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Water for Biodiversity Conservation and Livelihoods: Protecting Northernmost Tropical Deciduous Forest Relicts in Mexico

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1. Introduction

In the last two decades there has been a growing interest at a global scale to bring water resources management more squarely within biodiversity conservation policy. This interest has given rise to a diverse array of global water institutions, such as the World Commission of Dams (2000), that have emphasized the urgency of balancing human demands for water with the needs of the environment. These concerns, moreover, have begun to deeply affect the domestic policies of many countries, making scholarly evaluation of policy outcomes of extremely critical importance. However, analyses of what, exactly, might constitute effective conservation strategies in providing water for the environment, especially in developing countries, are still quite limited.

This study, based on a research in two local communities within the northernmost deciduous forest natural protected area in Sonora Mexico, “Sierra de Alamos Río Cuchujaqui” (SARC), expands greatly upon the existing work by addressing the challenges faced by developing countries seeking to protect their natural areas to maintain biodiversity and healthy watersheds, while sustaining economic livelihoods of local communities that are necessary for conservation goals in such a sensitive environment. Thus, this study aims to answer the following specific questions: What have been the role and strategies of the Mexican National Commission for Natural Protected Area (CONANP) to supply water for environmental conservation?; How do the practices of local livelihoods relate to the use of water for environmental conservation?; And how, and to what extent, have the conservation goals benefited the livelihoods of local communities?

Field and remote sensing research demonstrates that land cover in local communities is being degraded due to overgrazing and agricultural practices by local villagers. Economic development projects proposed by CONANP, such as a gila monster farm, ecotourism, and a nursery garden have not been successful. Despite their questionable economic success, these projects have been used to persuade people to introduce conservation programs using key natural resources, such as water. This is the case of the *retenidas*, which are check dams located in the streams that descend from the summit of the mountains and have the double purpose of preventing soil erosion and providing water for the surrounding environment.

Based on the theoretical concepts of Common Pool Resources and Institutional Framework (Ostrom, 2005), we examine how villagers have also found some advantages of the *retenidas* for their own, expecting the aquifer will recharge thanks to this infrastructure. In sum, the *retenidas* have been the means through which CONANP is able to secure water for environmental purposes, with a sufficient level of acceptability from the villagers. Thus, in these projects, CONANP have found a clever way to achieve conservation goals in a highly sensitive environment, providing water for both flora and fauna biodiversity in a deciduous forest relict.

2. Background

In the last decades, there has been a growing interest on a global scale about conservation and the sustainable use of the natural resources crystallized in the 1972 United Nations Conference on the Human Environment in Stockholm, the Brundtland Commission Report in 1987 and the 1992 United Nations Conference on the Environment and Development in Rio de Janeiro. This phenomenon is analyzed by Zimmerer (2006) and his collaborators in the volume: *Globalization and New Geographies of Conservation*, in which they offer an overview of recent geographical research in which globalization processes and environmental conservation, intersect.

According to Zimmerer, there are two premises regarding globalization processes and environmental conservation intersection: the first premise establishes that on one hand, global expansion of designated conservation areas is presented as a showcase of international and national environmentalism, and on the other hand, the designation of these areas generated disputes over the control the natural resources and the relationships with livelihood activities of the local people. The second premise of the new globalization processes of environmental conservation is the so-called “third wave,” which has pushed to expand incorporation of sustainability into a global system of protected areas and has forced conservation to interface increasingly with agriculture and other types of livelihoods and resource use (Zimmerer, 2006). This new approach involves biodiversity conservation with people, instead of without them.

Regarding water resources, scholars and practitioners have emphasized the urgency of balancing human demands with the needs of the environment (Postel & Richter, 2003; World Commission of Dams [WCD], 2000). The WCD, based in eight detailed case studies of large dams and in a survey of 125 large dams, concludes that regarding environment “[o]n balance, the ecosystem impacts are more negative than positive and they have led, in many cases, to significant and irreversible loss of species and ecosystems”. In this regard, one of the seven strategic priorities, called sustaining rivers and livelihoods states that “[r]eleasing tailor-made environmental flows can help maintain downstream ecosystems and the communities that depend on them” (WCD, 2000).

Postel and Richter (2003) establish that society’s relationship with freshwater ecosystems will need to change in several overarching ways. One of these ways is that “[t]he globalized trend toward the commodification and privatization of water requires a strong reaffirmation that water is a public trust to be preserved for the common good of this generation and those to come” (Postel and Richter, 2003). This suggestion corresponds with their proposal that governments must act swiftly to enact policies calling for freshwater reserves because the State, like the entity in charge of the public goods, must be the responsible of creating water

reserves. Undoubtedly this proposal contradicts the vision of water as an economic good, confirmed in the World Bank's principled pragmatism, which move on direction of market and privatization of the resources. These approaches exemplified the complexity of designing water policies. Everybody agrees the importance of safeguarding water for environmental conservation, but to determine what are the adequate mechanisms for this purpose, may result highly contested. In the same way, regarding the focus of this work, the indispensable question is, what is the significance of all these proposals for developing countries, and moreover what does it mean for local people and livelihoods depending on water? Thus, the central question suggested by this work is to what degree and how the inclusion of the use of water for environmental conservation influences existing livelihoods. A fundamental framework to examine this question is provided by the theory of Common Pool Resources.

