BASELINE DATA OF BIRD POPULATIONS IN THE SIERRA GORDA BIOSPHERE RESERVE, MEXICO: A CITIZEN SCIENCE APPROACH

By

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A Project Submitted in Partial Fulfillment of the Requirements

for the Degree of

Master of Natural Resource Management and Geography

University of Alaska Fairbanks

December 2017

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Abstract

This project tested the viability of converting a local environmental education group, "Eco Chavos" into a team of citizen scientists. In rural biosphere reserves in Mexico, with few resources and large resident populations, community-based biological inventory and monitoring has the potential to increase the impact of Mexican biosphere reserves by generating scientific information and engaging local residents in hands-on environmental education.

To test this, I formed a citizen science birding group and trained them in bird identification, survey techniques, data collection, and data management. The project began in January 2016 and in December 2016 I stopped mentoring the program and let it continue under its own leadership. Our team was composed of an Eco Chavos group and a resident ornithologist who conducted land and water-based surveys multiple times a month. As of August 2017, 160 bird species have been registered, including three species endemic to Mexico; the Crimson-collared Grosbeak (*Rhodothraupis celaeno*), Blue Mockingbird (*Melanotis caerulescens*), and Spotted Wren (*Campylorhynchus gularis*). The survey provided an inventory of bird diversity in the reservoir, and could serve as a starting point to measure occurrence and abundance over time. The data were published in the updated management plan of the Sierra Gorda Biosphere Reserve as well as in a new bird book, *Guía de Aves de la Presa Jalpan*. A new community group, "Aves de la Presa Jalpan" was formed and contributed information via an online public database. The database may be used by the international network of bird monitors to analyze population trends in both local Mexican bird populations and in international bird migrations. In addition, participants showed increased bird identification skills, leadership, increased interest in birds, and engagement in project tasks and planning. Infrastructure was built to encourage bird-watching tourism in the Biosphere Reserve and the foundation was set to continue this research in the future.

Acknowledgements

Looking back on the past three years, it is glaringly obvious that none of this would have been possible without the support of many teams of people. I would like to first thank my committee; Dr. Peter Fix, Associate Professor of Outdoor Recreation Management, Dr. Laura Conner, Research Assistant Professor of Science Education at the Geophysical Institute, and Dr. Lois Dalle-Molle, Research Coordinator with the National Park Service. Thank you for your constant support, positivity, and patience through the challenges of a three-hour time difference, questionable Internet connection, and getting to know each other over various video streaming programs.

Another team I couldn't have gone without is Peace Corps staff. Thank you especially to Nicole Salgado, Environmental Program Specialist at Peace Corps Mexico for always being there to lend an ear and a word of encouragement.

I would like to thank the people of Jalpan de Serra for accepting me immediately into their community. Doña Esperanza Coca and her children Alejandro and Denis welcomed me into their home for the first four months in site and were vital in my integration into an incredible group of friends who remain the most memorable and enduring part of my service. I would like to thank my community counterpart MVZ Juan Manuel Salazar Torres who collaborated with me to design and implement this project. He is continuing the work of promoting bird watching tourism in the Sierra Gorda Biosphere Reserve. This project also would not have been possible without my team of Eco Chavos.

To friends back home, thank you for the letters and phone calls to remind me that I still have a community in the US. And finally, thank you to my family for the enthusiasm and positivity, giving me the perspective, when needed, of how great it was to live and work on such a project in such a place.

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Introduction

This project examined the viability of engaging Eco Chavos in a citizen science biological survey as a way to provide quality scientific data while engaging the public and providing practical and empowering education in the Sierra Gorda Biosphere Reserve (SGBR).

The SGBR, Querétaro is the seventh largest biosphere reserve in Mexico and holds first place in ecosystem diversity. It is part of the Huasteca World Heritage Site and home to a population of 103,929 mostly Indigenous and agrarian residents living inside the Reserve's boundaries (SEDESOL, 2013). Land in the SGBR is mostly privately owned with just 3% federally owned (Grupo Ecológico Sierra Gorda, 2016). It is run by the National Commission of Natural Protected Areas (CONANP), and despite the area's ecological importance, is the least funded Natural Protected Area (NPA) in the country (M. Salazar, personal communication, November 20, 2016). The primary ecological challenges to the SGBR come from unregulated farming, logging, mining, and poaching. To respond to these man-made ecological pressures, the SGBR's primary goal is community outreach and engagement. Out of the 11 employees of the SGBR, 10 manage projects in rural development, leaving only one to complete all geological and biological monitoring (SGBR staff, personal communication, June 30, 2015).

My role as a Peace Corps volunteer was to run the SGBR environmental education program, Eco Chavos. In the Eco Chavos program, high school youth[1] identify an ecological or sustainable development problem in their community, determine a project to address that need, identify a protocol, complete the project, and educate their community and surrounding communities about the project. Their strategy lends itself to citizen science biological inventory and monitoring in which a problem is identified, a protocol followed, and a project enacted with varying levels of participation from the citizen scientists and a focus on education. Citizen science has the potential to address inventory and monitoring needs in NPAs by providing de facto employees to an otherwise understaffed program.

[1] The participating students are identified as Eco Chavos. In the paper, unless noted by the qualifier "program," the term Eco Chavos is referring to the student participants.

The potential of the Eco Chavos to complete a citizen science project was tested by implementing a bird survey of the Jalpan Reservoir to establish baseline bird population data. The Jalpan Reservoir is a man-made 69-hectare body of water that serves as important habitat for migratory and resident bird species. The SGBR is listed as an Important Bird Area by BirdLife International because of its biodiversity (BirdLife International, 2017). A total of 471 bird species have been registered in the SGBR (CONABIO, 2015). The Jalpan Reservoir became a designated Ramsar site in 2004 after a proposal from the Grupo Ecológico (Pedraza, 2003). The Ramsar convention was a 1971 intergovernmental treaty for conservation of important wetlands. The proposal for the Jalpan Reservoir to become a designated Ramsar site claimed that 140 bird species could be found around the Presa but there was no evidence to support that claim (BirdLife International, 2017).

The Sierra Gorda Biosphere Reserve

The SGBR is a large protected area located in the eastern Sierra Madres in the state of Querétaro (Figure 1). It is inhabited by 103,929 individuals living in 66 mostly Indigenous communities of Huasteca culture. The communities have a high poverty level and rely mainly on farming, livestock, logging, and small mining operations (CONANP, 2017).

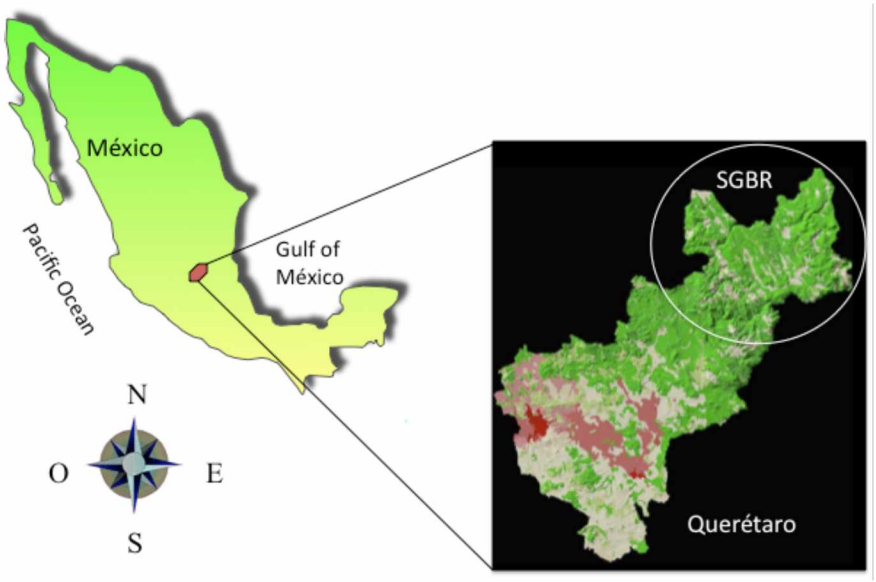

Figure 1. Location of the SGBR in the state of Querétaro (Gutiérrez-Yurrita, García-Serrano, Rebollar-Plata, 2012)

The Reserve was created in 1997 after the conservation efforts of a local nongovernmental organization (NGO), the Grupo Ecológico, and is the only NPA in Mexico to have been created by grassroots efforts (Grupo Ecológico Sierra Gorda, 2016). The SGBR has some of the highest ecosystem diversity and biodiversity in Mexico with 10 of the 11 ecosystems found in the country (CONANP, 2017). The SGBR is an ecotone, a junction of the biogeographical regions of the Nearctic and Neotropics. It includes three physiographical provinces: the Neovolcanic axis, the Central Plateau (Bajío) and the Sierra Madre Oriental. The Reserve has an altitude variation of 0 to 2500m above sea level and contains warm, dry, and temperate climates. The vegetation varies between desert scrub, thorn woodlands, pine forest, oak forest, temperate hardwood forest, low tropical deciduous forest and agricultural lands (Figure 2).

