by explicitly taking into account the different variables critical to successful management as specified [in the critical list of variables for sustaining the commons].”

The critical list (Table 2.1) is the result of researchers’ attempts to identify the variables applicable to most local common pool resource management scenarios. The complete, working list is in Chapter 3. Elinor Ostrom, a well-known CPR researcher, focused her career on disputing the Tragedy of the Commons based on the knowledge that it was not as pervasive as Hardin believed (Ostrom 1996, Hardin 1968). Ostrom strove to answer the question of why resources are exploited, as well as what conditions favor effective management, based on both efficient and inefficient cases. Her conclusions have led to a greater understanding of the consistent, though circumstantial dynamics of common pool resource management. Ostrom (1990) was the pioneer in this effort in identifying key variables, which she elaborates on in detail in her book “Governing the Commons: Evolution of Institutions for Collective Action.” In this work she outlines the theoretical framework based on case studies where governance and management have been both efficient and inefficient. She outlines the 8 design principles illustrated by long-enduring CPR institutions as well as the framework for analyzing institutional choice (Ostrom 1998, 2008). She also lists critical dependent and independent variables for efficient management of the commons, which she systematically used to analyze each case; for example small groups size, clearly defined boundaries in-group, well defined property boundaries, locally devised access and management rules, graduated sanctions, availability of low cost adjudication, accountability of monitors and other officials to users, matching restrictions on harvest to regeneration of resources, central governments should not undermine local authority, ease of enforcement of rules and monitoring as well as nested levels of appropriation provision, enforcement and governance. Wade (1994) aggregated 14 conditions relating to user demand, enforcement of rules, past successful experiences and level of dependence on the resources by the group as well as classifications for each (e.g. resources, technology, and relationship between users and the State). The specific variables that embody these and aggregated to this list by Wade were small resource system size, past successful experiences-social capital, small group size, interdependence among group members, high levels of dependence on the resource by group members and low-cost exclusionary technology. Baland and Plateau (1996) integrate private versus common property as an influence on management with regard to property rights and note that proximity to resource base, homogeneity among group members and past experiences are key enabling variables. They aggregated the following variables to represent these: shared norms, appropriate leadership, heterogeneity of endowments/homogeneity of identity and interests, fairness in allocation of benefits from resources, rules are simple and easy to understand, supportive external sanctioning institutions and appropriate levels of external aid. Agrawal (2003) noticed gaps in the collective conclusions of the previous authors and integrated certain characteristics of the physical resource itself like mobility of the resource and storage of the resource or its benefits. He also takes into account market and technological changes and reorganizes the list adding seven more variables to the list (low levels of mobility, possible storage of benefits of the resource, predictability, low levels of poverty, low levels of user demand, gradual changes in levels of demand, time for adaptation to new technology related to the commons, low levels of articulation with external markets, gradual change in external markets) based on careful analysis of how to close the gaps he perceived. Agrawal (2003) also broke the variables into categories that correspond to their area of application (Table 2.1). I added the physical condition of the resource (forest cover) for this analysis, which was

overlooked by the others, as an enabling variable (though sometimes taken into account in Community Based Natural Resource Management [CBNRM] analyses depending on the purpose of the study) and acts as an outcome variable in this study to determine the level of successful management.

**Table 2.1. The critical list of variables for sustaining the commons based on Elinor Ostrom's (1990) design principles. At that time there were eight, Wade (1994) added eight, Baland and Plateau (1996) added twelve and Agrawal (2003) added nine.**

<b>Variable Category</b>	<b>Variable</b>
<b>1. Resource system characteristics</b>	Small size (RW)
	Well defined boundaries (RW, EO)
	Low levels of mobility (AA)
	Possibilities of storage from benefits from the resource (AA)
	Predictability (AA)
<b>2. Group Characteristics</b>	Small size (RW, B&P)
	Well defined boundaries (RW, EO)
	Shared norms (B&P)
	Past successful experiences—social capital (RW, B&P)
	Appropriate leadership—young, familiar with changing external env, connected to local traditional elite (B&P)
	Interdependence among group members (RW, B&P)
	Heterogeneity of endowments, homogeneity of identities interests (B&P)
	Low levels of poverty (AA)
<b>3. Relationship between resource characteristics and group characteristics</b>	Overlap between user-group residential location and resource location (RW, B&P)
	High levels of dependence by group members on the resource system (RW)
	Fairness in allocation of benefits from common resources (B&P)
	Low levels of user demand (AA)
	Gradual change in levels of demand (AA)
<b>4. Institutional arrangements</b>	Rules are simple and easy to understand (B&P)
	Locally devised access and management rules (RW, EO, B&P)
	Ease in enforcement of rules (RW, EO, B&P)
	Graduated sanctions (RW, EO)
	Availability of low-cost adjudication (EO)
	Accountability of monitors and other officials to users (EO, B&P)
<b>5. Relationship between resource system characteristics and institutional arrangements</b>	Match restrictions on harvest to regeneration of resource (RW, EO)
<b>6. External Environment</b>	Technology: Low cost exclusionary technology (RW)
	Technology: Time for adaptation to new technologies related to the commons (AA)
	Low levels of articulation with external markets (AA)
	Gradual change in articulation with external markets (AA)
	State: Central governments should not undermine local authority (RW, EO)
	State: Supportive external sanctioning institutions (B&P)
	Appropriate levels of external aid to compensate local users for conservation activities (B&P)
	Nested levels of appropriation, provision, enforcement, governance (EO)

There is a great deal of evidence to support social factors as having the greatest impact on sustainability, recovery and conservation (Ostrom 1990, Agrawal 2003, Gari et al. 2017). Local managers are the closest link to the resource that government agencies, managers, policy makers and researchers have. They carry cultural, historic, practical and real-time, empirical knowledge that is key to the robust understanding of obstacles and problems inherent in particular complex human-ecological systems, as well as in their solutions-- particularly in the management of common pool resources (Ostrom 1990, Brenner & Job 2006). Significant management challenges persist in spite of the fact that scientific research has developed a plethora of robust monitoring data and complex models (Agrawal 2003, Merino-Pérez & Hernández Apolino 2004, Walters 2007, McCann et al. 2006, Landuyt et al. 2013). These challenges are intensified by the need to include human dimensions science together with ecological factors fundamental to forest health assessments and to inform management strategies. In order to implement and maintain practical and effective management strategies, local managers must be incorporated into management programs for greater accuracy, efficiency and cooperation (Chhatre & Agrawal 2008, Bray et al. 2004, Ostrom 1990). This requires integrative, multidisciplinary approaches that integrate the components of human-natural systems. Ideally, these methods will be designed to open dialogue and provide context for local managers so that their circumstances and context is taken into account.

Next, the Methods chapter (Chapter 3) will explain the social and physical context parameters in the critical list of variables for sustaining the commons, their operationalizing, statistical methods, forest cover change metrics, sample selection, and interview tools applied in this study to elucidate key variables and relationships for efficient, sustainable management of forests.

# CHAPTER 3: METHODS/MÉTODOS

## RESUMEN DEL CAPÍTULO

Las variables que se utilizaron en el análisis representan los parámetros de la lista crítica para sostener los recursos comunes, y el propósito del análisis fue determinar cuál de ellos ejerce una influencia significativa sobre la variable dependiente (cambio de la cubierta forestal a través del periodo del 2006 a 2015). En este capítulo, se elabora el contexto de cada variable con las métricas utilizadas para calcular su valor. Esto, utilizando un porcentaje normalizado para así conducir el análisis mixto de datos cualitativos y cuantitativos. Asimismo, se explica cómo se eligió la muestra de núcleos agrarios (NA) y los participantes, el instrumento de entrevista y observación directa. También se describe el análisis de cambio de cobertura forestal y la creación de los mapas de cambio para cada NA. Además, hay un conjunto de variables dependientes que miden el cambio de la cubierta forestal, compuesto por seis distintas categorías que describen diferentes tipos de cambio de cubierta forestal: bosque denso a bosque degradado, bosque degradado a no bosque y bosque denso a no bosque, todo lo cual implica pérdidas de área forestal o densidad de cobertura. Luego se describen cambios en la cobertura forestal en la dirección opuesta: Del no bosque al bosque degradado, es decir parcialmente restablecido, del no bosque al bosque denso, y del bosque degradado al bosque denso. Estos cambios se miden utilizando métodos de percepción remota y mapas de los resultados de cambio de cobertura con dos mapas para cada uno de los NA, comparando un mapa del período 2006 a 2010 y otro mapa del 2010 a 2015. Se explican luego los dos análisis estadísticos multivariados no paramétricos para analizar el grado en que se podría decir que las diferentes variables predicen la variable de resultado (cambio de la cubierta forestal). Primero, las correlaciones de Spearman se utilizaron para determinar si, y en qué medida, cada variable independiente podría estar relacionada con las variables dependientes. Segundo, se aplicó una regresión LASSO (Operador de reducción y selección absoluta mínima), en la que se identifican variables independientes que mejor explican las variables dependientes. Ambos análisis usaron el software estadístico R. Fueron elegidos los dos tipos de análisis porque el estudio está basado en un gran número de variables pero una pequeña muestra, para la cual los métodos estadísticos no paramétricos son adecuados y sus justificaciones están descritas en detalle.

This study will be using various methods to test whether the critical list (that according to theory are critical for enabling sustainable local management of the commons) are in fact applicable in four AN in the area of the MBBR. These four AN are all considered relatively efficient local forest managers, on the basis that they have had low or negative forest cover change over the past decade falling within the  $< 0.03\%$  forest cover loss threshold, as explained in Chapter 2.

The variables that are used in the analysis represent the parameters in the critical list for sustaining the commons, and the purpose of the analysis is to determine which of these exert significant influence over the outcome variable (forest cover change over time). Two nonparametric multivariate tests were used to analyze the extent to which the different variables could be said to predict the outcome variable (forest cover change). The critical list, the operationalizing of the parameters and the nonparametric multivariate models will be discussed in detail in this chapter.

There is also a set of dependent variables which measure forest cover change, made up of six different categories, which describe different forest cover change types: dense forest to degraded forest, degraded forest to non-forest and dense forest to non-forest, all of which imply losses of forest area or density. But in addition, there are forest cover changes in the opposite direction: from non-forest to degraded (i.e. partially regrown) forest, from non-forest to dense forest, and from degraded forest to dense forest. These changes are measured using remote sensing and mapping methods in each of the AN over the period 2006 to 2015.

## CRITICAL LIST OF ENABLING VARIABLES FOR SUSTAINING THE COMMONS AS ADAPTED FOR THIS STUDY

As discussed in Chapter 2, Agrawal (2003) modified the list of critical enabling variables for sustaining the commons, which was originally developed by Ostrom (1990) through her 8 design principles (DPs), Wade (1994), Baland and Plateau (1996). This has been explained in detail in Chapter 2 already. The critical list of variables as used in the analysis for this study is presented in Table 3.1. A number of variables in Agrawal's list have been excluded, for reasons that are explained below. Two variable categories (3 and 5) have been re-labeled for clarity.

**Table 3.1. The critical list of variables as adapted for use in this study. Also included are their abbreviations, what a high normalized percentage indicates and the hypothesized direction of the variable's relationship with loss of forest cover.**

Variable Category and abbreviation	Variable	High score indicates:	Hypothesized direction of relationship with loss of forest cover
<b>1. Resource system characteristics</b>			
ResSmSize	Small size	Smaller resource size	Negative
WDB1	Well defined boundaries	Better defined boundaries	Negative
<b>2. Group Characteristics</b>			
GrpSmSize	Small size	Smaller group size (population)	Negative
WDB2	Well defined boundaries	Better defined boundaries	Negative
ShdNorms	Shared norms	Greater level of shared norms	Negative
PSE	Past successful experiences	More past successful experiences	Negative
AppLeader	Appropriate leadership	Higher levels of belief in appropriateness of leader	Negative
IGM	Interdependence of group members	High interdependence of group members	Negative
HEIII	Shared identity	Higher levels of shared identity	Negative

Poverty	Low levels of poverty	Higher levels of poverty	Positive
<b>3. Extent of human pressure on the resource</b>			
Overlap	Low overlap between users and resource	Higher overlaps (resource is closer to residential area)	Negative
DepRes	High dependence on the resource	Higher levels of dependence on forest	Negative
Fairness	Fairness in allocation of benefits	Higher levels of fairness	Negative
Low demand	Low levels of demand for forest products	Lower levels of demand	Negative
<b>4. Institutional arrangements</b>			
REU	Rules are simple and easy to understand	Rules are easier to understand	Negative
LDAMR	Locally devised access and management rules	Mgmt rules are devised more locally than from outside	Negative
Easy enforce	Ease in enforcement of rules	Higher levels of ease in the enforcement of rules	Negative
GradSanct	Existence of Graduated sanctions	Greater presence of graduated sanctions	Negative
ALCA	Availability of low-cost adjudication	Greater availability of low-cost adjudication	Negative
Accountability	Accountability of monitors and other authorities to users	Greater accountability of monitors to users	Negative
<b>5. Extent to which rules take into account ecosystem potential</b>			
MHRHR	Match restrictions on harvest to regeneration of resource	Higher levels of matching of restrictions on regeneration	Negative
<b>6. External Environment</b>			
LCET	Presence of low-cost exclusionary technology	High levels of low-cost exclusionary technology are present	Negative
CGSNULA	Central gov should not undermine local authority	Higher levels of agreement central gov does not undermine local authority	Negative
SESI	Supportive external sanctioning institutions	Higher levels of awareness of supportive external sanctioning institutions	Negative
ALEA	Appropriate level of external aid	Greater agreement that levels of external aid are appropriate	Negative
NLAPEG	Nested levels of appropriation, provision, enforcement and governance	Greater presence of nested levels of appropriation, provision and governance	Negative

The labels for the variable categories 3 and 5 were changed to 'Extent of human pressure on the resource' and 'Extent to which rules are based on ecosystem potential', respectively, as the original names of these variable categories were confusing to non-practitioners. In all, seven of the original 33 variables have been excluded due to their inapplicability to this forest management system, leaving an operational set of 26. 'Low level of mobility' was excluded, as it does not apply to forest, which is fixed in space and would be the same in this respect for each AN. This was also true for the 'Possibility of storage of benefits' from the resource (e.g. timber). 'Predictability' was also excluded due to the rather consistent patterns of growth, natural reforestation and weather for all ANs. Also excluded was the 'gradual change in demand' variable as it is not within the scope of this thesis due to unavailability of data. 'Time for adaptation to new technologies' related to the commons was excluded since there is no real external exclusionary technology applied in the management of forests in the MBBR that would require adaptation (since the exclusionary technology employed is fences). 'Levels of articulation with external markets' and 'gradual change in articulation with external markets' were excluded due to the prohibition of sale of trees and wood products. While there is clandestine logging and tree cutting, there is no authorized or measurable articulation with external markets in the MBBR at this time. The 'appropriate leadership' variable was modified due to Agrawal's (2003) assertion that leaders be young. Instead, participants were given the liberty of expressing their perceptions about the appropriate age of leaders and compared to the leader they currently had.

## OPERATIONALIZING THE VARIABLES

Operationalization of each variable requires the selection of an indicator (or multiple indicators) that can be measured. Selection of the indicators is very important as it is the basis for all conclusions drawn once the data is processed; they are explained below, by variable category (Table 3.1).

**Table 3.2. The critical list of variables and their indicators.**

Variable Category	Variable	Abbreviation	Indicator(s)
<b>1. Resource system characteristics</b>	Small size (RW)	ResSmSize	Inversion percentage of area of a given AN to the total area of the 4 ANs
	Well defined boundaries	WDB1	a. Proportion of positive responses to question 'are boundaries well defined' b. Proportion of participatory maps showing similar boundaries c. Proportion of responses which agree with government established boundaries
<b>2. Group Characteristics</b>	Small size	GrpSmSize	Inverse percentage of population of a given AN to total population of the 4 ANs
	Well defined boundaries	WDB2	a. Inverse percentage of certificate holders to total adult population b. Number of certificate holders who do not participate in forest management c. Number of interviewee who said their participation had no influence on the outcome d. Number of certificate holders who said they did not participate in the decision making
	Shared norms	ShdNorms	a. Extent to which interviewees agree on the issues of (i) women participate (ii) women should participate (ii) women should be paid equal to men for rest activities b. Extent to which interviewees agree on the issue of harvesting norms
	Past successful experiences—social capital	PES	Extent to which interviewees agree on past successful experiences based on established events
	Appropriate leadership—young, familiar with changing external env, connected to local traditional elite	AppropLeader	Extent to which interviewees say their leader is appropriate or "good" based on established traits
	Interdependence among group members	IGM	a. Extent of participation of interviewees in conservation activities and b. % agreement whether non-participation creates difficulty for participants (either in the form of limited/contaminated resources, sanctions or greater cost, i.e. time, money, resources)
	Heterogeneity of endowments, homogeneity of identities interests	HEHII	a. % identifying with a indigenous ethnicity b. % Spanish speaking c. % indigenous language d. % participation in the various available conservation activities e. % participation in available livelihood activities
	Low levels of poverty	Poverty	Poverty index indicators like: a. Materials that were used to construct a dwelling b. The kind of floor present in the dwelling c. whether there was running water, access d. Type of drinking water (garrafón or pump) e. Electricity f. Appliances
<b>3. Extent of human pressure on the resource</b>	Overlap between user-group residential location and resource location	Overlap	Measurements of equal distance units from the furthest point in the settlement from the resource to the closest, taking the midpoint between the two as the midpoint of overlap. More detail in the text below.
	High levels of dependence by group members on the resource system	DepRes	Determination of dependence on ecosystem services such as water services, raw material, byproducts) through individual interviews, interviews with the local authorities, central governance authorities in charge of the CPR system and literature review (or all of them depending on availability). One point was deducted from the final, normalized value for all respondents who said they regularly used raw materials from the forest (like wood). A point was also deducted for those who said that they did not feel that the tree composition or density was important to ecosystem services.
	Fairness in allocation of benefits from common resources	Fairness	a. % saying distribution of tourism benefits is fair b. % saying distribution of PES benefits is fair c. % saying distribution of/access to resources is fair



	Low levels of user demand	LowDemand	a. Extent to which interviewees agree: How many households use wood for fuel and how often? b. Extent to which interviewees agree: How many households regularly use wood materials for building (sheds, fences, housing, additions, furniture)?
<b>4. Institutional arrangements</b>	Rules are simple and easy to understand	REU	Extent to which interviewees agree rules are easy to understand
	Locally devised access and management rules	LDAMR	a. Extent to which interviewees agree: Does the Asamblea/Comisariado have any influence on the reserve rules for your area? b. Extent to which interviewees agree: Of the current rules for the area of the reserve corresponding to your AN (and those were mentioned specifically), was the local authority involved in devising or modifying those rules?
	Ease in enforcement of rules	EasyEnf	Extent to which interviewees agree on the ease of enforcement of rules
	Graduated sanctions	GradSanct	Extent to which interviewees agree on there being graduated sanctions
	Availability of low-cost adjudication	ALCA	Extent to which interviewees agree there is availability of low cost adjudication
	Accountability of monitors and other officials to users	Accountability	Extent to which interviewees agree on there being accountability of monitors and other officials to users
<b>5. Extent to which rules take into account ecosystem potential</b>	Match restrictions on harvest to regeneration of resource	MRHRR	a. % agreement for the question 'are there restrictions on harvest that take into consideration regenerative needs (Yes/no)? b. % agreement as to whether those restrictions match CPR regeneration needs (Yes/no)?
<b>6. External Environment</b>	Technology: Low cost exclusionary technology	LCET	Presence of fences with points subtracted for discontinuity of fence
	State: Central governments should not undermine local authority	CGSNULA	a. Extent to which interviewees agree on Comisariado and Asamblea perception as to whether the central governing institutions respect local rules and practices (yes or no) b. Extent to which interviewees agree on whether there are conflicts between levels of authority and how often c. Extent to which interviewees agree on how those conflicts were resolved (were the local authorities consulted and respected) and whether each side felt the conflicts were properly managed (yes or no)? A point system was applied here where the affirmative responses of the questions on respect of local authority by central government agencies were averaged and then a point was deducted for each instance where they (Comisariado and the Asamblea members) felt the negotiations were improperly managed to the degree that they were in direct conflict with the local authority and established local practices.
	State: Supportive external sanctioning institutions	SESI	Extent to which interviewees agree on there being supportive external sanctioning institutions
	Appropriate levels of external aid to compensate local users for conservation activities	ALEA	Extent to which interviewees agree that there are appropriate levels of external aid
	Nested levels of appropriation, provision, enforcement, governance	NLAPEG	a. Extent to which interviewees agree on responses: Who makes the rules? b. Extent to which interviewees agree on responses to: Where do the different rules come from? c. Extent to which interviewees agree on: How are the different levels of rules determined and at what level of governance?

The process for operationalizing the variables is based on the theoretical context of the variables themselves. This context and subsequent metricizing is discussed in the following sections.

## INDICATORS FOR VARIABLES IN THE RESOURCE SYSTEM CHARACTERISTICS CATEGORY

Most CPR research agrees that small size of a common pool resource is helpful in efficient management, included by Ostrom (1990) and Wade (1994) in the first versions of the critical list. According to Ostrom (2000), the size of the group is sometimes inextricable from the size of the resource, which was considered the community in which the resource is found. However, no general metric for determination of size measure was specified in either work, and an arbitrary measure complicates scaling up for meta-analysis. Because size by nature is a relative measure, it

was necessary to determine the best unit for comparison. For this study, the resource area size is as much the area of forest as the area that contains the user-group (in part because it is a protected area) so that the entire area of the AN was used as the unit in the relative size measure.

**Table 3.3. Different categories for assessing size of the resource.**

Name	Area ha	Total AN population	Num. rights holders	Forest Area
Carpinteros	800	891	218	600
San Fransisco Curungueo	2275	2345	280	440
San Juan Zitácuaro	1465	1274	213	1397
Nicolas Romero	959	2106	285	959
<b>Total</b>	<b>5499</b>	<b>6616</b>	<b>996</b>	<b>3378</b>

A way to measure the size of a given AN is by comparing it to the sum of the total study area in the study, providing a local and relative size measure. For example, the relative size for Carpinteros would be calculated by dividing the total area of all of the AN in the study area by the area of Carpinteros--  $800/5499=15\%$  and the inverse percentage being the representation of the small size measure relative to the total area. This gives Carpinteros a percentage of 85% for small size, relative to the total land area of all AN in the study.

The 'well-defined boundaries' (WDB) variable, which refers to land boundaries as it is in the resource systems characteristics category, was first included in the DPs by Ostrom (1990) who considered clear boundaries necessary to provide clarity and focus for management actions. Wade (1994) found, after a review of various case studies, that when resources for monitoring and enforcement are limited, smaller areas are easier to manage with success. This is one of the more complicated variables to metricize due to the array of proxy measures possible. It is then important to determine whether the focus needs to be on one or more of the following: settlement boundaries, protected area boundaries, ecological boundaries, legal or political boundaries. Agrawal (2003) makes the point that if the flow of benefits is predictable and user group is stationary (ex. forests and some water resources) then well defined boundaries are useful, however when those are not the case it may be beneficial to have some plasticity in boundaries (ex. rivers, air). The influence on performance of the CPR system by the physical proximity or general location of the user-group and the resource itself should be investigated to determine the approach for determining indicators. Physical and legal/political boundaries are a first point of reference, if the latter are available. Moreover, because political boundaries can be questioned or rejected by local managers, participatory mapping is a reasonable approach to determine whether there are differences in perceived boundaries and political boundaries. In the case of some protected areas, local managers had historic access and settlement boundaries that were recently (relative to their history) modified by the central government to create conservation zones or facilitate conservation of the CPR system which may influence operationalizing. Both of these are also useful in giving context and informing assessment and intervention. This variable was measured by the existence of official political boundaries not just of the AN itself but also of the Reserve zones that fall within those borders (core and buffer zones). However, it was not as simple as measuring the political boundaries as there are issues in the AN with internal boundaries and issues with legitimacy of external boundaries of the AN with bordering settlements (discussed in detail in the section on each AN in chapter 4). Each AN started off with 100 points and as there were issues with boundaries detected, points were subtracted. Because, in some cases, there were discrepancies between the political boundaries established by the government in those recognized by the AN, the perception of how well the boundaries were defined was asked directly. Participatory mapping was also employed from which it was observed whether participants drew maps which showed similar boundaries, or maps with differing boundaries, which would indicate a lack of consensus on the matter. The relative percentage was determined for each indicator: 1) the number of positive responses to the

question of whether boundaries were believed to be well established, 2) the number of similar participatory-boundary maps versus the number of different ones and 3) the number of respondents who agreed or disagreed with the political boundaries established by the government. Because the different metrics are a combination of qualitative and quantitative data, a point system was devised. The well-defined boundary measure was initiated as 100%. The presence of illegitimacy of political boundaries as perceived by local managers was represented by -5. Where boundary conflicts were present inside the AN itself, 5 points were deducted. The presence of conflicts with boundaries of neighboring settlements resulted in a deduction of 5, as well. A five point deduction was due to the notable impacts by these discrepancies and the limited number of possible indicators to describe the discrepancies. For example, Carpinteros started with 100 points. They have discrepancies in the internal boundaries so 5 points was deducted. It also came out in the participatory mapping and interviews that there were discrepancies in the AN boundaries versus the RAN/PHINA political boundaries, resulting in another 5 point deduction. This gives Carpinteros a value of 90 for well-defined boundaries.

## INDICATORS FOR VARIABLES IN THE GROUP CHARACTERISTICS CATEGORY

For small size in the group characteristics category, the number of certificate holders was compared to the total population of each AN to get a sense of relative group size. Wade (1994) and Baland and Plateau (1996) who noted that the smaller the user-group, the more probable efficient management. However, Ostrom (1990) also discussed the portion of the population that has the rights to make decisions with regards to the resources and have a collective influence on the enforcement and possible development of rules (1990). Ostrom (1990) refers to the size of the user-group and not necessarily the authorized decision-making members though she discusses both. Since this CPR system is based on several subsets of managers and all residents use the forest resources regularly, the population of each AN was compared to the total number of residents of all four of the AN was used to determine relative size measure. So, Ostrom's (1990) size of user-group was applied here and it was the population of the AN as compared to the total population of all AN in the study, and as with the physical size measure, the indicator is the inverse of this percentage.

In the case of the 'well-defined boundaries' (WDB1) in the group characteristics category, the variable being measured is essentially the clarity of the social and institutional rules for participation in forest management. The context and questions can be adapted from Ostrom (1990) where clear boundaries provide greater control for users/managers over the resource by providing a structure for rules around appropriation/provision. In the majority of cases, particularly in protected areas, the overarching rules are established by the nature of the land tenure unit and are regulated by Federal law, resulting in authority provided for certain members who are afforded land rights by the central or local government. In this way, the group is defined by the government and upheld by local managers. It is possible that there is incongruence between the levels of governance, which would impact the clear definition of boundaries.

Generally, it is practical to use Ostrom's approach since it is common for both authorized and unauthorized members to use the resources. The rules are established by the nature of the land tenure unit and are regulated by Federal law. Ejidatarios (in ejidos) and comuneros (in ICs) are authorized to participate in decision-making through the Asamblea, while other residents are not due (Diario Oficial 1993, 2000). In this way, the group is defined by the government and upheld by local managers. For this study however, Ostrom's approach was used since not only certificate-holders but also many of the non-certificate holders participate in the actual conservation activities. In all the AN there were essentially three groups: the rule-making group (comuneros/ejidatarios authorized to participate in the Asamblea), the conservation group (which could be fluid but was made up of residents with responsibilities involving the care and protection of the resource) and the rest of the

population. The relationship/boundaries between the rule-making group and the conservation group established by the former was discussed in interviews, as well as observed. For every person in the certificate-holding group who said that they did not participate, a point was deducted from the average of the questions about group boundary perceptions. A point was also deducted from the total for every case where a participant voiced the feeling that their participation had no influence on the outcome. In conjunction, the relationship/boundaries between the conservation group and the rest of the users was also addressed. These two questions asked in the interviews act as an example of both the former and the latter: Does a member of your family (or yourself) hold a certificate? Do you participate in conservation activities? If not, are you permitted to participate in Asamblea decisions? Positive conservation behavior by participants or the greater population was not considered influential in fuzzy boundaries while negative behavior was. For example, in San Juan Zitácuaro the number of certificate holders is  $213/1274=17\%$ — and we use the inverse as the relative measure being 83%. From there, 1 point subtractions were made for lack of participation by certificate holders (-6 total) or the feeling that participation was not taken into account (-1) resulting in a final value of 70.

To determine whether norms are shared, the indicators are determined through the interview instrument. The context of questioning is based on Crawford and Ostrom (1992) who define norms as “shared understandings about actions that are obligatory, permitted, or forbidden.” Kang and Haab (2005) provided an analysis of DPs with a discussion of the primary role social norms play in governing CPRs. A variety of conservation-activity and norm-specific questions were asked (Margaret Skutch, personal communication; Richie and Lewis (2003) Ch. 6; Ostrom (1990) pp. 35-7). For example, questions about whether women participate, whether they should participate and whether they are compensated equally for conservation activities or should be, were asked. As well, there were questions about forest care and harvesting norms that were mentioned in interviews, for example whether specific species were selected or were considered off limits (cross-checking the normative with the rules). For each norm, the extent of agreement was measured as the percentage of responses supporting the most popular response option (for example out of 20 responses, if 15 said A while 5 said B, the extent of agreement would be 75%). Note that this means that maximum agreement would be 100% and minimum would be 50%. The final value was then calculated across all norms by averaging, giving us an overall value for the variable ‘shared norms’. Note also that no account is taken of ‘the political correctness’ of the norm (e.g. whether the interviewees favor women’s participation or not, what is being measured here is solely the extent to which there is agreement on the issue).

A similar process was used for ‘past successful experience’ (PSE). PSE is a clear manifestation of successful collective action and gives an indication of how well the collective has worked together in the past. Wade (1994) considers that PSE provides a basis for future cooperation and Baland and Plateau (1996) argue that past successful experiences provide a precedent for rule-abiding behavior and makes enforcement ‘easier and compliance more likely in the future’. Consequently, it is pertinent to determine what the past conservation experiences were and whether or not they were perceived as successful. This is also mentioned by Gari et al. (2017), who suggest that the age of a CPR system is important in its robustness. Examples of such experiences might be reforestation, conservation infrastructure improvement, fence construction (or any other exclusionary or physical protection approach), formation of patrols for monitoring and in some cases to aid others, clean-up of a resource, changes in resource use that have resulted in augmented resource quantity or services, etc. The interviewees were asked about past experiences in conservation and management (the specifics can be found in the questionnaires and in chapter 4). They were then asked which of them they considered successful and why. Each experience was coded as a successful or unsuccessful experience and the proportion of responses that were positive in this sense was used as the value for this indicator. This percentage was obtained using the same multi-indicator question protocol discussed above.

The indicators for the appropriate leader variable were decided based on Agrawal's (2003) and Ostrom's (1990) discussion of leadership. Because appropriate leadership is an issue that will vary according to local conditions, it is this author's opinion that what is "appropriate" cannot be determined a priori by researchers. Agrawal (2003) and Baland and Plateau (1996) suggest that leadership should be young, familiar with changing environments and connected to the traditional local elite. It would seem more informative to determine what the local managers themselves consider appropriate leadership, particularly if local managers vote for their leadership. To encourage deeper comprehension of local leadership, inform future interventions and honor local perceptions/needs, it is more practical to investigate local perceptions of appropriate leadership by asking this directly. 'Appropriate leader' was therefore determined by asking the interviewees what makes an appropriate leader. In other words, which qualities were perceived as defining a good leader? The elements were decided by personal communication with Margaret Skutsch, Agrawal's (2003) discussion of leadership, and Ostrom (1990). The modification that was made by the definition in this study versus what was suggested by Agrawal (2003) and Baland and Plateau (1996) was that, due to local perceptions of appropriate leadership, the definition was not limited to a specific age group. Interviewees were asked what age group they felt was appropriate. The respondents were given a list of leadership qualities: age, education level, experience in leading the community, conservation knowledge, conservation experience, speaking ability, availability to the people. Then they were asked if the current leader embodied those qualities. The reason for this process was to establish a working definition of appropriate or "good" leadership. Finally they were asked if they felt their leader was appropriate or good for the community. The results from that final question was the basis for the metric for this variable. The measure of the results for this variable was presence/absence, or yes/no.

The context for the 'interdependence of group members' (IGM) variable is taken from Ostrom (1990). It is based on the understanding that the choices made by the individual not only affect the collective but also must take into account the collective to be sustainable. She bases her determination on the theories of the firm and of the state. The main focus of Ostrom's (1990) context for interdependence of group members is the process that they follow to encourage coordinated strategies for use and appropriation that rely on contingent strategies (often showing contrary behavior and results to Hardin's tragedy of the commons) based on repetitive actions around the resource. This is reflected in local resource-use rules and the impact and perception of participation. The evidence for this is in participation in actions in which "individuals forego immediate returns in order to gain larger joint benefits when they observe others following the same strategy" (Ostrom 1990). The questions that arrive at interdependence are directly about participation in conservation activities and whether non-participation creates difficulty for participants (either in the form of limited/contaminated resources, sanctions or greater cost, i.e. time, money, resources). The direction of the questioning for the 'Interdependence of group members' variable was taken also from Ostrom (1990). Interviewees who were formal managers, (that is, certificate holders i.e. comuneros or ejidatarios) were asked about involvement first of household members and then of the other managers in conservation practices and whether a lack of participation impacted conservation and monitoring activities. Questions regarding income generating activities and the impact that conservation activities have had on households were asked. These questions were posed to provide context and a baseline for the metric questions. The interviewees were asked whether participation or non-participation had an impact on any of the previously mentioned elements. Interviewees were also asked about the perception of the role of participation in quality of conservation and enforcement of rules. They were also asked how non-participation was viewed. The percentage of same responses was determined for each of the two indicator questions (the impact of participation on conservation activities and quality of conservation and enforcement of rules) and then the values for all indicators were averaged to determine a normalized measure, as with previous multiple indicator measures.