A Common Pool Resource (CPR) refers "a valued natural or human-made resource or facility that is available to more than one person and subject to degradation as a result of overuse" (Dietz et al., 2002). Forests, irrigation systems, grazing lands, fisheries, groundwater basins are typical CPRs. CPRs share two characteristics: (1) it is costly to develop institutions to exclude potential beneficiaries from them, and (2) the resource units that are appropriated by one individual are not available for others (Ostrom, 1990). According to Ostrom, the first characteristic leads to the potential problem of free riding. The second characteristic leads to the potential problems of congestion and over-harvesting (2006).

Overuse of resources is a central topic in the "tragedy of the commons" presented by Hardin (1968). This approach predicts that when individual and group interests are in opposition, narrow self-interest will win over the common-interest. In this regard, overuse of the resource will be the final and inexorable outcome, and he states "as the human population has increased, the common has had to be abandoned in one aspect after another" (Hardin, 1968). Hardin suggests that an alternative to avoid the tragedy is "mutual coercion mutually agreed upon" maybe created by a central authority or by privatization of the resources, which will result in a more sustainable manner of using the resources.

However, as Dietz et al. argue (2002), the "tragedy of the commons" could be avoided by mechanisms that act in the interest of the collective good rather than narrow self-interest. Therefore, central authority and privatization are not the unavoidable alternatives to sustainable resources. Ostrom analyzes some long-enduring self-governance Common Pool Resources. She states eight design principles that allow these CPRs continue to exist throughout time (1990).

1. Clearly defined boundaries
2. Congruence between appropriation and provision rules and local conditions.
3. Collective-Choice arrangements
4. Monitoring
5. Graduated sanctions
6. Conflict-resolutions mechanisms
7. Minimal recognition of rights to organize
8. Nested enterprises

These principles, although not a recipe, are the basic characteristics of the study cases. Despite the free rider is a potential problem against the long-enduring self-governance, is not practical to exclude a user or not possible to force him to contribute to the costs of developing and maintaining the resource. Therefore, the free-riders take advantage of this situation for their own benefit. According to Dietz et al. (2002), "one 'solves' the free-rider problem when rules to regulate individual actions are adopted and accepted so that social

benefits and social costs are taken into account". Rules, according to Ostrom (1990), are closely related to the term institution; she defines institution as the shared concepts used by humans in repetitive situations organized by rules, norms and strategies.

A fundamental approach to the institutional issue is the Institutional Analysis and Development (IAD) framework. A key concept within IAD is action situation, which refers to an analytic concept used to study the immediate structure affecting a process of interest, particularly explaining regularities in human actions and results. Seven clusters of variables are used to describe the structure of action situation (Ostrom, 2005):

1. The set of participants,
2. The specific positions to be filled by participants,
3. The set of allowable actions and their linkage to outcomes,
4. The potential outcomes that are linked to individual sequences of actions,
5. The level of control each participant has over choice,
6. The information available to participants about the structure of the action situation, and
7. The cost and benefits assigned to actions and outcomes.

As CPRs scholars establish, a basic way to address the free rider problem is through the use of institutions and therefore the rules that influence the behavior of actors in diminishing the incentives to overuse, congest and destroy the resources. Consequently, rules are the perfect tool to reach an agreement about common behavior among users.

According to Ostrom (1990), rules are shared understanding among those involved that refer to enforced prescriptions about what actions are required, prohibited or permitted. Ostrom (1990) states that a first step toward identifying the working rules can be made by overtly examining how they affect each of the variables of an action situation. In this regard, she identifies seven clusters of rules that directly affect the components of their own action situations (Ostrom, 2005):

1. Boundary rules affect the characteristics of the participants.
2. Position rules differentially affect the capabilities and responsibilities of those in positions.
3. Authority rules affect the actions that participants in positions may, must, or must not do.
4. Scope rules affect the outcomes that are allowed, mandated and forbidden.
5. Aggregation rules affect how individual actions are transformed into final outcomes.
6. Information rules affect the kind of information present or absent in a situation.
7. Payoff rules affect assigned costs and benefits to actions and outcomes.

The IAD framework and rules configurations provide an important tool to measure how the "new" uses of water, such as environmental and biodiversity conservation, can match with preexisting uses. By using this framework, we analyze what the rules for use of natural resources of local people are and how those rules match with the new environmental conservation rules, particularly related to water resources developed by the CONANP in the study natural protected area.