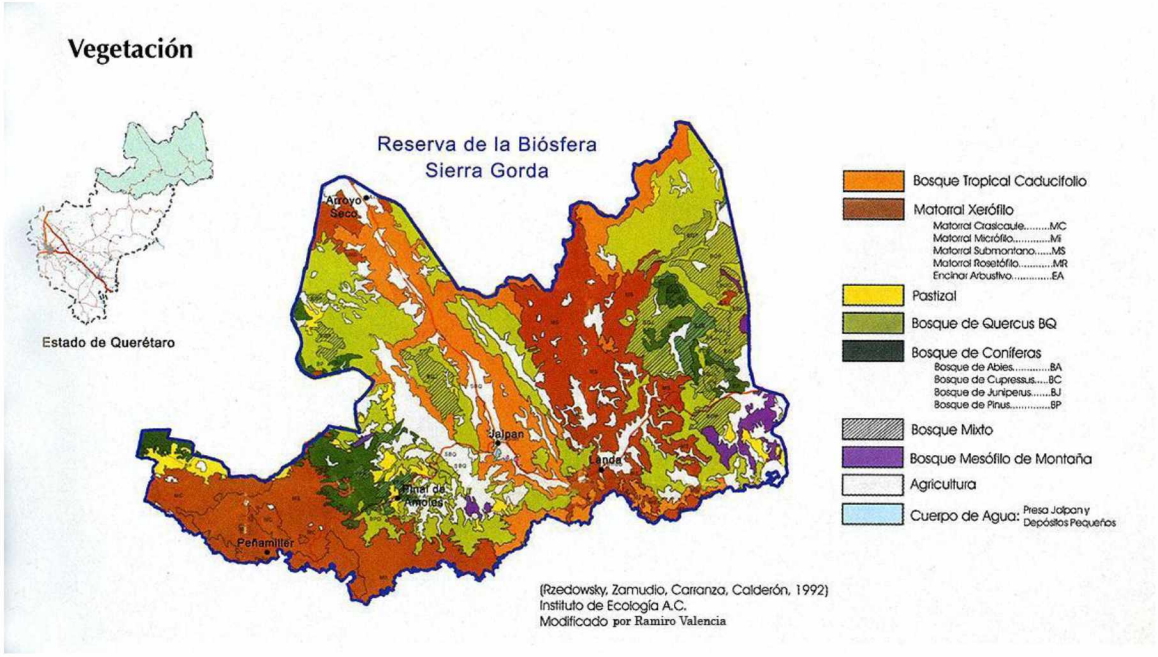

Figure 2. Map of vegetation of the SGBR (Rzedowski, Zamudio, Carranza, Calderón, 1992).

Despite its abundant natural resources, the SGBR is the least funded NPA in the country (M. Salazar, personal communication, November 20, 2016). It has a staff of 11 to manage an area of 3,800 square kilometers inhabited by over 100,000 individuals. Of the employees, 10 manage education and development projects leaving only one in charge of all inventory and monitoring. In this study, monitoring is defined as continual examination of specimens for identification and change over time. This one staff member is responsible for running monitoring programs for the endangered jaguar (*Panthera onca*), the aquatic axolotl (*Ambystoma mexicanum*), water quality, and monitoring of the spread of heavy metals through the trophic levels. The employee has the support of an NGO called United Corridors in a monitoring project of the military macaw (*Ara militaris*). Other support comes from collaboration with the Sierra Madre Oriental Ecological Corridor (CESMO), a protected wildlife corridor that includes the SGBR and 38 other NPAs, and spans five states running north to south over the Eastern Sierra Madres (CESMO, 2016).

The CESMO was created in 2013 by the Mexican government and the German agency Gesellschaft für Internationale Zusammenarbeit (GIZ), a service provider that assists the German government in international cooperation for sustainable development (GIZ, 2017). Their Mexico

chapter focuses on implementing projects in the fields of environmental and resource conservation, climate change mitigation, and sustainable energy. The most active GIZ project in the CESMO is a network of high school student volunteers called Eco Chavos.

The Eco Chavos program began as Eco Clubes in 1997 when the SGBR was run by the Grupo Ecológico. In 2012 the Grupo Ecológico turned over management of the Reserve to the Mexican government through CONANP. When the Grupo Ecológico turned over leadership, the Eco Clubes also fell under CONANP management and changed their name to Eco Chavos (S. Ortiz-Hernández, personal communication, June 30, 2015).

Eco Chavos are middle and high school students who volunteer during or after school to complete an environmental project for their communities. Each group does a diagnostic on their community, writes a project proposal to CONANP, writes a project grant to GIZ, completes a project for the benefit of their school or community, and implements an outreach program to teach surrounding communities about their project. Each school group operates under a teacher or community facilitator. Their projects usually reflect the specific needs of the communities. Desert communities tend to pursue rainwater harvest and water filtration projects while forested communities typically work in reforestation or wood-saving stoves. There are Eco Chavos groups throughout the five states that comprise the CESMO and 15 groups inside the SGBR.

The Eco Chavos became involved in a biodiversity project for the first time when the SGBR was assigned a new sub director, an ornithologist who was interested in the Jalpan Reservoir's bird population. Even though the Jalpan Reservoir was a designated Ramsar site, no formal study had ever been conducted on bird diversity and abundance of the area (BirdLife International, 2017). The sub director wanted to pursue this gap in knowledge . I proposed a collaboration with the Eco Chavos program to engage the local Jalpan Eco Chavos group in this study and test a citizen science project in the SGBR.

The study site is the Jalpan Reservoir, a man-made body of water with a surface area of 4.5 square kilometers and a volume of 8 million cubic meters. It was built as a water reservoir for

the town of Jalpan de Serra in the 1960s. It is the only lake in the SGBR and provides water for agriculture in the valley and for the town of Jalpan de Serra. Jalpan de Serra is the largest community in the SGBR with a population of 11,010 (SEDESOL, 2013).

The relationship between local residents and land managers is especially important in areas where residents share land ownership with land managers, such as in the national parks of Mexico. Within CONANP, the parks are usually heavily populated with residents who are not allowed to practice subsistence, but in specific areas can farm, raise livestock, cut trees, and mine. Since the land legally belongs to the residents, and CONANP rules are rarely enforced, the rules act more as suggestions for a more sustainable lifestyle. The government reimburses local landowners for livestock killed by wild predators but there is still widespread poaching of predators (U. Torres, personal communication, December 4, 2015). These actions go largely unchecked because the federal law enforcement, PROFEPA, is often too far away to respond to rural NPAs. Since law enforcement in the SGBR is not reliable, CONANP focuses on environmental education and rural development to mitigate activities that cause the most negative environmental impacts. With such a small staff, CONANP benefits from a close collaboration with local residents. Residents nearly always have a better understanding of the area and their traditional knowledge can also be identified as a type of citizen science (Science Communication Unit, 2013).

This study examines a citizen science bird survey in a Mexican NPA and was meant to inform other rural NPAs that have the same struggles of not having enough resources to pursue biological surveying projects. In this paper a bird survey is defined as determining status and trends in bird populations (Gregory, Gibbons, & Donald, 2004).

Literature Review

Citizen Science

Citizen science (CS) encompasses many different ways in which citizens are involved in science but is generally used to gather large amounts of data over a long period of time (Bonney et al., 2009). CS may include mass participation projects in which citizens submit wildlife monitoring data worldwide, as well as smaller-scale activities such as local groups researching their own communities (Science Communication Unit, 2013). CS is especially useful as a melding of education, outreach, and research, and it supports science, society, education, and environmental policymaking. It can require a high level of involvement with the public and it encourages citizen investment in environmental issues.

Haklay (as cited in Science Communication Unit, 2013) provides a useful categorization of CS projects by their level of participation (Table 1). There are four levels of participation in CS depending on the goals of the project. Level 1 is the least participatory and is defined as "crowdsourcing" which engages citizens in gathering data from placed sensors such as camera traps or water monitoring stations. Level 2 is "distributed intelligence," such as the online birding project eBird (eBird, 2017). Distributed intelligence projects ask citizens to collect and potentially interpret data. Level 3 is "participatory science" where participants are more involved in steering the direction of the research. Finally, level 4 is the most participatory and called "extreme citizen science," where citizens are involved at all stages in the development of the project and work to achieve goals that they determine themselves. Extreme CS can include projects where citizens are the driving force behind the research and professional scientists are not involved at all.

Table 1. Levels of Citizen Science by Haklay (as cited in Science Communication Unit, 2013).

Haklay's level	**Haklay's label**	**Description of CS engagement**
Level 1	Crowdsourcing	Citizens as sensors
Level 2	Distributed Intelligence	Citizens as basic interpreters
Level 3	Participatory Science	Participation in problem definition and data collection
Level 4	Extreme	Participatory science in problem definition, data collection, and analysis

Other terminology comes from Shirk et al. (2012) in their definitions of levels of involvement by citizen scientists with respect to project creation, rather than data collection. (Table 2).

Table 2. Shirk et al.'s (2012) Public Participation in Scientific Research from Ecology and Society 17(2): 29.

Shirk's label	**Description of CS engagement**
Contractual Projects	Communities ask professional researchers to conduct a specific scientific investigation
Contributory Projects	Generally designed by scientists and for which members of the public primarily contribute data
Collaborative Projects	Generally designed by scientists and members of the public contribute data but might refine project design, analyze data, and/or disseminate findings
Co-Created Projects	Designed by scientists and members of the public working together and some of the public participants are actively involved in most or all aspects of the research process
Collegial Contributions	Non-credentialed individuals conduct research independently with varying degrees of expected recognition by institutionalized science and/or professionals

Both Haklay and Shirk define levels of CS based not on the type of data collected, the purpose of the data, the amount of data, or the number of participants, but on the level of involvement of the participants. Gardiner et al. (2012) differ in that they categorize CS projects based on quality assurance methods. The two levels of quality assurance are "verified" citizen science, in which observations are checked by experts, and "direct" citizen science, in which observations are submitted without verification. The former would include all of Shirk et al.'s definitions except Collegial Contributions, with Collegial Contributions as the only level defined as direct citizen science. Haklay's CS levels 1-3 may be assumed also to be verified CS while his level 4 "Extreme" CS could be direct CS.