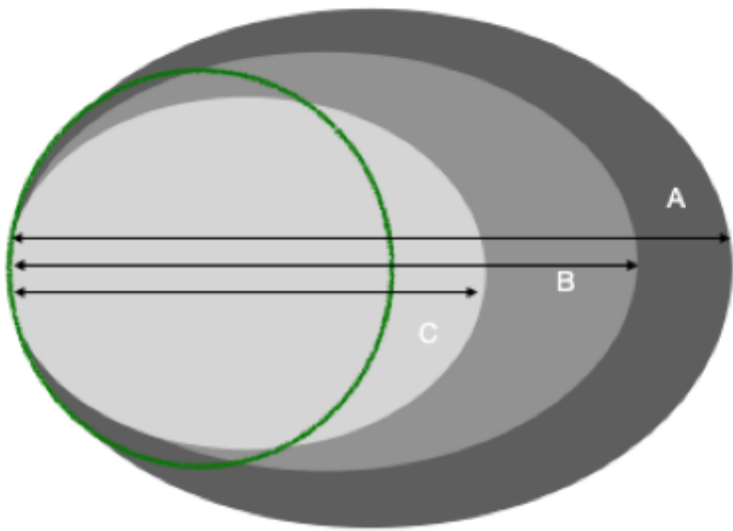
The context for homogeneity of identities and heterogeneity of interests (HEHII) is the criteria outlined by Baland and Plateau (1996), and Agrawal (2003) regarding class and ethnicity. Baland and Plateau (1996) outlined the empirical basis for this in their work that discusses several of the DPs they considered most pertinent to efficient management of CPR systems and the importance of this variable in successful cases. The inclusion of this variable is based on the theory proposed by Sugden (1984) that homogeneity of identity encourages greater cooperation and provision of useful resources. Ostrom (2002), notes the importance of cultural background, interests and endowments. Taking into account the diverse nature of CPR systems, livelihood is not always informative since some CPR systems have more to do with daily life or subsistence and not necessarily income generating activities. Weber et al. (2007) did a multiple-case analysis on ethnicity and migration in Indonesia that supports the hypothesis that ethnicity is fundamental to decision-making based on cultural practice. Homogeneity of identities and interests was determined through interview questions and observation regarding the ethnic group with which an individual or household identified and the activities the household participated in compared to the variety of activities that were available. The questions were based on the criteria outlined by Baland and Plateau (1996) and Agrawal (2003). The questions consisted of how they identified culturally and ethnically (indigenous, mestizo), what languages are spoken in their household (Spanish, indigenous) and if they identified as conservation participants through participation. A catalog of conservation interests (reforestation, alternate material use, conservation activities, income generating activities, and forest material use) was generated to determine how much heterogeneity of activity was present but was not used in the final measure. The agreement in identity responses were averaged to determine a value for each question and then an average for all of the questions was determined, as for previous multi-indicator measures. For example in NR, 23% of respondents identify as indigenous, 99% identify as mestizo, 2% speak an indigenous language, 75% participate in conservation activities, 17% participate in monitoring, and 60% participated in reforestation activities resulting in a normalized percentage of 55 for the community for this variable.

The poverty indicators were based on the Multidimensional Poverty Index (UNDP 2013). The empirical data for levels of poverty were determined by the 2015 census carried out by the government and these data were confirmed by data provided by the Comisariado and interviews. For example, I used criteria such as materials that were used to construct a dwelling, the kind of floor present in the dwelling, whether there was running water, access and type of drinking water (garrafón or pump), electricity, appliances (or lack of), etc. The percentage of dwellings in the AN with these characteristics was observed and/or taken from the census data. Interviews were also used to provide information on the perception of poverty. The perceptions of poverty were determined for consistency as well as non-statistical analysis. In the interest of clarity, the example of the metric calculation for Carpinteros follows: if the number of houses (350 total) made of wood (311 of 350 = 89%), having a dirt floor (276 of 350 = 79%), no plumbing (220 of 350 = 64%), no electricity (190 of 350 = 54%), type of drinking water as boiled water (300 of 350 = 86%), less than two appliances- e.g. stove or refrigerator- (319 of 350 = 91%), asbestos roofing (330 of 350 = 95%) are determined, then these relative values for each indicator are then averaged to determine a general, relative poverty measure:  $89 + 79 + 64 + 54 + 86 + 91 + 95 = 558 \div 7 = 80\%$ .

## INDICATORS FOR VARIABLES IN THE CATEGORY RELATIONSHIP BETWEEN RESOURCE SYSTEM CHARACTERISTICS AND GROUP CHARACTERISTICS (WHICH WAS MODIFIED TO “EXTENT OF PRESSURE ON THE RESOURCE SYSTEM”)

Overlap between user group and resource location (overlap) considers the distance to the areas of resource use and resource extraction from each household or user-group. This was the general criteria named by Wade (1994) and Baland and Plateau (1996), who suggest that the closer the resource user is to the resource, the better it will be maintained. Mapping information can be provided by the local authority (property area maps) in some cases

or the parcel maps provided by government agencies, GIS or simply based on field measurements, contingent on which is most accessible. The distances should be confirmed by field distance measurements or GIS, regardless.



**Figure 3.1** This graphic represents a hypothetical AN area and corresponding gradients of overlap illustrating how overlap was assessed using a three-part measurement. The green circle represents the resource area. Each letter represents a distance in the area of interest. The letter A corresponds to low overlap between the darkest oval and the outlined circle. The letter B corresponds to moderate overlap by the medium gray oval and the letter C corresponds to high overlap in the smallest oval.

The total distance from the use-zone resource boundary (portion of the green outlined circle near point A) to the farthest political boundary (the furthest point to the right of the line labeled as A) was the outer limit of low overlap and it can extend to the outer limit of the moderate overlap boundary (Figure 3.1). Hypothetically, we can set the distance from the farthest user-group boundary (the furthest point to the right of the line labeled as A) to the midpoint of the use-zone resource area (the area represented by the position just to the right of the word Resource in the diagram) is 2.5 kilometers. This area can be marked as 'low overlap' (letter A in Figure 3.1). That distance measure can then be further broken down into segments that represent the boundary between the low overlap segment (line A) and the moderate overlap area (line B), 1.75 km. The outer high overlap (line C) boundary was defined as the equal distance of 0.83 km from the outer moderate overlap boundary (the furthest boundary of the solid green circle, to the right of the word Moderate), creating equidistant segments for each overlap segment (Figure 3.1). The distances can then be calculated to determine the concentration of the residential portion of the settlement (or use-area) that was in the corresponding segment of overlap.

Wade (1994) considered that high dependence on the resource for services, subsistence and products was important for conservation; greater dependence would encourage them to manage the resource better. Level of dependence of users on the resource can be determined by proxy in ascertaining how users depend on CPR system products (e.g. ecosystem services such as water services, raw material, byproducts). This information was determined through individual interviews, interviews with the local authorities, central governance authorities in charge of the CPR system and literature review (or all of them depending on availability). Interviewees were asked about their perception of dependence, for context. It is important to keep in mind that, since the answers to perception questions can be consistently positive, contrary behaviors might not be represented unless the perception and behavior are not separated. The reason is that one can have positive perceptions and contrary behaviors, and this should be considered. The important focus is on how much the raw resources or services provided by the CPR system factor into practice by the user-group. The frequency of responses in each of these forms the basis for the indicator value. One point was deducted from the normalized value for all respondents

who said they regularly used raw materials from the forest (like wood). A point was also deducted for those who said that they did not feel that the tree composition or density was important to ecosystem services.

Fairness in allocation of benefits (fairness) revolves around ascertaining perceptions of fairness and how any benefits are distributed (Baland and Plateau 1996, Agrawal 2003, Richie and Lewis 2003). The assumption is that it will be associated with low deforestation rates. The reasons for this are discussed by Agrawal (2003), who mentions the influence of the social and socio-political dynamic, which can result in the sustainability of "asymmetric" distribution due to established socio-political dynamics (in other words, unequal distribution may not be considered unfair, in local perceptions). For these reasons, local perceptions of fairness can be more informative than external perceptions of fairness. Questions for the interviews with participants came from literature and data provided from the Comisariado and (Merino-Perez and Hernandez Apolinar 2004, WWF 2010, CONANP 2015), and include: are there any tourism activities? Who has access to activities associated with those? Who receives PES and how is it distributed? What are the resources that are subject to allocation? How are resources and access determined/distributed? Then participants can be asked whether they consider these fair. For each question, the answer was recorded as 'considered fair' or 'considered unfair'. An average of the proportion of the 'fair' responses across all the questions was taken as the value of the indicator. The dialogue around this variable has the additional benefit of being useful in giving context for future incentive development and strategies to enhance local management. It can also be empowering for the local managers to voice their perceptions, particularly where relationships are problematic between levels of managers.

Low levels of user demand (low demand) was determined based on the use of forest resources as well as the demand by activities and households for the forest resources, as interpreted by the criteria established by Agrawal (2003). For example, how many households and common activities require the use of wood material? This was determined by interviews with participants and data provided from the Comisariado and literature (Merino-Perez and Hernandez Apolinar 2004, WWF 2010, CONANP 2015). Some examples are: How many households use wood for fuel and how often? How many households regularly use wood materials for building (sheds, fences, housing, additions, furniture)? A point-system was used for this variable where the AN started with 100 points and each negative response resulted in a point deduction (-1). This approach had similar results to the protocol of averaging the affirmative responses, as both were attempted. This approach seemed to more realistically represent the actual impact of demand as it made the statistical analysis more sensitive and calibrated more closely to the field results in the model. The expression for this variable was yes or no.

## INDICATORS OF VARIABLES IN THE CATEGORY INSTITUTIONAL ARRANGEMENTS

Rules are simple and easy to understand (REU) is an important factor in rule adherence and thus in successful conservation. This variable was suggested for the critical list by Baland and Plateau (1996). They focus largely on rules that have some bearing on the socio-cultural and socio-economic constraints of the local user. The premise for this variable is that the simpler and easier to understand the rules are, the greater the likelihood they will be followed (Baland and Plateau 1996). So it is important to determine whether the rules governing a particular CPR system are, in fact, easy for local users and managers to understand. The indicator can be operationalized through a straightforward series of questions to capture the level of awareness and comprehension of the rules on the CPR system use and management. For example, what are the rules (this is also best verified at all levels of governance involved in rule-making and enforcement)? What do they mean (also best to verify at the various management levels for consistency)? Why are these particular rules in place? Are they easy or difficult to understand? It is useful to develop context and verify that the rules are known and how they are understood to ensure that any affirmative answers are both true in perception and practice. The measure for this question is the



extent of agreement to the direct question of whether the rules are easy to understand. The context is important to inform future strategy and in determining potential weak points in the rule structure in the descriptive element of research and reporting. This because there was consistent understanding and reciting of the rules, and was determined after data collection and coding. The answer to the question 'are the rules easy to understand' was expressed as yes or no, and the score was taken as the percentage of 'yes' responses. .

The locally devised access and management rules (LDAMR) variable was developed by Ostrom (1990, pp. 93) primarily and was supported by Wade (1994), Baland and Plateau (1996) and Agrawal (2003) for inclusion in the critical list. Ostrom (1990) explains that an external framework of rules can be helpful in maintaining the commons as long as local managers are involved in modifying them due to local needs and situational nuances as CPR systems change over time. This point of view is echoed by the others. They also agree that rule compliance is more likely if local users and managers have had a part in making the rules. The metric for this variable can be determined by looking at the current rules pertaining to the CPR system and determining how the current rules take into account any past local rules and/or whether the local managers have had any involvement in the development of the current rules and whether they feel the rules represent their needs or concerns. This variable was operationalized by looking at the reserve rules and how those were imposed, enforced and/or modified by the Asamblea. The questions were designed to assess how much influence the Asamblea had on the reserve rules and their implementation, taking into account that the rules were made and imposed by the Reserve Commission (CONANP) during the creation and later expansion of the reserve. The subjective value was determined through participant questioning in a Q and A session during the interviews with regard to their perceptions on the rule making agencies and current rules. The questions were as follows: Does the Asamblea/Comisariado have any influence on the reserve rules for your area? Of the current rules for the area of the reserve corresponding to your AN (and those were mentioned specifically), was the local authority involved in devising or modifying those rules? There was a three part process to determine the final normalized percentage value for this variable. The affirmative responses were averaged for each question and the averages for each were then averaged for the normalized percentage value. Then, the four-person Comisariado also participated in this line of questioning separately and their views also influenced the final score. A point was deducted from the interview average for each instance where the Comisariado voiced opposition to a given rule or management restriction. The expression for this variable was also a yes or no.

The context for the indicators for ease of enforcement of rules (easy enforce) was taken from Ostrom (1990). She discusses the importance of a norm of rule following having observed in her own work and that of other CPR researchers that if the majority follows the rules, more widespread and long-term compliance with rules is common. She also noted that social pressure is a significant factor in enforcement. Baland and Plateau (1996) also spend a great deal of time discussing the normative aspect of rules and how social pressure has an impact on ease of enforcement. In many cases, the rules have been established for some time so that it is possible to measure how easily the rules have been enforced in the past. There is a sort of inherent time factor in this variable as ease of enforcement is indicated by how often rules are broken and when they are, whether there is a positive or negative social effect. There were no exact figures with regard to rule breaking, but the tendency or an approximate percentage of the population considered to break rules was discussed, as well as perceptions on whether it was difficult to enforce them, as estimated by respondents in the interviews. The Comisariado has a loose record of who breaks the rules each year based on the experience of the Encargado de Orden (Keeper of Order) and this was discussed with the Comisariado and Asamblea. This was then checked by consulting the enforcers. So the score for this indicator was determined by looking at the subjective assessment of the local authorities and decision-making group (which includes the enforcers) in their answer to the question, are the rules easy to enforce?

The context for the indicators for graduated sanctions was also taken from Ostrom (1990) who based her conclusions largely on the work of Margaret Levi (1988). Levi (1988) talks about the contingent element of participation inherent in compliance with rules in a cooperative system. She found that “strategic actors” were compliant with a set of rules when two conditions were met: 1) There is a general perception that the collective objective is achieved and 2) that there is a general perception that compliance is common in the group. Levi found that enforcement enhanced the perception of legitimacy as well as compliance. Graduated sanctions act as an incentive to comply in what Levi (1988) termed a quasi-voluntary activity because it is the decision of the individual to comply based on whether they believe they will be caught. This could also provide some context for ease of enforcement of rules. However, it is foundational to the graduated sanctions that have the potential to strengthen rule adherence. If enforcement does not take into account circumstances (poverty, need) and the same punishment holds for singular as well as repeated rule-breaking, the legitimacy of the rules is called into question and compliance is less likely (Ostrom 1990). The presence of graduated sanctions was determined through direct questioning of the participants in the Asamblea and the Comisariado, as to whether it is the practice of the AN authority to use graduated sanctions and what the criteria are for determining the degree of graduation. It should be noted that the criteria for graduation of sanctions was for descriptive rather than statistical purposes.

The availability of low-cost adjudication (ALCA) was determined based on Agrawal (2003) and Ostrom (1990) definitions of what this means-- whether there is a system in place to help those who need formal conflict resolution that is either free or otherwise not cost prohibitive. The participants were asked if they had access to the Asamblea for adjudication of conflicts and it was taken into account whether they were certificate or non-certificate holders. They were also asked if there were external agencies that provided adjudication for conflicts, what they were and whether there was an associated cost. Thus the metric for this variable was the average of the affirmative answers to the two questions as to whether low-cost adjudication existed for conflicts that require adjudication by the Asamblea/Comisariado and external agencies.

Accountability of monitors and other officials to managers (accountability) was addressed by Ostrom (1990) and Baland and Plateau (1996). They all discuss the importance of an accountability structure to enhance compliance with rules as well to provide a sense of legitimacy to the process and the governance structure. The indicators were determined by asking what conflicts with monitors and other officials with regard to the forest care and management have there been and how transgressions and crimes were processed, as a baseline. Interviewees were also asked whether they felt that these outcomes and governance provisions were sufficient to provide accountability and, if not, what might be more efficient. The multi-indicator protocol was followed for the question of whether they believe that there is accountability of monitors and other officials to managers and a point was deducted from that value for each instance where the Asamblea members voiced a lack of accountability, a rule that created impunity or a lack of procedural accountability. The final expression for this variable was also a yes or no.

## **INDICATORS FOR THE VARIABLES IN THE CATEGORY RELATIONSHIP BETWEEN RESOURCE SYSTEM AND INSTITUTIONAL ARRANGEMENTS (MODIFIED TO: “EXTENT TO WHICH RULES ARE BASED ON ECOSYSTEM POTENTIAL”)**

The ‘match restrictions on harvest to regeneration’ (MRHR) is discussed by Ostrom (1990), Wade (1994) and Ostrom et al. (1994). In the latter, they devote an entire chapter to the different kinds of restrictions that are possible in the rules governing CPR systems. Their focus is on irrigation, though other systems are discussed throughout the book, taking this variable into consideration in its inherent importance in CPR management. This is an important variable to sustainability based on the reproductive and regenerative limitations inherent in any

CPR. This is an intuitive and obvious measure of sustainability as over-harvesting necessarily ensures damaging the potential of the resource base. The measure here is to determine whether the restriction on use and extraction in fact match the reproductive or regenerative needs of the natural resources in the CPR area. It is necessary to seek current information regarding the regenerative needs of the system and compare this to the off-take implied in the management rules. The questions become: Are there restrictions on harvest that take into consideration regenerative needs (Yes/no)? Do those restrictions match CPR regeneration needs (Yes/no)? The indicator of the 'match restrictions on harvest to regeneration' is then the extent to which both these questions have affirmative answers (average of the two sets of answers). The expression for the data was also a yes or no for this variable.

## INDICATORS FOR THE VARIABLES IN THE CATEGORY EXTERNAL ENVIRONMENT

Low-cost exclusionary technology (LCET) was highlighted in its importance to CPR success by Wade (1994). This refers to any technology that aids in the enforcement of rules and protecting the resource-base. This can be represented by fences, specialized fishing nets, water catchments or any number of other protective technologies which can be simple or complex but that have a low cost to users/managers. It was straightforward in the study area as the only technology to be considered was fences. The indicator includes both presence/absence of fences as well as maintenance issues (what percentage of the fence was in disrepair and whether they have the resources to fix it and monitor it). The presence of a partial fence would not act as exclusionary, and it was found that all the Ns had issues with the continuity and condition of the fences. The score was based on the frequency of responses indicating the presence of fencing, with a point deducted every time it was mentioned that a particular section of fence was in disrepair, and an additional point where it was known that this had been so for at least a year.

Supportive external sanctioning institutions (SESI) were measured by whether there were external agencies that provided financial, enforcement and monitoring support as described by Balland and Plateau (1996). They argue that external agencies provide further pressure to induce cooperation by local managers. External agencies are particularly pertinent since this study was conducted in an externally established protected area, the MBBR. There are two aspects of this variable that are worthy of inclusion. The first is whether the local managers are aware of pertinent external agencies and who they are. The second is the perception of whether the agencies were supportive in local governance, conflict resolution and rule determination. Because not all participants will be aware of all agencies it is not practical to count the answers where participants were unaware of particulars of the participating agencies and consider this to be negative. The value for the indicator of this variable is therefore the extent of agreement on the presence/absence of supportive external agencies. The answers to the question 'are there supportive external agencies' were coded as yes/no, and the score was the percentage answering 'yes'.

Central government should not undermine local authority (CGSNULA) was first a DP (Ostrom 1990) and was supported for inclusion by Wade (1994). Ostrom (1990) discusses the importance of the legitimizing of local authority in rule-making and enforcement by central governance institutions as an important element of long-term sustainability of management practices, while aiding in enforcement. Wade (1994) echoes this argument. Indicators for this variable are potentially both historic (including short-term) and perception-based. The line of questioning to elucidate the indicator for this variable revolves around the local authorities' and practitioners' perception as to whether the central governing institutions respect local rules, practices and enforcement. The data from the 'rules are easy to understand' variable is helpful here to establish what the rules are and to provide a basis for comparing local and external rules along with the data from supportive external sanctioning

institutions. The line of questioning centered on the Comisariado and Asamblea perception as to whether the central governing institutions respect local rules and practices (yes or no). Both levels (Comisariado/Asamblea and CONANP/SEMARNAT) were also asked if there are frequent conflicts regarding local authority, how those conflicts were resolved (were the local authorities consulted and respected) and whether each side felt the conflicts were properly managed (yes or no). The point system was applied here where the affirmative responses of the questions on respect of local authority by central government agencies were averaged and then a point was deducted for each instance where they (Comisariado and the Asamblea members) felt the negotiations were improperly managed to the degree that they were in direct conflict with the local authority and established local practices.

Appropriate levels of external aid (ALEA) was integrated by Baland and Plateau (1996) and speaks to compensation where opportunity costs impact the willingness and ability of local managers to participate. This needs to be measured by interviewee perception, mainly, since "appropriate" is essentially a subjective measure. A numeric value of money-aid provided by a given organization (where applicable) and resulting compensation for conservation activities was determined by consulting the fund providing agencies as well as the Comisariado to determine what aid has been provided and to corroborate. The main question was whether interviewees felt that the amounts of aid were sufficient to compensate for conservation activities- whether it be in monetary or other forms (yes or no). The indicator value was obtained from the frequency affirmative responses to that question.

The nested levels of appropriation, provision, enforcement and governance (NLAPEG) is one of Ostrom's (1990) DPs and she considered it one of the most fundamental. Her very simple breakdown of the context for this variable is that "establishing rules at one level, without rules at the other levels, will produce an incomplete system that may not endure over the long run." It is important to note that the previous variable speaks to the importance of congruence in the levels and rules governing the nested levels so that this variable does not stand on its own without the former. The variable is measured in terms of the presence or absence of hierarchical governance structure in practice and as assessed in interviews and literature (Ostrom 1990, Merino-Perez and Hernandez-Apolino 2004, Vidal 2013). The institutions responsible for rule-making are noted and documented (see Chapter 2). A list of the rules for forest conservation and management were then discussed with local and external authorities, for corroborative purposes. Ostrom (1990) provides a certain amount of focus on the rules at each level as indicators for this variable. Thus, the different layers of rules can also be used as evidence (and indicators) for the nested layers in accordance with the various authorities. The institutions responsible for rule-making have been noted and documented in the data for variables discussed earlier, including: central government should not undermine local authority (since one must determine where the central government's institutional authority lies as well as what the local authorities are), supportive external agencies (as these would be researched and listed and are pertinent to this variable), appropriate levels of external aid (as some of these agencies may be involved in enforcement and support but may be different from the previous two variables), availability of low-cost adjudication (some of the institutions or actors involved may influence any or all of appropriation, provision and governance but not be found in the previous variables) and accountability of monitors and other authorities to users. Specific questions regarding the State, Federal and international rules can be asked to determine whether and how these rules are incorporated into the local management strategies, enforcement, provision and appropriation in the use and management of the CPR. When informing strategies, it is important to gain insight into the perceptions of nested levels since the level can exist but if it is not present in the decision-making system (management perception) the influence may be very limited. For this reason, it may be pertinent to review questions to the local authorities regarding these rules, for example: who makes the rules? Where do the different rules come from (possible answers: Comisariado at the AN level, state SEMARNAT,

CONANP at the federal and even UNESCO at the international level)? How are the different levels of the rules determined and at what level? These questions were posed to obtain the local authority perception and awareness of the origin and purpose of some of the rules. They were also asked how the state and federal rules are incorporated into the local management strategies and enforcement. The responses were averaged for each question and then the values were averaged as in the multi-criteria examples above.

It was interesting and rather useful that a number of indicators worked for more than one variable. For example in the case of 'locally devised access and management rules' (LDAMR), the answers to the question of who makes the rules also reflects the position of central government and its respect for the local authorities, which as I found when doing interviews, speaks to respect and support demonstrated by central governing bodies. Appropriate levels of external aid are related to poverty and perceptions of poverty, and this was reflected in lines of conversation that focused on needs in general and on the need for offsetting the opportunity costs of conservation. For the nested levels of appropriation, provision, enforcement and governance, information gathered from some of the previous variables were useful: Central government should not undermine local authority (since one must determine where the central government's institutional authority lies as well as what the local authorities are), supportive external agencies (as these would be researched and listed and are pertinent to this variable), appropriate levels of external aid (as some of these agencies may be involved in enforcement and support but may be different from the previous two variables), availability of low-cost adjudication (some of the institutions or actors involved may influence any or all of appropriation, provision and governance but not be found in the previous variables) and accountability of monitors and other authorities to users.

## DATA COLLECTION METHODS

The data collected in this research were both qualitative and quantitative, as discussed earlier in the chapter (see Table 3.2). The data were used to obtain values for the indicators for each of the AN, as measures of the variables in the critical list. Semi-structured interviews were the primary form of data collection, while ethnographic observation, purposive conversations, literature and forest cover data were also utilized in this study.

## SEMI-STRUCTURED INTERVIEWS

The main method used to collect data was the semi-structured interview, administered to the head of each household in the sample. This interview was designed to gather data regarding basic household demography, economic characteristics, the participation in forest activities of each family, and information on forest use.

Surveys contained questions designed to gather the information needed to quantify the indicators for the variables. Because this research was focused on forest management, sampling aimed at finding both individuals involved in forest management decisions and individuals who are not authorized to make such decisions. Women were not directly targeted, as men in the study area principally perform forest management activities, however their participation was taken into account and noted, particularly as it is relevant to local norms, which is one of the variables included. The sample used for this study was not probabilistic and was not designed to statistically represent a general population beyond that of the comparison of the communities themselves. It was chosen as a common approach to case studies, to measure the same information in each community, and with the expectation that patterns would emerge once compared.

The collection of data used informant recall for many of the questions, such as area boundaries, forest product use, past successful experiences and regulatory guidelines. Informant recall is a widely used method of data collection in anthropology (Stepp 2002). Most households that provided information do not keep written records,

so responses to such interview questions may not be entirely accurate. In some instances, respondents indicated that they could not accurately remember specifics, such as the exact boundaries, or how many years they had been reforesting but had a general idea (which for the purposes of this study is sufficient in terms of the consistency among respondents). Overall, responses among heads of household do illustrate general trends and ranges within answers to questions that allow for reasonable probability values (75-90%).

## INTERVIEW INSTRUMENT AND PROCEDURE

Two interview instruments were designed for this study— one for the AN authorities (Comisariado) and one for the residents. The interview for the AN authorities consisted of 60 questions regarding AN demographic information, participation, rules and administration and programs and interventions for forest maintenance as well as a section on norms. The interview for heads of household consisted of 40 questions designed to elicit economic, demographic, institutional, and management history information. The instrument included a mixture of closed and open-ended questions. Closed questions provided demographic information about interviewee households and forest management practices. Open-ended questions involved perceptions about norms and leadership qualities, as well as information about forest activity participation of individuals and households (see appendix for the questionnaire forms).

Interviews were conducted in person with heads of household (or in their absence, another member of the household). All interviews were carried out in Spanish. Most interviews took place at participants' houses, but several were conducted in the Comisariado and in participatory mapping workshops (see below). A large majority of the interviews were recorded on a worksheet developed to make the interviewing process easier, and these worksheet responses were immediately transcribed following each day's round of interviews.

## SAMPLING PROCEDURES FOR RESPONDENTS

A total of 204 interviews were conducted; of those, 50 interviews were carried out, in each of the 4 AN. The interviewees were chosen based on willingness to participate in the study and whether or not they participated in the Asamblea (the sample included both certificate-holders and non-certificate holders). Participants were made aware of their rights as participants in a scientific investigation. In addition, interviews were held with the village authorities to obtain general information. Interviewees fell into three categories: 1) heads of household who participate in the Asamblea (20 per AN), 2) heads of household who are authorized to participate but do not (20 per AN) and 3) heads of household who are not authorized to participate (10 per AN). Each Comisariado was also interviewed. Because of cultural norms, predominantly men were interviewed. The ages of interviewees ranged from 19 to 78.

## PARTICIPATORY MAPPING WORKSHOPS

Four participatory mapping workshops were held in which members of the AN discussed and completed maps of their lands, forests etc. The workshops lasted 2 to 4 hours to enable participants a window of time to arrive. The purpose of these workshops was to stimulate dialogue around forest conservation and management, as well as to determine the consistency in understanding the boundaries from the local managers' perspective (Chambers 2008). The maps were used to note the consistency or differences in the perception of physical boundaries, catalog and corroborate of livelihood and sustenance activities, corroboration of the different activity and non-activity areas (ex. orchards, Oyamel stands, reserve zones) and to open dialogue about rules and enforcement.

## PARTICIPANT OBSERVATION

Participant observation was utilized to validate qualitative and quantitative data collected through other methods, to build trust among participants, and to generally help with understanding the meaning of data gathered. I spent time with participants in participatory mapping workshops, reforestation activities and I was able to observe the Asamblea itself. This method of data collection proved to be valuable in that it provided visualization of what activities people do in and with the forest that could have never been accurately described in an interview setting. Particularly important information gathered through this method included specifics about forest management and physical geography of the forest areas that only became apparent once I had visited in person. Participant observation allows the researcher to observe what people do, while other empirical methods are limited to evaluating what people say they do (Gans 1999).

## JUSTIFICATION FOR THE SELECTION OF THE SAMPLES

In this instance, the case studies have been selected to reflect the criteria outlined in Agrawal's (2003) work, as described in chapter 2. Purposive sampling was used to select AN that have been apparently successful in efficiently managing their forest, as determined by experts (Perez et al. 2011, CONAFOR 2012) and that were willing to participate. The underlying idea was to test whether these cases, all of which are known to have been relatively successful, in fact comply with the critical list of variables, and which variables seem to have the most effect. The criterion for 'efficiently managing their forest area' was, as explained in chapter 2, 'low loss of forest cover: < 0.03%'.

Further, it was determined that two indigenous communities (ICs) and two ejidos would be selected, in part based on Bonilla-Moheno et al. (2013) findings that indigenous communities (IC) manage their resources more efficiently than ejidos. And their assessment of whether this land tenure distinction influences the efficiency will be made.

Clearly the larger the sample, the more broadly applicable the results can be. However, in this study there were limitations of time and resources and it was decided that four cases was the maximum that could be covered in the thesis work. The AN were all within a relatively small geographical area and have many similarities, meaning that the results, if not generalizable to the whole world, may be relevant for the rest of the area, and therefore important for management of the Biosphere Reserve. The results, with this proviso, will add to the base of scientific literature on community resource management, as has been requested by researchers in the field (Agrawal 2003, Baggio et al. 2016, Barnett et al. 2016).

## FOREST COVER CHANGE MAPPING AND ANALYSIS

This approach consists of several steps using both ArcGIS and Google Earth Pro, all of which are available in the ArcGIS desktop resource (<https://desktop.arcgis.com/en/arcmap/latest/get-started/introduction/arcgis-tutorials.htm>) and the Google Earth Pro manual (<https://earth.google.com/intl/ar/userguide/v4/index.htm>), available online. The first step includes the use of Google Earth Pro Landsat imaging. The geographic location for image selection references the federal land registries Agrarian National Registry (RAN), the Pattern and History of Agrarian Nuclei (PHINA) and records from location coordinates from researchers at the National Autonomous University of Mexico (<http://phina.ran.gob.mx/phina2/>). Images within the border coordinates for each AN during the wet season were then reviewed to ensure no cloud cover and to be of a high enough visibility to determine forest cover (Ramirez-Herrera and Navarrete-Pacheco 2012). Images from 2006, 2010, and 2015 that were chosen as this period provided a baseline after the initial period of adjustment and logging events that were significant to

the forest cover story for the Reserve from 2006 to 2010 and then from 2010 to 2015 when different interventions were implemented (Vidal et al. 2014).

These geo-referenced (GEP) images were then inserted into ArcGIS. The three GEP images for each AN (2006, 2010, and 2015) were selected using the "Premium Quality" option, providing images with a fixed size of 4,800 by 3,225 pixels using three bands (RGB). All the images of the study areas were captured using the same fixed size to obtain a consistent level of detail. The images were north-oriented and set to vertical view. The terrain distortion caused by the topography was removed by unchecking the 'Terrain' box in the layers panel before the captures were made to minimize distortion. The image display was set so that it filled the screen for greater detail capture. The image was then rectified and saved as an Imagine image.

An accuracy validation was then performed using field data (groundtruth) for each AN compared to RAN/PHINA (classified data) using the confusion matrix feature in ArcGIS. Randomly generated assessment points were used to determine the validity of both sets of coordinates. The sampling strategy selected was 'stratified random'. One set of random points (assessment points) were generated from the groundtruthed-data. These were inserted into the confusion matrix with the target field setting set to groundtruth. The groundtruth field was populated with the field data value while the classified field was populated with a null value (-1) to calibrate. Then table was updated to include the value of each point based on the classified data, which was used to compute the confusion matrix. The result informs the validity of the coordinates.

Once the accuracy assessment was completed, the following process was followed to produce maps of forest cover change using the forest cover data and presented in two periods: 2006 to 2010 and 2010 to 2015. Six categories of forest cover change were established to represent the three general loss categories (1 to 2 or dense forest to degraded forest, 1 to 3 or dense forest to non-forest, 2 to 3 or degraded to non-forest) and the three general growth categories (2 to 1 or degraded forest to dense, 3 to 1 or non-forest to dense forest, 3 to 2 or non-forest to degraded forest). ESRI shape option was chosen in ArcMaps using the same dates for both the original images and Imagine images and borders were removed in GEP. The measurements were changed from universal measurements to meters for greater ease of analysis. Visual interpretation relying on was then used to determine what areas fell into the forest cover change categories. The three basic categories of forest cover were determined, 1) dense forest, 2) degraded forest, and 3) non-forest. From there, six categories of forest cover change were established to represent the three general loss categories (1 to 2 or dense forest to degraded forest, 1 to 3 or dense forest to non-forest, 2 to 3 or degraded to non-forest) and the three general growth categories (2 to 1 or degraded forest to dense, 3 to 1 or non-forest to dense forest, 3 to 2 or non-forest to degraded forest). Classifications used standard pixel-based maximum likelihood method and an object-oriented classification, based upon the two following steps. First, a region-growing algorithm-based segmentation was performed. Two parameters, "similarity" and "area", were used to control the segmentation procedure. To clarify, "similarity" is a threshold value that determines whether two neighboring objects are merged, while the "area" threshold is used to filter out the objects smaller than the established value (Bins et al. 1996). This segmentation was used to ensure greater precision in the determination of areas that fall under the same criteria. Second, a set of classified images was then produced using the same parameter "area" and a range of values for "similarity". Subsequently, whole objects were classified (where pixels of each object are assigned to the class occurring most frequently) using pixel-based classification. The areas corresponding to the particular categories were classified by creating bordered and labeled polygons that were color-coded to correspond to a given category for easier distinguishability (for example red corresponded in all maps for 1 to 3 or dense forest to non-forest). The image was enlarged using the zoom function to pinpoint the degree of forest cover and the borders were carefully established in the editor function to ensure precision for each area of forest cover change. Polygons were then



formalized in the digitizing process in ArcMaps and saved as a .shp file. Then the maps were saved as an image, the legends and the reserve boundaries were added and then saved as a PDF. These steps were repeated for all maps. All the data files that were used in ArcGIS are available in supplemental materials (S1).

## STATISTICAL ANALYSIS

Three statistical analyses were applied to the data represented by the independent variables. First Spearman's correlations were used to determine whether, and to what extent, each independent variable could be related to the dependent variables. Secondly, a LASSO (Least Absolute Shrinkage and Selection Operator) regression was applied, in which the independent variables which together best explain each dependent variable are identified. Both analyses used the R statistical software. They were chosen because the study is based on a large number of variables but a small sample, for which non-parametric statistical methods are well suited. The third is a MANOVA (multivariate ANOVA) to determine whether there was a statistical difference in land tenure type, between ejidos and indigenous communities.

### SPEARMAN'S CORRELATION

Spearman's correlations were conducted to detect correlations between the individual independent (explanatory) variables and the dependent variables, or outcomes (the forest cover change measures). Spearman's correlation coefficient is a statistical measure of the strength of a monotonic relationship between paired data, and also referred to as a Spearman's rank correlation; it measures the strength and direction of association between two variables by comparing the order in which they are ranked. For this reason it was chosen, since the data for this study require non-parametric and non-linear analyses. The Spearman correlation coefficient,  $r_s$ , can take values from +1 to -1. An  $r_s$  of +1 indicates a perfect association of ranks, a  $r_s$  of zero indicates no association between ranks and a  $r_s$  of -1 indicates a perfect negative association of ranks. The closer  $r_s$  is to zero, the weaker the association between the ranks. The Spearman's test provides a measure of significance of the  $r_s$  values calculated.