3. The study case

For this study, we selected two small farm communities or *ejidos* within the SARC natural protected area, located in the municipality of Alamos, along the western foothills of the Sierra Madre Occidental in the southeastern portion of the Mexican state of Sonora (Figure 1). The SARC natural protected area, with 92,889.69 hectares, was issued in 1996 funded by

the Global Environment Facility (GEF) (World Bank, 1997); it has been designed a Man and Biosphere (MaB) area and is currently administrated by the National Commission for Natural Protected Areas (CONANP) in Mexico (Díaz-Caravantes & Scott, 2011).

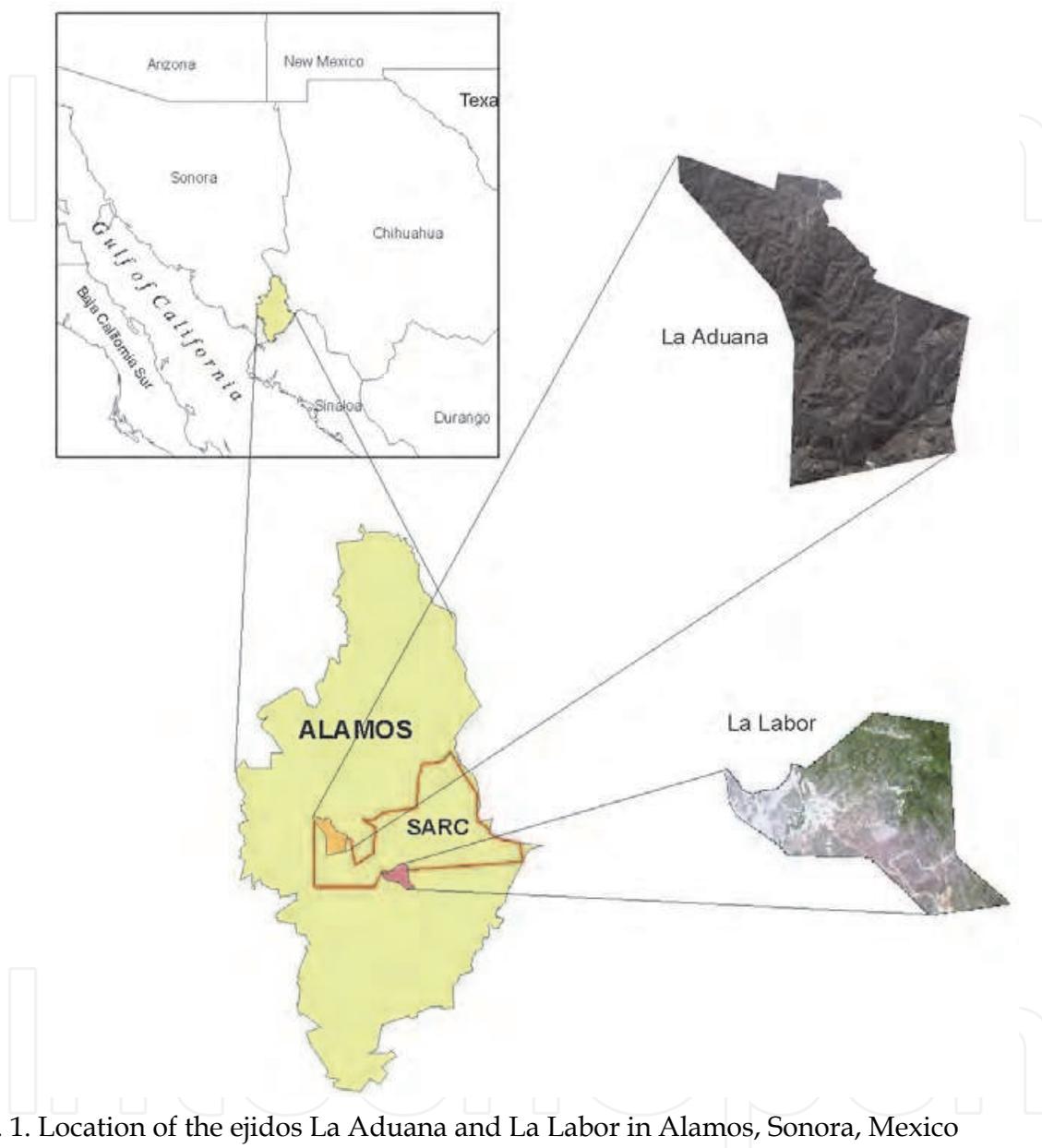


Fig. 1. Location of the ejidos La Aduana and La Labor in Alamos, Sonora, Mexico

The natural value of this area is recognized given its strategic location on the transitional zone between the Neartic and Neotropical biogeographic regions, and its extensive geomorphic and topographic variations. This creates considerable climatic and soil conditions variations to produce a complex mosaic of vegetation (Búrquez & Yrizar 2006). The rich mix of plant communities in the area include: pine and oak forest, oak woodland, foothills thornscrub (Van Devender et al., 2005), and the northernmost relicts of tropical deciduous forest in México. The existence of a rich and varied flora in the area has been reported, with the occurrence of about 1,100 species of vascular plants divided into 148 families. Protecting this rich biodiversity of flora and fauna was the main reason for the

SARC creation and has thereafter been the principal mission of CONANP (World Bank, 2004).