The greater number of categories of verified CS against direct CS appears to show that the majority of CS projects are verified; however, while many projects do use quality assurance methods to ensure high quality data, many others rely on large sample sizes to cancel out the effects of individual errors on overall accuracy (Science Unit Communication, 2013). Still more projects, such as eBird, use a combination of verification strategies with large sample sizes to ensure highest possible data quality.

The two most common issues with citizen science are that the data are not accurate enough because of a failing in methods or training, or that citizen scientists are more likely than professionals to systematically bias the data. Doubts about data quality and the reputation of CS as producing lesser-quality data make some government agencies hesitant to accept data produced by CS (Engel & Voshell 2002). These concerns can be mitigated by having the data verified by the same scientific institution that will be accepting the data, and by using trusted training and tools to mitigate inaccuracies.

When volunteers work closely with professional biologists, there is less opportunity for error in surveys and the added educational aspect may encourage participant retention (Crall et al., 2011). This pairing with professional biologists would make it easier for citizen scientists to grow their knowledge since they would have a professional on call acting like a mentor or tutor to encourage the specific interests of individual participants. Through role modeling, tutoring, and networking, a professional scientist has the potential to be an important resource for participants. The impacts of improved scientific literacy are especially far-reaching in communities with few professional opportunities. Trumbull et al. (2000) showed that participation in a CS project could open doors to careers in biology, tourism, or science in general, as a result of experience in scientific thinking.

In addition to ensuring the validity of data collection, curation, analysis and dissemination, project leaders must maintain community participation, interest, and education in order for a CS project to succeed (Bonney et al., 2009). Volunteers may already have an interest

in the topic since they are self-selected to participate, but there could be motivations other than intrinsic interest in the project. Participants could have a desire to support social, environmental or political change, gain skills, or increase employability. They could be motivated by the opportunity to visit beautiful study sites or to make social connections (Science Communication Unit, 2013). Every volunteer has their own personal motivation for participating (Danielsen et al., 2005) and a successful CS project must provide enough diverse rewards to motivate everyone involved.

This study used known best practices in creating citizen science projects from the Cornell Lab of Ornithology (CLO) model for developing a citizen science project (CLO, 2017). The CLO is a world leader in citizen science programming and has a special focus on bird inventory and monitoring. It has been found that projects that follow the CLO model can simultaneously fulfill their goals of recruitment, research, conservation, and education. In the development of their model, the CLO stated that more research was needed on the best methods of education through the citizen science process and on how that process may differ among different cultures and languages (Bonney et al., 2009).

Project Goals

With its success in advancing scientific knowledge as well as science literacy, citizen science would be a useful approach to test and refine in the SGBR. This study of the potential of Eco Chavos working as citizen scientists used and refined the CLO CS project protocol in Mexico, in Spanish, and in the context of rural Huasteca culture with all local participants.

The project intended to engage local citizen scientists in collecting baseline information about resident and migratory bird communities in and around the Jalpan Reservoir. It aimed to:

1. Generate new scientific data on the status of birds in the Jalpan Reservoir,
2. Increase the impact of SGBR environmental education by increasing scientific literacy of the participating Eco Chavos and having them provide outreach to their surrounding communities,
3. Promote bird-watching tourism in the SGBR.

Table 3. Goals, Approaches, and Desired Outcomes.

Goal	Approach	Desired Outcome
Generate new scientific data.	Utilize CS protocol and bird census protocol to conduct an inventory of bird species in the Jalpan Reservoir. Record species occurrence and abundance over time.	A database that includes names of the bird species, vulnerability statistics, biological information, and the number of individuals of each species viewed each month.
Improve environmental education in the SGBR.	Involve communities in CS surveying. Increase Eco Chavos's knowledge of bird species.	Increased community awareness of the importance of birds in the SGBR.Increased skill in bird identification demonstrated by Eco Chavos. Attitude change toward a more favorable view of the environment.
Promote bird-watching tourism in the SGBR.	Publish the first bird book of birds registered at the Jalpan Reservoir. Build an interpretive walkway along the Jalpan Reservoir.	Increased bird-watching infrastructure in the SGBR. Increased number of tourists participating in bird watching.

Methods

The goals of the project involve a bird survey, education, and birding tourism infrastructure. Methods pertaining to each goal are described in three separate sections below.

Bird Survey

CS Bird Survey Protocol

I worked with the CONANP ornithologist to devise a CS project that falls between participatory and collaborative citizen science, since volunteers work with scientists to refine the protocol, but they do not participate in data analysis.

Our protocol for creating and managing a CS group generally followed the steps developed by the CLO model for citizen science programs (Bonney et al., 2009):

1. Choose a question
2. Form a team
3. Refine protocols
4. Recruit participants
5. Train participants
6. Accept data
7. Analyze data
8. Disseminate results
9. Measure effects

The protocol was put into practice throughout the months of January to December 2016, and during those months was changed and refined to ensure participant retention. The group deviated from the 9-step protocol in the order in which the steps were enacted. We first chose a question, then formed a team, recruited participants throughout the project, trained participants, accepted data, disseminated results and progress during the same time period, further refined the protocols, gathered additional data, and finally analyzed the data and measured the effects.

Data Collection

The CLO provided guidelines for developing a CS project but the CS bird survey required another protocol specific to bird sampling in Mexico that would provide acceptable data to CONANP. Bird sampling data forms used were provided by the National Commission for the Awareness and Use of Biodiversity (CONABIO) and approved by CONANP staff members. CONABIO provided two sheets for gathering field data; one for point-count sampling and another for intensive search sampling (Appendix A). The study team consisted of the CONANP ornithologist, the Jalpan Eco Chavos, and me. For the month of January 2016, the study team met an hour before each survey trip for training. Training sessions involved listening to bird song recordings and practicing bird identification via flashcards. In the field, throughout the yearlong program, special care was taken to teach bird identification, sighting, behavior, diagnostic marks, and songs.

The initial bird survey trips were planned four times a month from January to December 2016. Survey days were on the weekends to accommodate the school schedules of the Eco Chavos. They were timed to begin an hour before and an hour after sunrise or sunset when there is the most bird activity. During surveying, the Eco Chavos were split into two groups, one with me and one with the CONANP ornithologist. Each group spent one hour at designated sampling points on opposite sides of the Jalpan Reservoir for point count sampling, and a second hour for intensive search sampling, walking a two-kilometer transect along the group's respective side of the reservoir (Figure 3). We wanted to sample on both sides of the reservoir to maximize the area observed. The two starting points were selected because they provide the most expansive view of the reservoir. From the starting points we limited the transects to two kilometers along the shoreline since two kilometers can be walked at an easy pace in one hour. Our field notes registered bird species viewed, the number of individuals of each species, time, date, weather conditions, location, and external factors such as the presence of human activity. Each group of Eco Chavos had one sheet of field notes for the hour spent observing from a stationary point and one sheet for the area search portion walking up and down the transect. Each student managed one bird watching tool, either the datasheet, binoculars, the camera, or the bird book. When a bird was spotted, the first priority was for a student to take a photo before it went out of sight.

Another student would use their binoculars to count the number of individuals present, and to describe the bird's markings to the student with the bird book. Depending on the amount of time the bird was visible, the students passed around the binoculars and studied the bird book photo in order to properly identify the bird. Once the ornithologist or I verified their identification, the student with the corresponding data sheet wrote down the bird's scientific and common names listed in the bird book. During the identification process, the ornithologist or I pointed out the diagnostic markings of that species or gave identification tips.

Figure 3. Aerial photo of Jalpan Reservoir showing land transects followed by Eco Chavos during bird survey. Routes were chosen based on availability of trails in dense vegetation with a view of the shoreline.

This sampling protocol changed in July 2016 due to an increasing lack of interest and declining volunteer numbers. I worked with the group to determine what changes would increase

participant retention. We decided in July to change our protocol to make the dates and hours of our trips less rigid. This resulted in greater engagement of participants but we had to abandon our scientific goals of baseline bird species occurrence and abundance. The new, flexible approach could not account for variations in bird population throughout the year since we could not make observations consistently. Our changes included making frequency and length of surveying trips more flexible. Our initial frequency and length was 2-4 surveying trips per month at two hours per trip; one hour of point-count sampling and one hour of intensive search. This proved to be too rigorous a protocol and participation dropped from 22 to zero participants in five months. The protocol was refined by changing the frequency and length of trips per month to be more flexible. Some months the group would only survey twice and other months would have up to six surveying trips. The protocol also changed from point-count sampling and intensive search to just intensive search. Intensive search trips could last from 30 minutes to four hours depending on how many birds we were registering and the engagement of the participants. This new, convenience sampling protocol ensured increased participation and motivation among participants but it compromised data on baseline occurrence and abundance.

Database

After the Eco Chavos took notes in the field, I transferred the data onto a Google spreadsheet. The spreadsheet included the bird species' common Spanish and English names, order, family, genus, species, migratory status, vulnerability and protection statuses, habitat, an identifying photo, and abundance per month (Appendix B).

The ornithologist and I had editing permissions on the online Google database (Base de Datos.xlsx., 2016) and the Eco Chavos only had viewing privileges. Participants could watch the progress of their work but not directly edit it. They could access it from any device that connects to the Internet and they all had permission to share viewing ability of the database with other interested parties.