### LASSO REGRESSION

The LASSO analysis is a relatively new approach that was presented by Tibshirani (1996) as an alternative for analyzing data sets with small samples and numerous variables. It is also referred to as a 'sparse regression' because it eliminates variables with low or no influence on the dependent variable and can fit models with small sample sizes. Generally, this method performs both variable selection and regularization to enhance the prediction accuracy and interpretability of the statistical model. The LASSO regression is designed to cope with two issues found in a multiple variable linear regression: the trade-off between variance and bias and the variable selection. When there are many more observations ( $n$ ) than parameters ( $p$ ) in a linear regression, the estimates of the model will have low bias and variance. However, when  $n$  is closer to  $p$ , variance of the estimates increases. If  $n < p$ , the least squares approach cannot be used as this causes the variance to increase to infinity. LASSO corrects for this by forcing the sum of the absolute value of the regression coefficients to be set to zero. LASSO does this by imposing what is termed a "penalty constraint" (under a specified, fixed value), which pushes the coefficients towards or to zero, dropping those that hit the zero threshold from the model. Thus, it effectively chooses a simpler model that does not include those coefficients. In this way, the LASSO method produces an easier-to-interpret model by eliminating a number of predictor variables. LASSO will be used to model the relationship between each of the six forest cover change categories and the relevant variables from the critical list. The 'glmnet' package in R software was used to perform the LASSO regression, as specified by Hastie et al. (2015).

The results from LASSO that will be reported are the regression coefficient and the R2 value. The regression coefficient is calculated and interpreted in a similar way as more common regressions, however because of the penalty constraint pushing the values towards zero, it is most informative in terms of directionality (sign) and numeric size relative to the other coefficients in the same category. The other output reported for this study is the R2 or deviance ratio.

The general R2 equation for LASSO is:  **$R^2 = 1 - \text{deviance}/\text{null deviance} = \text{deviance ratio}$**

The deviance ratio or R2 equation for LASSO is simply the comparison of the null model and data model to express the individual weighted influence of influential variables. In other words, we are able to quantify the direct effect of adding the selected variables to the model. The deviance of the selected model alone provides a value for how far the data deviate from a saturated model (the perfect fit), so smaller is 'better'. However, it does not illustrate how much information the individual variables are contributing. By looking at the R2, the comparison of empty (null) to selected (data) model, it is clear how much information is added by the data. In other words, it is informative for this study to provide this value indicating the influence of each significant variable on each forest cover change period.

It should be noted that LASSO does not produce a probability value (Lockhart 2014). Instead, it is minimizing the standard error (Hastie et al. 2015). Because of this, the deviance ratio is not interpreted like the R2 in conventional regressions because the deviance ratio essentially performs two functions. The first is to highlight the variable or cluster of variables that impact the model so that it is more the register of significance rather than the magnitude of significance, similar to the way the regression coefficient is interpreted in directionality and not in magnitude in LASSO. This output is provided based on the final ratio of impact of significant variables after all were tested against the null and the data model. The second is to show the difference in influence based on the difference in relative numeric influence among variables in a given category. The differences can be nominal but because they are manipulated by the penalty constraint, it is more a measure of the relative influence any variable reported exerted influence on the model for a given category of dependent variable, and it is useful to consider all influential variables after the penalty constraint is applied (Wainwright 2006). It should also be mentioned that because they are being compared individually, the outputs cannot be summed and the collective influence of a cluster of variables can have an emergent impact not apparent in their individual deviance ratio values (Wainwright 2006). Regarding the p-value, LASSO can predict the outcome but the constraint limits the model's ability to produce a probability due to the need to compare the value of interest to a known distribution of possible values (Xu et al 2008). However, currently there is no accepted method for determining a p value due to the penalty constraint that is responsible for the shrinkage that provides a simpler and more informative model. However, it is still a method that reacts well to sensitivity tests and is consistent when tested repeatedly (Puhl 2012, Xu et al. 2008).

## MANOVA

The multivariate analysis of variance (MANOVA) will be employed to compare multivariate sample means. The MANOVA will compare whether or not the newly created combination differs by the different groups, or levels, of the independent variable. This analysis tests whether the independent grouping variable simultaneously explains a statistically significant amount of variance in the dependent variable, categorized by land tenure type. The independent variables will be combined (critical variables for the two ejidos and then for the two ICs) and dependent variables (forest cover change categories) combined for each of the two groups (ejido vs. IC)-- to determine whether there is a statistically significant difference between the two land tenure types. Next follows Chapter 4, which provides a detailed overview of the ANs.

# CHAPTER 4: STUDY SITES/SITIOS DE ESTUDIO

## RESUMEN DEL CAPÍTULO

En este capítulo, se explora la operacionalización de las variables de la lista crítica, dando contexto teórico para los indicadores y métricas para su medición. Enseguida, los cuatro NA se presentan con los detalles demográficos basados en la lista crítica. También se presentan cuadros con los resultados de la operacionalización y la metricalización de cada variable. Ambos tienen sistemas de manejo de recursos en los que tanto los miembros certificados como los no certificados pueden acceder a los recursos naturales para su consumo y sustento, aunque sólo los miembros certificados tienen derechos formales sobre la tierra y su uso. La toma de decisiones se realiza a través de una Asamblea que consiste exclusivamente en miembros certificados y existe un organismo central llamado el Comisariado, que consiste en tres miembros: el Comisario, el Secretario y el Tesorero. Los detalles novedosos para cada comunidad se presentan en detalle según los análisis de lectura, demográficas, y las entrevistas y conversaciones.

## INTRODUCTION

This chapter discusses the context of the forest management and critical variables around the central actors in the study– the agrarian nuclei. First, the land tenure will be discussed in short detail in the first section that briefly lays out the context of the land areas of the AN and their decision-making structure. Then the operationalizing of the variables in the critical list is discussed. From there, the chapter is broken into sections pertaining specifically to each individual AN. For each AN section, the results of the interviews/surveys are presented as this forms the foundation and context for the subsequent statistical analysis, presented in Chapter 5. Lastly, the forest management strategy and literature review for each AN, which speaks to the importance of forest cover change as a simple indicator for management success in the context of this study.

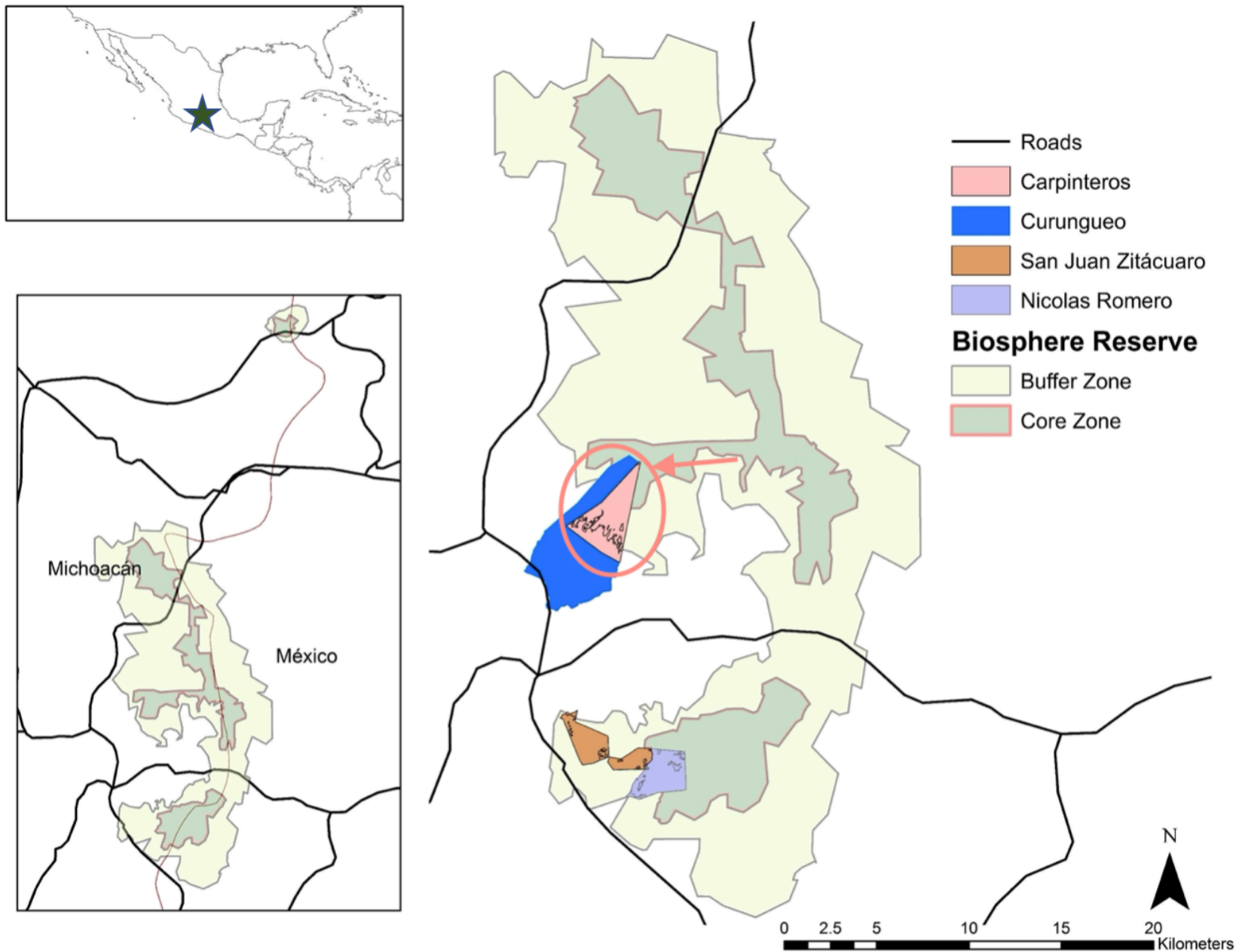
Two indigenous communities (IC) and two ejidos participated, whose land tenure definition is explained in Chapter 2. There are a number of similarities and some differences between these types of land tenure. The IC and the ejido were a means of giving land a federal qualification. The similarities between the two are actually many and both are considered to be ‘agrarian nuclei’ (AN). Both have systems of resource management in which both certified and uncertified members can access the natural resources for consumption and livelihood, although only the certified members have formal land rights. There may be 50 to 300 households with certified membership (i.e. land rights) within an AN. Alcorn and Toledo (1998) refer to such households as “user-manager(s) of a set of resources that belongs to everyone in the community”, but this ignores the fact that within the total population there are many families that do not include certified members (Table 4.1); the resources belong only to formal members. Certification and inheritance of rights are managed by these community members as are conservation and land-use strategies. Decision making is done through an Asamblea which consists only of certified members and there is a central management body called the Comisariado, which consists of three members, the Comisario (President), the Secretario and the Tesorero (Treasurer). Beyond these, there are further similarities and differences that are apparent as the AN are explored in greater detail. This chapter discusses in greater detail all of the established characteristics of the four cases selected for the study.

**Table 4.1. Comparison of certain demographic and area data for each AN.**

Name	Type of AN	Area ha	Num. households	Num. certified rights holders	Forest Area ha
Carpinteros	Indigenous Community (IC)	800	350	218	600
San Francisco Curungueo	IC	2275	493	280	440
San Juan Zitácuaro	Ejido	1465	425	213	1397
Nicolas Romero	Ejido	959	440	285	959

## CARPINTEROS, INDIGENOUS COMMUNITY

Carpinteros is located in the municipality of Zitácuaro with the geographical coordinates of 19°N 29' and 100°19' 0" W , 2220 m above sea level. The total area of the IC is approximately 800 ha of which more than half falls inside the reserve, partly in the core and partly in the buffer zone areas of the Reserve (300 ha and 260 ha respectively), with 40 ha of forest completely outside the Reserve. The forest area is thus approximately 600 ha, while 200 ha are used for agrarian activities.



Map 4.1. Map of the MBBR with Carpinteros identified.

## HISTORY AND DEMOGRAPHICS

The formal history was unknown by the respondents but it was suggested that it was founded around 1950 or before but was not registered with PHINA until 1982. There was very little information online with regard to this and conflicting information, otherwise. There are 218 comuneros with agrarian certificates (140 active in the Asamblea, of which 134 are men and 6 are women). In total there are 350 families in the IC and a total population around 891 people, 433 of which are male and 458 female. The population consists of approximately 437 minors and 454 adults, with 80 of them being 60 years and older. Those who are not comuneros are family members of comuneros. It has no manzanas or parajes due to its small size. There is a great deal of social cohesion in this community which should make norms and rules much easier to enforce, according to CPR research. The community leader is very charismatic and it is clear that while not all of the community members find him agreeable, they all have a great deal of respect for him. It should be noted that I went back to speak with the community about the results in October 2015 and the leader had changed. However, the previous leader was still very involved in community development projects and was working closely with the newly elected leader to maintain the projects in progress as well as aiding in developing new ones.

## INDIGENOUS POPULATION OF CARPINTEROS

Fourteen inhabitants of Carpinteros live in indigenous-language speaking households where eight of the citizens 5 years and older speak an indigenous language as well as Spanish. This is according to the public record. Several

of the interviewees mentioned understanding Mazahua but not speaking it and/or having a relative that understood or spoke it. Many also mentioned a stigma attached to speaking the indigenous languages. Their identity centers around three categories: indigenous, mestizo, and Mexican. Some households identify as indigenous even though there may be no indigenous language speaker in the household (6). Those who do not, tended to consider themselves both mestizo and Mexican (27).

## GENERAL ECONOMIC CONDITIONS

Of the 350 households, Carpinteros has approximately 272 dwellings. According to the 2014 National Census, of these households 189 are common houses or apartments, 83 have a dirt floor and 7 have only one room. Sanitation varies as 168 of households have water-based bathroom installations, and 170 are connected to the public water supply. 180 households have access to electricity. There are no households with a computer, while 43 own a washing machine and 151 households are equipped with one or more televisions. The majority have asbestos roofing and building material ranges from wood to adobe to concrete. Many structures have a combination of building materials.

Orchards are a common livelihood activity where they produce avocado and peach. Other domestic cultivates are produced mainly for personal consumption, like maize and beans. Large livestock is prohibited but some families have pigs, turkeys and chickens. There is an oyster mushroom (*Pleurotus ostreatus*) production activity which some community members participate in. The mushrooms are consumed locally as well as sold in local markets. They mushrooms are quite rich and tasty, and are associated with a reasonable market price. There are also various residents that work as temporary, traveling manual laborers. There are also some that immigrate to the US though respondents were not comfortable discussing specifics with regard to the number and the amount of remittances that their families receive.

## GOVERNANCE

The IC is governed by the Comisariado (made up of the president, the secretary, the treasurer and the Consejo de Vigilancia- whose job is oversight of the Comisariado) and the Asamblea made up of the agrarian certificate holders (i.e. comuneros). Decisions are made by consensus (with fifty-one percent of those present to vote making up a majority). The Asamblea meets every two months with special meetings for unexpected events when necessary. Participation is around 80% and they allow non-certified members of the community to sit in on the meetings. Part of the reason for this is to give the younger generation a chance to see how the process works and inform themselves as to the decision-making process. Young community members are very much encouraged to attend though many do not return frequently due to frustration at not being able to participate due to non-comunero status (until certification is passed down by older relatives through property ownership).

This IC participated in PROCEDE (Programa de Certificación de Derechos Ejidales y Titulación de Solares- Ejido Rights and Solare Tenure Certification Program) and their outer boundaries were formally established and recorded in the RAN (Registro Agrario Nacional- National Agrarian Registry), but they did not have individual plots surveyed and parceled. This was by decision of the Asamblea and the authorities say that they did not allow PROCEDE to determine the parcel boundaries due to the future risk of privatization and inappropriate government oversight. The parcels are therefore informally defined as far as the central government is concerned but within the community are fully accepted.

## SURVEY RESULTS BY VARIABLE

This section shows the results obtained by the interviews and demographic review. All the information that was available and collected are presented here. The questionnaire is available in the Appendix.

The scores of Carpinteros with regard to the 26 variables derived from the critical list and used subsequently in the analysis, are as shown in Table 4.3. As explained in Chapter 3, these scores are normalized (expressed as percentages of a standard or ideal value). The normalized percentage represented by the final values are the percentage of 100 based on the criteria established for variables in the critical list of variables for sustaining the commons, also described in Chapter 3. These are the same for all AN.

**Table 4.2. Critical variables and normalized scores for Carpinteros.**

Variable Category	Variable	Final value for analysis
<b>1. Resource system characteristics</b>	Small size	87
	Well defined boundaries	90
<b>2. Group Characteristics</b>	Small size	88
	Well defined boundaries	80
	Shared norms	82
	Past successful experiences—social capital	90
	†Appropriate leadership—young, familiar with changing external env, connected to local traditional elite (Modified to local perception)	69
	Interdependence among group members	94
	Heterogeneity of endowments, homogeneity of identities interests	94
	Low levels of poverty	80
<b>3. Extent of human pressure on the resource</b>	Spatial overlap/distance between user-group residential location and resource location	80
	High levels of dependence by group members on the resource system	96
	Fairness in allocation of benefits from common resources	89
	Low levels of user demand	1
<b>4. Institutional arrangements</b>	Rules are simple and easy to understand	99
	Locally devised access and management rules	39
	Ease in enforcement of rules	85
	Graduated sanctions	79
	Availability of low-cost adjudication	96
	Accountability of monitors and other officials to users	92
<b>5. Extent to which rules take into account ecosystem potential</b>	Match restrictions on harvest to regeneration of resource	90
<b>6. External Environment</b>	Technology: Low cost exclusionary technology	90
	State: Central governments should not undermine local authority	41
	State: Supportive external sanctioning institutions	38
	Appropriate levels of external aid to compensate local users for conservation activities	1
	Nested levels of appropriation, provision, enforcement, governance	90

From the table, we can see the overview that is told by the variable values. The resource system is relatively small and has well defined boundaries, fitting enabling criteria established by the critical list. The group system

generally complies with all of the criteria for the critical list with all values except for two. Appropriate leadership was relatively low at 69% (though still higher than 50%) and poverty (80%) which should be a number below 50, showing that there is flexibility in the impact of these two variables in this particular case. It is indicated that the group size is small, well defined, norms are shared and interdependence is relatively high. As well, there are sufficient past successful experiences to encourage sustainable management and there is relative homogeneity of identity. The Extent of Human Pressure on the Resource category had one variable in non-compliance with the criteria established by the critical list: Low demand (1%), though it should be noted that the extraction rules permit wood materials to be removed in the human-use (buffer) zone. Overlap of user group residential location on resource location (80%) is high so that the CPR theory is supported in that high overlap results in better management. Dependence on the resource (96%) and Fairness (89%) were in compliance with values well above 75%, showing that perceptions of fair distribution and allocation of resources is present among respondents and they feel highly dependent on the resource system in general. The Institutional arrangements category showed majority compliance with the critical list criteria except in the case of Locally devised access and management rules, which was 39%, and tells us that local managers have very little to do with the making of the management rules and are aware of it. From the values, we can see that the respondents considered the rules easy to understand (99%) and easy to enforce (85%). There was a significant presence for Graduated sanctions (79%) meaning that such sanctions were part of the enforcement strategy of local rules. Availability of low-cost adjudication (96%) was also strongly present as the *Asamblea* and *Comisariado* provide this service, along with external agencies like the Town Hall and forest management agencies listed in the next section. Accountability of monitors and other authorities to users (92%) was also highly present for similar institutional support from the aforementioned authorities, though the respondents felt this was most applicable to their local authorities. In terms of matching the harvest to regeneration of the resource, the reserve rules specifically take this and endemism into account (90%). In the External environment category, all of the values were the same for all ANs as they all refer to variables pertaining to external authorities and institutions that are the same for the entire reserve and any (if nominal) variation is based on awareness of external actors by the respondents.

## FOREST MANAGEMENT

Forest management in the IC Carpinteros is largely regulated by the rules prescribed for the reserve by external institutions such as PROFEPA, SEMARNAP and CONANP. This IC won the National Indigenous Forestry Merit award for two consecutive years (2012-13) to celebrate their efficient forest management. They achieved this, in spite of lacking a formal management plan beyond the general rules imposed by the Reserve authorities and local management actions. In the last decade, there has also been an intervention by UNAM and a local NGO Alternare, where researchers and specialists have been working with the community to develop livelihood alternatives, management capacity building (cistern construction, tree planting, etc.) and advice on forest-related issues and programs. Notably, these efforts have been augmented in the last 5 years (from 2015) due to promotion of this by the community leader and word of mouth between communities (personal communication). This is not an unusual way for AN to involve themselves in conservation activities or pursue development programs. Of the total of 8 AN I interacted with (though only 4 ultimately participated), all but 2 had some kind of program involvement resulting from word of mouth from one community to another.

There are programs by CONAFOR (Program for Forest Environmental Services- 2003 and Payments for Carbon, Biodiversity and Agroforestry Services- 2004, which were merged into a single program, ProArbol in 2006) and The Monarch Butterfly Fund (payments for reforestation- 2007) that result in payment for ecosystem services (PES) and compensation for reforestation efforts for every year that they participate or renew participation. Respondents were, in their majority, unsure of the amount of the PES payments and their distribution but said that in the past they had been put to use for the community in paying for vigilance and community works (water



conservation and buildings for community use). They also responded that they felt the money was used fairly (90%) as it was put to community works and not spread out only among certificate holders. They also expressed the sentiment in the vast majority (99%) that external support was not enough to offset opportunity costs for the livelihood activities that they are no longer permitted to participate in (such as livestock and certain farming practices and products) due to the obligation to conserve Reserve land as well as participate in conservation activities.

Many respondents were unsure of the role of external authorities in forest management and enforcement of forest rules (beyond the police). However, they rely on the Asamblea and the Comisariado, who would deal with any forest-related issues both internally and externally. In general, the current local authorities were well versed in the basic rules of management and extraction but without proper guidance and reinforcement of rules and law, there are oversights and the rules are loosely followed in some cases (evidenced by the response of some interviewees in the use of Oyamel and collection of plants from all areas of the reserve— core and buffer zones). However, the forest is generally well protected (as evidenced in the high forest cover density and a negative rate of forest cover change from 1993 to 2006 (Navarrete et al. 2011)) and the reforestation and forest protection activities carried out by the majority of the community as well as the two consecutive years of the Indigenous Forestry Merit Award. The IC also has a small colony of Monarchs that they are hoping will encourage tourism and related livelihood alternatives (Image 4.1).



**Image 4.1. Photo courtesy of Dr. Pablo Jaramillo and MBF of the evidence of the small colony of Monarchs in the core zone contained in the northeast portion of the IC.**

The internally derived rules are informal but well known and consistently observed (according to respondents and evidenced by the condition of the forest). There are very few members of the community who disobey the rules. Those members face a great deal of social pressure as well as sanctions and loss of rights imposed by the Asamblea and the small size makes anonymity difficult. No human uses are permitted in the core zone, though reforestation has taken place there. In the buffer zone certain activities are allowed, such as a certain level of thinning and collection of fallen trees and branches for fire prevention, reforestation and NTFP collection. The rules originate from the government organization but are discussed and upheld in the Asamblea. For example, there are sanctions and fines in place for those who extract wood without permits or permission, and the

Asamblea determines these. The IC only involves the external institutions when there are conflicts with extraction by outsiders.

The resources most commonly used from the forest are fallen trees, fallen wood, diseased trees, non-timber forest products (NTFPs including soil, animals, honey and herbaceous plants) and there are regulations for cutting live trees (non-native species or species considered less important— Oyamel, Oak and Pine are more protected than the others though Oak and Pine are historically the species used for construction and fuel material). Sales of wood from their forest are completely prohibited. The comuneros have the right to take out two truckloads of wood per year for personal use but in order to have the right to do so they must participate in the forest conservation and protection activities such as monitoring/vigilance, reforestation, fire control and prevention, community works, etc. (Images 4.2 and 4.3).



**Image 4.2. Seven men participated in the cistern building capacity program with funding provided by the Monarch Butterfly Fund (MBF) and skills provided by Alternare June 2013 at the Alvaro Obregon Elementary School in Carpinteros. Several are shown polishing the cistern floor. One of the participants was quoted saying, “The rainy season has just started, and water collected in this cistern will be a valuable resource to this school during the dry season”. Photo provided by MBF.**



**Image 4.3. The finished cistern, June 17, 2013. Photo provided by MBF.**

## SAN FRANCISCO CURUNGUEO, INDIGENOUS COMMUNITY

This community is located in the Municipality of Zitácuaro, Michoacán with the coordinates 19° 28' N, 100° 20' W, 2170 m. The total area of the IC is approximately 2275 ha. The IC consists of 5 manzanas or parajes all of which have agricultural plots and some with forest area falling inside the buffer zone:

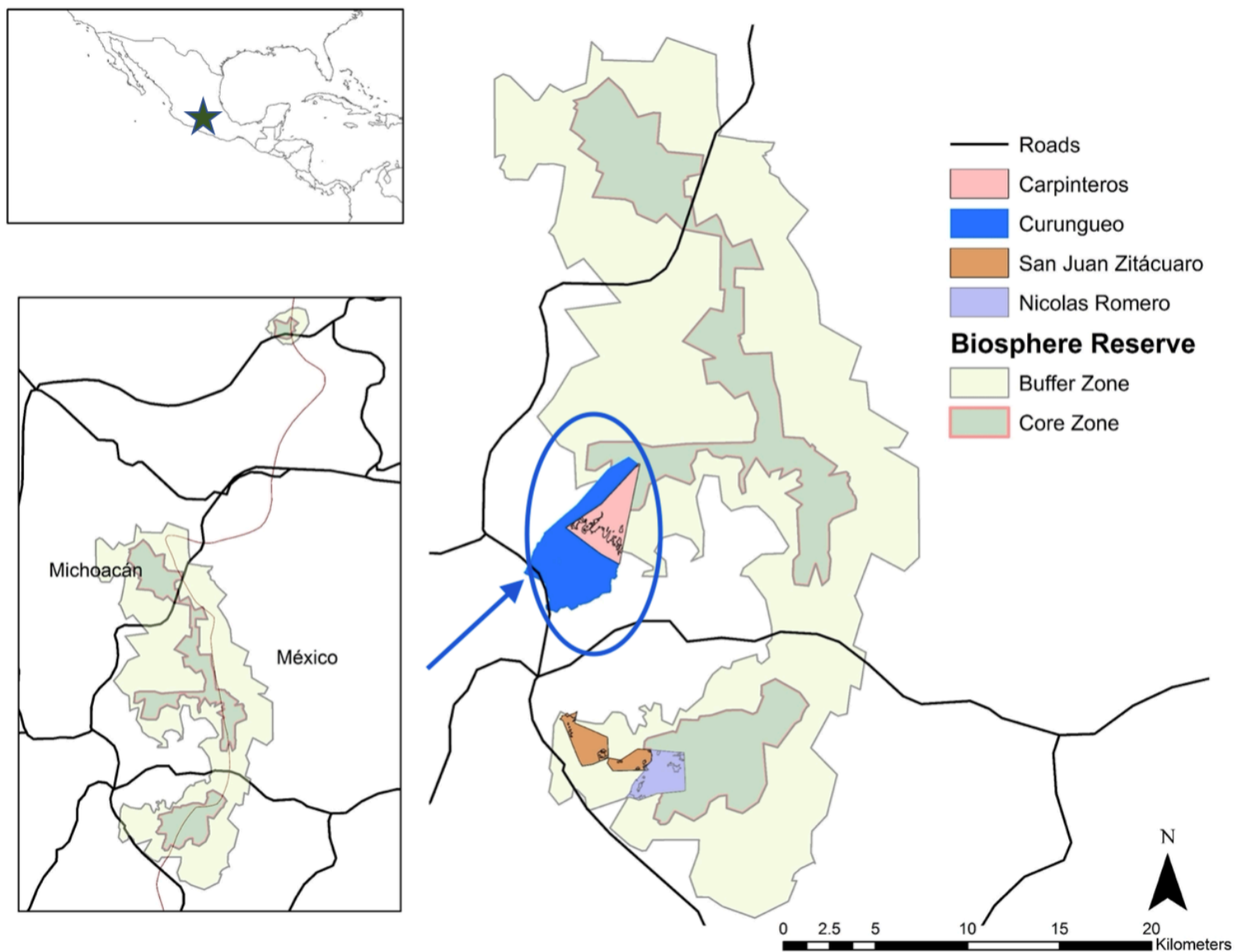
Curungueo center- valle verde, Juzagado Viejo, Savinal, Granjero, Los Llanitos

Rincón de Curungueo- Llano de Curungueo

Sombrerete- Puentezuelas

Loma Larga

Loma Mesa- Bechi



Map 4.2. Map of the MBBR with San Francisco Curungueo identified.

## HISTORY AND DEMOGRAPHICS

The overall population of San Francisco Curungueo (also known as simply Curungueo or Pueblo de Corundas, referred to in this study as SFC) is 2435 persons, 1203 male and 1232 female. The population consists of 1138 minors and 1297 adults, with 138 of them being 60 years and older. There is a much less social cohesion in this community which, according to CPR theory, should make norms much more difficult to enforce. The community leader is very charismatic and it is clear that while not all of the community members find him agreeable, they

generally have a great deal of respect for him. It should be noted that I went back to speak with the community about the results and the leader had been re-elected.

## INDIGENOUS POPULATION

Thirty-eight inhabitants of SFC live in households identified as indigenous. Seven citizens (5 years and older) speak an indigenous language. Many middle-aged and younger members mentioned a stigma attached to speaking indigenous languages. Several interviewees mentioned understanding an indigenous language and/or having a relative that spoke or understood one. As with Carpinteros, their identity centers around three categories: indigena, mestizo, and Mexican. Some households identify as indigenous even though there may be no indigenous language speaker in the household (2). Those who do not, tended to consider themselves both mestizo and Mexican (37).

## GENERAL ECONOMIC CONDITIONS

According to census information, in SFC there are 493 households. Of these households 475 live in common houses or apartments, 140 of which have a dirt floor and 42 have only one room. Sanitation varies as 421 of the houses have water-based bathroom installations and 401 are connected to the public water supply. The economic conditions allow for 455 households to access electricity. 16 households own a computer, 161 own a washing machine and 428 are equipped with one or more televisions according to census information (date and ref). The majority (>80%) have asbestos roofing here as well.

Orchards are a common livelihood activity in SFC where the majority produce peach and avocado. There are also some who cultivate maize and beans though this is generally for personal consumption. Large livestock is prohibited by MBBR rules but some families have pigs, turkeys and chickens for household consumption. There are also various residents that work as temporary, traveling manual laborers. There are also some that immigrate to the US though respondents were not comfortable discussing specifics with regard to the number and the amount of remittances that their families receive, which was similar to the response in the other ANs.

## GOVERNANCE

This IC is also governed by the Comisariado (made up of the president who is in charge of forest management and resources, the secretary, the treasurer and the Encargado de Orden and Jefe de Tenencia– who are in charge of committee oversight and general administration duties, respectively) and the Asamblea made up of the agrarian certificate holders. Decisions are made by consensus, with a majority being 51% of those present. The Asamblea meets every two months with special meetings for unexpected events when necessary. Participation is around 60% and they allow non-certified members of the community to sit in on the meetings. Part of the reason for this is to give the younger generation a chance to see how the process works and inform themselves as to the decision-making process so that they can be knowledgeable when they inherit the agrarian certificate holding. The Comisariado did mention that there is currently an issue with agrarian certificates that have not been renewed by those whose direct relatives have died and to whom the rights directly pass. This has been problematic in terms of Asamblea participation and community cohesion.

This community has much lower social cohesion than Carpinteros, as demonstrated by the values for the group interdependence variable (84/94, respectively) and heterogeneity of endowments, homogeneity of identities interests variable (80/94, respectively). It has been speculated by residents to be a result of past authorities not acting in the best interest of the IC. For example, the previous president was rumored to have given property rights to political figures for avocado production in the buffer zone. Moreover, there is a significant issue with

substance abuse among the young and unemployed population. It is also notably larger than the other IC and ejidos, lending itself to greater difficulty in motivation and organization. There is a sense of desperation among the residents that do not leave to work in urban centers around Zitácuaro (some as far away as Mexico City or the State of Mexico). All those interviewed voiced a desire to stay in their community or at least nearby. Both residents of certain parajes and the Comisariado committee are seeking greater support from the Reserve Authorities and NGOs that have funds and possibilities for capacity building and conservation education as they feel that this would help change the culture of the areas where conservation is not considered a priority. They are also interested in sustainable livelihood alternatives. The parajes most interested in forest conservation are: Rincón de Curungueo, Curungueo center and Loma Larga. The parajes Sombrerete and Puentezuelas are less interested in forest conservation activities due to the high opportunity costs of substituting current livelihood activities with conservation activities.

The Comisariado observed that of the more than 500 certified members in the census only 280 actually participate in the Asamblea. Some have passed away or have left the community but the families have been unable to update the census of certificate holders and that this is prejudicial to the community. There are a number of residents that have a right to the agrarian certificate but do not have one, further complicating participation and organization. This creates some confusion and inconsistency with regard to participation and shared responsibility.

## SURVEY RESULTS BY VARIABLE FOR SAN FRANCISCO CURUNGUEO

This section shows the results obtained by the interviews and demographic review. All the information that was available and collected are presented here. The questionnaire is available in the Appendix.

**Table 4.3. Normalized percentage values of the variables used in the analysis for San Francisco Curungueo (SFC).**

Variable Category	Variable	Final value for analysis	
<b>1. Resource system characteristics</b>	Small size	61	
	Well defined boundaries	88	
<b>2. Group Characteristics</b>	Small size	63	
	Well defined boundaries	75	
	Shared norms	82	
	Past successful experiences—social capital	90	
	Modified to local perception	†Appropriate leadership—young, familiar with changing external env, connected to local traditional elite	64
		Interdependence among group members	84
		Heterogeneity of endowments, homogeneity of identities interests	80
<b>3. Extent of human pressure on the resource</b>	Low levels of poverty	82	
	Spatial overlap/distance between user-group residential location and resource location	60	
	High levels of dependence by group members on the resource system	75	
	Fairness in allocation of benefits from common resources	89	
<b>4. Institutional arrangements</b>	Low levels of user demand	1	
	Rules are simple and easy to understand	89	
	Locally devised access and management rules	39	

	Ease in enforcement of rules	74
	Graduated sanctions	79
	Availability of low-cost adjudication	96
	Accountability of monitors and other officials to users	83
<b>5. Extent to which rules take into account ecosystem potential</b>	Match restrictions on harvest to regeneration of resource	90
<b>6. External Environment</b>	Technology: Low cost exclusionary technology	90
	State: Central governments should not undermine local authority	41
	State: Supportive external sanctioning institutions	38
	Appropriate levels of external aid to compensate local users for conservation activities	1
	Nested levels of appropriation, provision, enforcement, governance	90

For SFC, the resource system is relatively large (69%) in comparison to Carpinteros and still has well defined boundaries (88%) thus still fitting enabling criteria established by the critical list. The group system generally complies with all of the criteria for the critical list with all values except for one. Appropriate leadership was relatively low at 64% (though still above 51%) and poverty (82%) which should be a number below 50, showing that there is flexibility in the impact of these two variables in this particular case. It is indicated that the group size is small but not as small as the other AN (63%), well defined (75%), norms are shared by a vast majority (82%) and interdependence is relatively high (84%). As well, there are sufficient past successful experiences (90%) to encourage sustainable management and there is relative homogeneity of identity (80%). The Extent of Human Pressure on the Resource category had one variable in non-compliance with the criteria established by the critical list: Low demand (1%), though it should be noted that the extraction rules permit wood materials to be removed in the human-use (buffer) zone and that a large portion of the AN area is outside of the reserve (Map 4.2). In the Extent of human pressure on the resource category, overlap of user group residential location on resource location (60%) is lower so we can expect more difficulties in management of extraction. Dependence on the resource (75%) was the lowest for all the AN though Fairness (89%) was still high, showing that perceptions of fair distribution and allocation of resources is present among respondents. The Institutional arrangements category showed majority compliance with the critical list criteria except in the case of Locally devised access and management rules, which was 39%, and tells us that local managers have very little to do with the making of the management rules and are aware of it in all of the AN. From the values, we can see that the respondents considered the rules easy to understand (89%) though not as easy to enforce (74%), though the value is still close to 75%. There was a significant presence for Graduated sanctions (79%) meaning that such sanctions were part of the enforcement strategy of local rules. Availability of low-cost adjudication (96%) was also strongly present as the Asamblea and Comisariado provide this service, along with external agencies like the Town Hall and forest management agencies listed in the next section-- and though all AN have this infrastructure, the ICs were and the ejidos were consistent in their respective values. Accountability of monitors and other authorities to users (83%) was also present for similar institutional support from the aforementioned authorities, however to a slightly lesser degree and like Carpinteros was perceived most effective with regards to local authorities. In terms of Matching the harvest to regeneration of the resource, the reserve rules specifically take this and endemism into account (90%) in the entire MBBR. In the External environment category, all of the values were the same for all AN.