Robichaux and Yetman (2000) provide a comprehensive plant list for the Río Cuchujaqui, illustrating the extraordinary biodiversity of this ecosystems mosaic. Among the most common plant species in the area are elephant tree (*Bursera microphylla*), peachwood (*Haematoxylon brasiletto*), silk cotton tree (*Ceiba acuminata*), fernleaf acacia (*Acacia millefolia*), honey mesquite (*Prosopis glandulosa*), feather tree (*Lysiloma watsonii*), Mexican cypress (*Taxodium mucronatum*), Mexican cedar (*Cedrela odorata*) and higuierillas (*Ficus sp.*). Reported animal species include: gila monster (*Heloderma suspectum*), mountain lion (*Puma concolor*), jaguar (*Panthera onca*), ocelot (*Leopardus pardalis*), jaguarundi (*Herpailurus yagouaroundi*) and military macaw (*Ara militaris*). (CONANP, 2011).

Ejidos are small-scale communal lands that were created as part of Mexico's massive land reform in the postrevolutionary decades of the 1930s and 1940s in order to redistribute productive land (via expropriation from large landowners) to landless peasants. An ejido is composed with at least 20 members called *ejidatarios*. In the past, the individual *ejidatario* could not use their parcel as collateral for credit, nor could they legally rent or sell their parcels. The reforms to Article 27 of the Mexican Constitution in 1992 changed these provisions, and now ejido parcels can be legally rented or sold to other *ejidatarios* or to private buyers.

Ejido "La Labor de Santa Lucia" (La Labor), located in the western portion of the SARC natural protected area, occupies an approximate extension of 27.6 square kilometers with an elevation ranging from 260 to 572 meters above sea level. The main settlement in La Labor has approximately 134 inhabitants. Ejido La Aduana, in the eastern portion of the SARC, ranges from 210 to 1756 meters above sea level, with an extension of 45 square kilometers. Here the main settlement is occupied by 236 inhabitants (INEGI, 2005).

Conditions of occupation and land in the area have been determined mostly by the practice of small-scale seasonal agricultural and extensive cattle breeding, with the U.S. beef market as the principal destination of the production. Agriculture, deforestation, induced grassland and secondary vegetation are, for example, the main land use types around human settlements in La Labor (Figure 2). According to remotely sensed derived land use / land cover classifications obtained from aerial photography (1998) and high resolution satellite imagery (2007), deforestation and land degradation, induced by human activities have increased in a decade, threatening biodiversity conditions in La Labor (Sánchez-Flores et al., 2009).

4. Methods

Ostrom states that in training research identifying and measuring institutions it is important to stress the concept of rule-in-use rather than focusing on rules-in-form (1990). In other words, institutions are the rules that people develop to specify the dos and don'ts related to a particular situation, even when those rules may not exist in written documents. In this regard, the field researcher cannot be a survey worker asking a random sample of respondents about their rules. These statements have important methodological implications. The IAD framework privileges the empirical field research. Thus, examining rule configurations involves basically the collection of qualitative data, consistent with standard data collection procedures used in ethnographic practice.

