The Paradox of Culturally Useful Invasive Species: Southern Cattail (*Typha domingensis*) Crafts of Lake Pátzcuaro, Mexico

Guadalupe Maldonado
California State University, Fullerton

Robert Voeks
California State University, Fullerton

ABSTRACT

This study explores the cultural, economic, and ecosystem impacts of an invasive plant species, southern cattail (*Typha domingensis*), on the indigenous Purépecha community of Lake Pátzcuaro, Mexico. Locally known as *chuspatel*, the species inhabits the same lacustrine space as the native southern bulrush (*Schoenoplectus californicus*), known locally as *tule*. In order to control the species, southern cattail is routinely mechanically harvested in parts of the lake. Southern bulrush, on the other hand, is native to the lake, has similar ecological characteristics as southern cattail, and has long been used by indigenous crafts persons. Our initial goal was to explore the distribution and possible negative effects of an invasive plant on a culturally important native wetland plant species. Data collection included open ended interviews, participant observation, and GIS-based vegetation mapping of the two species. Contrary to expectations, our results revealed several cultural, economic, and possibly ecosystem service benefits associated with the arrival and spread of this invasive organism. Cartographic data show that the two species overlap in distribution in the lake. Observations suggest that the invasive species may provide an additional ecosystem service of enhanced habitat for an endemic snake subspecies (*Thamnophis eques patzcuaroensis*). Moreover, rather than displacing a culturally useful native species, the invasive southern cattail has been incorporated into the repertoire of local crafts and now represents an important addition to the income and culture of the Purépecha. Our study suggests that greater management emphasis should be placed on local and cultural values when considering the overall impacts of invasive organisms.

KEYWORDS: *Purépecha, GIS, wetlands, ethnobotany, southern bulrush, Lake Pátzcuaro garter snake*

RESUMEN

Esta investigación explora los ecológicos, económicos, y culturales impactos de una planta

invasora, southern cattail (*Typha domingensis*), sobre la comunidad Purépecha del lago de Pátzcuaro, México. Conocida localmente como *chuspatel*, la especie habita el mismo espacio lacustre que southern bulrush (*Schoenoplectus californicus*), conocido localmente como *tule*. Para controlar la especie, chuspatel se recolecta mecánicamente de manera rutinaria en algunas partes del lago. Tule, por el contrario, es nativo al lago, tiene muy similares ecológicas características como chuspatel, y ha sido durante mucho tiempo utilizado por personas artesanías indígenas. Nuestro objetivo inicial era explorar la distribución y los impactos culturales asociados con el desplazamiento de una especie de humedal nativa útil por una planta invasora. La recopilación de datos incluyó entrevistas abiertas, observación participante y mapeo de vegetación basado en cartografía de las dos especies. Contrariamente a las expectativas, nuestros resultados revelaron varios beneficios culturales, económicos y posiblemente del ecosistema asociados con la llegada y propagación de este organismo invasor. Los datos cartográficos sugieren que ambas especies se superponen en la distribución en el lago. Nuestras observaciones sugieren que la planta invasora puede proporcionar un servicio ecosistémico adicional como hábitat mejorado para una subespecie de serpiente endémica (*Thamnophis eques patzcuaroensis*). Además, en lugar de eliminar una especie nativa culturalmente útil, chuspatel ha sido incorporado en el repertorio de artesanía local, y ahora representa una importante adición a la renta y la cultura de la comunidad Purépecha. Nuestro estudio sugiere que se debe poner mayor énfasis en los valores locales y culturales al considerar los impactos generales de las especies invasores.

PALABRAS CLAVE: *Purépecha, sistema de información geográfico, humedales, ethnobotánica, tulares, Lago de Pátzcuaro culebra de jaretas*

INTRODUCTION

Invasive species, or invasive alien species (International Union for the Conservation of Nature [IUCN], 2020), are non-native organisms often introduced by humans that exert a level of economic or ecological harm in their new environment (Ehrenfeld, 2010). Once introduced, they colonize the area and become naturalized by reproducing for several generations without human assistance. This process is achievable through the combination of the species' competitiveness and adaptability to new environments (Radosevich et al., 1997). The economic impacts of terrestrial invasive species on a global scale are estimated to be in the billions of dollars per year (Olson, 2006). Pimentel et al. (2005) estimate their cost just in the United States at $120 billion per year. Their documented impacts on ecosystem services vary from disrupting carbon storage and stream discharge to pollination systems (Harrison et al., 2014; Linders et al., 2019), and their negative effects on species diversity is considered second only to global habitat change (Mollot et al., 2017).