## FOREST MANAGEMENT

The people in this IC are interested in conserving their forest, particularly in light of the fact that previous leaders did not make conservation a priority and conservation efforts have been only recently considered part of their

common activities. In fact, it was mentioned in the interviews by residents of the paraje el Rincón de Curungueo and in the center of the IC that the previous Comisariado allowed part of the forest in the buffer zone to be cleared for avocado production by external political leaders, and not members of the community, for which there has been no recourse. There was a general sense of disgust about this, which largely seemed based on the concern that local climate, socioeconomic disparity and ecosystem services have been negatively impacted by forest-related corruption.

Residents of the paraje Rincón de Curungueo are concerned about landslides as a result of deforestation that occurred close to their residences. They also voice concern about the lack of water as the available water has diminished over recent years. They are asking that the current Comisariado focus reforestation efforts there not just to their benefit but to the general good of the forest and the ecosystem services that have been diminished by its absence.

Loma Larga, Curungueo center and Rincón de Curungueo are very interested and disposed to participate in reforestation activities. Sombrerete and Puentezuelas are not very interested as they see more value in avocado production than forest conservation, however they are concerned about the diminished water supply. In spite of the understanding that this is an indirect consequence of deforestation they are more interested in the short-term economic benefits that avocado production provides than the long-term costs of not participating. There was some mention that a factor in this is the ability to stay in their home.

The adult population (middle-aged and older) voiced concern with regard to forest conservation and expressed worry that the younger generation is unaware of its importance. The concern was that younger community members are more focused on short-term economic benefits from production activities that may be counterproductive for conservation efforts. Some of the younger people interviewed commented that few of this age group participate in community activities and those that do are not taken into consideration in decision-making (since they are not authorized participants in the Asamblea). They cite this as a cause of low motivation. This also has an element of distancing in the sense of identity of younger members from the older, more traditional members. This may influence social cohesion and identity. This will be discussed in the conclusion chapter.

The majority of respondents (95%) felt that women should definitely participate in conservation activities since there are many of them and many who do not have gainful employment but said that the older men do not allow them to as they are expected to dedicate themselves solely to the household activities. There was also concern by men on the vulnerability of the women and their safety if they were to participate by themselves.

The forest plays a very important role for this community since they obtain a number of direct benefits like fuel for cooking and heating, water, mushrooms, and other NTFPs as well as promoting social unity. The resources most commonly used from the forest are fallen trees, fallen wood, diseased trees, non-timber forest products (NTFPs including soil, animals, honey and herbaceous plants) and there are regulations for cutting live trees. Non-native species or species considered less important are generally the first to be selected. Oyamel, Oak and Pine are more protected than the others though Oak and Pine are historically the species used for construction and fuel material. It is understood that Oyamel is important for the butterflies and forest health. Sale of wood from their forest is completely prohibited both by the reserve rules and by the local rules. The comuneros (agrarian certification holders and authorized participants in the Asamblea) have the right to take out wood for personal use but in order to have the right to do so they must participate in the forest conservation and protection activities (vigilance, reforestation, fire control and prevention, etc.) and obtain a permit from the Comisariado.

The AN is involved in PROCEDE and allowed the organization to officiate in the formalization of parcel boundaries under a previous Comisariado, for which there was some repentance but the reason was not clear. There are programs by CONANP, The Monarch Butterfly Fund, Alternare and a few others that result in payment for ecosystem services (PES) and compensation for reforestation efforts as well as capacity building and community works. Respondents were, in their majority (75%), unsure of the amount of payment under PES and their distribution but said that they believed that the current president had put the funds to use for the community in paying for forest vigilance and community works (water conservation and community buildings). They also responded that they felt the money was used fairly (90%) under the current Comisariado. The vast majority (96%) felt that external support was not enough to offset opportunity costs for the livelihood activities that they are no longer permitted to participate in (like livestock and certain farming practices and products) due to the obligation to conserve reserve land as well as participate in conservation activities. Many have felt limited in alternative strategies.

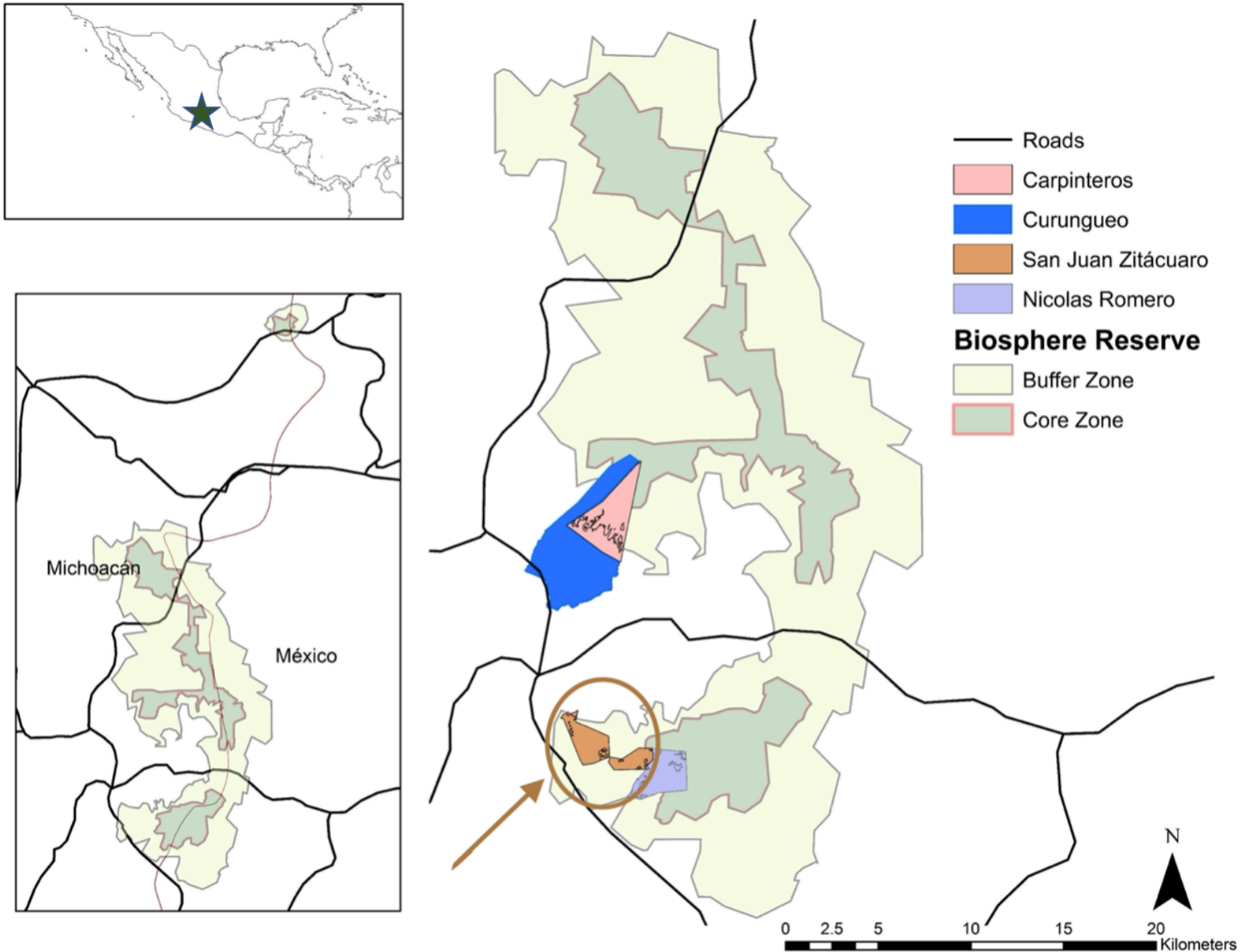
There was a general feeling by IC authorities and respondents that external authorities were not supportive enough in capacity building efforts or reinforcement of laws. There were also complaints that the Técnico Forestal that corresponds to their IC never followed through on helping renew and redesign the forest management plan even though they paid 30,000 pesos for the service. They also voiced frustration over a lack of accountability and recourse for services paid for by NGOs or promised as in the example of Fundación Cuitzmala, who promised payment for conservation activities and have still not paid the amount promised since 2010 (the NGO having fallen behind in the payments, which have come in sporadically and in small amounts) as well as a small NGO paid to aid in the renovation and design of the forest management plan that was never delivered (Biocenocis A.C.). The comisariado has been reelected and the committee is working to create a new management plan and pursue further conservation efforts. They have felt frustrated with the lack of guidance and resources (though mostly the former).

## EJIDO SAN JUAN ZITÁCUARO

The ejido San Juan Zitácuaro is located in the municipality of Zitácuaro with the geographical coordinates of 19°N 29' "and 100°19' 0" W, approximately 2180 m above sea level. They have a total land area of 1465 ha. All but a small portion of the ejido falls within the buffer zone.

The ejido is made up of 5 parajes: Emiliano Zapata (some refer to the whole ejido by this name), Polvorine, El Aguacate, Flor de Lis and Manzanillo. All parajes have agricultural plots and forest area located in the buffer zone in the Cerro San Juan Zitácuaro and extending to Cerro Cacique.





Map 4.3. Map of the MBBR with San Juan Zitácuaro identified.

## HISTORY AND DEMOGRAPHICS

The ejido was formed in 1936. There is a population of 1274 people, of whom 213 are certified ejidatarios.

## INDIGENOUS POPULATION

In some manzanas there are still inhabitants that speak Mazahua (an indigenous language previously common in the region) resulting in a total of 195 inhabitants who speak the language with others who claim to understand it but are unable to speak it. There is less stigma here with regard to speaking and understanding indigenous languages than was noted in the ICs. There were also more households that identified as indigenous (50%).

## GENERAL ECONOMIC CONDITIONS AND LIVELIHOODS

In San Juan Zitácuaro there are approximately 425 households. Of these households 379 are living in common houses or apartments, 108 are without floor and about 20 consist of one room only. Of the total households, 352 of the normal households have water-based bathroom installations, 92 are connected to the public water supply, 320 have access to electricity. The economic situation allows 15 households to own a computer, 77 own a washing machine and 269 households are equipped with one or more televisions.

San Juan Zitácuaro cultivates a variety of produce particularly since the climate lends itself to orchard production. There are avocado and peach orchards as well as corn, bean, cilantro, chile manzano and assorted other vegetable and greens cultivation. There is also livestock production both for household consumption as well as livelihood (cows, sheep, goats, turkeys, chickens). One family participates in apiculture. Previously a family participated in a resin collecting activity but this was abandoned due to lack of capacity and guidance in making it economically feasible.

Some of the respondents fall into the category of jornaleros that work outside the community, as discussed in the previous sections. They mentioned that the economic stimulus provided by PES and conservation activities helps to create work sources inside the community where there currently are none for those without agrarian certification but is not enough to offset opportunity costs for other activities. They also mention that some have worked in the US for periods of time and those families benefit a great deal from the remittances but none of the participants would give us actual figures on how many are in the US and how much is sent in remittances, and the subject was not pressed.

## GOVERNANCE

Respondents made it a point to mention that the current Comisariado is the most supportive authority with regard to resolving conflicts and organizing the community. They also mentioned that he has been very good at designing projects and was open to new projects that benefit the community, though they did comment that he has a very stoic personality and a sometimes brusque manner. Interestingly, he was secretary in a previous administration as well as president from 2005-2008. A number of respondents also mentioned that they consider women more trustworthy than men in governance, evidenced by the presence of a female Consejo de Vigilancia (who acts as the oversight for the Comisariado committee). Various respondents mentioned being interested in seeing her become the next ejido president. Apparently women were not in the committee until 2005 when a woman was elected as Secretary of the committee and then another woman was elected Consejo de vigilancia in the 2012-2015 committee and again in the current one.

The respondents and Comisariado committee spoke about some conflict generated by the previous Comisariado committee due to a lack of transparency and mismanaged funds. There are allegedly several lawsuits that have been filed against the previous president and claims that he has refused to return the truck that was given to the ejido for management purposes. One of the claims was debunked (and clarified with the Comisariado) and an outside source told us that some of the money was used to hire people from a different ejido (Rincón de Ahorcados) due to the lack of support within the ejido for certain conservation activities but that he did this without consulting the Asamblea. This is highly controversial since all decisions are supposed to go through the Asamblea before being implemented. This autocratic leadership style was corroborated by respondents and was voiced as the cause for the current tension in the ejido with regard to the new Comisariado committee.

They have decided to ensure that all decisions, plans and projects go through the Asamblea and are pressuring all ejidatarios to participate as participation under the previous committee declined significantly. There was also a division created due to the conflicts generated by the transition of the previous committee to the present one. In fact, on March 30, 2015 there was a forest fire that was purportedly started by frustrated supporters of the previous committee. Thankfully minimal damage was sustained. The allegations of how and why the fire was started have not been substantiated beyond the word of the current committee. It is interesting to note that incidents like these are apparently not uncommon around the reserve, according to various and consistent personal communications.

## SURVEY RESULTS BY VARIABLE FOR SJZ

This section shows the results obtained by the interviews and demographic review. All the information that was available and collected are presented here. The questionnaire is available in the Appendix.

**Table 4.4. The normalized percentages for the variables used in the analysis for San Juan Zitácuaro (SJZ).**

Variable Category	Variable	Final value for analysis	
<b>1. Resource system characteristics</b>	Small size	66	
	Well defined boundaries	90	
<b>2. Group Characteristics</b>	Small size	81	
	Well defined boundaries	70	
	Shared norms	89	
	Past successful experiences—social capital	92	
	Modified to local perception	†Appropriate leadership—young, familiar with changing external env, connected to local traditional elite	80
		Interdependence among group members	97
<b>3. Extent of human pressure on the resource</b>	Heterogeneity of endowments, homogeneity of identities interests	90	
	Low levels of poverty	72	
	Spatial overlap/distance between user-group residential location and resource location	90	
	High levels of dependence by group members on the resource system	90	
	Fairness in allocation of benefits from common resources	90	
<b>4. Institutional arrangements</b>	Low levels of user demand	10	
	Rules are simple and easy to understand	99	
	Locally devised access and management rules	39	
	Ease in enforcement of rules	32	
	Graduated sanctions	89	
	Availability of low-cost adjudication	83	
	Accountability of monitors and other officials to users	92	
<b>5. Extent to which rules take into account ecosystem potential</b>	Match restrictions on harvest to regeneration of resource	95	
<b>6. External Environment</b>	Technology: Low cost exclusionary technology	90	
	State: Central governments should not undermine local authority	41	
	State: Supportive external sanctioning institutions	38	
	Appropriate levels of external aid to compensate local users for conservation activities	1	
	Nested levels of appropriation, provision, enforcement, governance	90	

In San Juan Zitácuaro, the resource system is relatively large (63%) in comparison to the largest (Curungueo) and still has well defined boundaries (90%) also falling into the enabling criteria established by the critical list. The group system generally complies with all of the criteria for the critical list with all values. Appropriate leadership was relatively high at 80%, which was in fact the highest for all AN. Poverty was lowest for this ejido (72%), though

still high with regards to the criteria for the critical list. The group size is smallest for this AN at 83%, well defined (70%), norms are shared by a vast majority (89%) and interdependence is extremely high (97%). Past successful experiences is also extremely high (92%) which has been established to encourage sustainable management. There is high homogeneity of identity (90%). The Extent of Human Pressure on the Resource category had one variable in non-compliance with the criteria established by the critical list: Low demand (10%), though it has been noted that the extraction rules permit wood materials to be removed in the human-use (buffer) zone. In the Extent of human pressure on the resource category, overlap of user group residential location on resource location (90%) is very high so we expect better forest cover for this ejido. Dependence on the resource (90%) was the highest for all the AN along with Fairness (90%), showing that perceptions of fair distribution and allocation of resources is present among respondents along with a high dependence on the resource as a system. Like the two ICs, the Institutional arrangements category showed majority compliance with the critical list criteria except in the case of Locally devised access and management rules, which was 39%, and tells us that local managers have very little to do with the making of the management rules and are aware of it in all of the AN. However, in spite of the other high values, Ease of enforcement of rules was low at 32%. The extraction and management practices prior to the Reserve expansion were cited for this low value. From the other values, we can see that the respondents considered the rules easy to understand (Table 4.4) almost to a person (99%), which is contradictory to the difficulty in enforcement, though it does reinforce the idea that these variables are in fact separate. There was a significant presence for Graduated sanctions (89%) meaning that such sanctions were a significant part of the enforcement strategy of local rules for SJZ. Availability of low-cost adjudication (83%) was also strongly present (though less so than the ICs) as the Asamblea and Comisariado provide this service, along with external agencies like the Town Hall and forest management agencies listed in the next section. Accountability of monitors and other authorities to users (92%) was very high, similar institutional support from the aforementioned authorities, and like the ICs was perceived most effective with regards to local authorities because of the Asamblea. In terms of Matching the harvest to regeneration of the resource (95%), it was highest for this AN in spite of the presence of this rule across the entire MBBR, which could be due to the entirety of the ejido being in the buffer zone as well as localized ejido culture (though this was not specifically investigated). In the External environment category, all of the values were the same for all AN.

## FOREST CONSERVATION

The people in this ejido are investing in conserving their forest, and while they currently have no economic resources coming in for the payment of the full time patrols, all ejidatarios contribute out of pocket to maintain the patrols 24 hours a day. They have three shifts- one in the morning, one in the afternoon and evening and the last overnight. Women are involved in patrols during the day but not after dark. All physically able ejidatarios (male and female) participate in reforestation, care for planted trees and fire prevention activities. In many cases their family members also participate. They were quite proud of having won the National Forestry Merit award in 2012 which resulted in a monetary award of 80,000 pesos to go towards conservation activities. They are concerned at this time because they informed us that there is illegal extraction carried out by nearby CIs and ejidos (Nicolas Romero, Crescencio Morales, Francisco Serrato) and even theft or destruction of fencing material, which they are finding costly and difficult to replace. They have fencing for part of the ejido but have not had the resources to fence the entirety of the ejido due to the destruction and required maintenance of the fence in the problem areas.

The adult population (middle-aged and older) are quite concerned with forest conservation and express worry that the younger generation is unaware of its importance as they are not required to participate, though some do. Some of the younger people interviewed commented that few participate in community activities and those that

do are not taken into consideration in decision-making (since they are not authorized participants in the Asamblea) which they cite as a cause of low motivation. This is consistent with the other ANs.

There was also concern about water conservation as they provide water to urban areas and other communities and ejidos and are considering charging usage rights as a means to make income for forest and ejido maintenance. There is also concern about climate change. Some of the older participants remember the 1960s when Cerro San Juan Zitácuaro was completely deforested for agriculture. Some respondents mentioned having noticed local climate change and felt that it made the importance of their forest conservation efforts more important as they believe that a healthy forest mitigates the effects of climate change locally and globally. Science would generally agree with them.

The vast majority of respondents (99%) felt that women should definitely participate in conservation activities since there are many of them and many who do not have gainful employment. This is evidenced by their general participation in all conservation activities and their knowledge of it. There was a greater autonomy among the women in SJZ versus SFC and Nicolas Romero and they had a greater authority, in conservation terms.

As in the other AN, the forest plays a very important role for this community since they obtain a number of direct benefits like fuel for cooking and heating, water, mushrooms, and other NTFPs as well as promoting social unity. The larger focus for this ejido was the ecosystem service provided by water as they have a large amount of water resulting from the forest topography and hydrologic factors. Since they provide for nearby urban areas and others in the reserve, they were concerned about compensation and over-use. The respondents want authorities to help protect and organize care and conservation activities and enforce conservation rules to ensure compliance. The majority of respondents (99%) said that it was easy to follow the rules because they are well explained and intuitive (Image 4.4).

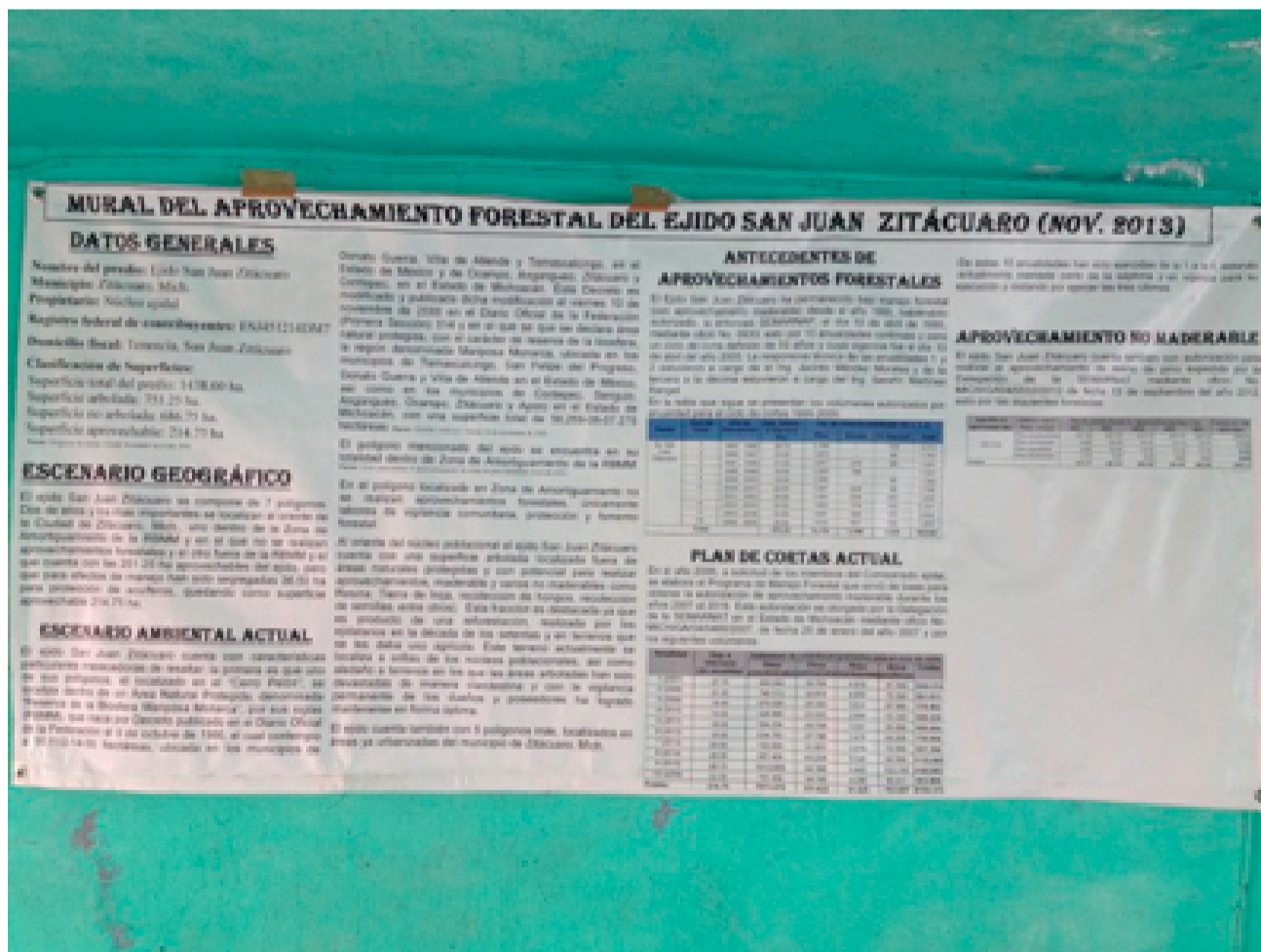


Image 4.4. Ejido forest management rules. At the Casa Ejidal (the office where the Comisariado committee is based and the Asamblea is held) their general management plan, a brief overview of past management actions and reasons for conservation, was hanging on the wall.

Respondents commented that they were very happy to have someone from an external institution come in and ask them about their conservation work and concerns. The residents feel that while the external authorities are sometimes helpful, they are not integrated into the management strategies of the Reserve as much as residents would like, particularly considering the water that the ejido provides for areas in and out of the Reserve. They are also frustrated that they are expected to care for the forest and are heavily fined if they do not follow the rules with regard to extracting wood however, when there are fallen trees or trees in dangerous condition (fallen on houses or at risk of damaging property) the external authorities are very slow to respond to their petitions and in cases where the wood becomes unusable or stolen as a result of the time it takes for CONANP, PROFEPA and CONAFOR to issue permits. They also mentioned frustration with the quality of the forest technicians who are certified by CONAFOR, as many have done poor quality work that has resulted in delays in PES payments and wood extraction. This was a common complaint, in fact, among ANs. Residents are frustrated there is no real recourse when a forest technician doesn't do their job properly. The only recourse is to consider the payment made to him lost money and seek out the aid of a new one. They have recently contracted a different technician who they say has been working out much better than the previous one. .

The ejido authorities are more than interested in forest conservation activities but cite a lack of capacity and support from the Reserve authorities and ask that this support be provided as soon as possible. They are also very interested in alternative livelihood strategies that are environmentally friendly and sustainable. They have also developed forest education programs (Image 4.5). It was quite impressive that they have cared for all of their forest area and not just the forest that is in the Reserve area. In fact, a large portion of the Cerro San Juan Zitácuaro was used for agriculture until the 1960s. Then around 1968 reforestation efforts were made and have been maintained since. There was a recent resin collecting activity but had been abandoned in 2014 (Image 4.6). Unfortunately, the satellite images through Google Earth only go back to 2004. It is unclear how much the intense winter storm in March of 2015 affected the forest but many areas sustained damage (Image 4.7).



Image 4.5. An example of an “interpretive forest walk” as part of an environmental education program in the Cerro San Juan Zitácuaro.



**Image 4.6.** The resin collecting activity was abandoned due to cost inefficiency and lack of capacity with regards to collection and processing, according to the Comisariado.



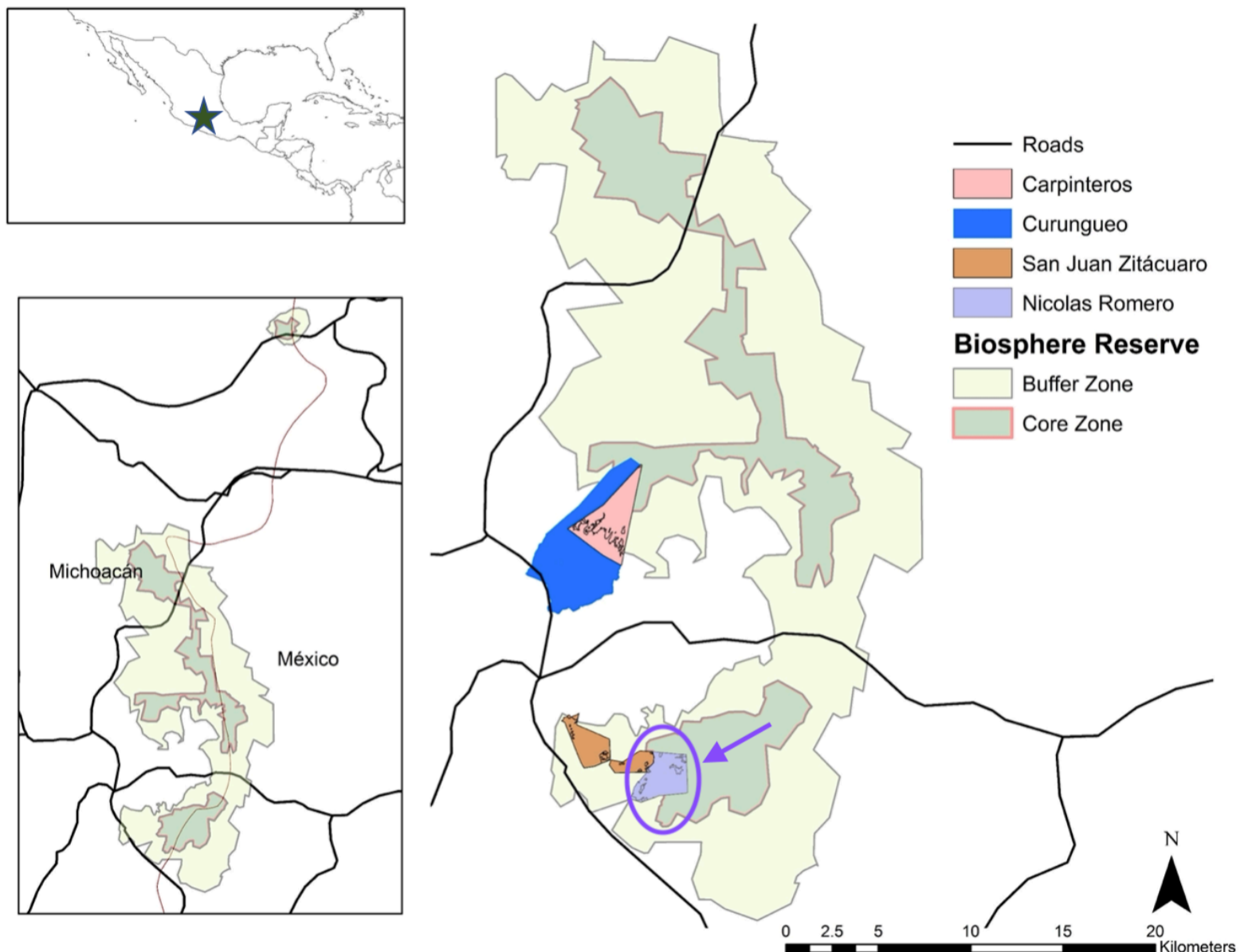
**Image 4.7.** There was significant damage caused by the winter storm in 2015 that resulted in snow and high winds in the area in mid-March. They are awaiting permits to remove the fallen wood.

With regard to PES, the ejido receives a certain quantity (though not specified) for conservation activities (seasonal) which comes from CONAFOR and that they have used the money to pay the forest patrols and water conservation activities and projects. The interviewees felt that the payments were put to good use. The majority said it was better to use it for conservation activities rather than dispersed among individual ejidatarios as cash, though there were only a few who disagreed. Other instances of PES were distributed among ejidatarios even if they only resulted in a small disbursement amount.

## **EJIDO NICOLÁS ROMERO**

The Ejido Nicolas Romero is located in the southeast of the municipality of Zitácuaro. It shares a border to the north and west with the ejido San Juan Zitácuaro, to the east with the Indigenous Community (IC) Crescencio Morales and the State of Mexico and to the south with Chichimequilas and the State of México. The ejido is made up of 3 manzanas or “parajes”: 1st manzana “Pueblo de Nicolás Romero”, 2nd manzana “Pueblo de

Nicolás Romero and Cerro Ancho” and the 3rd manzana “Nicolas Romero and the Cedars”. All parajes have agricultural plots and forest area located inside the MBBR in the buffer zone in Cerro Pelón and Cerro Cacique. The ejido is additionally bordered by Nicolas Romero IC which was broke away after the establishment of the ejido (40 years ago) due to management differences. There is conflict between the two due to competition for resources and credit for forest management, protection services and area rights. The boundaries are still under dispute. There is also conflict between the IC and the ejido as there is a great deal of forest area and water availability in the IC that the ejido is vying for rights to, claiming that there is no legal foundation for the land rights of the IC (which appears to be false according to PHINA).



Map 4.4. Map of MBBR with Nicolas Romero identified.

## HISTORY AND DEMOGRAPHIC INFORMATION

The ejido was established in 1930. The population is 2106 (with 285 ejidatarios) and the total land area is 959 ha, according to RAN. There is some discrepancy in population numbers due to the conflict in boundaries and land area that is ongoing with the IC of the same name, so that the population number is approximate. There is a great deal of social cohesion in this community which should make norms much easier to enforce according to theory. It is clear that while not all of the community members find him agreeable, they all respect the ejido leader. However, it was clear that this ejido has a different perception of leadership in general than the members of the break-away ICs did, since they make up the Asamblea and all members consider themselves equally high in social status with their leader. This is different from the IC as the leader there seems to be considered of higher status.



This could be due to a few factors- the first is that the ejidos consider leadership an obligation while the ICs appear to view it as a privilege. The second is that the ejidos have a different concept of community and involvement when there are payments distributed among ejidatarios for ecosystem services and land management (which we see in both the ejidos in this study). In the ICs, the payments were used for community projects and/or community works (buildings, water cisterns, etc.), while in the ejidos it was usually divided up into a very small, per certified landowner payment.

## INDIGENOUS POPULATION

In some manzanas there are still inhabitants that speak fluent Mazahua (approximately 113 though many respondents said they understood but could not speak it) and the ejidatarios consider themselves indigenous, still continuing some of the traditions and customs typical of this group. Here again we see that the ejidos have a lower stigma attached to speaking and understanding indigenous languages, as well as identifying as indigenous.

## GENERAL ECONOMIC CONDITIONS AND LIVELIHOODS

Nicolas Romero cultivates a variety of produce. As in the other ejido and ICs, there are avocado and peach orchards. Like San Juan Zitácuaro, they also cultivate corn, bean, cilantro, chile manzano and assorted other vegetables and greens. They also have livestock (cows, sheep, pigs, turkeys, chickens) that is both for personal consumption and livelihood purposes. One ejidatario has a Rainbow Trout production activity run by the family.

In this ejido there were also some of the respondents that fall into the category of jornaleros, as discussed in the other ANs. They mentioned that the economic stimulus provided by PES and conservation activities helps to create work sources inside the community where there currently are none but is not enough to offset opportunity costs for other activities. They also mention that some have worked in the US for periods of time and their families benefit a great deal from the remittances. They also said that property in the ejido has been sold to private holders from outside which provides certain benefits to the ejido in the form of aesthetics and capital but can be problematic in terms of participation and rule enforcement.

## GOVERNANCE

A large percentage of respondents (75%) considered that the current comisariado was limited in his leadership abilities by being poorly organized and having a limited understanding of the rules for forest care and maintenance. They also felt he was taking little initiative to involve the ejido in incentive programs provided by external institutions for PES, other incentive payment programs and conservation activities. As previously mentioned, they were hearing about a number of other programs in other AN by word of mouth. They felt that his interest was more in his personal projects than to any benefit of the ejido. Many voiced frustration at the lack of rule enforcement and forest patrols by the current leadership though the same respondents mentioned that the secretary was more interested in forest management and conservation than the Comisariado so that some attention was dedicated to it.