Data were available to view by anyone with the link to the Google Sheets database. I also created a Naturalista project called "Aves de la Presa Jalpan," and any of the participants could

upload their photos and data onto that project. Naturalista is the Spanish version of iNaturalist, an online base of plant and animal registries. It is crowd sourced and available to anyone online to participate or view (http://www.naturalista.mx/projects/aves-de-la-presa-jalpan). The Eco Chavos were encouraged to upload their bird sightings to Naturalista but uploading was not a primary goal of this project.

Environmental Education

Community involvement

The Eco Chavos planned on giving three presentations in different communities for their community outreach requirement. They presented their progress, methods, and findings at an Eco Chavos retreat, World Wetland Day, and International Migratory Bird Day. These presentations were meant to inspire participants to study on their own and design creative ways of presenting their work. They also created a Facebook group (https://www.facebook.com/proyectoapj/) and scheduled an interview on the local radio station to increase their educational outreach.

Measuring changes in knowledge, skills, attitudes, and behavior

In April 2017, the Eco Chavos were tested for knowledge and skills gained in bird identification. The group of Eco Chavos who had gone through the yearlong birding program tested against a group of Eco Chavos new recruits who had not yet started a project. Both groups were tested in bird identification and ability to use bird surveying tools. Each student was given a bird book and shown a photo of nine birds. The students had 10 minutes to use their bird books to identify as many of the nine birds as possible and write down their scientific names (Appendix C).

During the yearlong bird survey, I used behavioral observation to track the attitude and behavior change of the group. Behavioral observation was conducted in a natural setting over a long span of time, following the best practices described in Oskamp and Schultz 2005. I took notes in a journal after surveying trips and saw trends over time in the progress of individuals gaining (or never gaining) an interest in birds. I looked for diagnostic actions of a change in

attitude towards birds, noting their participation levels, interests, and roles they played within the social dynamics of the group. I also kept an attendance sheet that records dates of surveying trips and how many students attended each outing. I took notes in a calendar of the dates when the students had breakthroughs in leadership such as the first time they initiated a bird surveying trip and the first time they suggested a trip to a bird festival. The calendar also records the frequency of surveying trips, fundraising events, outreach events, presentations, and appearances on the radio show. I kept a digital record of our group texting communications to observe involvement in group discussions.

Tourism Infrastructure

Bird book

We published a bird book that was informed by the results of the bird study. January to December 2016 was spent in a bird species inventory and recording species occurrence over time to inform bird watchers of the best months for bird diversity in the SGBR. January to June 2017 was spent compiling the findings and designing the bird book with CONABIO for printing. The bird book used photos taken in situ by the citizen scientists and followed guidelines for CONANP bird guides from CONABIO.

Guides

The Eco Chavos were scheduled to attend a certification course to become bird guides in February 2017. This was an optional certification that would increase the infrastructure of bird watching tourism in Jalpan. A list of the names of the interested Eco Chavos was given to the Jalpan Municipal Tourism Office to provide an option for tourists to hire a local bird guide who was familiar with birds of the area.

Promotion

Interpretive signs are useful tools for enhancing visitor experience in natural areas (Hughes & Morrison-Saunders, 2010). Five signs were designed that described the Jalpan

Reservoir, Ramsar wetlands, local flora and fauna, birds of the area, and rules of behavior when recreating outdoors in a NPA. In addition, a two-kilometer boardwalk was designed with three bird observation towers along the Jalpan Reservoir.

Results

Bird Survey

As of August, 2017, 160 species from 22 orders and 54 families were recorded (Appendix C). The study recorded 71 residential species, 88 migratory species, and one accidental species. Out of the species recorded, 41 were aquatic and 119 were terrestrial. The most numerous species were the cattle egret, blue-grey gnatcatcher, great-tailed grackle, and neotropic cormorant. Three species were recorded that are endemic to Mexico: the spotted wren, blue mockingbird, and crimson-collared grosbeak. This study registered 20 species more than were previously known to exist at the Jalpan Reservoir. We could not make conclusions of species occurrence over time but we did collect occurrence data intermittently. The data recorded showed that the greatest number of species is at the Jalpan Reservoir during the migration months of March and April, and of August and September (Figure 4). This matches with known bird migration patterns but it also matches with my attendance list. During migration seasons we also happened to have the greatest number of Eco Chavos participants.

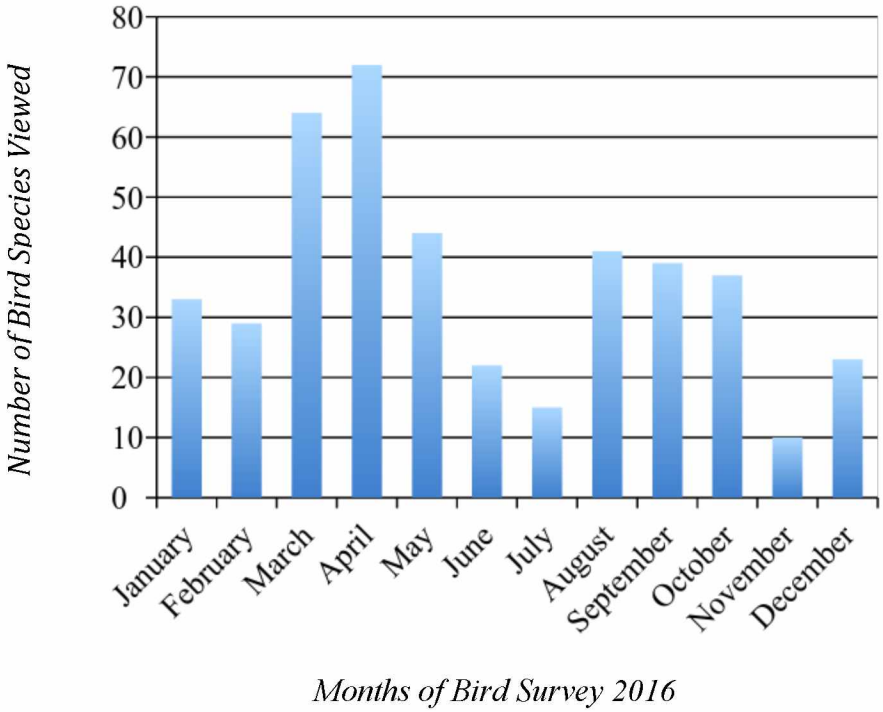

Figure 4. Number of bird species observed monthly in the Jalpan Reservoir 2016

As of November, 2017, data from survey trips were entered covering the period from January, 2016 to August, 2017 after which the CONANP ornithologist stopped uploading data to the Google Database. The data are included in the SGBR management plan that will be published as of December, 2017. The Naturalista database was created on March 10, 2016. As of November, 2017, 15 bird species were uploaded by the public.

Environmental Education

Knowledge, skills, behavior, and attitudes Assessment

On the bird identification skills test, the students who had completed the project demonstrated higher ability to identify birds using a bird book compared to students who did not participate in the program. The average correct identification by students who did not participate in the project was two birds out of nine. The average correct identification of the students who did participate in the project was nine out of nine.

Over time, student behavior changed in the form of increased attendance during surveying trips, increased punctuality on trips, more active conversation regarding birds on social media on the part of the Eco Chavos, and increased leadership in the form of initiating activities related to the bird survey. During the trip to Veracruz, that the Eco Chavos planned, they volunteered with professional bird monitors to watch a raptor migration. During the trip, I observed their motivations growing from being primarily socially motivated to having a genuine interest in birds themselves as demonstrated in more conversation about birds, more students memorizing scientific names, and increased participation in group discussion and planning.

Community Outreach

The Eco Chavos presented at seven events. They presented progress on their project twice on the radio, reaching roughly 200,000 listeners each time. They presented at their local Eco Chavos retreat in the SGBR to 80 other Eco Chavos as well as at an Eco Chavos retreat in another state, presenting to roughly 200 other Eco Chavos. They presented twice in Jalpan during World Wetlands Day, and once for the municipality. They traveled to a nearby village to present

during International Migratory Bird Day, and finally, they presented to a National CONANP audience in the state of Puebla.

Tourism Infrastructure

Bird book

The data were published in a bird book in July 2017 and given to CONANP for distribution, for loan, and for official use. The publication of 1,000 copies was funded by CONABIO with the agreement that a second version may be published a year later if more species are registered. The bird book, *Guía de Aves de la Presa Jalpan*, features all 160 species registered in the Google Database as of August, 2017. The bird books are in Spanish and English. They include two QR codes. The first QR code links to a CONABIO bird song library so users of the bird guide can look up the song of the bird they identify. The other QR code is a link to the *Aves de la Presa Jalpan* Naturalista project so that users of the bird guide can add their observations to the project.

Guides

For the duration of the project, the Eco Chavos participants were not certified as bird guides. However, three of them were contracted in July, 2017 to guide a tourist group from the Mexican state of Tamaulipas on a two-day bird watching trip around the Jalpan Reservoir.

Promotion

The Jalpan municipality collaborated with the project and constructed a boardwalk along the Eastern side of the Presa Jalpan following the Eastern transect of the project. The two-kilometer boardwalk includes three bird observation towers and six interpretive signs (Appendix D).

Discussion

Motivation

Successful management of a project requires not only maintaining the protocol and scientific accuracy but also maintaining the motivation of volunteers (Hochachka et al., 2012). Volunteer motivation can be increased by many means such as keeping the protocol simple (Bonney et al., 2009), emphasizing the impact volunteers' work will have on policy (Cornwell & Campbell, 2012), making data collection and records into a game (Science Communication Unit, 2013), appealing to competitiveness, and increasing social capital of the group (Hochachka et al., 2012).