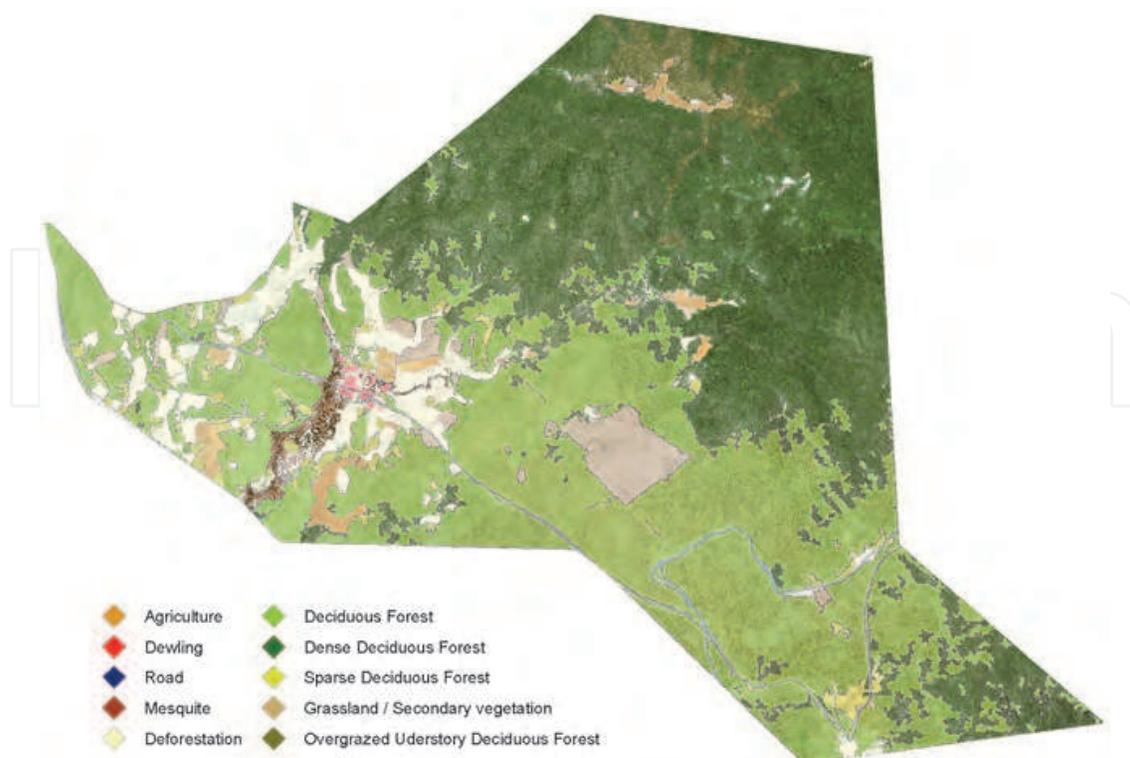


Fig. 2. Land use / land cover conditions in ejido La labor (Sánchez Flores et al., 2009).

Snowballing is one of the ways to approach potential informants. The method consists of using one contact to recruit another contact that in turn can put the researcher in touch with someone else (Flowerdew & Martin, 2005). Following the snowballing method, during the summer of 2008 and 2009 around 40 interviews were conducted with local villagers through a process of referral. In addition, we conducted around 20 interviews with key governmental agents of CONANP and environmental practitioners working in the study area.

5. Livelihoods of local communities

There are six principal productive activities in these study cases: cattle breeders in both communities, farming in the two communities, forestry exploitation in La Labor and craftsman's activities, tourism and mining in La Aduana.

An extensive cattle breeding is practiced throughout the entire SARC natural protected area. The principal destination of the calves is the U.S. beef market. According to the livestock official census, in la Labor the cattle population is 490 on average and in la Aduana the cattle population is 237 on average. Inside the SARC area farming is present. There are mainly seasonal agricultural activities practiced on a small scale. Farmland has occupied 81 hectares in La Labor and 26 hectares in La Aduana on average in the last ten years. The difference is due to the fact that in La Labor there is more flat land than in La Aduana.

In the case of La Labor there is an exploitation of the "vara blanca" (*Leucaena involucrate*) (Felger et al., 2001), which is highly demanded to make stakes that support growing plants, like tomatoes and grapes, in intensive agricultural areas of northern Mexico. In the case of La Aduana, according to the villagers and field observations, the forestry products are insignificant and the local people only use them for domestic purposes.

In La Aduana there is religious tourism due to the regional devotion of the Virgen de Balvanera, who is the patron saint of the community. The principal date of the celebration is on November 20 although, according to the villagers, there are visitors almost every weekend. Additionally, there is a famous restaurant owned by North Americans called “La Casa de la Aduana,” which attracts some visitors to the community, mainly North Americans. There are two groups of craftswomen linked to the tourism in La Aduana. One was founded in 1979 and currently has 15 members. The other was formed in 2005 and has 6 members.

In La Aduana, mining activity has played a central role in the history of the community. Although now it is only practiced on a small scale (almost insignificant), at the town’s foundation in the XVI century, it was the principal activity. The reopening of a mine called La Quintera in the 1950s explains why many people moved from Chihuahua and other regions along the country to La Aduana. These people helped to found the Ejido La Aduana in the 1970s.

6. The role of the CONANP

The SARC natural protected area was issued in July 1996 under the legislation and policy of the National Commission for Natural Protected Area (CONANP). As the World Bank document, “Mexico Protected Areas Program: Proposed Restructuring Project,” indicates, projects of Protected Areas were financed by a combination of Global Environment Facility (GEF) with other institutions (World Bank, 1997).

According to the CONANP officers, the official version of the management program has not been issued because it is in revision in Mexico City. However, in the draft version of the management plan written on 1994 by the current director of the SARC area, there are three principal management specific programs: Conservation, Public Use and Recreation, and Community Development. On the Conservation section there are three subprograms Management and Protection of the Natural Resources, Inspection and Surveillance, and Research and Environmental Management (CONANP, 1994).

On the Public Use and Recreation program are established the objectives of promoting the nature tourism, guaranteeing the economic benefits of this activity to the Reserve and the local communities, and to make aware the visitors and local people about the role of the SARC area in preserving biodiversity and the rational use of natural resources.

On the Community Development program are stated the objectives of increasing the participation of the local communities in the protection and management of the natural resources, collaborating in the enhancement of the economic conditions of the local people and owner of the natural resources and developing, showing and spreading sustainable practices in farm, livestock, forest and tourist activities. A key benefit for the local communities designated within a Natural Protected Area was the employment generated by the projects. In the construction of the infrastructure and in the reforestation plans the CONANP has hired local workers.