## SURVEY RESULTS BY VARIABLE

**Table 4.5. The normalized percentages used in the analysis for this ejido, Nicolas Romero.**

Variable Category	Variable	Final value for analysis
1. Resource system characteristics	Small size	85
	Well defined boundaries	85

<b>2. Group Characteristics</b>	Small size	68
	Well defined boundaries	65
	Shared norms	81
	Past successful experiences—social capital	75
Modified to local perception	†Appropriate leadership—young, familiar with changing external env, connected to local traditional elite	25
	Interdependence among group members	82
	Heterogeneity of endowments, homogeneity of identities interests	55
	Low levels of poverty	78
<b>3. Extent of human pressure on the resource</b>	Spatial overlap/distance between user-group residential location and resource location	85
	High levels of dependence by group members on the resource system	80
	Fairness in allocation of benefits from common resources	52
	Low levels of user demand	14
<b>4. Institutional arrangements</b>	Rules are simple and easy to understand	75
	Locally devised access and management rules	39
	Ease in enforcement of rules	32
	Graduated sanctions	89
	Availability of low-cost adjudication	83
	Accountability of monitors and other officials to users	73
<b>5. Extent to which rules take into account ecosystem potential</b>	Match restrictions on harvest to regeneration of resource	90
<b>6. External Environment</b>	Technology: Low cost exclusionary technology	60
	State: Central governments should not undermine local authority	41
	State: Supportive external sanctioning institutions	38
	Appropriate levels of external aid to compensate local users for conservation activities	1
	Nested levels of appropriation, provision, enforcement, governance	90

The resource system is the second smallest (83%) in comparison to the smallest, Carpinteros, and still has well defined boundaries (85%) fitting the enabling criteria established by the critical list. The group system generally complies with all of the criteria for the critical list with all values. Appropriate leadership was non-compliant with the critical list criteria at 25%, which was in fact the lowest for all AN. Poverty was 78%, which is still high with regards to the criteria for the critical list. The group size is second smallest of all AN at 68%, moderately defined (65%), norms are shared by a majority (81%) and interdependence is high (82%). Past successful experiences is lowest (75%) for this AN. There is low homogeneity of identity (55%), which is in fact the lowest for all the ANs. The Extent of Human Pressure on the Resource category had one variable in non-compliance with the criteria established by the critical list: Low demand (14%), though it should be noted that the extraction rules permit wood materials to be removed in the human-use (buffer) zone. In the Extent of human pressure on the resource category, overlap of user group residential location on resource location (85%) is very high so we expect better forest cover maintenance for this ejido. Dependence on the resource (80%) was in the high range for all this AN. Fairness was very low (52%), showing that perceptions of distribution and allocation of resources is unfavorable among respondents. Like the two ICs and the other ejido, the Institutional arrangements category showed majority compliance with the critical list criteria except in the two cases of Locally devised access and

management rules (39%) and Ease in enforcement of rules (32%), which were both in non-compliance with the critical list criteria. The extraction and management practices prior to the Reserve expansion were cited for this low value as well as conflict between this ejido and IC of the same name (discussed in the next section). From the other values, we can see that a majority of respondents considered the rules easy to understand (75%), which is contradictory to the difficulty in enforcement though this ejido had by far the lowest value of all ANs. There was a significant presence for Graduated sanctions (89%) meaning that such sanctions were a significant part of the enforcement strategy of local rules. Availability of low-cost adjudication (83%) was also strongly present (though less so than the ICs) as the Asamblea and Comisariado provide this service, along with external agencies like the Town Hall and forest management agencies listed in the next section. Accountability of monitors and other authorities to users (73%) was the lowest for this ejido and like the ICs and SJZ it was perceived most effective with regards to local authorities because of the Asamblea. In terms of the variable representing Matching the harvest to regeneration of the resource (90%) was consistent with the ICs likely due to the presence of this rule across the entire MBBR. As mentioned in the other sections, the External environment category shows the values were the same for all AN and the reason for the consistency in the variables is that they all refer to external authorities and institutions that are the same for the entire reserve and any (if nominal) variation is based on awareness of external actors by the respondents, which was the same for all AN.

## FOREST CONSERVATION

The forest plays a very important role for this community since they obtain a number of direct benefits like fuel for cooking and heating, water, mushrooms, and other NTFPs as well as promoting social unity. The respondents want authorities to help protect and organize care and conservation activities and enforce conservation rules as well as provide more economic support for conservation activities and the provision of ecosystem services (water in particular- Image 4.9).

The respondents are very proud of the culture of reforestation and natural regeneration of their forest in the ejido. However, the people in this ejido are concerned about forest management citing lack of interest and action on the part of the current president of the ejido. They say that many still adhere to the rules previously established (only taking out fallen or dead trees and fallen branches) with regard to forest use and conservation but that the lack of enforcement of the rules is creating a great deal of tension and disorder. There is some enforcement of rules-- when trees or raw materials are stolen there are sanctions determined by the Asamblea and the material is confiscated (Image 4.8).



**Image 4.8.** Here is a picture of wood recently confiscated in the Casa Ejidal already processed into building materials, with permission from the Comisariado president, pictured (Offices of the Comisariado and meeting place of the Asamblea).

The Asamblea still tries to maintain order as a group but it is difficult when they do not have the support of the Comisariado committee. For example as mentioned earlier, there is barely any patrolling of the forest making illegal extraction easy. This is due to lack of supervision by the president and Comisariado, and the programs in place previously have been neglected. We were informed that the IC Nicolas Romero helps limit the illegal extraction by patrolling in the ejido but they have to stay along the boundaries to avoid conflict. There is a great deal of conflict between the ejidatarios and avecindados due to illegal extraction as well as conflict between the ejido and the indigenous community of the same name over resource and land rights. This is evidenced by a sensitive border dispute between the two. Limited land rights access is cited for the formation of the IC 40 years ago separating the 4th, 5th and 6th manzanas from the ejido. The ejido seeks to delegitimize the IC's claim to land and water in an effort to reintegrate the IC into the ejido. Some of the between the ejidatarios and avecindados are due to illegal extraction. The ongoing tension over to whom the territory belongs leads to other conservation and socio-political challenges.

Many respondents (80%) mentioned "talla hormiga" which is the slow but persistent extraction of wood without permits for material and fuel. We were also informed that there are frequent illegal logging events where 20-30 trees are removed at a time and residents are frustrated by the lack of support on the part of the president. In fact, we were informed that on December 31 2015, twelve Oyamel were taken out of the Reserve area illegally as well as 27 cedars taken from the Macheros area on the border with the State of Mexico early this year.

According to the committee, the ejido has a 'mafia' that steals wood to sell since they make a reasonable income from it and they cited gambling and substance abuse as connected to the problem. They also mentioned that the offenders are avecindados (residents of the ejido without ejidatario status) and not ejidatarios. The president informed us that he is trying to enforce the rules but has little or no support from external authorities and conflicts with local laws. For example, they cannot detain the offenders or the same offenders can go to the police and

claim kidnapping, which results in stiff fines through lawsuits. They also voiced frustration with regard to the inordinately long wait periods for use permits for wood that has fallen or been extracted and confiscated and the fines imposed if the wood is used before a permit is issued; this particularly in light of the winter storm that left many fallen and broken trees. They also voiced frustration over the legal process that fines them doubly since the offenders are first individually fined by PROFEPA and then the ejido is fined for not enforcing the extraction rules. The respondents felt that it was fair to enforce the rules but that the expectations that they stand alone (without external sanctioning agencies) in enforcing extraction rules was unfair and counter productive. They are also frustrated that when there are fallen trees or confiscated wood, the external authorities are very slow to respond to their petitions and in cases the wood becomes unusable or stolen as a result of the time it takes for PROFEPA to issue permits. They mentioned further frustration with the quality of the forest technicians who are certified by CONAFOR as many have done poor quality work that has resulted in delays in PES payments, fines and wood extraction. They are frustrated there is no real recourse when a forest tech doesn't do their job other than to consider the payment made to them lost money and seek out the aid of a new forest tech. This was consistent among all ANs.

Respondents and ejido authorities also voiced frustration with the external institutions that provide trees for reforestation (primarily the municipality) as they provide trees not acclimated to the zone. The municipality is also untimely in their provision of the seedlings that have been distributed during the rainy season (August-September) when their roots are too small to anchor properly and they do not have sufficient time to grow deep enough into the soil to reach the water table in time for the dry season. This results in high mortality rates. The participants also explained that planting in the rainy season is difficult and sometimes dangerous and that the

appropriate time for planting is just before the rains begin (May-June). They have voiced these concerns but so far they have fallen on deaf ears.

Respondents said that they receive PES funds from CONAFOR but they told us that they only supply 3 months of minimum wage (60 pesos per day) per year for patrol activity. The majority felt that this was better than nothing (90%) but that it was not enough to offset opportunity costs (99%). In the case of PES given by the Fondo Monarca, the money is divided among the ejidatarios and not put toward community works or services. However, there have been community works projects through Alternare with regard to rain-water conservation. They were unwilling to specify the amount received. The non-ejidatarios (avecindados) voiced frustration at this since some also participate in conservation activities and feel they should benefit from them payments. This arbitrary disbursement is cited as possible incentive for illegal extraction and lack of participation in conservation activities. The adult population (middle-aged and older) is quite concerned with forest conservation rules and decisions and express worry that the younger generation is unaware of the importance of understanding the process, as they are not required to participate in the Asamblea. Some of the younger people interviewed commented that few participate in community activities and those that do are not taken into consideration in decision-making (since they are not authorized participants in the Asamblea) which they cite as a cause of low motivation, again consistent with the other ANs.



**Image 4.9.** Throughout the visit I witnessed the abundant water resources in this ejido. There is continuous, running water year round (the picture was taken in the dry season though it was a relatively wet winter there is normally not this abundance of water in other areas).



**Image 4.10. New reforestation area in Macheros.**



**Image 4.11. A closer look at the reforested area: Pine seedlings planted in the last few years (2012-2015). There is pine and Oyamel but the pine took much more readily than the Oyamel and is more abundant in previous reforestation efforts so they are focusing mainly on pine in this area.**

Concern about water provision, as they provide water to urban areas and other communities and ejidos, was a consistent topic. In fact, we were told that they supply water to Mexico City, Zitácuaro, Ocampo and Ciudad Hidalgo by both internal and external sources. They voiced frustration at the lack of compensation provided for the provision of water to these urban areas as well as worry that it was being taken out faster than it can be replenished. A respondent was quoted as saying, "If we received payment for protecting the water resources, they would take care of it better than if it was their own children."

There was also a great deal of frustration voiced with regard to the forest technicians as they have had difficulty in finding competent ones. This was again consistent among all ANs. We were informed that the current technician has received payment even though he has not provided any reports or services and if any service is provided they have to pay separately from the contract payment (13,000 pesos yearly). The president said that they seek to replace him but that he will not be suggesting replacement until the president leaves office in 2017.

The majority of respondents felt that women should definitely participate in conservation activities since there are many of them and many who do not have gainful employment. This sentiment is evidenced by their general participation in all conservation activities and the women's knowledge of conservation practices. It was also interesting to note that there was previously a female president of the Comisariado in 2003 for this ejido. Many are hoping the current Tesorera would run for Comisariado in the next election.

Respondents commented that they were very happy to have someone from an external institution come in and ask them about their conservation work and concerns. They voiced strong concerns that the external authorities are corrupt and impractical (two examples being mentioned above). They also feel that they are not integrated into the management strategies of the reserve as much as they would like, particularly considering the water that they are providing for areas in and out of the Reserve and feel that greater compensation for providing these services would have a positive impact on conservation on both ends (intentional repetition to represent interviewee emphasis).

## SUMMARY

For all of the differences, it is clear that the four AN studied have a great deal in common. In general, the local managers have shown efficiency in forest management as evidenced by the positive forest cover change from 2006-2015. They certainly voice interest and show investment of time and limited resources. Where there has been capacity building and provision for water storage and public works (at least in these four AN) there is a greater sense of community satisfaction. All AN have demonstrated a willingness and interest in caring for the forest and the services it offers. What was not mentioned was the fondness prevalent among those interviewed for the Monarch butterfly and the forest.

All of the AN ask for greater support in law enforcement and payments for ecosystem services (PES) due to the amount of effort required for each in order to protect the forest and eco-services. It is a reasonable request, particularly when the patrols require constant participation on administrative and participatory levels. They are both also dependent on one another at the moment as PES is often used as compensation for those who patrol since monitoring has a high opportunity cost and does not generate monetary returns in itself. Since the resources they protect are important for raw materials, water availability and in some cases Monarch habitat (which can influence tourism and PES) it would seem advantageous to respond to the needs of local managers that overlap with the needs of the Reserve and the managing agencies that receive federal and international funds for care and maintenance of the reserve. The next chapter presents the results of the operationalized variables and statistical analyses in Chapter 5, Results.

# CHAPTER 5: RESULTS

## RESUMEN DEL CAPÍTULO

Este capítulo se presenta en tres partes. Primero, se presenta el Resumen del capítulo de las variables explicativas utilizadas en el análisis. Segundo, sigue los análisis y mapas de cambio de la cobertura forestal, presentado enseguida el análisis MANOVA de tenencia de tierra. Tercero, sigue una discusión a fondo de los análisis estadísticos de las correlaciones de Spearman y la regresión LASSO. Se examinaron dos comunidades indígenas (CI) y dos ejidos. Hay varias similitudes y algunas diferencias entre estos dos tipos de propiedad de tenencia de tierra. El análisis MANOVA no mostró ninguna diferencia con respecto al tipo de tenencia. Los valores normalizados utilizados para los análisis estadísticos se derivan de los indicadores de las variables en la lista crítica y datos recopilados del campo. Estos análisis se realizaron para demostrar hasta qué grado se requiere el cumplimiento de los criterios establecidos para las variables de la lista crítica para alcanzar tasas bajas de pérdida de cobertura forestal y altas tasas de ganancia de la cobertura forestal, lo que en conjunto indican la eficiencia del manejo forestal, como ha sido explicado en el capítulo 3 de Métodos. La gran mayoría de las puntuaciones de las variables explicativas fueron situadas entre el 76 y el 100% del valor ideal (el 100% representa el valor ideal para el criterio establecido en la teoría para las variables críticas). Ninguna variable obtuvo 100 puntos en ningún NA, aunque se identificaron dos (2) casos con una puntuación de 99, y 12 mayor de 90. Dieciséis (16) variables llegaron a exactamente 90% y veintiséis (26) llegaron a 80 o mayor de 80. Dos variables, Niveles Apropriados de Apoyo Externo (Appropriate Levels of External Aid) y Niveles bajos de Demanda (Low Levels of Demand), tuvieron puntuaciones consistentemente bajas las cuales claramente no cumplen con los criterios presentes en la lista crítica. En la categoría de Arreglos Institucionales, la variable Reglas de manejo de derivación local (Locally Devised Management Rules) tuvo la misma puntuación en cada uno de los cuatro casos y en la categoría Entorno externo, cuatro de las cinco variables no demostraron ninguna diferencia entre los NA, por lo que estas cinco variables se retiraron del análisis. Estos resultados demostraron que no se requiere un 100% de cumplimiento con el criterio establecido para todas las variables, por lo menos en estas combinaciones. Los resultados obtenidos de los análisis muestran algunas consistencias, así como algunas inconsistencias con las relaciones esperadas según la teoría de sistemas de recursos comunes. Las correlaciones de Spearman de variables dependientes e independientes han indicado que la mayor parte de las variables independientes no parecen tener influencia en las transiciones forestales examinadas, esto sugiere que no todas las variables en la lista crítica tienen que lograr 100% para asegurar un manejo eficiente. Este análisis muestra además que algunas de las variables parecen explicar los incrementos en la cobertura forestal, aunque no a las pérdidas. Curiosamente, se encontró que una de las variables (Resource small size o Tamaño pequeño del recurso) tuvo valores positivos para la transición del bosque degradado al bosque denso (2 a 1), pero negativo para la transición de no bosque al bosque degradado (3 a 2, reforestación). Si bien estas direcciones de las variables significativas son parte de las expectativas, es decir, positivas, para la transición 2 a 1, no son las esperadas (negativas) para la misma. La regresión LASSO puede ayudar a aclarar algunas de estas incertidumbres, así como proporcionar apoyo adicional a los resultados de la correlación. Tres variables (superposición, pequeño tamaño del sistema de recursos y dependencia de los recursos) están asociadas con aumento de cobertura forestal con valores positivos, que están en consonancia con la teoría y por lo tanto subyacente a la lista crítica. Simultáneamente, estas mismas tres variables están asociadas en una dirección negativa con la pérdida de bosque, lo que también concuerda con la teoría. La pobreza, que según la teoría está asociada con un mayor riesgo de deforestación. Es notable que no sea indicada como tal en los resultados de esta investigación. En cambio, está positivamente relacionado con el aumento de la cubierta forestal. Por otra parte, la Equidad (que se entiende como una condición importante para asegurar que las



comunidades manejen bien los bosques) está relacionada positivamente con la pérdida de bosques. El tamaño pequeño de los recursos también muestra una relación inversa con la transición del bosque denso a no bosque (1 a 3), lo que es contrario a la teoría, ya que el tamaño más pequeño es mejor para un manejo eficiente según teoría. La variable pobreza muestra una relación positiva con la recuperación del bosque (no bosque a bosque denso). Hay que decir que hay incoherencia en los hallazgos sobre el papel que desempeña la pobreza en el cambio de cobertura forestal de acuerdo con un estudio de Busch y Ferretti-Gallon en el 2017. La homogeneidad de la identidad y la facilidad de la aplicación de las reglas están relacionadas negativamente con las tasas de transición de no bosque a bosque densos, pero con coeficientes mucho más bajos que los anteriormente mencionados y por lo tanto menos impactante al modelo. La variable de equidad también surge como una relación contraria a la teoría, ya que menos equidad conduce al crecimiento y la recuperación de los bosques y una mayor equidad parece conducir a un aumento de la pérdida y degradación. Finalmente, y la relación mas reducida, la disminución de tamaño pequeño del recurso resulta en un aumento de degradado a no-bosque (o aumentar tamaño pequeño del recurso para disminuir la categoría 2 a 3). Todo esto se discute en detalle en este capítulo.

## RESULTS OF FOREST COVER CHANGE FROM 2006-2015

### RESULTS OF FOREST COVER CHANGE FOR THE IC CARPINTEROS

The results of the indicator for forest cover show that Carpinteros complies with the working definition of efficiency that was used in this study. The matrices consist of 3 classes (dense forest, degraded forest and non-forest) and have been constructed for each of the three area categories (core zone, buffer zone and zone outside the MBBR).

The following tables and maps represent the results for forest cover area in hectares per year (Table 5.1), Forest change trends (Map 5.1 and 5.2), transition rates for the period 2006-2010 (Table 5.2) , forest cover per zone per year (Table 5.3), and the annual transition rates for the periods 2006-2010 and 2010 -2015 (Table 5.4). The area was calculated based on geographical data calculated using Google Earth Pro satellite images (Landsat) and ArcGIS. The annual transition rates were calculated for each type as total area divided by the forest cover area for each zone. Accompanying the tables and maps are the forest cover change maps for the periods of 2006-2010 (Map 5.1) and 2010-2015 (Map 5.2). They were generated with the coordinates of each AN from The National Agrarian Registry (RAN/PHINA). The overall trends show that forest cover increases, non-forest remains consistent and degraded forest declines.

**Table 5.1. Results for forest cover over the period of 2006-2015, Carpinteros**

Map class	Year/ Area in Ha		
	2006	2010	2015
1. Forest	520.61	554.09	573.06
2. Degraded	78.03	45.97	26.87
3. Non forest	253.60	252.17	252.28

Forest cover change by class 2006, 2010, 2015

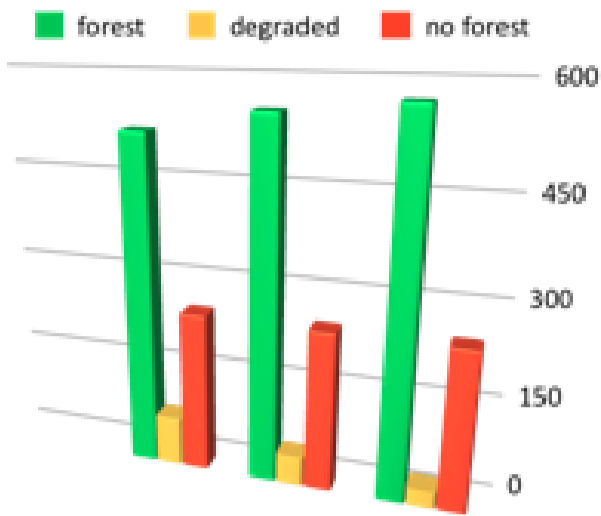


Figure 5.1. Graph showing the trends in forest cover trends for Carpinteros 2006-2015.

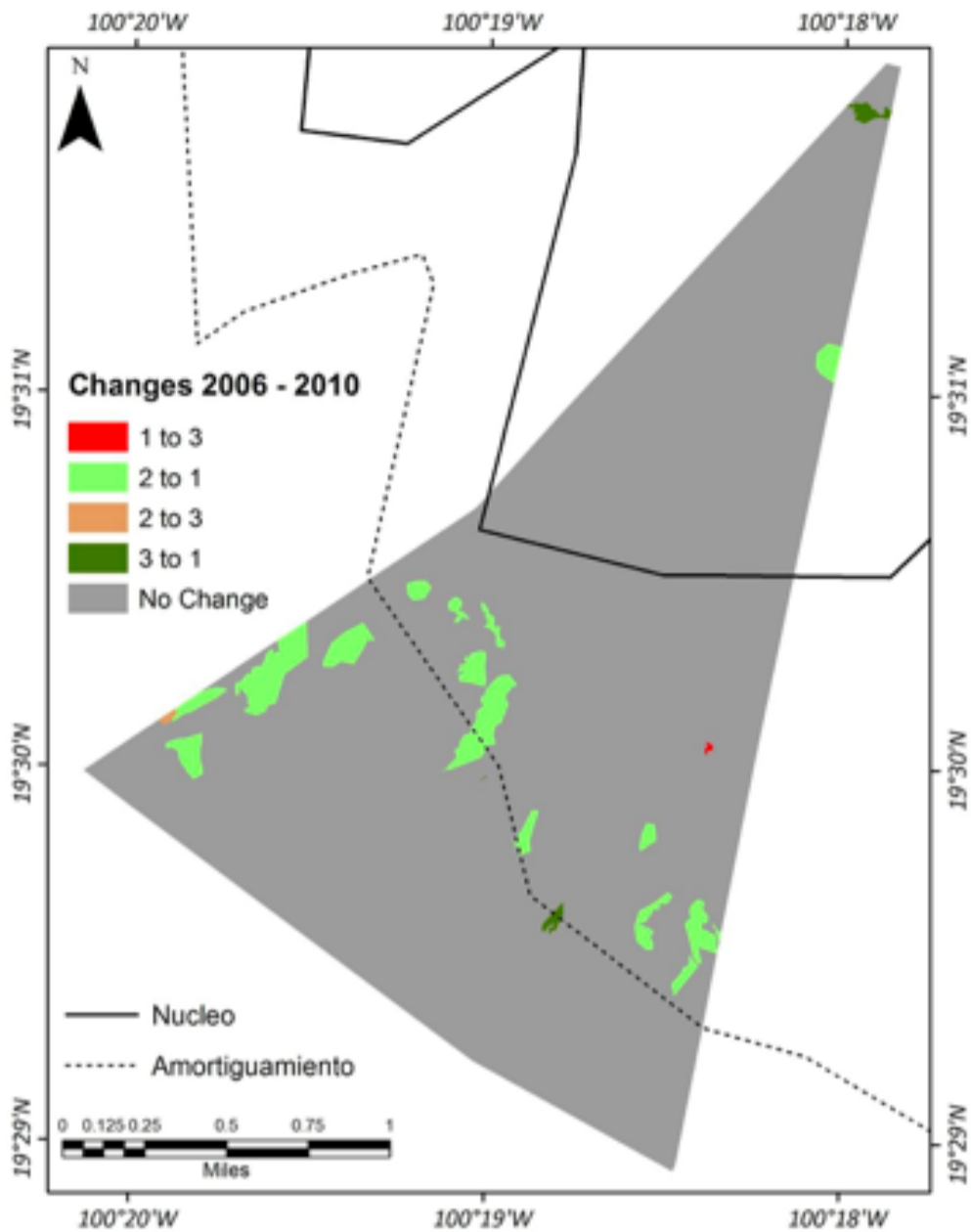
Table 5.2. Transition rate change for Carpinteros for the periods 2006-2010 and 2010- 2015 where 1 = dense forest, 2 = degraded forest and 3 = non-forest.

From*	To*	Annual transition rate % 2006 to 2010	Annual transition rate % 2010 to 2015
1	2	0%	0.17%
1	3	0.014%	0.061%
2	1	3.73%	2.19%
2	3	0.004%	0.22%
3	1	0.22%	0.27%
3	2	0%	0

Table 5.3. Forest cover area per zone per year for Carpinteros.

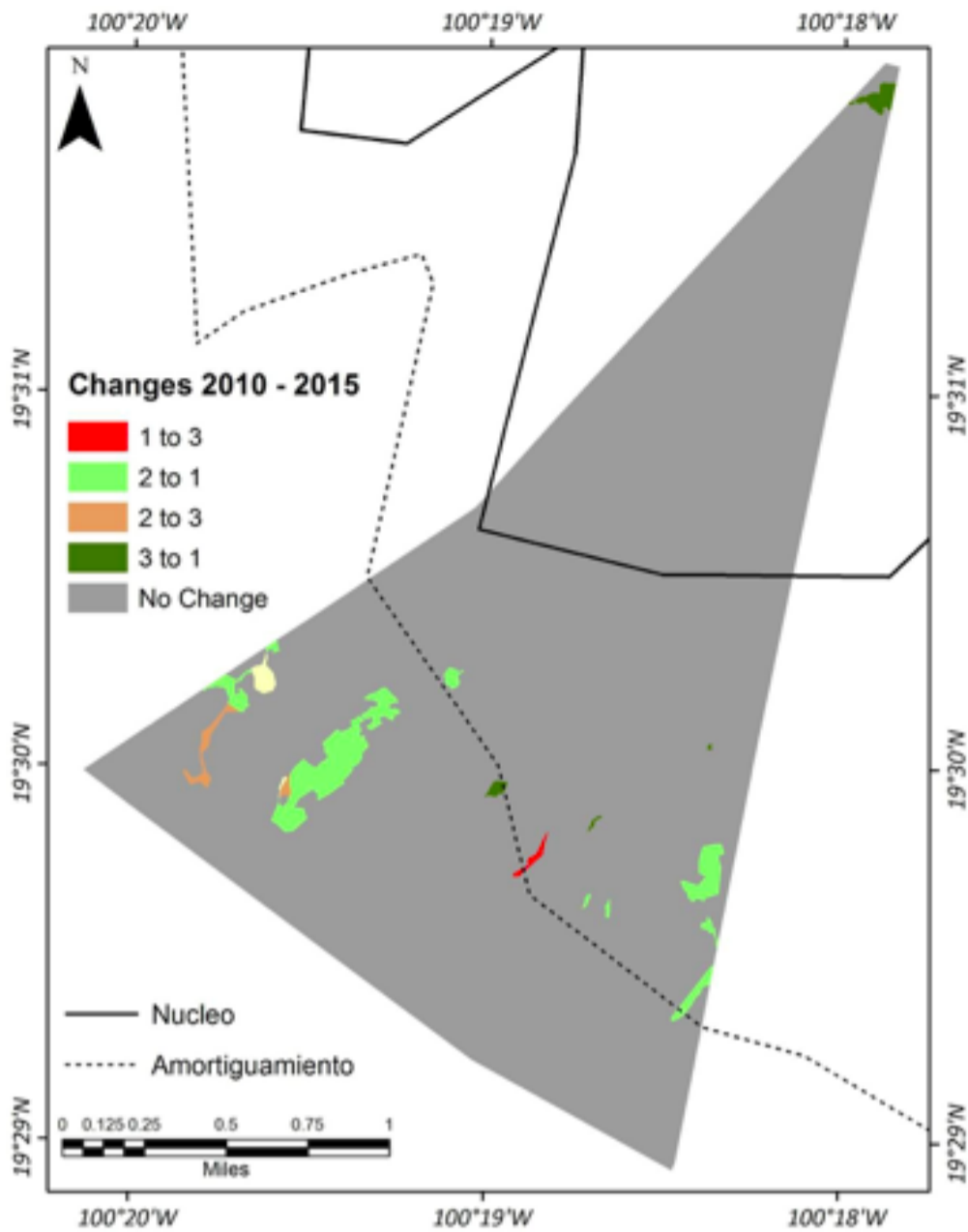
Year -->	2006			2010			2015		
	1	2	3	1	2	3	1	2	3
Core	224.2	1.64	4.31	226.94	0	3.17	228.54	0	1.57
Buffer	253.4	32.93	12.03	250.26	18.17	11.92	255.49	12.77	12.09
outside reserve	61.04	43.46	237.26	76.88	27.8	237.07	89.08	14.10	238.63

On the forest cover change map 2006-2010, the grey area is area that has shown no change (Map 5.1). The light green areas are those that have converted from degraded to dense forest. The dark green areas are those that have been converted from no forest to dense forest and the red area is that which has been deforested from dense forest to no forest. The orange area is area that was degraded but then converted to non-forest. The solid line is the boundary of the core zone while the broken line marks the boundary of the buffer zone.



Map 5.1. Forest cover change map for the period 2006-2010. In the upper NE portion (core zone) of the IC where the forest is predominantly Oyamel, there is a small Monarch colony about 1.5 km<sup>2</sup>. Just below that is the pine area, which ends right around the border where the core zone (dark green) meets the buffer zone (light green). The upper half of the buffer zone is mixed forest (Pine, Oak, Cedar, Alder, Heath, etc.) and below that in the lower NE half of the buffer zone is scrubland. The lower portion of the IC below the buffer zone is mostly avocado and fruit orchards as well as agriculture.

On the forest cover change map for the period 2010-2015 the gray area is the area that has shown no change (Map 5.2). The light green areas are those that have converted from degraded to dense forest. The dark green areas are those that have been converted from no forest to dense forest and the red area is that which has been deforested from dense forest to no forest. The orange area is area that was degraded but then converted to non-forest. The solid line is the boundary of the core zone while the broken line marks the boundary of the buffer zone.



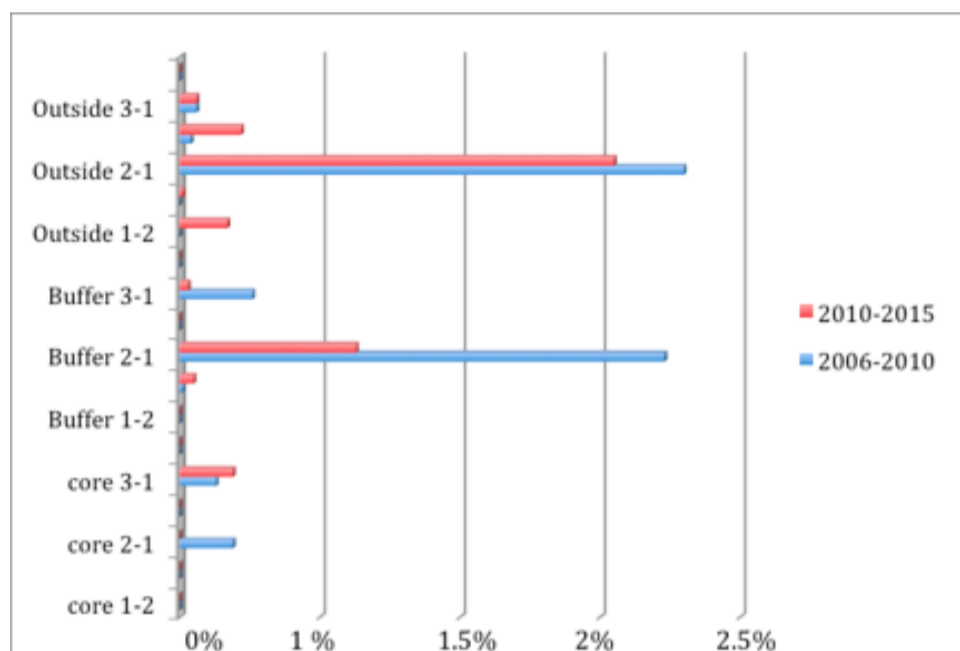
Map 5.2. Forest cover change map for the period 2010-2015 for Carpinteros.

The annual transition rates were relatively small (Table 5.4). The total negative change for 2006-10 was 0.15% while positive change was 4.14%. The total negative change for 2010-15 was 0.27% while positive change was 2.46%. Any class not represented was 0.

Table 5.4. Annual transition rates for the periods 2006-2010 and 2010 -2015 calculated as total area divided by the forest cover area for Carpinteros.

Zone	From*	To*	Annual transition rate % 2006 to 2010	Annual transition rate % 2010 to 2015
core	1	2	0%	0%
core	1	3	0%	0%
core	2	1	0.19%	0%
core	2	3	0%	0%
core	3	1	0.13%	0.19%
core	3	2	0%	0%
Buffer	1	2	0%	0%
Buffer	1	3	0.01%	0.05%
Buffer	2	1	1.73%	0.63%

Buffer	2	3	0%	0%
Buffer	3	1	0.26%	0.03%
Buffer	3	2	0%	0%
Outside	1	2	0%	0.17%
Outside	1	3	0%	0.01%
Outside	2	1	1.8%	1.55%
Outside	2	3	0.04%	0.22%
Outside	3	1	0.06%	0.06%
Outside	3	2	0%	0%



**Figure 5.2. Graph of forest cover trends by class, zone and period for Carpinteros.**

There is a general trend of positive forest cover change but the overall change is also quite low. In 2010 we see that the buffer zone has some very limited negative forest change (0.1%). The total negative change for 2006-10: 0.15%; Positive change 2006-10: 4.14%. The total negative change for 2010-15: 0.27%; Positive change 2010-15: 2.46%. This demonstrates that the overall change was positive in all zones. This is particularly interesting as the rules for management in the MBBR only apply to the core and buffer zones. It should be noted that the lack of change is also a factor in these figures, however with the increase in forest cover in general it speaks to the efficient management of the forest in this IC.

## RESULTS OF FOREST COVER CHANGE FOR THE IC SAN FRANCISCO CURUNGUEO (SFC)

The following tables and figure represent the results for forest cover area in hectare per year (Table 5.5), Forest change trends (Figure 5.3 and 5.4), transition rates for the period 2006-2010 (Table 5.6), forest cover per zone per year (Table 5.7), and the annual transition rates for the periods 2006-2010 and 2010-2015 (Table 5.8). Accompanying the tables and figures are the forest cover change maps for the periods of 2006-2010 (Map 5.3) and 2010-2015 (Map 5.4). The analysis shows that forest cover rises slightly, non-forest slightly increases and degraded forest increases (Table 4.8 Figure 5.3). The data for the number of hectares for each type per year can be seen in Table 5.5. The results show that SFC also fits the criteria for efficient management.

Table 5.5. Results for forest cover over the period of 2006-2015 for SFC.