Aquatic ecosystems have similarly witnessed significant negative economic and ecologic impacts from invasive species. Invasive plants in Florida lakes have led to a $6

billion loss in fishery production (Marbuah et al., 2014). The presence of European loosestrife (*Lythrum virgatum*) in Florida wetlands requires $45 million per year to control (Lovell et al., 2006). There are also numerous examples of negative ecological impacts resulting from invasive aquatic species (Havel et al., 2015). The giant reed (*Arundo donax*), for example, a perennial cane plant native to the Mediterranean Basin and Middle East, represents a well-documented example from California. Ehrenfeld (2003) showed that native vegetation unaffected by the presence of giant reed contains double the number of organisms, biomass, and invertebrates.

Without discounting the negative economic and ecological impacts of invasive organisms, some studies have been equivocal in terms of their impacts, and some have even reported positive outcomes. In Florida, for instance, the presence of the invasive perennial Christmasberry tree (*Schinus terebinthifolius*) represents a useful source of nectar for bees during the winter when other flowering plants are not available (Ewel et al., 1999). Similarly, the Amazonian water hyacinth (*Eichhornia crassipes*), one of the most aggressive aquatic invaders in the world, has been shown to remove heavy metals such as selenium, manganese, and chromium from aquatic environments (Zheng et al., 2016).

The economic effects of invasive aquatic plants are almost wholly negative at the regional and national level. At the local level, however, particularly where the livelihoods of Indigenous people are often closely tied to the natural world both for subsistence and for local commerce, the economic impacts of invasive plant species are not nearly so one-sided. Shackleton and Shackleton (2018) report from the South African Kalahari, for instance, that invasive plants are used by local people for food, fiber, fuelwood, fodder, and shade. Weedy greens in southern Italy make a significant addition to the region's much-touted Mediterranean diet (Motti et al., 2020). Invasive weedy greens represent important cultural and nutritional dimensions in the lives of sub-Saharan Africans and their American diaspora (Vandebroek & Voeks, 2018). Furthermore, a significant portion of tropical plant pharmacopoeias consist of invasive plant species, several of which have been developed into life-saving pharmaceutical drugs (Voeks, 2004; Balick & Cox, 2020).

This paper explores the impacts of southern cattail (*Typha domingensis*), an invasive aquatic plant species, in Lake Pátzcuaro, Michoacán, Mexico. The lake is in a large, closed lake basin at over 1900 meters above sea level. It is inhabited by a rich assortment of birds, mammals, fish, invertebrates, and reptiles, several of which are endemic. Among these is the endemic Lake Pátzcuaro garter snake (*Thamnophis eques patzcuaroensis*), which is readily identified by brilliant yellow coloration on the underside of its head and tail (Conant, 2003).

Lake Pátzcuaro has a rich cultural history that dates to the pre-Hispanic Tarascan Empire. The Indigenous people, known as Purépecha (or Tarascan), originated around the lake. The center of the Purépecha heartland was in central and northern Michoacán, focusing on Zacapu, Cuitzeo, and Lake Pátzcuaro basins. The Tarascan empire covered more than 75,000 square kilometers, which

made it the second largest in Mesoamerica (Fisher, 2007; Kurnick & Baron, 2016). By the mid-1400s, the Purépecha had an established identity, local economy, ethnicity, rule, and language (Gorenstein & Pollard, 1983; Bellamy, 2018).

The current identity of the Purépecha of Lake Pátzcuaro is vital to the concept of *indigenismo*, a socio-political movement in Latin America and Mexico. According to Bengoa (1995), Lake Pátzcuaro is one of the most important locations for *indigenismo* in all of Latin America. The indigenous identity that the Purépecha embodied and carried through the generations became an essential factor for the present-day struggles that the Purépecha face, and it allowed them to fight for their rights, claims, and recognition of their struggles (Urrieta, 2017). The Purépecha community depends in large measure on tourism for their local economy. Tourists in turn see Lake Pátzcuaro as the home of an intact Purépecha culture—as the heart of *indigenismo*—and attach their own indigenous narrative to the community. Mestizo tourists in particular are often searching for some connection to an indigenous culture that they claim or hope to be a part of, if only distantly, by claiming a Purépecha relative or ancestor.

Along with the region's rich history, the Purépecha community has retained the traditional practice of weaving by using vegetation native to Lake Pátzcuaro, especially southern bulrush (*Schoenoplectus californicus*). Over the years, fashioning crafts for tourists has emerged as a mainstay of the Purépecha economy. A second wetland species, the invasive southern cattail (*Typha domingensis*), is thriving in the lake as well. Southern cattail is able to flourish in a range of challenging environments, including high salinity lakes and wetlands that most aquatic plants cannot tolerate. Its prolific production of wind-dispersed seeds allows the species to colonize distant wetlands. And its considerable height, rapid growth rate, and aggressive clonal propagation can result in dense monoclonal populations, clogging lakes, ditches, and canals (Bansal et al., 2019).