In February 2016, 22 student volunteers expressed interest in the project. Participation was voluntary and I hoped to make it rewarding enough to gain loyalty. This project initially relied on social rewards to motivate participant retention among high school students. Participants were presented with opportunities for socialization and new experiences together.

The project started with high participation but was nearly canceled when the number of Eco Chavos volunteers slowly dropped to zero after months of following a strict protocol. It was only after changing the protocol to make it more flexible that the volunteers came back. This is consistent with recommendations to match research methods and tasks to the volunteers (Bonney et al., 2009).

To increase attendance, I asked the Eco Chavos participants to give suggestions for how to refine the protocol and I gave them more leadership roles in the project. They took over planning the times and dates for surveying trips while keeping with the best practices of morning and evening trips to see the greatest amount of birds, and weekends to accommodate the schedules of the whole group. They independently planned and fundraised for a trip to Veracruz for a National Bird Festival after expressing interest in repeating their previous experience volunteering as bird monitors during the Veracruz Raptor Migration. These trips were especially critical in increasing their interest in science. Their direct experience working with professional bird monitors exposed them to the possibilities of being involved in science as adults. After

these trips, the Eco Chavos participants demonstrated increased interest in the project. Some asked to take bird books home with them to study and some demonstrated increased ability to identify birds in the field based on sight and sound. This behavior did not occur during the application of the initial protocol. Rather, it occurred after incrementally reducing my leadership role and allowing the students to fill the leadership void naturally. Giving participants leadership roles was found to be an effective motivational strategy to increase participation in this CS project.

Additional motivation was introduced to the group when a member of the Jalpan community started lending us his kayaks to monitor birds from the lake as well as on the shores. This element of a new sport added novelty and a sense of play to the survey trips.

Changes in Protocol

After the Eco Chavos reworked the protocol to be more flexible, it was understood that after the first year, no conclusions on bird abundance or occurrence over time could be made. After just 20 months of surveying, no conclusions can be made on occurrence or abundance of birds. Conclusions can be made on bird inventory. As the project continues, participants will continue to record the number of each species viewed over time. If data are collected over many years, utilizing consistent methods and generating a large enough sample to represent all time periods, it may be used to show occurrence and abundance. Even though the data collected in 2016 are not sufficient for conclusions in bird abundance, the students did accurately map species occurrence throughout the year as shown by influxes of species during migration season (Figure 4).

Observations made in the implementation of this project show that CS participants were sometimes unable to conduct as rigorous work as professionals. The change in our project protocol came about not because of a scientific need but in order to maintain motivation. This was a Level 3 participatory citizen science project that was collaborative in design in that the citizen scientists assisted in refining, if not designing the protocol.

The Eco Chavos also took over leadership in recruiting. They recruited new Eco Chavos participants in their own high school at the beginning of every semester. These recruitments correlated with a boost in interest when the population of participants was diversified. Recruiting within the high school social network began as an open invitation every semester to join the bird surveying group but once the students took over leadership of recruiting they became more exclusive. They continued to recruit during presentations at their school but also personally invited other students that they chose. This made the group exclusive, which likely deterred otherwise interested students but on the other hand made the group a popular one that many students wanted to join.

Another recruiting tool was holding ecological events such as riverside cleanups. This involved the greater community of Jalpan, and connected the Eco Chavos group to interested community members. It was during one of these outreach events that the connection was made with the community member with a kayak company. He lent us his kayak inventory once a month to monitor birds by water (Figure 5). He became part of our regular outings and helped the Eco Chavos feel like their project was interesting and important (K. Echavarria, personal communication, August 9, 2016).

In bird watching trips using intensive search methods, we found the group size could reach a point that was detrimental to the possibility of registering birds. With the added logistics of kayaks, 10 students was the ideal group size to ensure water safety. Since the group was exclusive in these ways, the population of citizen scientists was refined over the months to 10 very dedicated participants.

We were able to register more new species after the protocol change. With the increased flexibility to monitor at inconsistent times and especially at night, we registered nocturnal species we would not have been able to see under the original protocol. We also spent more hours registering birds during peak migration season instead of cutting our time short under the original protocol.

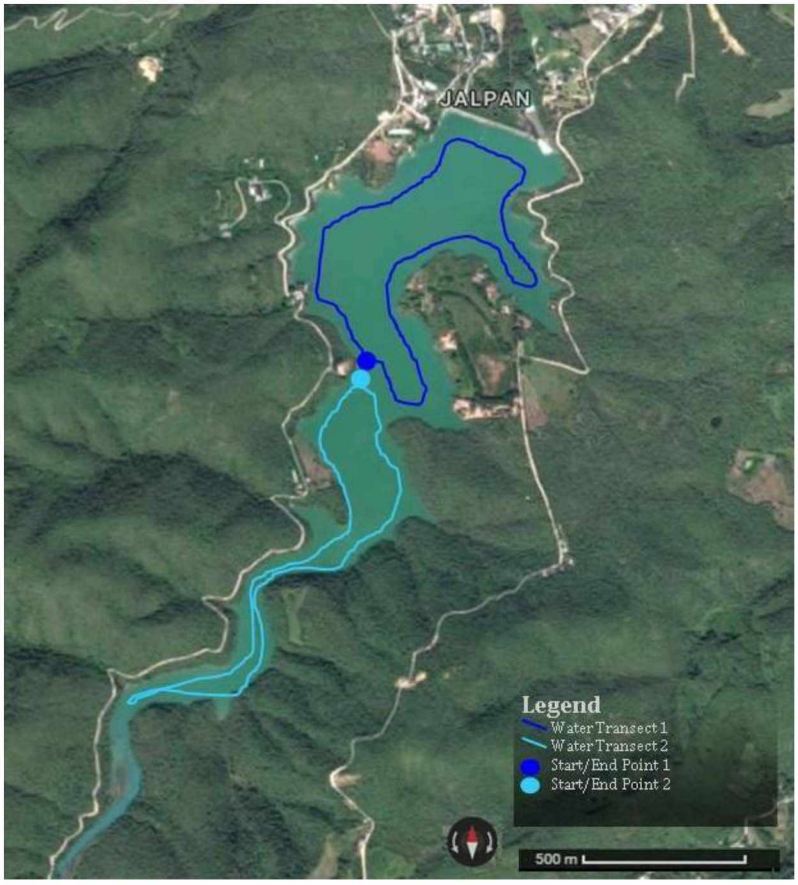

Figure 5. Aerial photo of Jalpan Reservoir showing water transects followed by Eco Chavos using kayaks.

Sustainability

This project was designed for 1-3 years of bird surveying. As of December 2017, the Eco Chavos participated for 20 months. However, the project began without following the official Eco Chavos framework of working within their school with a local teacher facilitator. Nevertheless, the original high school director supported the bird project and allowed it to count as an extracurricular activity for participating students. When I left the group the high school had a new director who wants the Eco Chavos to start a new project for the school unrelated to their previous bird work (B. Oliva, personal correspondence, 2017). The director won't continue to give extracurricular credit to Eco Chavos participating in the bird study, but the students might continue to participate anyway.

Tourism

Tourism is growing quickly in the SGBR. The Jalpan tourism office agreed to keep a list of the phone numbers of interested Eco Chavos so that if a tourist wants to pay for a bird watching trip, a trained Eco Chavo can guide them using the bird book that the Eco Chavo personally contributed to. This would increase employment opportunities for locals living in the SGBR.

Database

The goal of collecting data was to provide information to policy makers and the scientific community. Data have been analyzed to appear in the Biosphere Reserve management plan in December 2017. The CONANP ornithologist has access to edit and further analyze the database on Google Sheets to continue the project. I managed the database up until April 2017 and trained the ornithologist to take over completely in April, 2017. He kept the database up to date until August 2017, when there was sufficient data to publish in the management plan.

Bird identification was accurate thanks to the resident expert validating bird registries for the duration of the project. The study successfully conducted a bird survey, but not bird monitoring. It was not successful in measuring fluctuations in bird species occurrence over time or abundance over time because of inconsistency in time spent surveying per month. During months of more surveying trips, more species were registered and there were fewer species registered on months with fewer surveying trips. The more years this survey is conducted, sampling and count inconsistencies across months should be minimized, and the more accurately it can represent bird occurrence.

Recommendations

One Database

It is important for participants to track, view, and edit data they create (Bonney et al., 2009). This project managed two databases at the same time; the Google Drive Database, and Naturalista. All data collected were recorded on the Google Drive database where the participants could track and view their data but not edit it. The Naturalista project was considered an optional database that participants could engage with if they chose to. Participants ended up not uploading much of their data to Naturalista, preferring to track the results of their project on the Google Drive database and interact through the Facebook group page. I would recommend in the future using only Naturalista to store data instead of the Google Drive database so that participants have more opportunities to be engaged in data management. If other data is required that does not fit into the Naturalista framework, it can be tracked privately by the project managers so as not to distract attention from the participants.

Budgetary constraints

This project was fully funded from multiple sources; GIZ, CONABIO, the Jalpan Municipality, and the kayaking company "Soy Sierra Gorda." GIZ provided bird survey materials, CONABIO provided printing services for the bird book and the six interpretive signs, the Jalpan Municipality provided the boardwalk with three observation towers, and "Soy Sierra Gorda" provided kayaks as surveying tools. Relatively small amounts of funding from multiple sources provided the resources necessary for this project and considering the rate at which I observed funding sources come and go, I would recommend continuing to search for many small amounts of funding from diverse sources when working with rural Mexican NPA's.