Map class	Year/ Area in Ha	Year/ Area in Ha	Year/ Area in Ha
	2006	2010	2015
1. Forest	359.6	360.1	341.7
2. Degraded	379.7	423.2	443.3
3. Non forest	1118.2	1128.2	1125.6

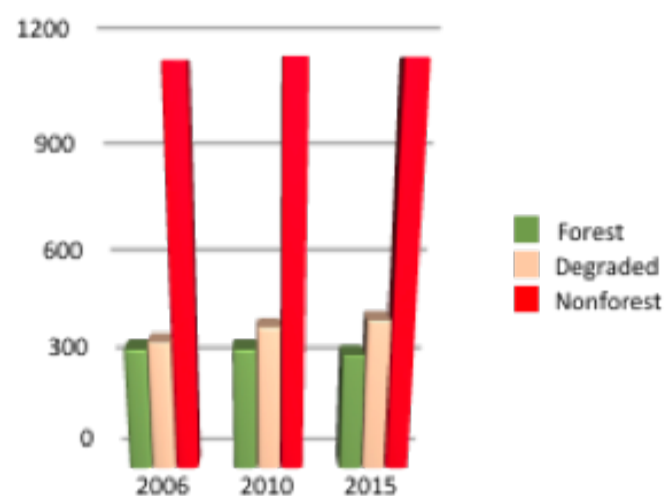


Figure 5.3. Graph showing the trends in forest cover trends for SFC 2006-2015.

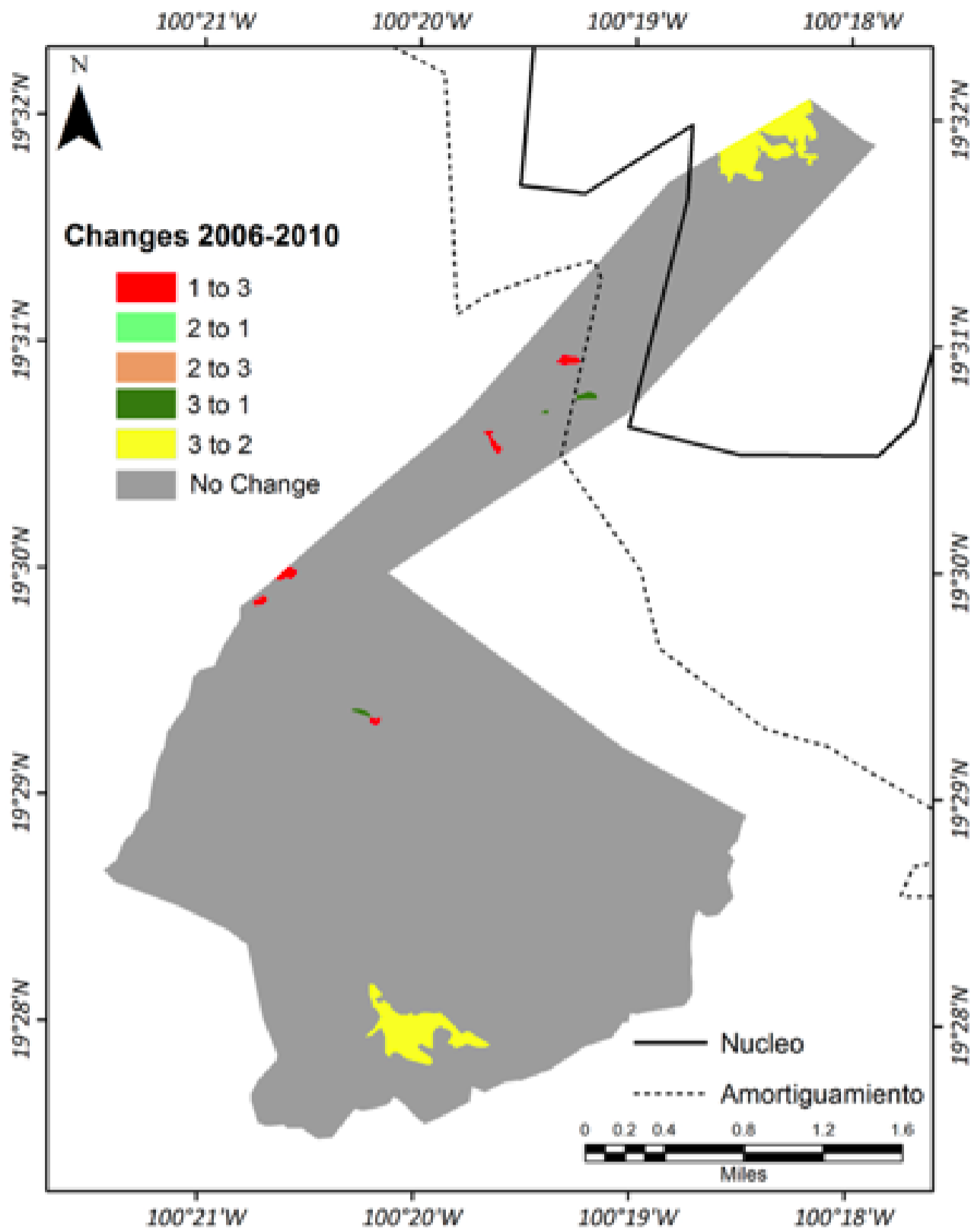
The transition rates over the period 2006-2015 are relatively small based on the percentages (Table 4.8). The greatest transition was 2.3% from non-forest to degraded forest in 2010. The second highest was non-forest to degraded in 2015 and the next highest was forest to non-forest in 2015 at 1.5%.

Table 5.6. Transition rate change for SFC for the periods 2006-2010 and 2010- 2015 where 1 = dense forest, 2 = degraded forest and 3 = non-forest.

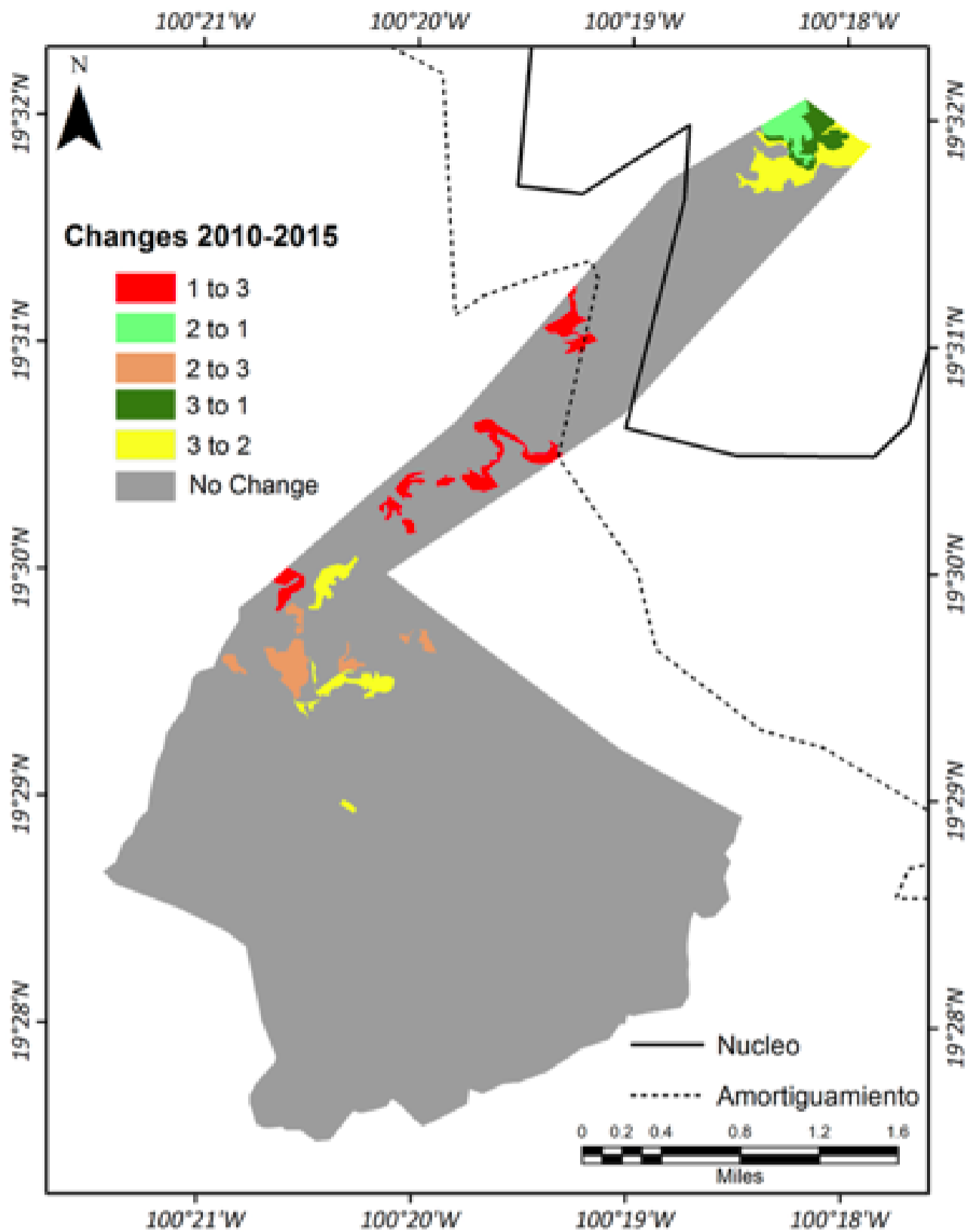
From*	To*	Annual transition rate % 2006 to 2010	Annual transition rate % 2010 to 2015
1	2	0%	0.6%
1	3	0.2%	1.5%
2	1	0%	0.5%
2	3	0%	0.6%
3	1	0.22%	0.6%
3	2	2.3%	1.8%

Table 5.7. Forest cover area per zone per year for SFC.

Year -->	2006			2010			2015		
	1	2	3	1	2	3	1	2	3
Core area	116.2	0	53	116.2	23	31	136.7	32.53	0
Buffer	98.2	0	0.90	99	0	0.10	98.1	0	0.95
Outside reserve	145.2	379.7	1118.2	144.9	401.2	1097.1	107	410.8	1124.6



Map 5.3. Forest cover change map for the period 2006-2010, SFC, IC. The majority of the IC falls outside the reserve and is highly developed in urban terms. There are 299 ha in the core zone (hard line) and 140 ha in the buffer zone (dotted line).



Map 5.4. Forest cover change map for the period 2010-2015 for SFC.

The annual transition rates show that the greatest areas of transition were outside the reserve area (Table 5.8, Map 5.5). Moreover, the transition was negative, from dense forest to degraded forest in both periods. Both periods also showed a 1% increase in non-forest to degraded forest (which would imply recovery, whether it be anthropogenic or natural). Otherwise the transition was nominal in all categories, ranging from 0 to 0.7% across categories for both periods. The period of 2006-2010 showed an increase in forest cover from degraded to dense forest.



Table 5.8. Annual transition rates for the periods 2006-2010 and 2010-2015 calculated as total area divided by the forest cover area for SFC.

Zone	From*	To*	Annual transition rate % 2006 to 2010	Annual transition rate % 2010 to 2015
core	1	2	0%	0%
core	1	3	0%	0%
core	2	1	0%	0.5%
core	2	3	0%	0%
core	3	1	0%	0.6%
core	3	2	1.1%	1%
Buffer	1	2	0%	0%
Buffer	1	3	0%	0.04%
Buffer	2	1	0%	0%
Buffer	2	3	0%	0%
Buffer	3	1	0.04%	0%
Buffer	3	2	0%	0%
Outside	1	2	0%	12.2%
Outside	1	3	0%	1.4%
Outside	2	1	1.8%	0%
Outside	2	3	0.04%	0.8%
Outside	3	1	0.06%	0.07%
Outside	3	2	0%	0.7%

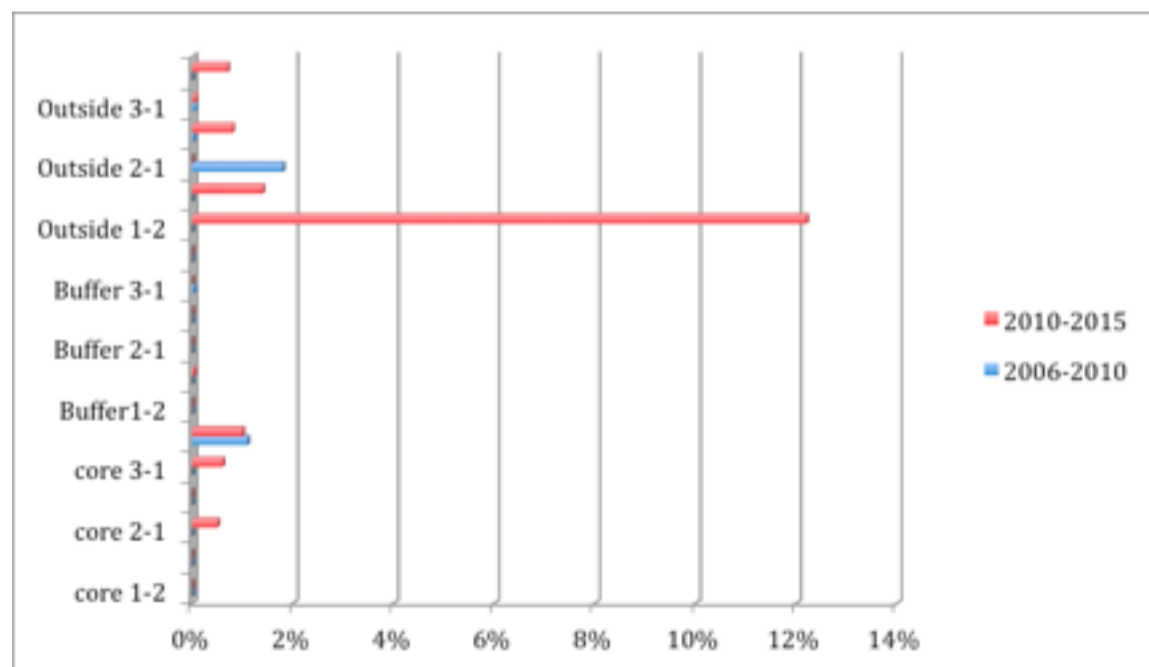


Figure 5.4. Forest cover trends by class, zone and period for SFC.

Forest cover change in this IC differed significantly between the zones inside the Reserve and those outside. For the period 2006 to 2010, the buffer zone showed some negative forest change however, it is nominal (0.4%) while there was 3% positive change with 1.1% in the core zone, 0.04% in the buffer zone and 1.9% in the area outside the MBBR. The total negative change for 2010-15 was 14.44% (with the entirety of that negative change outside the MBBR) while the total positive change for 2010-15 was 2.87% in the core and buffer zones. This demonstrates that the overall change was positive in the zones inside the MBBR but negative in the areas outside. This is quite

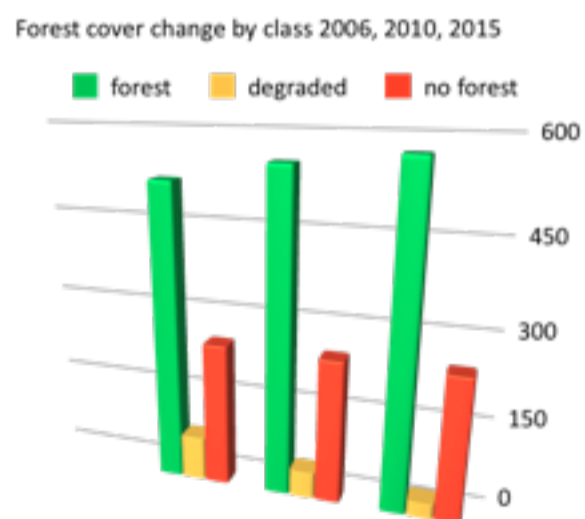
different from the example in Carpinteros where there was positive change for all zones. In SFC, with a much larger area outside the reserve, this implies that the previous land cover practices and urbanization increased land cover change without concern for forest area outside the reserve while the management rules inside the reserve had positive results with regard to forest cover. It should be noted that the lack of change is also a factor in these figures, however with the increase in forest cover in the core and buffer zones it speaks to the efficient management of the forest in this IC as influenced by the Reserve regulations.

## RESULTS OF FOREST COVER CHANGES FOR THE EJIDO SAN JUAN ZITÁCUARO (SJZ)

The general trends in the data show that forest cover increases, non-forest slightly decreases and then plateaus and degraded forest decreases over the 9 year period. The data shows that San Juan Zitácuaro falls within the criteria of the working definition of efficient forest management.

**Table 5.9. Results for forest cover over the period of 2006-2015 for SJZ.**

Map class	Year/ Area in Ha	Year/ Area in Ha	Year/ Area in Ha
	2006	2010	2015
1. Forest	521	554	573
2. Degraded	78	46	27
3. Non forest	254	252	252



**Figure 5.5. Visual representations of the trends in forest cover trends for SJZ 2006, 2010 and 2015, respectively.**

The transition rates for SJZ show an overall positive transition from degraded to dense forest for the period 2006-2010 and non forest to dense forest for 2010-2015. Otherwise the changes are nominal for the other categories for both periods.

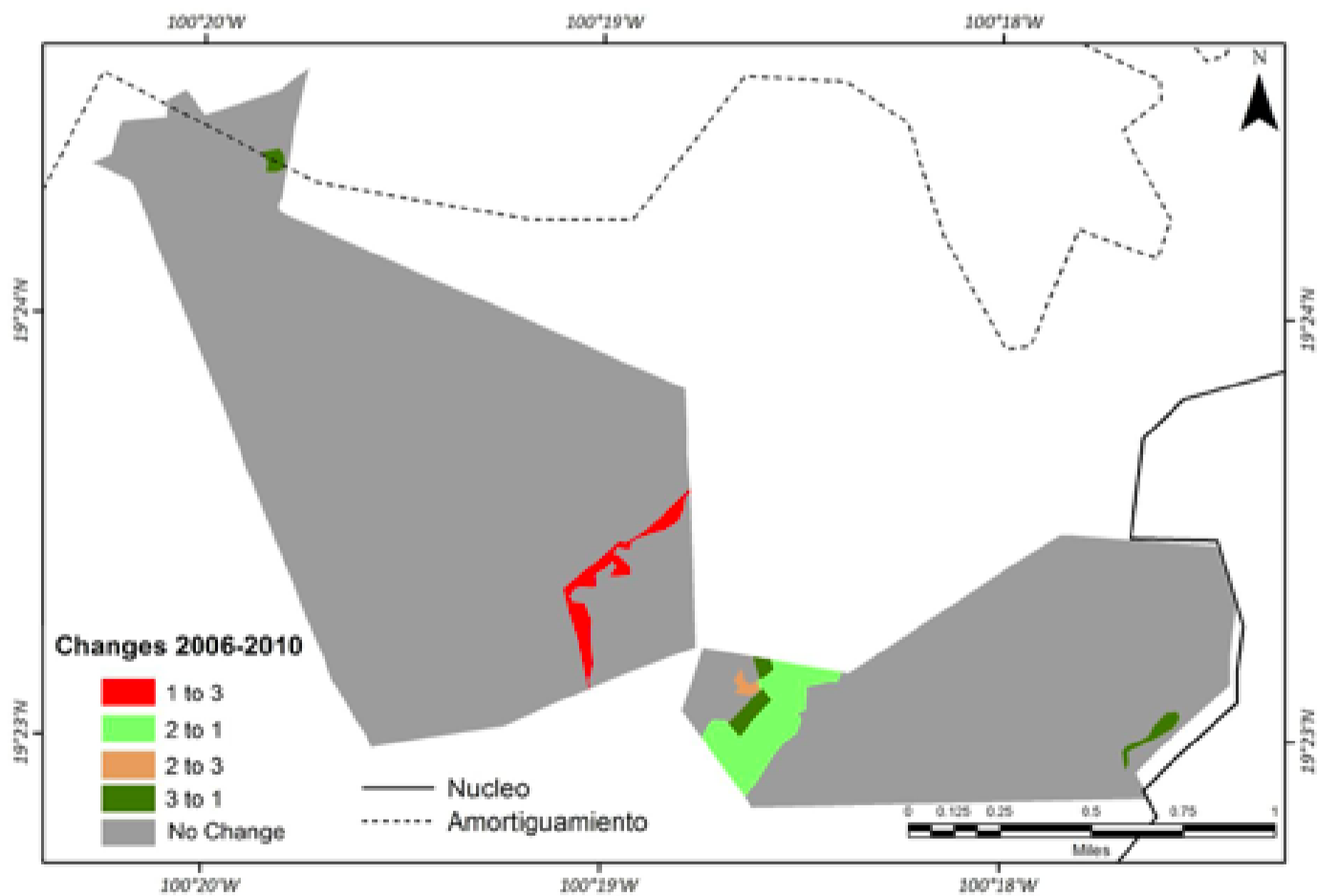
Table 5.10. Transition rate change for SJZ for the periods 2006-2010 and 2010- 2015 where 1 = dense forest, 2 = degraded forest and 3 = non-forest, per zone.

From*	To*	Annual transition rate % 2006 to 2010	Annual transition rate % 2010 to 2015
1	2	0%	0%
1	3	0.6%	0%
2	1	1.5%	0.4%
2	3	0.08%	0%
3	1	0.5%	2.3%
3	2	0%	1.8%

Table 5.11. Forest cover area per zone per year for SJZ.

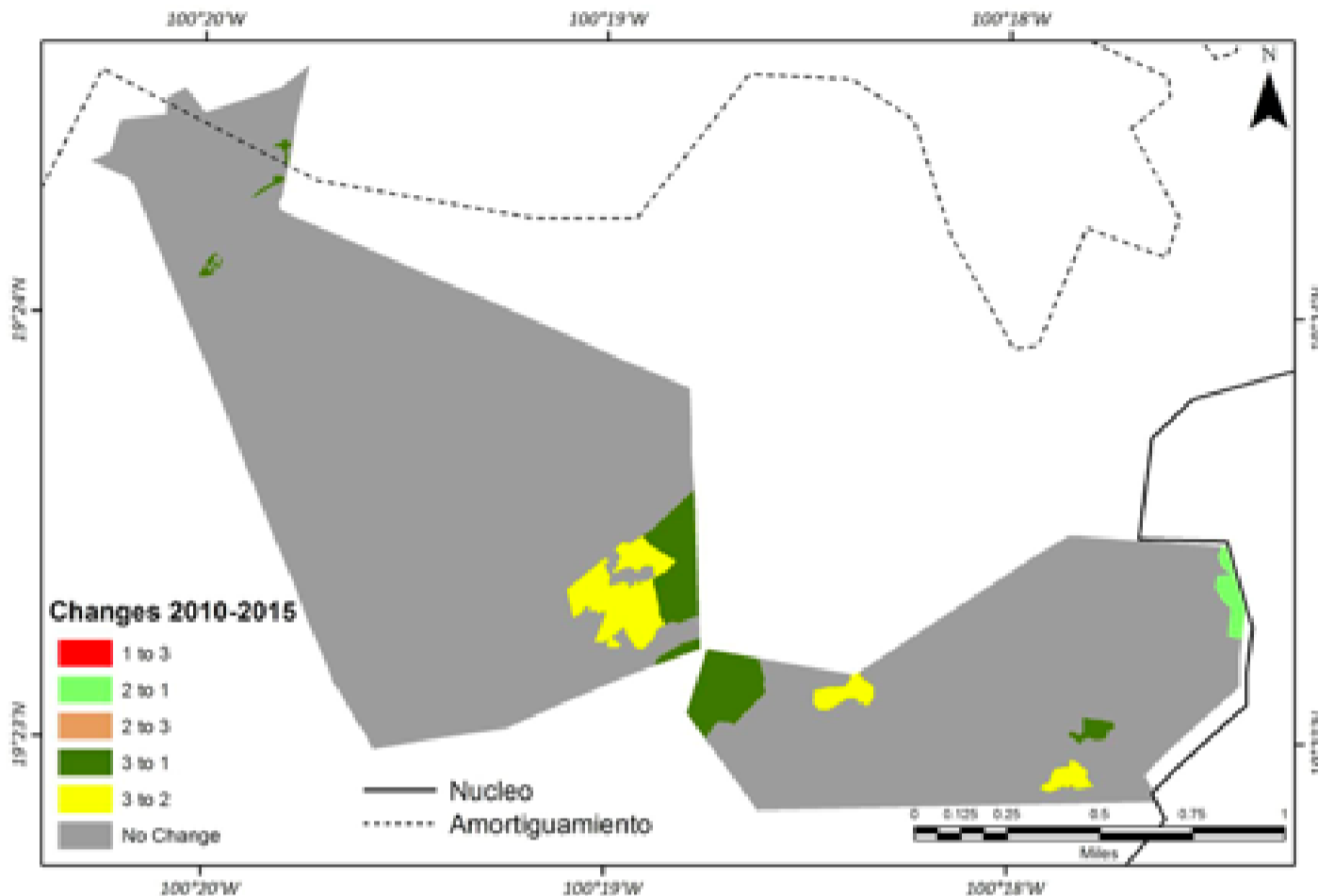
Year -->	2006			2010			2015		
	1	2	3	1	2	3	1	2	3
Area (ha)									
Buffer	502.1	16.3	37.9	514	2.7	54.5	536.3	15.7	20.1
Outside reserve	0	0	11.3	0	0	10.5	0	0	10

On the forest cover change map for the period 2006-2010, the gray area is area that has shown no change (Map 5.5). The transition rates for each period are shown in Table 5.10. The largest transition was non forest to dense forest (0.62%) for this period which was followed by some negative change (0.11%) degraded to non-forest.



Map 5.5. Forest cover change map for the period 2006-2010. The buffer zone is delineated with a broken line and the core zone with a solid line.

The forest cover change map for the period 2010-2015 is similar to that of 2006-2010 (Map 5.6). Note that this ejido is completely inside the buffer zone. In an interesting expression of boundary imprecision, the CONANP Reserve boundary lines are 80km different from the RAN political boundaries of the ejido which was present for both ejidos. The largest percentage transition was from non forest to dense forest (3.41%) followed by degraded to dense forest (2.66%) for this period.



Map 5.6. Forest cover change map for the period 2010-2015 for San Juan Zitácuaro.

The annual transition rates are quite small (Table 5.12, Map 5.6). The overall changes were positive as the highest percentages for both periods were degraded to dense forest. There was some negative change from degraded to non forest in the period 2006-2010.

Table 5.12. Annual transition rates for the periods 2006-2010 and 2010 -2015 calculated as total area divided by the forest cover area for SJZ.

Zone	From*	To*	Annual transition rate % 2006 to 2010	Annual transition rate % 2010 to 2015
Buffer	1	2	0%	0%
Buffer	1	3	0.9%	0%
Buffer	2	1	0%	0.45%
Buffer	2	3	0.11%	0%
Buffer	3	1	0.62%	3.41%
Buffer	3	2	0%	2.66%
Outside	1	2	0%	0%
Outside	1	3	0%	0%
Outside	2	1	0%	0%
Outside	2	3	0%	0%

Outside	3	1	0.07%	0.05%
Outside	3	2	0%	0%

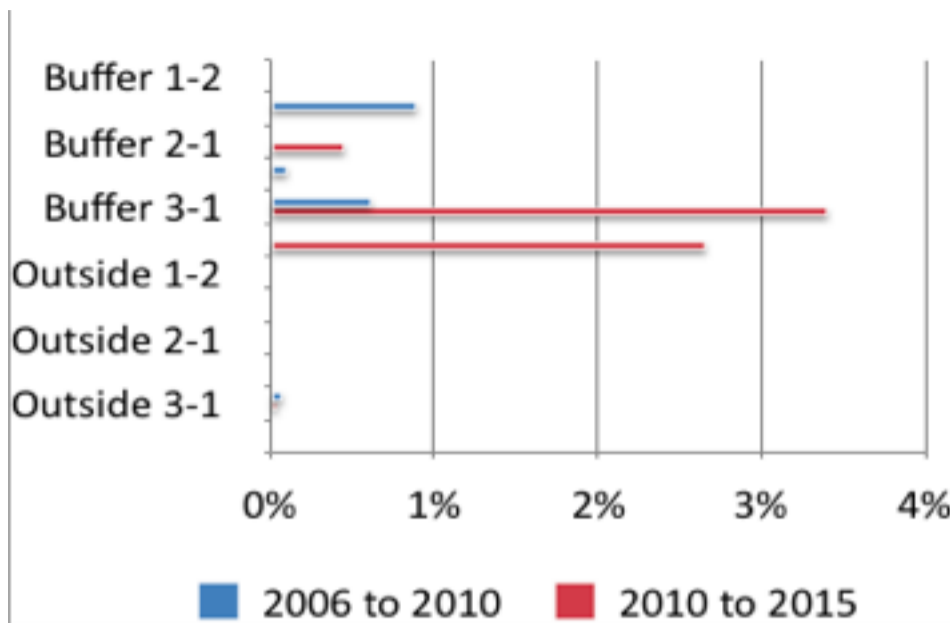


Figure 5.6. Forest cover trends by class, zone and period for SJZ.

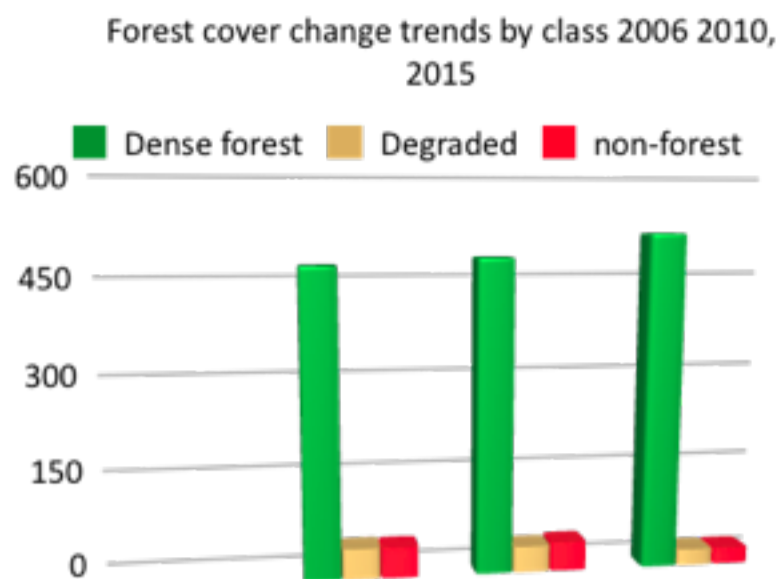
The transition rates for SJZ are what we would expect to see as the vast majority of this ejido falls inside the buffer zone of the reserve. This would indicate that, in general, the rules are being followed with regard to restricted human use, reforestation and care of the forest. The difference in border coordinates (Map 5.5 and 5.6) is notable in the case of these ejidos and the inconsistency appears to be indicative of the occasional lack of communication between and among agencies resulting in a difference in the reserve boundaries and the ejido boundaries, which should technically be in agreement.

## RESULTS OF FOREST COVER CHANGE FOR THE EJIDO NICOLAS ROMERO

Here are the results of the indicators for forest cover for Nicolas Romero. The data shows that this ejido also complies with the working definition criteria of efficient forest management. The area was calculated based on the geographical data calculated using Google Earth Pro satellite images (Landsat) and ArcGIS. The annual transition rates were calculated for each type as total area divided by the forest cover area for each zone. Accompanying the tables and figures are the forest cover change maps for the periods of 2006-2010 (Map 5.5) and 2010-2015 (Map 5.6). They were generated with the coordinates of each AN from The National Agrarian Registry (RAN/PHINA). The data shows that forest cover increases, non-forest decreases and degraded forest decreases over the 9 year period.

Table 5.13. Results for forest cover over the period of 2006-2015 for Nicolas Romero.

Map class	Year/ Area in Ha		
	2006	2010	2015
1. Dense forest	470.1	480.6	515.1
2. Degraded	47.2	39.8	24.5
3. Non forest	46.5	43.6	24.4



**Figure 5.7.** Visual representations of the trends in forest cover trends for Nicolás Romero 2006, 2010 and 2015, respectively.

The annual transition rates show that the transition was positive, from degraded and non-forest forest to dense forest in both periods. This would imply recovery, and we can assume that is due at least in part to the reforestation efforts in which Nicolas Romero participates in yearly (more on this can be found in the chapter on agrarian nuclei). Otherwise the transition was nominal in all categories, ranging from 0 to 0.7% across categories for both periods. This is what we would expect to see since the ejido falls inside the buffer zone of the reserve.

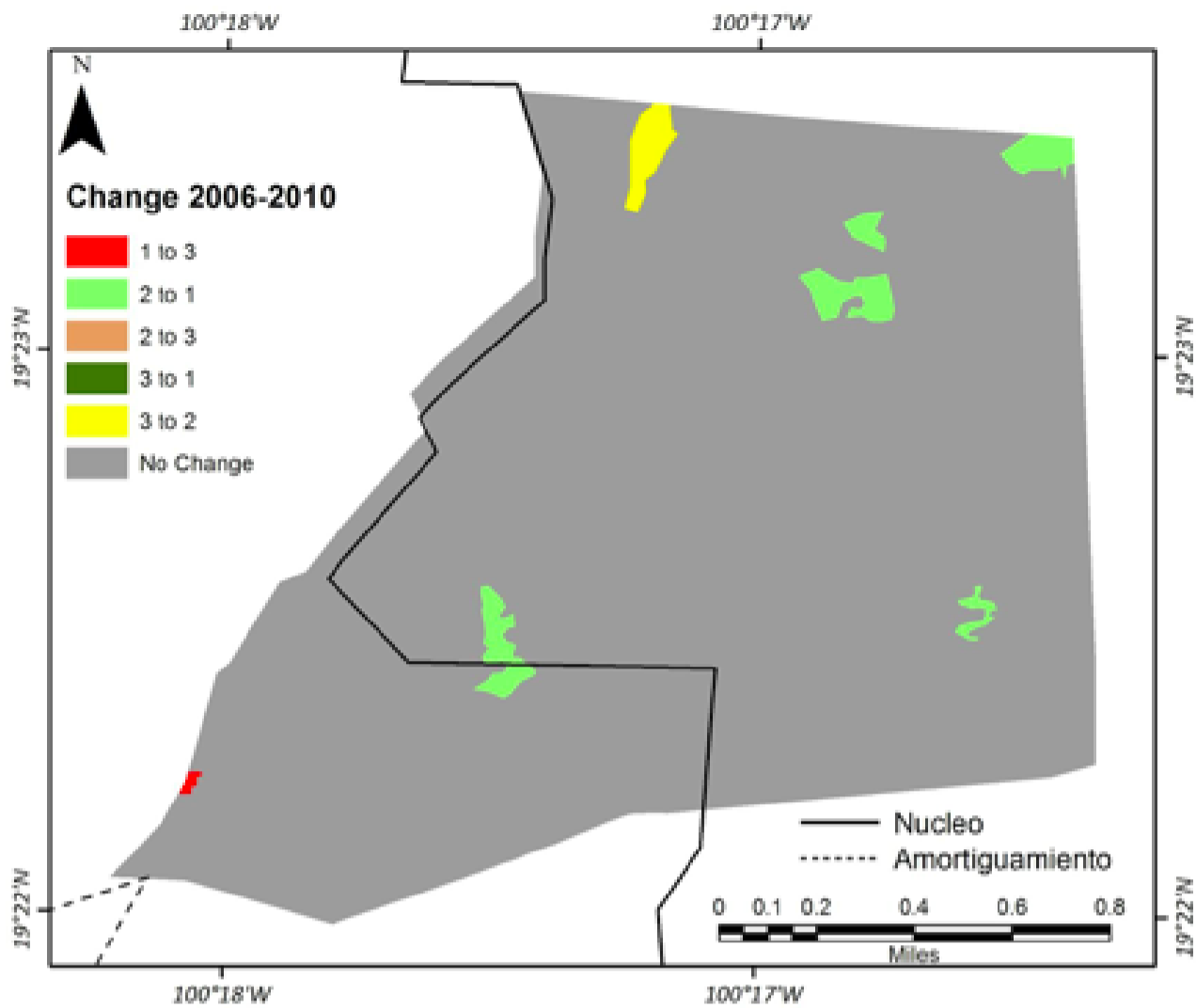
**Table 5.14.** Transition rate change for Nicolás Romero for the periods 2006-2010 and 2010- 2015 where 1 = dense forest, 2 = degraded forest and 3 = non-forest.