The next stage is examining the CONANP projects in the local communities. The interest of this exercise, as we established above, is to analyze the interaction of CONANP with local people and resources.

CONANP has implemented five main projects in the communities, divided in two categories: economic development and environmental. The economic development projects are: the gila monster’s farm in La Labor, the ecotourism in both communities, and the

nursery in La Aduana. The environmental projects in both communities are the reforestation plans and the *retenidas* or stone check dams for runoff control.

The Gila monster farm was established in 2001. According to the villagers, the CONANP tried to establish this farm with the purpose of helping the community and increasing the population of this species. One villager said that supposedly they would sell 25% of the total population of the gila monsters for \$1,500 dollars each, and the rest would be set free. The villagers received special training to manage these species and CONANP built the facilities for the farm. The villagers said that they were very excited and hopeful with the project. However, this project never came through because CONANP did not get the permit for the project, and now the facilities are abandoned. Additionally, it is not clear what the potential market for the gila monsters was. According to the villagers CONANP said that they would sell these species to the North Americans, however this market was never proven to exist. The CONANP tried to establish a recreation area near to the gila monster farm. However, the project has never worked and nobody has visited the area.

In La Aduana the CONANP began to build a lodge for tourists four years ago. The CONANP also planned a hiking trail by the area and an area to practice rappelling. Some people are very hopeful and excited with these projects in La Aduana. However, as one villager said, the CONANP has delayed almost four years in finishing the lodge. Four years ago the CONANP proposed a project to establish a nursery of plants in La Aduana. However, the project has not been finished and no plants have been sold at this point.

The CONANP also tried to plant native species, 15 hectares in La labor and 50 hectares in La Aduana. These species include palo mauto (*Acacia millefolia*), honey mesquite (*Prosopis glandulosa*) and palo colorado (*Caesalpinia platyloba*). However, none of these projects worked. According to some villagers, the problem is that the CONANP did not plant in the adequate season and this happened because the CONANP received the grant and it must be spend it as soon as possible because if not the "money would go to another place".

Regarding water resources, since 2000, the CONANP has implemented the constructions of around 800 *retenidas* throughout the natural protected area. These are stone check dams located in the streams that descend from the summit of the mountains. According to the CONANP agents, the *retenidas* have the double purpose of preventing and recovering soil erosion and providing water to its surrounding environment.

According to the CONANP, the ancestors of the current people had implemented this kind of work in the region, but the villagers "lost this knowledge". In an interview, the head of this project stated that the CONANP emphasizes this to encourage the villagers to accept the project.

There are two principal "benefits" relating to the *retenidas*. The first benefit of this project is the employment generated for the villagers. A second benefit, according to the CONANP, which has been assumed by the villagers, is that the *retenidas* will recharge the aquifer. However, neither CONANP nor the villagers have a clear idea of to what degree these works will contribute to this purpose. In an interview, the chief of this project stated that the CONANP told the people that the *retenidas* would contribute to the aquifer in order to encourage the villagers to accept the project. He stated, "you cannot say to the people that this project is really for the benefit of the flora and fauna, because they may not accept it".

In summary, of the five projects implemented by CONANP, the only one that that has been relatively successful is the *retenidas*.



Fig. 3. Retenidas for runoff control in La Labor

7. Using the rule configurations

The next stage is to analyze how the rule configurations for use of water resources of local people correspond or conflict with the CONANP policy. In other words, we analyze what are the rule configurations of local people regarding water resources and how the use of water for environmental purposes was included into these rule configurations. However, prior to these analyses, it is necessary to describe the formal organization of the study cases.

La Aduana y La Labor de Santa Lucia have a set of rules regarding the formal organization: La Aduana as an ejido system enacted in the 1970s, and La Labor de Santa Lucia as a producers association enacted in 1992. These types of organizations provide to these groups some significant rule configurations. In both groups, there is a document, which specifies who the members of the group are; therefore the boundary rule regarding access to the resources is defined. Additionally, it is defined that each month the members of the group should meet to agree on all the issues regarding the organization of the resources.

Moreover, this document defines what the positions rules within the group are: president, secretary, and treasurer that have the mission of solving all the problems of the group regarding the natural resources and sometimes beyond. However, it does not explain what is the position rules regarding each economic activity (i.e. grazing land and farmland) and what the authority is and scope rules of these activities. For that reason, in the following sections we analyze the principal rules of each activity related to the use of water for the environment.

Involving water resources, the most considerable productive activities are cattle breeding and farming. Here these uses and how they correspond or conflict with the use of water for environmental and biodiversity conservation are analyzed.

7.1 Cattle breeding

There are two aspects that define a CPR: it is difficult to develop institutions to exclude potential beneficiaries from them, and the resource units that are appropriate by one

individual are not available for others. The cattle breeding activity fulfills these criteria. In both communities, there is a common land used to graze, in which is difficult to exclude the members of the group, and the resource used by the cows of a member cannot be used for others.