Other Eco Chavos groups in the SGBR also have access to GIZ funding for the basic materials for their projects. Eco Chavos groups could request more funds directly from CONANP and CONABIO. Their separate municipalities could provide transportation and other funding depending on their project, and local community or tourism groups could also support their project. To my knowledge, other Eco Chavos groups in the SGBR have only requested

funding from GIZ. Under the right circumstances, other NPAs could follow a similar strategy as the Eco Chavos. If they have environmental education groups based on individual communities, they could solicit funding on the national, state, NPA, and community levels.

Acceptance of Data

Cornwell et al. (2012) describes a study where the participants were so invested in their project that they formed valid disagreements with managers and believed that they could manage the project better than the professional scientists. This possibility opens up new opportunities for research in remote locations or about specific topics where professional scientists are no longer the experts. However, this high level of citizen science, where community members operate independently of professionals, is not recommended in NPAs if the community intends for their data to be accepted by NPA land managers. They should work with and alongside land managers to ensure acceptance of their data. Mexican government officials and urban experts are less likely than rural experts to accept data collected by rural citizen scientists (M. Salazar, personal correspondence, 2016). Co-created and collaborative citizen science projects are the highest levels of citizen science I would recommend in Mexican NPAs.

Access to an Expert

Because of the expert or professional scientist being the limiting factor, in rural areas it makes more sense to take a CS research opportunity when that expert is available rather than designing a project and looking for an expert afterwards. Luckily, the expert on an area often lives in that area. According to Bonney et al. (2009), the expert should be a professional but that depends on the type of knowledge and training required for the project. If specific, local knowledge is desired, I believe the expert could be a local non-professional in some circumstances as long as they work closely enough with the governing agencies to ensure acceptance of their data.

Proposed Changes to High-School Citizen Science Framework

Through my observations of Eco Chavos groups in the SGBR, I recommend three strategies for other high school groups interested in citizen science. They should include diverse

motivational strategies, avoid resemblance to school or work, and be self-directed learning opportunities.

Diverse motivational strategies ensure participant retention. Citizen scientists are volunteers and are not obligated to participate or continue with a project for any set amount of time. Motivational strategies should be built into the protocol and the project should be flexible enough to allow changes depending on the interests of the group. Working with an already-established group is helpful in CS (Danielsen et al., 2005) since established groups likely have motivational strategies such as social capital already developed.

One deterrent I observed in high school volunteer groups was the perception that a CS project was too much like school. Depending on the context of a CS project, having a school teacher as a group leader could either take away a sense of fun from the project by making it feel like school, or it could benefit a school-related project by lending more authority or even offering school credit for participation. In either situation, students are more engaged if they have a larger leadership role in the project. Often, a leadership structure already exists in a previously established group. A new CS project could be an opportunity to rework an existing leadership structure by holding elections at regular intervals, or existing leadership could continue if it has served the group well thus far. Elections among a group is beneficial because presumably the volunteer wants to be elected and the majority of the group wants them to have a leadership position. However, assigning a leader does not automatically turn that person into a skilled leader, it simply delegates them increased responsibility. Often, leaders in a group emerge naturally to organize, motivate, plan, or lead the group in other ways and they should be given the opportunities to do so.

Likewise, opportunities for self-directed learning should be presented depending on the students' interests. I observed that participants often naturally form specialties within a group and encouraging these specializations improves group dynamics and makes each participant feel like a necessary part of the team.

A CS project cannot exist without citizen scientists so participant engagement is prioritized over consistency in data sampling. This limitation determines the types of projects appropriate for citizen science.

Conclusion

This project set out with the goals of generating new scientific data on bird populations at the Jalpan Reservoir, increasing environmental education and community participation in science, and improving infrastructure to encourage bird watching tourism in the SGBR. These goals were accomplished through participatory methods working with CONANP and a previously established environmental program.

This project conducted the first bird inventory of the Ramsar site, the Jalpan Reservoir. It resulted in a database that continues to grow as more information is gathered on birds in the Jalpan Reservoir. CONANP land managers can now use this data to inform management decisions and track bird population changes over time.

During the project, citizen scientists demonstrated an increase in scientific literacy and skills. They gained experience in biological surveying, bird identification, and using the tools of wildlife surveyors. Participants gained leadership skills and experience in a new scientific field. The project allowed them to travel, interact with professional biologists, and build a marketable skill set. Some participants are now employed as bird guides for visitors to the SGBR, and others have expressed interest in furthering their education to become biologists. One participant developed skills in bird photography, won a photography contest for her bird photo, and has now developed her own photography brand.

The bird watching infrastructure that was generated increased the exposure of tourists and the larger community of Jalpan to the concept of studying birds and valuing them for their biodiversity, beauty, and importance in the ecosystem. The infrastructure established was a bird book of the Jalpan Reservoir, an interpretive boardwalk along two kilometers of the waters' edge, and signage teaching about birds, ecology, and Ramsar wetlands. Eco Chavos participants are also available as bird guides with intimate knowledge of the area. Thanks to the Eco Chavos' outreach programs, about 200,000 people have been reached by radio, 280 other students have been reached at Eco Chavos events, and 300 community members have been reached in their

own communities. Increased bird watching tourism could result in more birders using the bird books and using the QR code to participate in the Naturalista citizen science project, increasing the database of registered species in the Jalpan Reservoir.

Rural NPAs with a local population could work with local citizen scientists to fulfill their dual purpose of generating scientific information as well as broadening their environmental education impact. However, citizen science project coordinators should design their projects carefully to ensure participant engagement and accuracy in data collection. Some projects are only suitable for a certain level of CS, and trying to force a certain type of citizen scientist into a more advanced role or a less advanced role than their interests could result in the necessity to completely change the structure or goals of a project. There is no single structure to follow when designing a CS project. Depending on the needs and abilities of the researcher, leader, or group of participants, a CS project can provide everything from simple data collection to a more engaged public, better relations between land managers and local people, and a greater impact on conservation.

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Appendices

Appendix A: Bird Survey Sheets

Anexo 1 Formato para el registro de aves mediante el método de conteo por puntos.

Estado _____ **Municipio** _____ **Fecha** _____

Localidad _____ _____

Hora de inicio del muestreo _____ **Hora de término del muestreo** _____

Tipo de hábitat _____ **Vegetación dominante** _____

Nombre del monitor _____ **Página** ____ **de** ____

# PUNTO	ESPECIE	# INDIVIDUOS	OBSERVACIONES

Anexo 2 Formato para el registro de aves mediante el método de búsqueda intensiva.

Estado _____ **Municipio** _____ **Fecha** _____

Localidad _____ _____

Hora de inicio del muestreo _____ **Hora de término del muestreo** _____

Tipo de hábitat _____ **Vegetación dominante** _____

Nombre del monitor _____ **Página** ____ **de** ____

# PARCELA	ESPECIE	# INDIVIDUOS	OBSERVACIONES

Appendix B: Bird Data Results

	COMMON NAME	HIGH COUNT	NOTES
Charadriformes			
Laridae			
Larus heermanni	Heermann´s Gull	1	Special protection, Semi-endemic, Nearly threatened (IUCN)
Leucophaeus atricilla	Laughing Gull	1	
Recurvirostridae			
Himantopus mexicanus	Black-necked Stilt	2	
Recurvirostra americana	American Avocet	1	
Scolopacidae			
Actitis macularius	Spotted Sandpiper	10	
Calidris mauri	Western Sandpiper	1	
Calidris minutilla	Least Sanpiper	2	
Ciconiformes			
Ciconidae			
Mycteria americana	Wood Stork	2	Special protection
Columbiformes			
Columbidae			
Columbina inca	Inca Dove	10	
Columbina livia	Rock Pigeon	4	Exotic
Columbina passerina	Common Ground Dove	2	
Streptopelia decaocto	Eurasian Collared Dove	20	Exotic
Zenaida asiatica	White-winged Dove	20	
Coraciformes			
Alcedinidae			
Chloroceryle americana	Green Kingfisher	5	
Megaceryle torquata	Ringed Kingfisher	5	
Momotidae			
Momotus momota	Blue-crowned Motmot	1	
Cuculiformes			
Cuculidae			
Coccyzus americanus	Yellow-billed Cuckoo	1	
Crotophaga sulcirostris	Groove-billed Ani	3	
Geococcyx velox	Lesser Roadrunner	1	
Piaya cayana	Squirrel Cuckoo	1	
Falconiformes			
Falconidae			
Caracara cheriway	Crested Caracara	1	
Falco peregrinus	Peregrine Falcon	1	Special protection
Falco sparverius	American Kestrel	1	