From*	To*	Annual transition rate % 2006 to 2010	Annual transition rate % 2010 to 2015
1	2	0%	0%
1	3	0.05%	0.09%
2	1	1.92%	4.25%
2	3	0%	0%
3	1	0%	2.03%
3	2	0.6%	1.5%

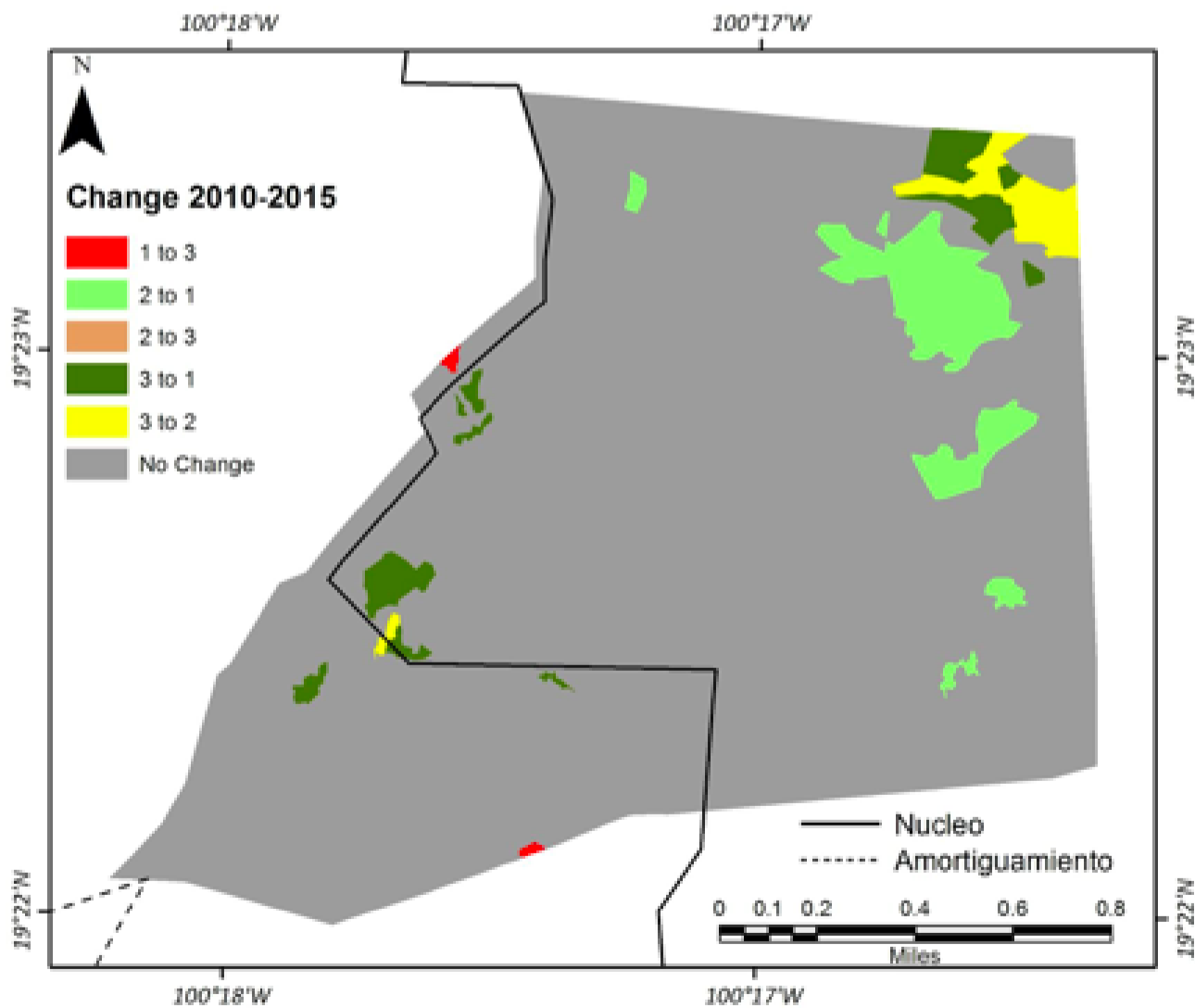
**Table 5.15.** Forest cover area per zone per year for Nicolas Romero.

Year -->	2006			2010			2015		
Area	1	2	3	1	2	3	1	2	3
<b>Core area</b>	12	4	2	13	2.86	2.54	14.8	2.52	2
<b>Buffer</b>	512.1	38.2	17	534	22	15.53	554.8	10.1	7

Similar to San Juan Zitácuaro, the CONANP Reserve boundary lines are 80km different from the RAN political boundaries of the ejido, evidenced by the space between the political boundary of the ejido and the Reserve zone boundaries.



Map 5.7. Forest cover change map for the period 2006-2010. The buffer zone is delineated with a broken line and the core zone is marked with a solid line.



Map 5.8. Forest cover change map for the period 2010-2015.

The annual transition rates are quite small (Table 5.16). The overall changes were positive as the highest percentages for both periods were degraded to dense forest.

Table 5.16. Annual transition rates for the periods 2006-2010 and 2010 -2015 calculated as total area divided by the forest cover area.

Zone	From*	To*	Annual transition rate % 2006 to 2010	Annual transition rate % 2010 to 2015
core	1	2	0%	0%
core	1	3	0%	0%
core	2	1	2.3%	5.5%
core	2	3	0%	0%
core	3	1	0%	2.45%
core	3	2	0.74%	1.9%
Buffer	1	2	0%	0%
Buffer	1	3	0.2%	0.4%
Buffer	2	1	0.8%	0%
Buffer	2	3	0%	0%
Buffer	3	1	0%	0.08%
Buffer	3	2	0%	0.13%

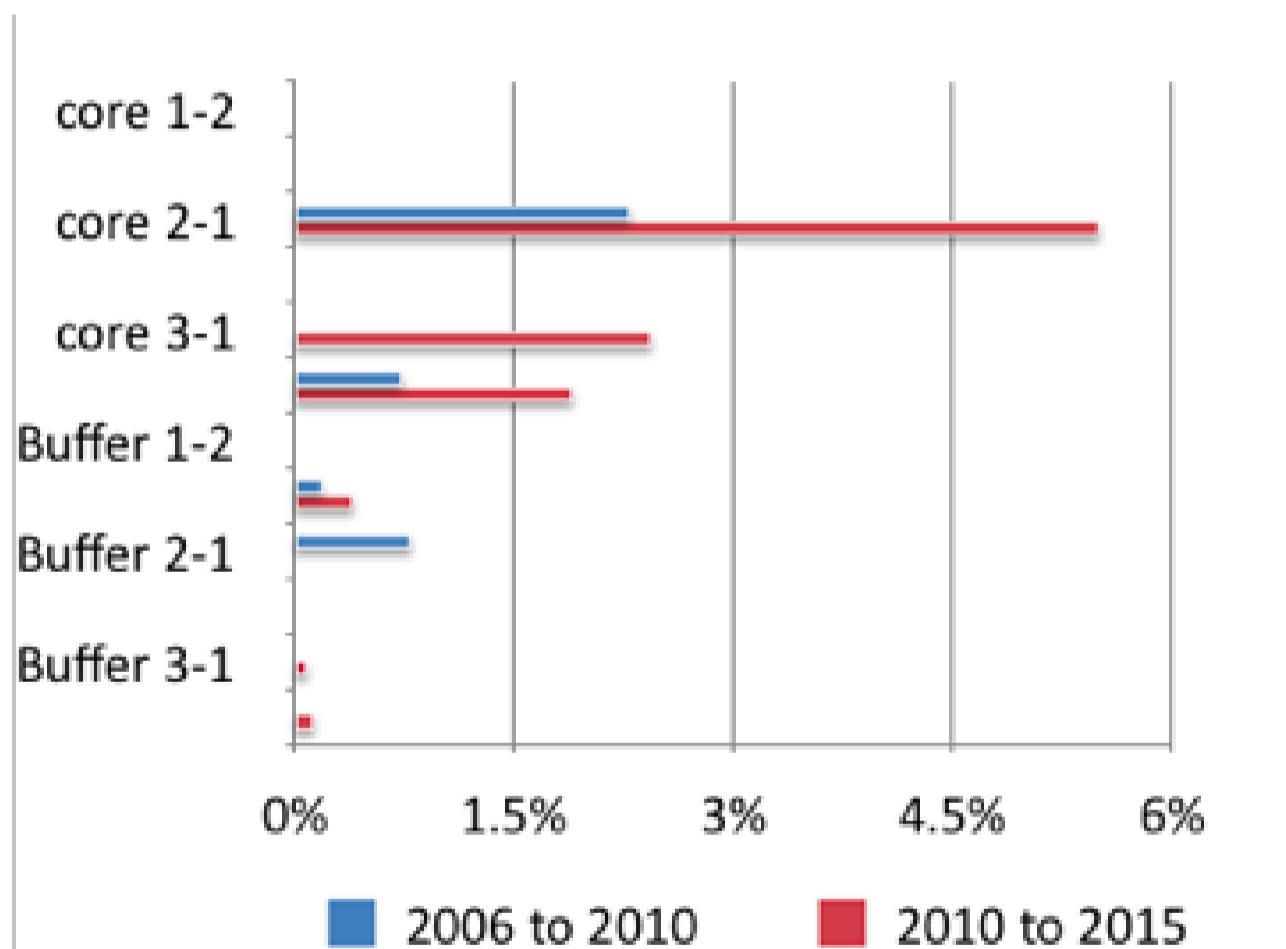


Figure 5.8. Forest cover trends by class, zone and period for Nicolas Romero.

In Nicolas Romero, the overall changes were positive as the highest percentages for both periods were degraded to dense forest. This is ideal for a buffer zone in a protected area in the sense that some change is inevitable since it is open to restricted human use so that the lower the amount of change, the closer to the goal of preservation. This demonstrates the utility of the reforestation efforts and participation in them. This would also



suggest that despite critique of the authorities, the rules are functional and being followed. However, both the authority and the certificate holders alike felt that the rules were harder to enforce over the last few years and that the conflict between the ejido and the IC of the same name contributed to rule-breaking behavior on both sides. The difference in border coordinates (Map 5.7 and 5.8) is notable in the case of these ejidos and the inconsistency appears to be indicative of the occasional lack of communication between and among agencies.

## ANALYSIS OF LAND TENURE IMPACT

A MANOVA was conducted to ascertain whether, in this limited sample, there was any statistical difference in land tenure unit in its impact on the outcome variable, forest cover loss over time. There was no statistical significance registered after performing the test in two different combinations. First, the analysis was conducted by looking at the entire group and outcomes to determine if there was a statistical relationship between groups (2 ejidos and 2 indigenous communities) with regard to the six forest cover change categories. The p value was 0.60 for all 6 outcomes. Then it was tested by combining all forest cover gain sub-variables to determine whether there was any impact on general categories of gain and loss according to land tenure type. Again, the p value was well above 0.05 ( $p=0.62$ ). According to this sample, there is no statistical difference between land tenure types. This is likely due to small sample size.

Carpinteros has forest area outside the reserve boundaries and was the only one that showed forest cover improvement outside the boundaries. All AN showed improvement in the buffer-zone, where land use is limited and regeneration is taken into account. The core zone is completely protected from human use as far as the rules are concerned so we would expect to see positive or no change there. According to the MANOVA, there was no significant difference between ejidos and ICs with regard to forest cover change. The results of the forest cover change analysis show that the reserve rules may well be a significant factor in the management of the forest and in land-cover change.

## OVERVIEW OF OPERATIONALIZED VARIABLES FOR EACH AN

The normalized values of the variables used in the analysis are shown in Table 5.17. These values, determined from interviews, existing demographic data and maps, vary between the ANs studied (See Chapter 4 for the values for each AN; Tables 4.3-4.6). The intention is to clarify which of these variables have significant impact on rates of forest cover change, values for which were presented in chapter 4, and thus to test the reliability of the critical list, i.e. to show to what extent compliance with the criteria established for the variables (as measured by their normalized scores) is necessary to achieve low rates of forest loss and high rates of forest area gain, which taken together indicate forest management efficiency.

There were considerable variations in the values of the independent variables between AN. To give just a few examples, Appropriate Leadership in Nicolás Romero had a much lower value than in the other AN, as there were strong negative perceptions regarding the current leadership in this ejido. Concerning the variable Overlap of user group to resource (which refers to the distance between the living area and the forest resource), SFC had a much higher score than the other AN because the user-group in this AN is more concentrated around the resource. The vast majority of the scores for the explanatory variables were between 76-100% of the ideal value (100% representing the ideal value for the critical variables). No variable scored 100 in any AN, though there were two cases with a score of 99, and 12 above 90. Sixteen variables were exactly 90 and 26 were 80 or above. Two variables had consistently low scores, which clearly do not comply with the criteria in the critical list. These were Appropriate Levels of External Aid and Low Levels of Demand. In the category Institutional arrangements, the variable Locally Devised Management Rules had the same score in each of the cases and in the category, External

Environment, four of the five variables demonstrated no difference between the AN and so these five variables were dropped from the analysis.

**Table 5.17. Normalized values for the explanatory/independent variables used in the analysis. SJZ = San Juan Zitácuaro; NR =Nicolás Romero. Variables marked in red were not used in any of the analyses because they did not vary between the four cases. Blue is level 4 (100-76), level 3 is green (75-51), level 2 is yellow (50-26) and level 1 is red (25-0). Blue and green are in majority compliance, while yellow and red are in non-compliance. Note: For the case of gain in forest cover, the expected direction of the variables would be reversed.**

Variable Category and abbreviation	Variable	Carpinteros	SFC	SJZ	NR	High score indicates:	Hypothesized direction of relationship with loss of forest cover	Actual direction of relationship with loss of forest cover
<b>1. Resource system characteristics</b>								
SmSize	Small size	87	61	66	85	Smaller resource size	Negative	Negative
WDB1	Well defined boundaries	90	88	90	85	Better defined boundaries	Negative	Negative
<b>2. Group Characteristics</b>								
SmSize	Small size	88	63	81	68	Smaller group size (population)	Negative	Negative
WDB2	Well defined boundaries	80	75	70	65	Better defined boundaries	Negative	n/a
ShdNorms	Shared norms	82	82	89	81	Greater level of shared norms	Negative	n/a
PSE	Past successful experiences	90	90	92	75	More past successful experiences	Negative	n/a
AppLeader	Appropriate leadership	69	64	80	25	Higher levels of belief in appropriateness of leader	Negative	n/a
IGM	Interdependence of group members	94	84	97	82	High interdependence of group members	Negative	n/a
HEHII	Shared identity	94	80	90	55	Higher levels of shared identity	Negative	Negative
Poverty	Low levels of poverty	80	82	72	78	Higher levels of poverty	Positive	Negative
<b>3. Extent of human pressure on the resource</b>								
Overlap	high overlap between users and resource	80	60	90	85	Higher overlaps (resource is closer to residential area)	Negative	Negative
DepRes	High dependence on the resource	96	75	90	80	Higher levels of dependence on forest	Positive	Negative
Fairness	Fairness in allocation of benefits	89	89	90	52	Higher levels of fairness	Negative	Positive
Low demand	Low levels of demand for forest products	1	1	10	14	Lower levels of demand	Negative	n/a
<b>4. Institutional arrangements</b>								
REU	Rules are simple and easy to understand	99	89	99	75	Rules are easier to understand	Negative	n/a
LDAMR	Locally devised access and management rules	39	39	39	39	Mgmt rules are devised more locally than from outside	Negative	n/a
Easy enforce	Ease in enforcement of rules	85	74	32	32	Higher levels of ease in the enforcement of rules	Negative	Negative
GradSanct	Existence of Graduated sanctions	79	79	89	89	Greater presence of graduated sanctions	Negative	n/a

ALCA	Availability of low-cost adjudication	96	96	83	83	Greater availability of low-cost adjudication	Negative	n/a
Accountability	Accountability of monitors and other authorities to users	92	83	92	73	Greater accountability of monitors to users	Negative	n/a
5. Extent to which rules take into account ecosystem potential								
MRHRR	Match restrictions on harvest to regeneration of resource	95	90	95	90	Higher levels of matching of restrictions on regeneration	Negative	n/a
6. External Environment								
LCET	Presence of low-cost exclusionary technology	90	90	90	60	High levels of low-cost exclusionary technology are present	Negative	n/a
CGSNULA	Central gov should not undermine local authority	41	41	41	41	Higher levels of agreement central gov does not undermine local authority	Negative	n/a
SESI	Supportive external sanctioning institutions	38	38	38	38	Higher levels of awareness of supportive external sanctioning institutions	Negative	n/a
ALEA	Appropriate level of external aid	1	1	1	1	Greater agreement that levels of external aid are appropriate	Negative	n/a
NLAPEG	Nested levels of appropriation, provision, enforcement and governance	90	90	90	90	Greater presence of nested levels of appropriation, provision and governance	Negative	n/a

The starting point for this analysis is that all the AN are a priori efficient managers of their forests since all had forest cover losses of less than 0.03% per annum, and indeed were selected for this characteristic. Table 5.17 shows the extent to which each AN complies with the 'ideal' values of each of the variables from the critical list. Values are normalized, i.e. expressed as a percentage of the ideal value. The first observation is that there are high levels of compliance for many of the variables, including Well defined boundaries, Shared norms, Interdependence of group members, Graduated sanctions, Availability of low cost adjudication, Matching harvest restrictions to regeneration, and Nested levels of appropriation provision enforcement and governance; indeed the vast majority of variables fell into level 4 or 76-100%. Nevertheless not all ANs comply with ideal values on all variables, and there are some variables on which the majority do not comply (Locally devised access and management rules, Easily enforcement of rules, Central government should not undermine local authority, Supportive external sanctioning institutions, and Appropriate levels of external aid). In addition there are some outstanding exceptions where individual AN fail to comply, for example Nicolas Romero scored much lower in certain variables. Appropriate leadership in NR had a much lower value than the others due to perceptions of the current leadership in the ejido. NR also scored lower for Shared Identity (there was much less cohesion in perceptions of identity), Fairness (due to the perception of unequal access) and Low cost exclusionary technology as the fence was in disrepair and was not considered a priority by the current Comisariado. There is a significant difference in Overlap for SFC as the user-group nearest the resource was more concentrated and active in that zone than the others. From this it is possible to say that 100% compliance with the critical list is not necessary to maintain efficient forest cover.

## STATISTICAL ANALYSES

### SPEARMAN'S CORRELATION: INDEPENDENT VARIABLES TO DEPENDENT VARIABLES

The results of the correlation between the variables and the outcomes can be seen in table 5.18. Statistically significant correlation values have a p value equal to or lower than 0.05. The analysis of the Spearman's correlation showed five independent variables had a strong correlation, two positive and three negative, with two of the dependent variables, both of which are transitions which involve increases in forest (Table 5.18). The other forest cover change categories showed no significant correlations with any of the independent variables.

**Table 5.18. Spearman's correlation of independent to dependent variables. Only coefficients with significant p values (< 0.05) are shown. Cells with a double-dash are those that were not significant.**

Outcomes	Independent variable	Correlation (Rs)	P value
<b>Forest cover loss</b>			
1 to 2: dense to degraded forest	—	—	—
1 to 3: dense forest to non-forest	—	—	—
2 to 3: degraded forest to non-forest	—	—	—
<b>Forest cover gain</b>			
2 to 1: degraded forest to dense forest	ResSmSize	0.83	0.0108
	HEHII	0.73	0.0390
3 to 2: non-forest to degraded forest	ResSmSize	-0.78	0.0225
	GrpSmSize	-0.81	0.0159
	DepRes	-0.81	0.0159
3 to 1: non-forest to dense forest	—	—	—

This analysis shows that only gains in forest, not losses, could be accounted for by the independent variables and that the process of natural regeneration (transition from degraded to dense forest) clearly follows a different logic from the transition from non-forest to degraded forest, which implies human effort for reforestation. The variables highlighted were: ResSmSize, HEHII, GrpSmSize, and DepRes.

### LASSO REGRESSION

As explained in Chapter 3 Methods, a LASSO regression is a regression that imposes a penalty constraint that results in shrinkage. The variables that were reported in significance after shrinkage are reported below. The outputs that are reported are the R2 (1- deviance/null deviance) and the regression coefficient. It is for this reason that the R2 will be reported in Table 5.19 as a decimal and discussed as a percentage. The overall R2 value can be interpreted as how well the model is explaining the outcome measure of interest, using the critical list of variables. Each coefficient also lists an R2 value. As LASSO removes variables from the model one at a time, the individual coefficient R2 represents how much information would be lost if that variable was removed from the model. These values will not sum exactly to the overall R2 due to additional changes in the coefficient values as more shrinkage is performed and the coefficient values are changed. This regression, like the Spearman's correlation, better explains forest gains than losses as the largest R2 appear in gain categories (Table 5.19). Each category will be discussed individually below.

Table 5.19. LASSO results for the independent and dependent variables. An asterisk denotes the variable with the greatest percentage of influence and the total R2 for the category is in bold-type.

Forest cover change transition	Independent variables included in the model	R2	Deviance	Regression coefficient
<b>Loss of forest</b>				
<b>Transition 1 to 2</b>	3 variables together	<b>0.3822</b>	1.96	
	Overlap*	0.3540		-0.00988
	Fairness	0.018		0.0009
	ResSmSize	0.019		-0.00057
<b>Transition 1 to 3</b>	3 variables together	<b>0.3876</b>	0.34	
	DepRes*	0.09		-0.0172
	ResSmSize	0.02		-0.0108
	Overlap	0.023		-0.0081
<b>Transition 2 to 3</b>	3 variables together	<b>0.3394</b>	2.11	
	Overlap*	0.2352		-0.0086
	Fairness	0.0071		0.0018
	ResSmSize	0.00044		-0.0005
<b>Gains of forest</b>				
<b>Transition 2 to 1</b>	3 variables together	<b>0.7255</b>	0.02	
	ResSmSize*	0.6953		0.0955
	Overlap	0.019		0.01008
	Fairness	0.024		-0.0067
<b>Transition 3 to 2</b>	3 variables together	<b>0.6629</b>	0.05	
	DepRes*	0.3251		-0.0632
	ResSmSize	0.0025		-0.0247
	Overlap	0.0010		-0.0030
<b>Transition 3 to 1</b>	3 variables together	<b>0.3147</b>	0.13	
	Poverty*	0.0300		0.0310
	EasyEnforce	0.0128		-0.0128
	HEHII	0.0057		-0.0057

#### Transition 1 to 2: Dense to degraded forest

The three most significant variables relating to this transition together explain ~38% (R2: 0.3822) of the total variation between ANs. Overlap has the most influence on this, based on the coefficients. This variable, which is negatively related to the outcome variable, explains approximately 35% of the variation in outcomes across the four ANs. Since high scores on this variable imply greater overlap, the results are inconsistent with theory (greater proximity of the resource to the living areas leads to more loss of forest in the form of degradation). Adding in the Resource System Small Size and Fairness contributes only an extra 3%. The signs for Small Size and Fairness in the regression are also negative, so one can infer that larger forest area results in more degraded forest (consistent with theory). The Fairness variable however does not comply with theory, which posits the hypothesis that Fairness contributes to the chance of good forest management.

#### Transition 1 to 3: Dense forest to non-forest

Resource Dependence and Resource System Small Size are contributing the most to the explanation of the transition from dense forest to non-forest (1 to 3). Overlap contributes the least. This implies that as size increases, deforestation increases; as dependence on the resource system decreases, deforestation increases; and as overlap increases, deforestation decreases (all these variables show negative relations to the outcome, but as shown in Table 5.17, the values on the Small size and Overlap variables are already inverted). The size variable results are consistent with theory, since it is hypothesized that larger areas of resource are more difficult to manage and control than smaller ones. Overlap is consistent with theory in this case. Resource dependence is contrary to what theory suggests. High dependence on the resource should theoretically decrease deforestation. The reasons for this unexpected result will be elaborated on in the discussion section, below.

#### Transition 2 to 3: degraded forest to non-forest

The three variables that emerged as the best explicators of this transition are Small Size of the resource (negative), Overlap (negative) and Dependence (positive), which together explain about 34% of the variation ( $R^2: 0.3394$ ). Overlap is the most significant in this, and as the transitions discussed above, this is contrary to theory: as overlap (proximity) increases, deforestation (2 to 3) increases. Second, as fairness increases, deforestation (2 to 3) increases.

#### Transition 2 to 1: degraded to dense forest

For the transition degraded to dense forest (2 to 1), the regression equation explains a large ~72.54% of the variance in the outcome variables ( $R^2: 0.7255$ ). Resource Small Size (negative relation), Overlap (positive relation), and Fairness (positive relation to the outcome) are the contributing variables. Again, the size variable is consistent with theory. Overlap was not as the positive coefficient indicates that the lower the overlap the greater the reforestation or recuperation of the forest. Fairness was also contrary to theory as this result shows that as Fairness increases, reforestation decreases.

#### Transition 3 to 2: non-forest to degraded forest

The three variables which together explain 66% of the variation in this transition are Dependence on the resource (negative), Small Size of Resource (negative) and Overlap (negative). Dependence is the best explanatory variable for this outcome, which could represent either reforestation or natural recuperation on abandoned lands. The coefficients indicate that as dependence on the resource system decreases, reforestation increases, which is in line with the theory. This is followed by Small Size and Overlap.

#### Transition 3 to 1: Non-forest to dense forest

This transition includes both reforestation and natural regeneration of forests as a result of abandonment of agriculture. The three most powerful variables together explain ~32% of the variation between the ANs ( $R^2=0.3147$ ). Poverty (positively related) has the greatest influence on this transition ( $R^2=0.0300$ ): as it increases, reforestation increases. This goes against theory behind the critical list that hypothesizes that Poverty tends to have an inverse relationship with reforestation, although it must be said that a broad swathe of practicing foresters consider Poverty one of the root causes of deforestation. The other variables, Homogeneity of identity and Ease of enforcement of rules are both negatively related to rates of transition from non-forest to dense forest but with much lower coefficients.

# CHAPTER 6: DISCUSSION/DISCUSIÓN

## RESUMEN DEL CAPÍTULO

Como se muestra en el capítulo 5, las correlaciones de las variables dependientes e independientes de Spearman indicaron que la mayoría de las variables independientes parecen no tener influencia en las transiciones forestales observadas. El análisis de regresión de LASSO mostró además que la dependencia de la base de recursos, el tamaño pequeño del sistema de recursos y la pobreza eran las variables más influyentes para la explicación de los aumentos en la cubierta forestal, aunque existieron otras variables de menor influencia. En cuanto a la segunda pregunta de la investigación que busca establecer si el tipo de tenencia, ejido o comunidad indígena, tiene un efecto en el manejo de bosque, se determinó la necesidad de una muestra más amplia. Referente a la tercera pregunta del papel de tipo de núcleo agrario a escala pequeña no se capta una diferencia significativa señalando la necesidad para una muestra más amplia. De manera profunda, se respondieron a las preguntas de investigación en este capítulo. El detalle principal radica dentro de los objetivos de investigación. Estos proporcionaron una gran entendimiento de las variables influyentes y las posibles razones por las cuales estas variables alcanzaron el significado que se obtuvo, según los métodos que fueron utilizados.

En lo pertinente al primer objetivo de investigación, este enfoque proporcionó un estudio bastante detallado de cuatro casos en el RBBM. Se mostró útil esta prueba de un método general y relativamente rápido así como una base para la comparación de otros estudios de casos de manejo de recursos comunes en la RBMM, ya que proporciona la información y los elementos analíticos para satisfacer los requisitos expresados por los investigadores destacados en el tema de manejo de recursos comunes. En referencia al segundo objetivo de investigación, se proporcionaron métricas prácticas y sistemáticas de operacionalización para cada variable y de la lista crítica aplicada a este estudio, cosa que se discutió a fondo en el capítulo 3 y evidenciada por los resultados reportados en el capítulo 5. En cuanto al tercer objetivo de investigación, se aplicó un análisis estadístico eficaz a los datos para determinar algunas relaciones estadísticas entre una lista amplia de variables pertinentes.

## INTRODUCTION

The limitations of traditional statistical analyses are noted when juggling a large number of variables, which was mentioned by Agrawal (2003). He stated that “scholars of commons need to deploy theoretically motivated comparative case analyses to identify the most important causal mechanisms and narrow the range of relevant theoretical variables and their interactions, to more effectively and rapidly move toward advancing our understanding of how institutional sustainability can be achieved on the commons” in critical assessments of commons research from both 2003 and 2014. Both papers make pleas for a more systematic set of variables and for analytical methods to effectively compare a large number of variables per sample. As Agrawal (2003) and others note, the difficulty with including so many pertinent variables is statistical washout, and a number of CPR researchers also mention this, in facing the dilemma of the need to take all of them into account (Baggio et al. 2016, Barnett et al. 2016, Frischman et al. 2014, Agrawal 2003). This study used a large number of variables, to ensure that all issues thought to affect management of common resources were covered. Important findings of the present study, as has already been explained, are that efficient forest management is possible even when many of these variables are not at their ideal values, and secondly that most variables had no statistical association with differences in forest cover change.

Agrawal (2003), in his paper *Sustainable Governance of Common-pool Resources: Context, Methods, and Politics*, makes the point that “the major concern of writings in common property is to show that variations in forms of property rights make a difference in management outcomes.” Because ejidos and indigenous communities have some differences in access and management rules, it seemed appropriate to look at whether there were any significant differences between them. When the dependent forest cover change variables were grouped by type of community tenure (ejidos versus ICs), no statistically significant difference in forest cover transition rates were found. Although a non-parametric test suitable for small sample sizes (MANOVA) was used, it is clear that this result may in part reflect the very small sample size. For that reason the result is considered insufficient to refute or confirm either Bonilla et al. (2013) who suggested the ICs manage forest better, or Miteva et al. (2019), who found that ejidos manage resources better.

Much was learned about the communities specific to the investigation of the critical variables in the context of the MBBR. As requested by Agrawal (2003), this study addresses the repeated calls for “systematic testing of variables, ...to carefully specify the contextual and historical factors relevant to success.” A salient point in terms of this is the simple exercise of obtaining systematic information on all variables across the different communities (see Chapter 4: Study sites). While descriptive studies may not be considered to provide scientific rigor in and of themselves, they are very useful in the empirical analysis of management systems. The results from this study demonstrate that there is utility in the descriptive and/or diagnostic elements of this study, even though few of the variables proved statistically significant in terms of explaining forest cover change. Indeed, the details obtained from the demographic data, field visits and interviews were very informative and provided pertinent insights into concerns and successes related to current management strategies and policies. For example, in Carpinteros where there was the most positive forest cover change, including in areas outside the reserve, we see that community members had a very good relationship with the Comisariado and, while there was high poverty, cooperation and participation were very high and consistent in that AN. There was also high overlap, which is theoretically ideal for CPR system management. Another example of the value of the exercise in developing detailed descriptive data through semi-structured interviews, besides the variable tables with the results from the



interview instruments, was the discussion on appropriate levels of external aid in the compensation of conservation activities. This is because, though it was not found statistically significant as regards the forest cover change outcomes, it was an important concern and complaint made by 99% of the respondents, in all the ANs. The descriptive approach is also useful for dialogue between governance levels and agencies and provides a voice and a specific presence for the local managers (i.e. members of the communities) and their knowledge and concerns. Besides concerns about compensation for conservation activities (falling under Appropriate levels of external aid), Supportive external sanctioning institutions, Central government not undermining local authority and Accountability of monitors and other officials to users were all topics of concern for local managers and these concerns will be brought to the attention of CONANP in a respectful report. Furthermore, the descriptive approach is useful in explaining potentially counter-intuitive results. For example, some variables turned out to be strongly significant for four of the 6 forest cover change categories (two loss categories and two recovery categories) but in some cases the direction of the relationship was contrary to theory, for which a detailed discussion is provided in the third research objective (to perform a rapid statistical analysis to determine which of the variables on the critical list appear to influence forest cover change over time).

## DISCUSSION OF STATISTICAL RESULTS

The results obtained from the analyses show some consistencies as well as some inconsistencies with hypothesized relationships as well as with CPR theory. This section will lay out the general results for reference and go into a deeper discussion, particularly of the LASSO regression, to explain the possible explanations for the results that were obtained. The Spearman's correlation will begin the discussion in the next paragraph.

The Spearman's correlation analysis shows that gains in forest could be accounted for by the five of the independent variables (Resource Small Size, Homogeneity of Identity, Group Small Size, and Dependence on the Resource) but that the process of natural regeneration are affected by a (partly) different set of variables. Moreover, different processes of natural regeneration (transition from degraded to dense forest, versus non-forest to degraded forest) follow different logics, that is, they are associated with different variables. This analysis shows that some of the critical variables do seem to explain gains in forest, however, losses in forest are not found to correlate with the explanatory variables in this analysis. Interestingly, while the directions of the significant variable Resource small size is as expected based on theory (i.e. positive) for transition degraded forest to dense forest, it is not as expected (i.e. negative) for the transition from non-forest to degraded forest. This intriguing finding indicates that these two transitions may be controlled by quite different social factors. This was not explained in the current research analysis, and further investigation is clearly called for. This, and the need for a more comprehensive approach, provoked an additional statistical analysis (LASSO regression) that is discussed in the next paragraph.

The LASSO regression helps to clarify some of these uncertainties, as well provide additional support to the correlation findings, as they share two prominently influential variables (Dependence on the resource base, Resource system small size). The LASSO regression analysis showed that groups of variables had influence on the model, with three being more prominent in explaining forest cover gains: Dependence on the resource base, Resource system small size, and Poverty (see Table 6.1). As can be seen from the overview in Table 6.1, three variables (overlap, resource system small size, and resource dependence) are consistently associated with forest gains (and with positive values) which is in keeping with the theory underlying the critical list. At the same time, these same three variables are associated in a negative direction with loss of forest, which also follows the theory in two of the variables regarding the relationship to forest cover loss. Resource small size is the outlier showing an inverse relationship with the transition of dense forest to non-forest (1 to 3), which is counter to theory that

predicts that smaller size is better for efficient management. There are two ways to interpret this. One is that this research does not support the CPR theory, at least in a protected area. The other is that, as Busch and Ferretti-Gallon (2017) found, size is not a significant factor as the results of their meta-analysis showed no indication that Small size impacted forest cover, making variability in results feasible. Regarding Resource small size, which is a significant variable in all forest cover changes except the change from degraded forest to non-forest, there is an inverse relationship to forest cover change.