As we established before, the membership to a formal organization defines the boundary rules in the study cases. However, the members of these groups are not the only ones that can possess cows that graze in the land. It is usual that a relative, for example a son or a grandson, could be the owner of some cows. Yet, this relative must have a direct blood relation with a member of the organization in order to be accepted by the other members. Another boundary rule involving cattle breeding is the so-called *partido* system. Particularly in La Labor, there is a system in which a member of the association can include, as a part of his herd, some cows from an outsider. The deal with the outsider is that of every three calves, one is for the member of the organization and two for the outsider. The *partido* is a strategy for increasing the herd, or getting some economic benefits by selling the calves to the U.S beef market.

There are two principal sources of water for cattle breeding activities: the *represos* and the *norias*. The *represos* are like dikes made of soil (Figure 4a) that are used to provide water for the cattle. The *norias* (Figure 4b) are shallow wells used for water cattle provision. In most cases these sources are complementary. During our fieldwork, four *represos* were visited, and all of them were near a *noria*. For example, the *noria* and the *represo* shown in Figure 4 are located 300 meters apart. This strategy has the purpose of recharging the *noria*, even when the *represo* is dried, according to the villagers, the *noria* continues with water because of the recharging effects of the *represos*.



Fig. 4a



Fig. 4b

Fig. 4. The principal sources for water cattle provision. a. Represos and b. Norias

In the last years, due to the shortage of precipitation in the region, the number of *represos* has been incremented as it can be observed in Figure 5. This trend shows the importance of the *represos* for water cattle provision and also shows that the *represos* is a common practice in the municipality, and even more in the study cases.

Following the boundary rule of the access to the grazing land, in La Labor all the cattle related to a member of the group have the right to use the *norias* of the common land.

As mentioned above, some of the villagers have the idea that the *retenidas* will help to recharge the aquifer, and consequently the *norias*, similar to what *represos* do. We argue that

this is an important reason why the villagers have opened their boundary rule to the CONANP. The villagers have the previous practice of building *represos* for water cattle provision, and for that reason the CONANP has had success in spreading the idea that the *retenidas* will help to recharge the aquifer, although the high uncertainty of this presumption.

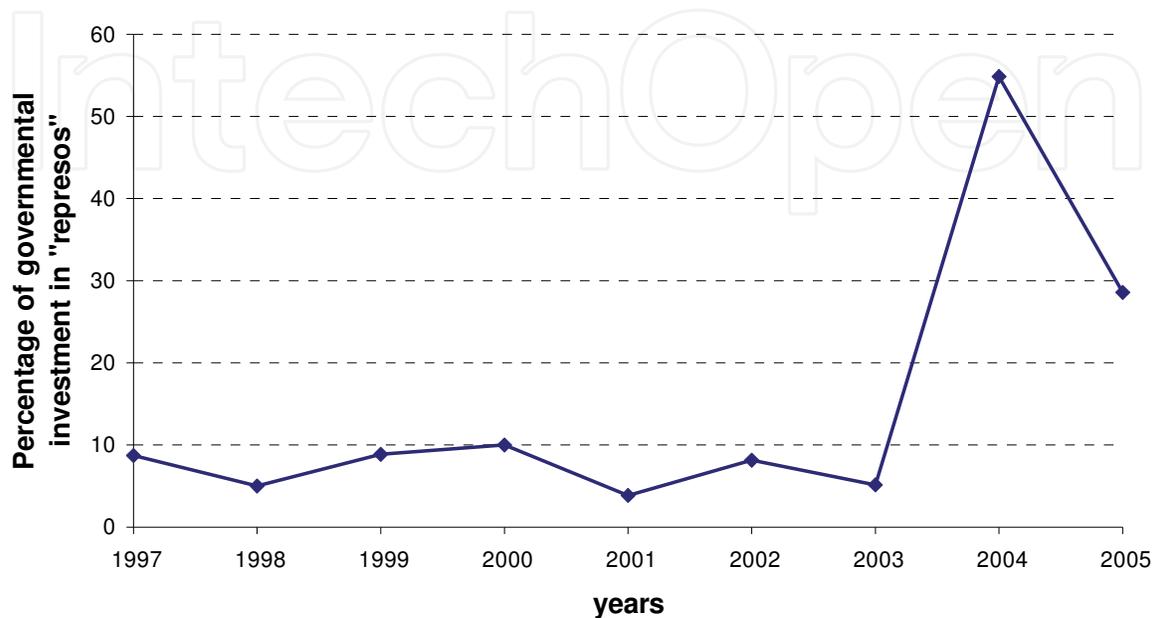


Fig. 5. Trend of the amount of *represos* in the municipality of Alamos

Of course, the jobs that the CONANP has generated and the promise of development projects to encourage the people to accept the *retenidas* are important, but we argue that this similarity between the *represos* and the *retenidas* has been the means through the CONANP was able to be incorporated as a participant of the boundary rules of La Labor and La Aduana.