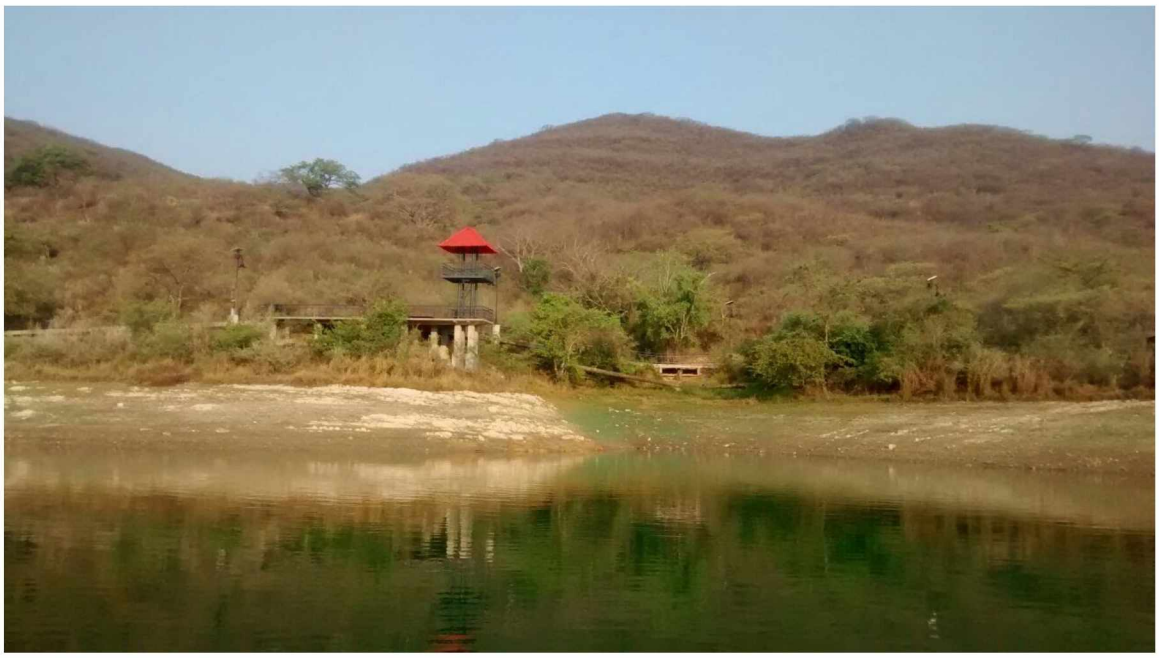
	COMMON NAME	HIGH COUNT	NOTES
Icteridae			
Dives dives	Melodious Blackbird	3	
Icterus cucullatus	Hooded Oriole	4	Semi-endemic
Icterus galbula	Baltimore Oriole	3	
Icterus graduacauda	Audubon Oriole	3	Cuasi-endemic
Icterus gularis	Altamira Oriole	3	
Molothrus aeneus	Bronzed Cowbird	15	
Molothrus ater	Brown-headed Cowbird	20	
Quiscalus mexicanus	Great-tailed Grackle	40	
Mimidae			
Melanotis caerulescens	Blue Mockingbird	2	Threatened, Endemic
Mimus polyglottos	Northern Mockingbird	1	
Toxostoma longirostre	Long-billed Thrasher	2	Cuasi-endemic
Motacillidae			
Anthus spragueii	Sprague´s Pitpit	1	Vulnerable (IUCN)
Passeridae			
Passer domesticus	English Sparrow	1	Exotic
Paridae			
Baeolophus atricristatus	Black-crested Titmouse	2	
Baeolophus wollweberi	Bridled Titmouse	1	
Parulidae			
Basileuterus belli	Golden-browed Warbler	1	
Basileuterus rufifrons	Rufous-capped Warbler	20	Cuasi-endemic
Cardellina pusilla	Wilson´s warbler	5	
Geothlipis trichas	Common Yellowthroat	3	
Mniotilta varia	Black-and-white Warbler	2	
Oreothlypis celata	Orange-crowned Warbler	1	
Oreothlypis ruficapilla	Nashville Warbler	2	
Parkesia motacilla	Louisiana Waterthrush	1	
Parula pitiayumi	Tropical Parula	1	
Setophaga coronata	Yellow-rumped Warbler	1	
Setophaga dominica	Yellow-throated Warbler	1	
Setophaga magnolia	Magnolia Warbler	1	
Setophaga virens	Black-throated Green Warbler	1	
Polioptilidae			
Polioptila caerulea	Blue-grey Gnatcatcher	70	
Ptiliogonidae			
Ptilogonys cinereus	Gray Silky Flycatcher	1	Cuasi-endemic
Thaupidae			

	COMMON NAME	HIGH COUNT	NOTES
Thraupis abbas	Yellow-winged Tanager	2	
Thraupis episcopus	Blue-gray Tanager	2	
Thyrannidae			
Pyrocephalus rubinus	Vermilion Flycatcher	2	
Troglodytidae			
Campylorhynchus gularis	Spotted Wren	2	Endemic
Catherpes mexicanus	Canyon Wren	1	
Thryomanes bewickii	Bewick´s Wren	1	
Troglodytes aedon	House Wren	1	
Turdidae			
Hylocichla mustelina	Wood Thrush	1	
Myadestes occidentalis	Brown-backed Solitaire	1	Special protection
Turdus grayi	Clay-colored Thrush	20	
Tyrannidae			
Camptostoma imberbe	Northern Beardless Tyrannulet	1	
Contopus cinereus	Tropical Pewee	1	
Empidonax albigularis	White-throated Flycatcher	2	
Megarynchus pitangua	Boat-billed Flycatcher	10	
Mitrephanes phaeocercus	Tufted Flycatcher	1	
Myiarchus cinerascens	Ash-throated Flycatcher	1	
Myiodynastes luteiventris	Streaked Flycatcher	2	
Myiozetetes similis	Social flycatcher	10	
Pitangus sulphuratus	Great kiskadee	5	
Sayornis nigricans	Black Phoebe	1	
Tyrannus melancholicus	Tropical Kingbird	6	Semi-endemic
Tyrannus tyrannus	Eastern Kingbird	1	
Tytiridae			
Pachyrampus agliae	Rose-throated Becard	1	
Vireonidae			
Vireo cassinii	Cassin´s Vireo	1	Semi-endemic
VIreo gilvus	Warbling Vireo	1	
Vireo griseus	White-eyed Vireo	2	
Vireo solitarius	Blue-headed Vireo	1	
Pelecaniformes			
Ardeidae			
Ardea alba	Great White Egret	7	
Ardea herodias	Great Blue Heron	5	
Bubulcus ibis	Cattle Egret	80	Exotic
Butorides virescens	Green Heron	3	
Nycticorax nycticorax	Black-crowned Night Heron	2	

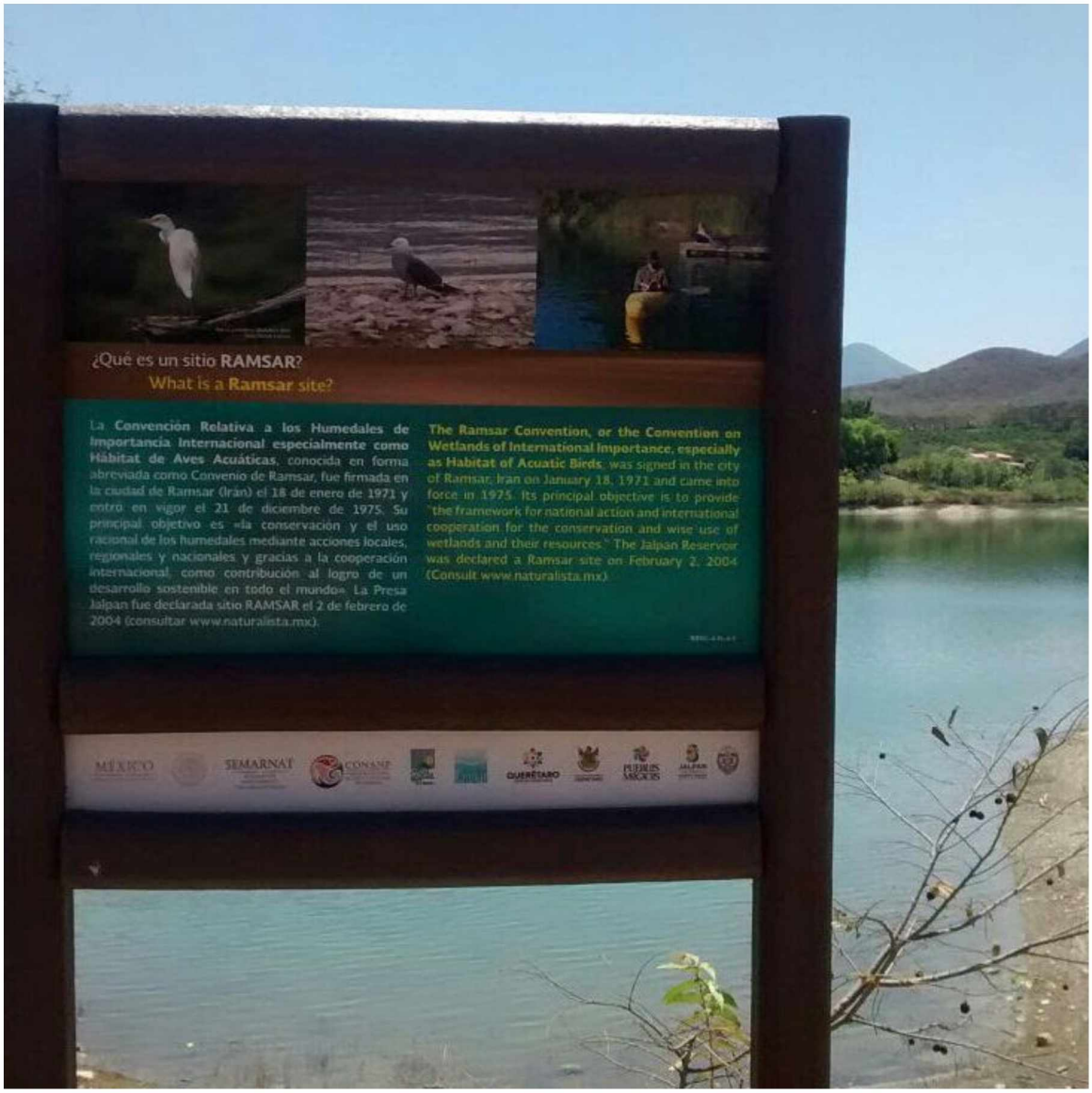
	COMMON NAME	HIGH COUNT	NOTES
Egretta caerulea	Little Blue Heron	2	
Egretta thula	Snowy Egret	35	
Egretta tricolor	Tricolored Heron	1	
Pelecanidae			
Pelecanus erythrorhynchos	American White Pelican	10	
Pelecanus occidentalis	Brown Pelican	2	
Threskiornithidae			
Eudocimus albus	White Ibis	3	
Plegadis chihi	White-faced Ibis	3	
Piciformes			
Picidae			
Melanerpes aurifrons	Golden-fronted Woodpecker	4	
Picoides scalaris	Ladder-backed Woodpecker	1	
Sphyrapicus varius	Yellow-bellied Sapsucker	1	
Podicipediformes			
Podicipedidae			
Podilymbus podiceps	Pied-billed Grebe	20	
Tachybaptus dominicus	Least Grebe	2	Special protection
Psittaciformes			
Psittacidae			
Eupsittula nana	Olive-throated Parakeet	1	Special protection
Myiopsitta monachus	Monk Parakeet	5	Exotic
Strigiformes			
Strigidae			
Glaucidium brasilianum	Ferruginous Pygmy Owl	1	
Tytonidae			
Tyto furcata	Barn Owl	1	
Suliformes			
Anhingidae			
Anhinga anhinga	Anhinga	1	
Phalacrocoracidae			
Phalacrocorax brasilianus	Neotropic Cormorant	38	
Trogoniformes			
Trogonidae			
Trogon elegans	Elegant Trogon	2	
Trogon mexicanus	Mountain Trogon	1	