The LASSO analysis also showed that less Overlap, greater Poverty, lower Dependence on the resource and larger Resource system size were associated both with forest gain and with mitigation of forest loss. CPR theory and most research tells us the opposite (Tucker 2008, Agrawal 2003, Wade 1994, Ostrom 1990, respectively). The other variables that were associated with Poverty in the LASSO regression were Homogeneity of identity and Ease of enforcement of rules. These both showed a negative relation with rates of transition from non-forest to dense forest, although with low coefficients. This negative relationship for both is inconsistent with Busch and Ferretti-Gallon's (2017) meta-analysis, as well as theory. The trend could be explained by the low normalized percentages for that variable in all the AN. As an interesting aside, Busch and Ferretti-Gallon also found a statistically significant relationship between indigenous people and forest cover maintenance, which would be interesting to explore in future research. Specifically, the Poverty variable shows a positive relationship with recuperation of forest (non-forest to dense forest), though its explanatory power is not as strong as some of the other variables which are significant as regards this forest cover change category. This relationship goes against conventional theory that hypothesizes that Poverty has a negative effect on reforestation, although it must be said that there are now mixed results regarding the impact of poverty and deforestation (Busch and Ferretti-Gallon 2017). While poverty is commonly associated with deforestation, they found that greater poverty was associated with lower deforestation (p.16), and our findings tend to support this. A possible explanation might be that there is a certain amount of community altruism, as well as any compensation associated with rule-following being incentive to comply with reserve rules as well as participate in any community conservation activities, as mentioned in the section pertaining to each AN, particularly in Carpinteros and SJZ.

Loss in the form of change from dense forest to non-forest (1 to 3) was linked to Fairness and Resource small size. Both findings are contrary to CPR theory (Agrawal 2003, Busch and Ferretti-Gallon 2017). The Fairness variable also emerges with a relationship contrary to theory in that less Fairness leads to growth and recovery of forest and increased. Fairness appears to lead to an increase in loss and degradation. There are a few possible reasons for this. The first is that perceptions of fairness are influential, since the operationalizing of this variable was based on perception of fairness. Rule enforcement and PES may be influencing the forest cover outcome which in turn creates the appearance of a lack of fairness. The perceptual fairness measure revolved around allocation of resources (enforcement of rules factors in here), which included PES and many felt that PES payments should go to individuals not to the community as a whole, which may have influenced the scores on this variable. Perception of fairness varied but was in fact lowest in Nicolas Romero, which had the highest forest cover change rates in recovery categories at 10.3%, considerably higher than the other AN (with 6.5, 6.3 and 3.24%). This signals a need to look at fairness through a different lens and to consider whether PES works in the way it is intended to. There is a possibility, also considered by Busch and Ferretti (2017), that the dynamic as regards fairness changes with protected area status, limited resources, and available social capital. This is worth taking into consideration in the future.

Finally, and the smallest relationship in every category but the category where this variable dominated (deforestation 1 to 3), decreased ResSmSize results in an increase in degraded to non-forest (or increase ResSmSize to decrease the 2 to 3 category). Since small size is an inverse relationship, i.e. smaller size means

more resources available or bigger is better. This could be a factor of the area of protection having a positive influence on forest cover. However, this counterintuitive result, along with the others mentioned, provide an argument for more cases (larger sample of the reserve).

In terms of the second research question about the necessity of full compliance with the criteria for the critical variables, full compliance with the established theoretical criteria is not necessary for efficient forest management (at least in the time frame analyzed in this study). Full compliance is defined as a value of 100% for a given variable. In spite of there being no variable with 100% compliance with theoretical criteria and even some variables in non-compliance (Low levels of demand, Appropriate level of external aid, and Appropriate leadership for Nicolas Romero), all AN still fell within the threshold of < 0.03% forest cover loss during the decade observed here.

**Table 6.1. Detailed breakdown of the LASSO results and forest cover change transitions. The (-) indicates a negative coefficient and the (+) indicates a positive coefficient.**

	Transition Category	R2	Most significant variable	Consistent with theory?	Additional variables	Consistent with theory?
<b>Transitions involving loss of biomass</b>	1 to 2 (degradation)	<b>0.38</b>	Overlap (-)	Yes	Fairness (-)	No
					Small size resource (-)	Yes
	1 to 3 (deforestation)	<b>0.39</b>	Small size resource(-)	Yes	Dependence	No
					Overlap (-)	No
	2 to 3 (deforestation)	<b>0.34</b>	Overlap (-)	Yes	Fairness (-)	No
				Small size resource (-)	Yes	
<b>Transitions involving increases in biomass</b>	2 to 1 (natural recuperation or reforestation)	<b>0.73</b>	Small Size resource (+)	Yes	Overlap (+)	Yes
					Fairness (-)	No
	3 to 1 (natural regeneration or reforestation)	<b>0.32</b>	Poverty (+)	No	Ease of enforcement of rules (-)	No
					Homogenous identity (-)	No
	3 to 2 (Natural regeneration or reforestation)	<b>0.66</b>	Dependence (-)	Yes	Small size resource (-)	No
					Overlap (-)	Yes

## SUGGESTIONS AND OBSERVATIONS

Sample size was a limitation in this study, which should be regarded as a preliminary attempt to better understand the application of the critical list. Involving a greater number of AN and more numerous interviews would obviously provide a more robust analysis. Also it would have been better to include some AN which have clearly not achieved efficient management, but the circumstances at the time did not allow this. Indeed, at the time this research was being conducted, a thorough analysis of the Monarch Butterfly Biosphere Reserve (MBBR) was not possible due to conflicts in the reserve coupled with time and resource limitations. It would be interesting, and generally useful, to see the whole reserve modeled. A fully modeled reserve would likely give greater insight into management interventions, where they should be focused in the MBBR and how the reserve's needs change over time and in what areas. Along with this, a larger number of interviews in each AN. It would also be more informative to policy development and strategy assessment. It would also be useful to monitor the results for the next decade to both measure stability of the results and to identify the factors that influence fluctuations in forest cover in each zone and sub-zone. Such monitoring could make use of the baseline that was provided by this work. From there it would be interesting to conduct an analysis with regards to the land tenure

category to see if the kind of land tenure system is also an influence on the outcome since this study was not able to throw much light on this question. Looking at the impacts of different variables on gains versus losses in forest cover change is particularly useful, in itself, for informing policy and management strategy. In seeing the difference in those that enable positive forest cover change versus negative, we can zero-in on specific focal points that influence management. While influencing internal policy can be a challenge, particularly in community based natural resource management (CBNRM), it is not impossible from an external perspective. Providing reports with information like that provided in this study is a way to provide suggestions respectfully and an opening for productive dialogue.

There was some evidence that useful dialogue was stimulated around the reporting of the results in the case studies. When the communities were briefed on the results, they were shown the forest cover change maps which appeared to be both informative and visually intuitive, giving the local managers practical insight into the basis for one of the fundamental MBBR rules, Match harvest to regeneration requirements. Those present in the Asamblea briefings voiced approval in being informed, all remarking that this was not common practice though they felt it should be. All AN were critical when asked about the openness of dialogue with external managers and institutions. In all cases, the Comisariado offered appreciation as they felt that the briefing was useful to provide concrete management information in their discussions and negotiations with external organizations that offered support and/or authority in rule-making. Almost every common pool research study shows that there must be good communication between the levels of government and the managers to ensure successful, long-term sustainable management (Ratner et al. 2014, Saunders 2014). Improving communication and bringing the local managers and authorities together is also a strong suggestion by UNESCO and other international NGOs. More open dialogue would improve legitimacy and enforceability of decisions (Suddaby et al. 2017), and would theoretically strengthen conservation as an aspect of cultural identity (Saunders 2014, Poe et al. 2014, Pretty et al. 2006, Stevens 1997), making it easier for the local managers to understand and enforce rules (Ostrom 2008). Since dialogue between governance levels was a point of contention (that there was not enough of it), this step of investigating and informing the various levels could open dialogue and would enhance mutual support in the modification and enforcement of management rules.

Another example is the issue of perceived Fairness in appropriation and allocation of benefits, particularly in the context of allocation of raw wood materials and water resources. One consistent complaint was the excessive length of time it took to get permission to access fallen or diseased trees and non-timber forest products associated with them. In many cases it took months or permission was never granted, in spite of the waste and hardship that resulted from the restriction in access. Around the variables of Central government should not undermine local authority and Supportive external sanctioning institutions, there was dissatisfaction among community members with the management of conflicts by State and National management organizations like CONANP, SEMARNAT and the Federal Police, making rule enforcement and conflict management by AN governing bodies inconsistent and difficult; as a result, conflicts between AN could go on for years, even decades. Ideally, more consistent and open dialogue would rectify these lapses or at the very least address them before they had any negative impact on managers and users. Another consistent complaint was the lack of capacity and quality of the services provided by the Forestry Technicians that were assigned to the AN. These technicians are supposed to provide required, certified management strategies, which also speaks to Accountability of authorities to user groups. These strategies have influence over the resource allocation process with state and national organizations, the access to timber products and the other means by which local managers can work with the forest for livelihoods and materials. The two ejidos also had the benefit of water resources not available to the two CIs, though they are not charging for external use of this resource to urban

areas. The authorities in both ejidos did mention wanting to charge users for the service but are currently prevented from doing so by State and national authorities.

Thus, the dialogue suggests the need for a more detailed and efficient feedback loop between the Nested levels of governance that would benefit from the detail and dialogue provoked by this kind of analysis and would hopefully aid in developing more rapid responses to issues in the decision-making chain, even though this variable did not emerge as statistically significant. This approach combining the descriptive and statistical could also be easily integrated into central government institutional processes with regard to monitoring and assessment, with the double benefit of providing much needed dialogue and interaction with the nested levels of governance that is currently lacking. It is urgent to have the means to react quickly to significant external pressures on CPR systems and often urgent needs for management strategy modification as a result of present and looming environmental crises across the globe. An important feature of this is a record providing comprehension of the human-natural system and the interactions with the various levels of governance.

In terms of governance, ideally the external governing agencies would consider this kind of analysis and interaction with AN for evaluation of management outcomes and to inform future strategy and policy changes as part of the overall monitoring and management plan. In this way, a certain level of nested-level institutional continuity would be encouraged and a feedback loop would be created where the local managers have a direct voice in the process. As both a suggestion for future research and a necessary tangent, it is worth deeper inquiry to determine how the Identity variable manifests. If it is a consistently influential variable in some scenarios, it behooves managers in developing policy to integrate this element, still underestimated and underrepresented in the larger theoretical framework. Certainly, it opens a line of inquiry for conservation planning, though it is not a new one (Poe et al. 2014, Pretty et al. 2006, Escobar 1998). In fact, Poe et al. (2014) provide insights into creating indicators and metrics specifically for identity. This is very pertinent to future research and will be taken into account by this researcher in that context.

## EMERGENT POINTS

Relevant to the previous argument on more efficient dialogue, and as mentioned in Chapter 4, there is an interesting tension in the management of the reserve between the need for central governance versus the need for local governance. There is evidence that the centrally determined rules associated with the MBBR have been beneficial in conservation. However, it is also clear that central governance could benefit greatly from greater participation by local managers, given that the rules have to be locally interpreted and enforced. While the consensus at the level of the AN was that the rules are easy to understand, it was also noted by the local managers that the rules did not take into account local needs, and did not allow for timely, passive harvesting (for example of diseased or fallen trees as discussed in an earlier section).

There is also an indicator that may be influential (which could be integrated into an index as suggested by Agrawal 2003) in the Heterogeneity of interests and homogeneity of identity that has not been previously considered in itself. According to Thomas (2015) and Hiron et al. (2016), cultural ecosystem services (CES) are a key factor in management and valuation of conservation areas and areas of high biodiversity and have been largely neglected. They both discuss the impact that taking CES into account has on management success. This kind of descriptive/exploratory approach to assessing management outcomes lends itself to covering this indicator since it could easily be incorporated into the semi-structured interview process and provide important insights into the intersection of conservation and culture. Both Thomas (2015) and Hiron et al. (2016) provide a framework and theoretical justification for approaching the cultural value perceptions around ecosystems. This would be important to consider in future research and as a focal topic.

A final point regarding emergent topics is that in all of the literature on resource management and management strategies, monitoring is a consistent recommendation. Ostrom (1990), discusses how monitoring ensures the efficacy of strategies over time. This has been strongly supported by the research since (Gari et al. 2017, Baggio et al. 2017, Busch and Ferretti-Gallon 2019). There are many changes to a system that can result in a need to modify strategy to ensure the goal of sustainable and equitable management that, without monitoring, would result in management failure. Monitoring saves time and resources if properly conducted and helps to assure resiliency in the face of natural or human induced disturbance or catastrophe to natural systems of common pool resource management. Though it is not currently part of this study, it is my hope that the approach outlined in this thesis can be useful in future studies or even in monitoring the AN that participated here.

## PERTINENCE TO RELEVANT RESEARCH

The results of this study (particularly the LASSO regression) appear consistent with one of the assertions made by Baggio et al. (2016) that one variable cannot explain why some CPR systems are successful and some are not. Clusters of interconnected variables however do seem to have influence on the success of CPR systems as shown in meta-analyses, e.g. Baggio et al. (2016). Busch and Ferretti-Gallon (2017) provided a meta-analysis based primarily on key words and econometric drivers specifically related to forest cover change but found it difficult to generalize given the diverse and multivariate nature of CPR studies and varying criteria for operationalizing the variables. In spite of some inconsistencies in operationalizing, they came to the conclusion that there were clusters of variables that influenced forest cover that varied across cases, which makes sense in complex systems. Among the cases examined in this study, however, no strong patterns were found. The LASSO regression and Spearman's correlation in the present study give insight into which variables are most influential in a given case. LASSO gives further credibility to the critical list (beyond the original DPs) as a pertinent and preliminary diagnostic tool to determine the 'health' of a CPR system, as it showed the varying intensity of influence by various variables in the list that went beyond the DPs. Further, the critical list results in a basis for comparison for other CPR case studies as it provides the indicator context and analytical elements to satisfy the requirements expressed by CPR researchers (Agrawal 2003, Baggio et al. 2016, Barnett et al. 2016, Busch and Ferretti-Gallon 2017) and a descriptive comprehension of the system useful for inter-level dialogue and enhanced cooperation.

This preliminary study presents a method that makes it possible to analyze 27 variables (some with multiple indicators), while comparing quantitative and qualitative data to determine directional impact. The approach provides a path forward to resolving the issue of overfit models that have plagued CPR studies (Agrawal 2003, Baggio et al 2016, Barnett et al 2016, Gari et al 2017, Busch y Ferretti-Gallon 2017). It is also supportive of the idea that cooperation and dialogue between local and external actors is important to success and it provides a baseline to directly encourage those. Many of the results (both statistical and descriptive) speak directly to the need for a feedback loop between the Nested levels of governance that would benefit from the detail and dialogue provoked by this kind of analysis and would hopefully aid in developing more rapid responses to issues in the decision-making chain. This approach could also be easily integrated into central government institutional processes with regard to monitoring and assessment, with the double benefit of providing much needed dialogue and interaction with the nested levels of governance that is currently lacking (according to the interviews, see Chapter 4 and Agrawal (2006). This preliminary, rapid assessment analysis also shows some implications as an approach to highlighting strong and weak points in CPR systems management to determine what areas require deeper digging, and attention, to ensure long-term sustainability of areas of importance to the health not only of humans but in maintaining biodiversity in a biosphere reserve of global importance. In this way, it could provide a compass for interventions, as well. However, further application of this approach in the MBBR is necessary for a more robust determination of the broader applicability.

# CHAPTER 7: CONCLUSIONS/CONCLUSIONES

## CONCLUSIONES

En resumen, este estudio sugiere que los resultados de décadas de investigación sobre RCP, resumidos en la lista crítica de variables para mantener los bienes comunes, constituyen una base sólida, o conjunto de parámetros, para el análisis del sistema de RCP. Es a la vez sólida en su coherencia con respecto a las variables críticas del sistema de RCP, así como lo suficientemente flexible para tener en cuenta los matices circunstanciales inherentes a los elementos individuales de los sistemas de RCP. Incluso con una muestra muy limitada, fue posible determinar que varias variables influyeron de manera significativa en el manejo forestal en estos casos. Además provocaron preguntas útiles sobre aquellas variables que mostraban contrarias a la teoría junto con el impulso para un análisis más completo de casos de la reserva. A medida que evolucionó el principios de diseño o DPs de Ostrom (1990), también la lista crítica de variables para sostener los comunes evoluciona. La forma de facilitar esa evolución es ponerla a prueba. Con acuerdo con respecto a la operacionalización de las variables al menos en general y cuando sea aplicable en general, la capacidad de escalar de manera efectiva y fácil los resultados en metanálisis sistemáticos es sencilla. La utilidad descriptiva de los casos individuales y la provisión de un conjunto coherente de parámetros establecidos proporcionan una base para sistematizar los metanálisis de RCP, respondiendo a las llamadas de los investigadores de RCP para lo mismo. El elemento estadístico también es accesible. El método de regresión de LASSO está disponible en varias versiones, incluyendo el código necesario para glmnet en R (como se proporciona en la bibliografía bajo Hastie et al. 1998). Este enfoque tiene un requisito de entrada relativamente bajo en términos de tiempo y recursos, lo que lo convierte en una herramienta de evaluación útil con implicaciones para señalar qué áreas necesitan más atención. Este tipo de enfoque sistemático e inclusivo sería un paso positivo y abarcador hacia una información más efectiva sobre el manejo y la política de los sistemas RCP.

Para terminar, debido a la gran cantidad de información que proporciona el método, los resultados provocativos de este estudio y el diálogo que se estimuló con los gestores locales, se ha demostrado que la lista crítica es tanto una herramienta descriptiva como diagnóstica. Este estudio proporciona una justificación e ímpetu para una mayor exploración de las variables críticas a través de todo AN en la reserva para ver si esta área demuestra consistentemente resultados que son en cierto modo contrarios a la teoría. Este proceso también proporciona una voz necesaria para cada AN y sus órganos de toma de decisiones, proporcionando a su vez una base para apoyar sus necesidades y esfuerzos en el ámbito de la gobernanza y la conservación. La información sirve para muchos propósitos, desde informar las estrategias de manejo local hasta proporcionar información sobre el éxito del programa de conservación federal e internacional y futuras intervenciones. En otras palabras, hay razones convincentes para seguir el modelado de la totalidad de la reserva para tener una línea de base del cambio de la cubierta forestal para el siglo 21st, para agregar a los casos de manejo del sistema de RCP y sus variables influyentes, y buscar mayores patrones entre los casos en el área meta-análisis para informar el manejo actual y adaptativo.

## CONCLUSIONS

In summary, this study suggests that the results of decades of CPR research—summed up in the critical list of variables for sustaining the commons—forms a strong basis, or set of parameters, for CPR system analysis. It is both robust in its consistency with regard to critical CPR system variables as well as sufficiently flexible to take into account the situational nuances inherent in individual elements of CPR systems. Even with a very limited sample,

it was possible to ascertain that several variables were significantly influential in forest gain in these cases and provoked useful questions about those variables that showed contrary to theory...along with impetus for a more thorough set of cases from the reserve. As Ostrom's (1990) DPs evolved, so are the critical list of variables for sustaining the commons. The way to facilitate that evolution is to apply it. With agreement on the operationalization of variables (at least in general and where broadly applicable), the ability to effectively and easily scale up the results into systematic meta-analyses is straightforward. The descriptive utility of individual cases and provision of a consistent set of established parameters provides a basis for systematizing CPR meta-analyses, answering the calls by CPR researchers for the same. The statistical element is also accessible. The LASSO regression method is available in several versions including the necessary code for glmnet in R (as provided in the bibliography under Hastie et al. 1998). This approach has a relatively low input requirement in terms of time and resources, which makes it a useful appraisal tool with implications for signaling what areas need more focus. This kind of systematic and inclusive approach would be a positive and encompassing step towards more effective informing of CPR management and policy.

In closing, because of the great quantity of information that the method provides, the provocative results of this study, and the dialogue that was stimulated with local managers, the critical list has been shown to be both a descriptive and diagnostic tool. This study provides a justification and impetus for further exploration of the critical variables across all AN in the reserve to see if this area consistently demonstrates results which are in some ways contrary to theory. This process also provides a necessary voice for each AN and their decision-making bodies, in turn providing a basis for support of their needs and efforts in the realm of governance and conservation. The information serves many purposes from informing the local management strategies to providing insight into federal and international conservation program success and future interventions. In other words, there is compelling reason to pursue the modeling of the entirety of the reserve to have a baseline of the forest cover change for the 21st Century, to add to CPR system management cases and their influential variables, and to look for greater patterns among cases in area meta-analysis to inform current and adaptive management.



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# APPENDIX/APENDICE

## Household Questionnaire in English

What is the size of the forest area to which you have access? (use mapping here?)

What are the boundaries of that area? (cognitive mapping)

How many members live in the household?

What are the identities:

Comunero, ejidatario, other: \_\_\_\_\_

What languages are spoken in your household? \_\_\_\_\_

affiliation with an indigenous group? \_\_\_\_\_

political group: \_\_\_\_\_

other group: \_\_\_\_\_

How does this affect your participation in the asamblea?

\_\_\_\_\_

What groups are you involved in?

asamblea,

reforestation,

vigilancia,

cultivation

other

How are people chosen to be in a given group (other than the asamblea)?

participation voluntary?

Is

Do you or members of your household participate in community or ejido activities with regard to forest or otherwise?

What activities do you act out as a group?

Asemblea-

forest care activities-

reforestation activities-

env education activities-

other\_\_\_\_\_

Should women be involved in forest work?

If so, in what activities do they or should they participate in?

vigilancia-

reforestation-

other-

---

Do any of the women in the household participate in any of these activities?

Which ones?

vigilancia-

reforestation-

other-

---

How much firewood do you use per day?

per week?

Are different forest types managed differently?

Oyamel- is it used for household or material use?

Pine- Is it used for household or material use?

Other tree species? Uses?

Short term benefits

Firewood: How much firewood is used per day?

timber (w/o taking into account regeneration),

NTFP (resin, hongos, fruits, roots, medicinal plants)

Long-term benefits taken into account in management:

ecosystem services

timber regeneration

Does any household income come from forest?

What income generating activities do you and those in your household participate in?

Ganadería (donde forrajean)

artesania (madera?)

cultivar (where)

servicios como comida (leña?)

música (instrumentos hechos donde?)

carpintería (¿cómo consigue su madera?)

u otros servicios

Madera (tallar, leña)

productos del bosque como hongos, resina, frutas

Where are they sold?

local markets

tourist spots

intermediaries

other

Do prices vary from season to season?

year to year?

What is the variation? (in case this is not answered in the previous questions)

What interventions in terms of reforestation and vigilancia have occurred over the last 5 yrs? 10 yrs? 20 yrs?

Do you feel they were successful (i.e. did forest quality, ecosystem services like water and variation in forest products improve)?

What organizations are involved in compensation for conservation activities?

What are the activities? (reforestation, infrastructure improvement)

Is aid distributed equally among units?

Who has access to participate? Is it open access?

Did the expansion of the reserve affect activities and living arrangements?

How?

What qualities are necessary in an appropriate leader?

Age

gender

experience

accessibility

knowledge of external laws and rules

connected with external authorities

well spoken

other

Should leaders be members of Political parties?

Does the current leadership lives up to this? On a scale of 0-5 where 0 is no and 5 is very much so: 0 1 2 3 4 5

Is the asamblea a fair means for making decisions for the ejido/community?

Does the Asamblea meet the needs of the community?

How is it viewed to not participate in the asamblea?

Do you or members of your family participate in the asamblea?

Should compensation for forest related activities and PES be distributed among community members or should it be put toward activities that aid in the care of the forest (like vigilancia, fencing)?

Who makes the rules for permission for forest related activities?

Asamblea

Comisariado

CONAFOR



Municipio

How does one get permission for such activities?

Asamblea

Técnico forestal

Is there a system that controls or is intended to control the use of forest products for extraction of products? Yes/  
No

What duties and responsibilities are associated with these permissions?

Are the rules that restrict use of forest resources easy to understand?

Of the list of rules (list to follow) for what reason do you think the rule was established?

Are the rules observed?

Are there mechanisms in place to enforce the rules?

What are those mechanisms?

What are the sanctions?

Are they graduated to take into account levels of severity and individual cases?

How is it viewed if people break rules? (like taking wood for firewood or NTFPs, for example)

45 What happens if there is a dispute?

Where does one go to resolve a dispute? For example when people take trees out illegally, when there is illicit removal of forest products? Water use?

Are the leaders accountable to the people with regard to allocation of resources, conflict resolution: What happens if a leader does not follow rules of allocation or causes a conflict (example?)

What mechanisms are in place for this

What are the external bodies responsible for sanctions when rules are broken?

Are they fair?

Are they consistent?

Methods in place to protect the forest (exclusionary technology):

Are fences used?

Are there other exclusionary methods? Vigilancia included here?

Are any methods cost-prohibitive?

Is it unavailable to some for reasons other than cost?

Why?

What do the people interviewed consider poverty:

How do you define poverty?

How is poverty related to forest management:

Do poor people use more forest products?

Is poverty related to norm and rule following w/regard to resource extraction and use:

Do poor people tend to break rules with regard to extraction for personal use or for gaining household cash? for household resources?

Is there greater or lesser involvement in the group activities by poorer groups?

Is there greater involvement in state programs by poorer groups?

Do those who live closer to the forest areas use it more?

Do they care for it more?

### **Household Questionnaire in Español**

(OJO pon atención en el nivel de pobreza del hogar que están entrevistando y anótalo aquí- 0-5 donde 5 es mucha pobreza, 3 es algo de pobreza y 0 es nada de pobreza)

¿Qué tipo de casa tiene? Madera material adobe

¿Qué tipo de techo?

¿Qué tipo de piso?

¿Qué tipo de baño? Agua letrina

¿Con que cocina? Leña gas

¿Cuántos integrantes hay en este hogar? \_\_\_\_\_

Es el encabezado:

Ejidatario

Comuneros

Posesionario

Alquilador

avecindado

Es alguien más en el hogar:

Ejidatario

Comunero

Posesionario

Alquilador

Avecindado

¿Qué idioma domina en su hogar? \_\_\_\_\_

Hay alguien que hable otro idioma?

¿Se considera esta familia indígena o mestiza?

otro: \_\_\_\_\_

Cuales son las actividades en las cuales uno podría participar

invernadero (producción de arbolitos)

sembrar arboles

cuidando los arbolitos plantados ..

prevención de incendio (vigilar)

hacer brechas para prevenir la propagación de incendios

actividades que ayudan a conservar el suelo

otro

¿Participa usted u otros miembros de la familia en actividades que corresponden al bosque?

En qué área del bosque se hacen estas actividades? (señala en el Mapa)

En cuales actividades se involucra usted?

reforestación

vigilancia

prevención de incendio

invernadero o preparar los arbolitos para plantarse en el bosque

otro

Cuáles intervenciones han ocurrido con respecto al bosque y cuando?

Reforestación

Conservación de recursos (ex. agua, agregar orgánicos al suelo,

¿Es voluntaria la participación? Sí.....No

¿Se paga la participación? Salario jornalero gastos

¿Todos los que quieren participar pueden o es selectivo? Sí No

¿Quién escoge o decide quién puede participar?

¿En qué manera fueron exitosas?

Mayor salud de bosque

Mayor flujo de agua

Más productos de bosque

Unidad comunitaria

Beneficios económicos (pagos por servicios de ecosistema PES)

Resultó en premios o incentivos de fuera

En su opinión, cuáles son los beneficios de largo plazo a la comunidad de estas actividades?

Ecoservicios (agua, aire limpio, polinización)

Ingresos al futuro de madera regenerada

La cohesión social

Dinero para vigilancia u otras actividades relacionadas con el cuidado del bosque

Cuales organizaciones están involucradas en compensar por los tipos de intervenciones que hemos hablado en las cuales participa?

¿Cree que la compensación es suficiente?

¿Cree que la compensación se aplica de manera justa?

¿Tiene usted una parcela que usa para agricultura? (que señale en el mapa y que se marque)

¿Hay una parcela con bosque o una porción de parcela con bosque? (señale en el mapa donde)

Cuales actividades generan ingreso en su hogar?

Varían los precios de una temporada a otra?

¿Cada año?

Si se vende alguno de los productos del bosque ¿cual porción de su ganancia del ingreso total de la familia se proveen estos productos?

menos de la mitad de los gastos

más de la mitad de los gastos

más o menos la mitad

Y para la recolección, que parte del bosque usan? (señalar en el map)

Preguntas relacionadas con subsistencia:

Que tipo de bosque es el que usan (oyamel/pino/encino/pino-encino)?

Carbón	recolectado por uso personal	comprado
--------	------------------------------	----------

Madera	recolectado por uso personal	comprado
--------	------------------------------	----------

Postes	recolectado por uso personal	comprado
--------	------------------------------	----------

NTFPs (donde se recolecta?)

Hongos    Sí o No    donde se recolecta:

Fruta    Sí o No    donde se recolecta:

Resina    Sí o No    donde se recolecta:

Plantas Medicinales    Sí o No    donde se recolecta:

otro: \_\_\_\_\_

(NORMAS)

Ahora tengo algunas preguntas acerca de sus opiniones personales con respecto al manejo del bosque como muchas veces no preguntas pero sus opiniones son muy importantes

Claro que se requieren líderes para el manejo y conservación del bosque. Cree que los líderes deben de ser:

Maduros/de media edad   más joven   no importa

Hombres   mujeres

Escogidos por su experiencia con asuntos de bosque

Escogidos por su experiencia en organizar grupos

Escogidos por su accesibilidad

Por su conocimiento de reglas y normas

Por sus conexiones con autoridades externas

Inteligentes (habilidad de comunicarse)

otro

---

¿Cree que el líder actual en cuestiones de manejo de bosque logran estos puntos? En una escala de 0-5 donde 0 es no y 5 es mucho: 0 1 2 3 4 5

¿Logra representar las necesidades de la comunidad actualmente?

¿Deben los líderes tener una afiliación fuerte con un partido político?

¿Eres miembro de un partido político?

¿Deben las mujeres estar involucradas en el trabajo en el bosque y/o su manejo?

En el caso de que sí, en cuales actividades deben participar?

vigilancia

reforestación

otra

---

Están involucradas en una de estas actividades las mujeres o una mujer en su hogar?

Cual?

vigilancia

reforestación

otra

La mayoría de los ejidatarios o comuneros asisten a las juntas de la asamblea?

¿Los que asisten participan?

Sí siempre

A veces

Casi nunca

Como se ve no asistir o no participar?

¿Usted sabe si la comunidad recibe dinero de PSA?

Usted cree que el dinero de PSA debe distribuirse entre todos o se debe usar para actividades con costo que sirven para cuidar el bosque (como vigilancia o cercas)?

---

¿Quién hace las reglas del uso de PSA?

Asamblea

Comisariado

CONAFOR

Municipio

Técnico forestal

Hay reglas para el uso/extracción de productos del bosque en áreas donde aplica PSA? Sí No en otras áreas? Si No

¿Cuáles tareas y/o responsabilidades vienen con permisos e incentivos como PSA?

---

¿Son fáciles de entender y seguir las reglas y restricciones acerca del uso y manejo del bosque?

Sí No

De la lista de reglas que sigue, ¿por qué crees que se estableció tal regla?

(apunta en otra hoja)

En general, la gente respeta las reglas? Sí No

Cómo es que se refuerza las reglas?

la misma gente señala los que no las observa

la vigilancia observa quien no observa las reglas

¿Cómo se lleva a cabo un juicio para quien no cumple las reglas?

---

¿Cuáles son los castigos?

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Los castigos toman en cuenta circunstancias individuales (ej. como pobreza o necesidad o edad)? Sí No

¿Cómo se ve si la gente rompe reglas? (como sacar leña de áreas protegidas, por ejemplo)

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¿Qué pasa si hay un conflicto interno?

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¿Qué pasa si hay un conflicto externo?

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¿Con quién acuden para resolver un conflicto? (por ejemplo cuando árboles son sacados ilegalmente u otros productos del bosque o agua?

Comisariado

Encargado del orden

Asamblea

Otro \_\_\_\_\_

¿Qué pasa si un líder no observa las reglas de distribuir los recursos o causa o está involucrado en un conflicto?

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Hay autoridades externas que aplican castigos cuando se rompen las reglas (o que tan atentos son)?

CONANP \_\_\_\_\_

CONAFOR \_\_\_\_\_



Municipio \_\_\_\_\_

Policia \_\_\_\_\_

Otra \_\_\_\_\_

Son justos?

Son parejas?

Methods in place to protect the forest (exclusionary technology):

¿Se usan cercas?

¿Hay otros métodos para proteger el bosque? Vigilancia?

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Si hay cercas ¿como se mantienen?

Hay métodos de sacar unas especies y no otras (como pino o encino versus oyamel)?

Sí      No

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### **First Questionnaire associated with the variable indicators for local authorities.**

This was administered by the primary researcher (The idea is for it to be a bit short and sweet so they have an idea of what kind of information I am interested in and not to overwhelm).

How the forest is administered

(Start with a map of the community/ejido)

Please show me where the forest areas are.

What are each used for or off-limits/conserved? (Paying close attention to specific terms they use for areas that are conserved and those that are used and how they are broken down).

What kind of forest (Oak, pine, Oyamel, mixed) in each forest area?

State of the forest: what kind of condition are they in?

How does the location of the forest (buffer /core) affect mgmt.? Formal (Reserve rules, forest mgmt. plan) and/or informal.

Who has the most influence over the forest mgmt. decisions?

What is the process for decisions?

Set rules for how these lands should be used

Adjudicate if there are disputes between people relating to these lands

Notify other authorities if he knows there are infringements of forest law going on

Select individuals for specific works (such as patrols)

What is the structure of the comisariado (i.e. who are the members and what are their functions)?

How are the asambleas organized (i.e. tell me about the assemblies- who attends, how frequent, what is discussed)?

Use of Resources

What resources are used from the forest?

How are they used?

How frequently are they used? (Short term vs. long-term benefits of resources)

What would you say are the main uses of the forest of the individual households?

Firewood

Timber for personal use

Timber for sale

Non timber forest products (hongos, medicinal plants, honey)

NTFPs for sale

Opportunity costs offset by PES or other activities

Has this changed much in the last 20 years?

Is there much variation per parcel, per household?

Back to administration questions

Could you help me understand how the most important rules for forest management are made (i.e. role of the Asamblea and the commission in creating the rules) for example for the following issues:

This set below is for if they are interested in continuing the discussion or will be applied to the second questionnaire:

## *Norms*

I would like to ask your own personal opinion on a number of matters relating to forest management:

Should women be involved in forest work, for example in

Nursery work

Planting trees

Trees thinning and felling

Patrolling/brigades

Other

Individuals in forest work such as patrols should be compensated financially or not

How should people be selected for participation in forest patrols

Everyone should take their turn, except the sick and infirm

People should volunteer

Especially poorer people in the community should be offered the chance (assuming financial compensation, see above)

Others

What qualities make a good leader in forestry matters?

Independence from political affiliations

Expertise in forest technical matters

Impartiality/honesty

Age/gender

Should funds from outside (Fondo, MBF, CONAFOR) for PES should be spent on compensation to individuals involved and for equipment and inputs needed, or should (at least a part) be distributed among all community members.

## *Interventions*

What experiences and interventions have there been with regard to the forest area in the last 5 yrs? Since the reserve was established? Have practices changed since the reserve was established/expanded?

What is the perception of success and failure with regard to these?

Will success be determined by outcome (learning and improving) or by immediate results or both? How are successes determined? For example, if a new security measure is put in place, a reforestation intervention, a new policy

Does the leadership (comisariado y asamblea) reflect the needs presented by the areas and the community as a whole? The leadership of the Reserve (CONANP)?

What are the levels and types of asset ownership (what can people own and how do they generate income)? How do people get what they need- clothes, uniforms for their kids? What are the different types of capitals(what can and do people invest in to have a colchón)?