However, there is a certain degree of tension between the CONANP and the villagers because of the function of the *retenidas* and the *represos*. In both communities, the producers have asked to the CONANP to build *retenidas* for cattle water provision, like the *represos* do, but the CONANP has not attended that request. A CONANP employee, who says that the people have asked *retenidas* in the lower streams, confirmed this. He states: "but this is an economic purpose and our mission is not the economic, but rather the conservation of the natural resources".

7.2 Farming

As established above, two aspects define a CPR: it is difficult of excluding users and the resource used is not available to others. The farming activity is not depending of an irrigation system; rather a seasonal agricultural activities depending of the rainfall is practiced. In this way, the study cases are not CPRs relating to water resources. Yet, regarding access to the land, the farmland can be considered a CPR because physically it is difficult to exclude the members of using farmland, and the land used by a member can be used for others.

The boundary rule regarding farming activity is defined by the membership to a formal organization similar to the cattle activity. Thus, only the ejido members can access to land

for farming purposes, and in this case it is not possible to be used by the outsiders, unlike to the case of the cattle breeding throughout the *partido* system.

In the last ten years in La labor have been used for farming 81 hectares and La Aduana 26 hectares on average. Prior to the project of the *retenidas* some villagers with the support of the federal agencies have built some *trincheras* located in the lower streams (similar to the *retenidas* but with a different technique) to “irrigate” the land. However the *trincheras* did not work well because the speed of the water is extremely rapid and the water moved the *trincheras*, and in some cases, they were broken. Perhaps, since the villagers observed that the technique of the *retenidas* is better than the *trincheras* because they are more resistant to the speed of the water, some villagers have asked the CONANP to build *retenidas* near the farmland. Yet the CONANP has refused this petition with the argument that the agency is focused on the conservation of the natural resources, rather than economic purposes.

Thus, similar to the cattle water provision there was a previous use of check dams, although with different techniques and different purposes. This previous use and the expectation that the *retenida* could be built for farm purposes make possible the opening of the boundary rule to include the CONANP as another participant in the appropriation of water.

Then, although the *retenidas* have been relatively successful, there is a potential problem regarding the expectation of the villagers. As well as the expectation that the *retenidas* helped to open the boundary rule, there is the risk that the perception of the people changes if they do not receive a direct benefit in the long term.

8. Conclusions

In analyzing the relationship between biodiversity conservation and economic sustaining livelihoods in the SARC, we found that the institutional role of CONANP has been quite decisive to achieve a delicate balance. It is evident that the economic development projects, such as the gila monster farm, ecotourism, and the nursery, promoted by the CONANP, have not been successful. However, the *retenidas* as an environmental project have had relative success because the CONANP has achieved the implementation of this project with a sufficient level of acceptability from the villagers. A first approach suggests that although the economic development projects are empty promises in both ejidos, the projects, and also the temporal jobs generated by them, have been pragmatically used to persuade the people to introduce the conservation programs that benefit biodiversity conditions in the SARC natural protected area.

Using the rule configurations proposed by the IAD framework, we conclude that the previous use of *represos* for water cattle provision and *trincheras* for farming are fundamental explanations of why the CONANP could open the boundary rule regarding water resources. The use of *represos* (and *norias*) was a common practice among the villagers that was incremented in the context of water scarcity in the last years. In addition, the use of *trincheras* was a common practice as a way of irrigating the farmland.

However, we argue that although the *retenidas* have been relatively successful, there is a potential tension between the CONANP and the villagers due to the degree of expectation on the *retenidas*. The first expectation is that the *retenidas* will recharge the aquifer and consequently be useful for water cattle provision. Yet, the available information suggests that there is a high uncertainty about to what degree this would happen. The second expectation is regarding the potential uses for farmland. In summary, the same degree of expectation that facilitated the acceptance of the *retenidas*, and opened the boundary rule,

could be a significant problem if the perception of the people changes regarding the benefits obtained of these projects. Regardless of the potential benefits for economic activity, we suggest that retenidas might produce beneficial effects to maintain de natural conditions that sustain biodiversity in the SARC natural protected area.

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The book covers several topics of biodiversity researches and uses, containing 17 chapters grouped into 5 sections. It begins with an interesting chapter considering the ways in which the very biodiversity could be thought about. Noteworthy is the chapter expounding pretty original "creativity theory of ecosystem". There are several chapters concerning models describing relation between ecological niches and diversity maintenance, the factors underlying avian species imperilment, and diversity turnover rate of a local beetle group. Of special importance is the chapter outlining a theoretical model for morphological disparity in its most widened treatment. Several chapters consider regional aspects of biodiversity in Europe, Asia, Central and South America, among them an approach for monitoring conservation of the regional tropical phytodiversity in India is of special importance. Of interest is also a chapter considering the history of the very idea of biodiversity emergence in ecological researches.

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