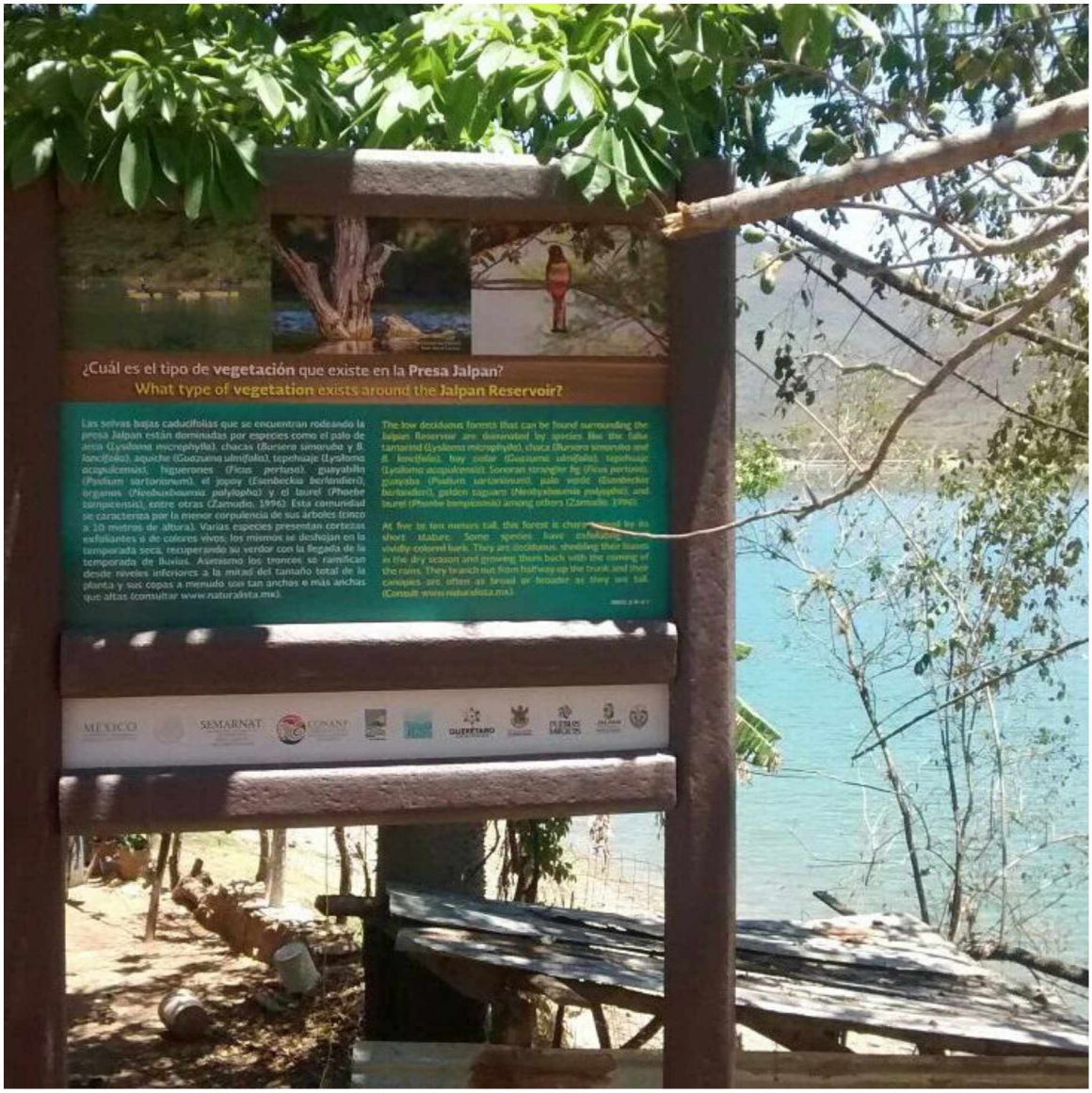
Appendix C: Bird ID Practicum

Appendix D: Bird Tourism Infrastructure




BIENVENIDOS
WELCOME
Sitio RAMSAR
Presa Jalpan
RAMSAR site
Jalpan Reservior


¿Qué es un sitio RAMSAR?
What is a Ramsar site?
La Convención Relativa a los Humedales de Importancia Internacional especialmente como Hábitat de Aves Acuáticas, conocida en forma abreviada como Convenio de Ramsar, fue firmada en la ciudad de Ramsar (Irán) el 18 de enero de 1971 y entró en vigor el 21 de diciembre de 1975. Su principal objetivo es «la conservación y el uso racional de los humedales mediante acciones locales, regionales y nacionales y gracias a la cooperación internacional, como contribución al logro de un desarrollo sostenible en todo el mundo». La Presa Jalpan fue declarada sitio RAMSAR el 2 de febrero de 2004 (consultar www.naturalista.mx).
The Ramsar Convention, or the Convention on Wetlands of International Importance, especially as Habitat of Acuatic Birds, was signed in the city of Ramsar, Iran on January 18, 1971 and came into force in 1975. Its principal objective is to provide "the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources." The Jalpan Reservoir was declared a Ramsar site on February 2, 2004 (Consult www.naturalista.mx).
MÉXICO
SEMARNAT
CONANP
QUERÉTARO
JALPAN


¿Cuál es el tipo de vegetación que existe en la Presa Jalpan?
What type of vegetation exists around the Jalpan Reservoir?
Las selvas bajas caducifolias que se encuentran rodeando la presa Jalpan están dominadas por especies como el palo de arco (Lysiloma microphylla), chacas (Bursera simaruba y B. lancifolia), aquiche (Guazuma ulmifolia), tepehuaje (Lysiloma acapulcensis), higueranes (Ficus pertusa), guayabillo (Psidium sartorianum), el jopoy (Esenbeckia berlandieri), órganos (Neobuxbaumia polylopha) y el laurel (Phoebe tampicensis), entre otras (Zamudio, 1996). Esta comunidad se caracteriza por la menor corpulencia de sus árboles (cinco a 10 metros de altura). Varias especies presentan cortezas exfoliantes o de colores vivos; los mismos se deshojan en la temporada seca, recuperando su verdor con la llegada de la temporada de lluvias. Asimismo los troncos se ramifican desde niveles inferiores a la mitad del tamaño total de la planta y sus copas a menudo son tan anchas o más anchas que altas (consultar www.naturalista.mx).
The low deciduous forests that can be found surrounding the Jalpan Reservoir are dominated by species like the false tamarind (Lysiloma microphylla), chaca (Bursera simaruba and B. lancifolia), hoy cotar (Guazuma ulmifolia), tepehuaje (Lysiloma acapulcensis), Sonoran strangler fig (Ficus pertusa), guayaba (Psidium sartorianum) palo verde (Esenbeckia berlandieri), golden saguaro (Neobuxbaumia polylopha) and laurel (Phoebe tampicensis) among others (Zamudio, 1996).
At five to ten meters tall, this forest is characterized by its short stature. Some species have exfoliating, vividly colored bark. They are deciduous, shedding their leaves in the dry season and growing them back with the coming of the rains. They branch out from halfway up the trunk and their canopies are often as broad or broader as they are tall. (Consult www.naturalista.mx)
MEXICO
SEMARNAT
CONANP
QUERÉTARO


¿Qué animales habitan la Presa Jalpan?
What animals inhabit the Jalpan Reservoir?
MÉXICO
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CONANP
QUERÉTARO


Durante tu visita:
•En esta Área Natural Protegida el aprovechamiento de flora y fauna está normado por ley, por lo que esta prohibido cazar, recolectar, capturar o extraer cualquier tipo de especie.
•Respeta en todo momento las indicaciones que encuentres en la señalización y las que brinde el guía asignado.
•Transita sólo por rutas autorizadas.
•Evita fumar o encender fogatas para prevenir incendios forestales.
•Prohibido usar explosivos ya que dañan severamente el ecosistema.
•Evita introducir plantas exóticas y mascotas.