By means of ethnographic interviews, participant observation, field surveys of the invasive and native aquatic vegetation, and GIS (Geographic Information Systems) analysis, this article explores some of the cultural, economic, and ecosystem impacts of the non-native southern cattail on Lake Pátzcuaro and the Purépecha weavers who depend on the lake for their livelihoods.

LAKE PÁTZCUARO

Lake Pátzcuaro is a subtropical lake with a surrounding wetland in Michoacán, Mexico (Rendón-López et al., 2016) (Figure 1). The lake is 50 kilometers wide east to west and 33 kilometers long north to south. It is four to five meters deep around its southern margin at its shallowest (near Huecorio), and 11 to 12 meters deep in its deepest region (Rosas et al., 1985; Chacón-Torres & Rosas-Monge, 1998; Quintas et al., 2016; Rendón-López et al., 2016). Lake Pátzcuaro is endorheic, meaning that it is closed with no available outflow (Bernal-Brooks et al., 2002). Although it contains some artificial navigation channels (Rendón-López et al., 2016), the Chapultepec channel is the only permanent water channel (Chacón-Torres

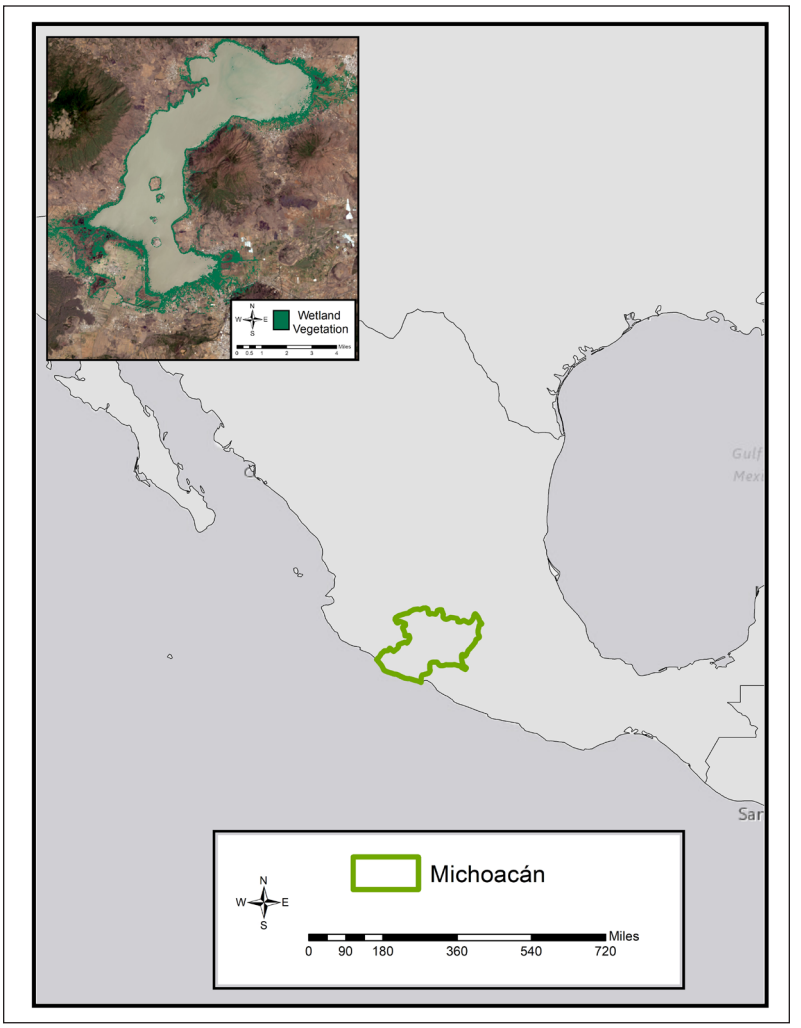

Figure 1. Overview map of the general location of the study site, Lake Pátzcuaro, Michoacán, Mexico.

& Rosas-Monge, 1995). Despite maintaining water year-round, there has been a significant decrease in recent years in the water level of the lake due to diminishing rainfall starting around 1979. Lake recession has been noted through numerous studies as well as through aerial imagery (Bernal-Brooks et al., 2002; Quintas et al., 2016). Water pollution has also become a problem in the lake because of sewage, wastewater, and fish or plant agricultural waste (Rosas et al., 1985).

FLORA AND FAUNA

The vegetation surrounding Lake Pátzcuaro consists of forests of pine, alder, and oak. Approaching the lakeshore, it transitions from extensive cropland to wetland vegetation. Salt marsh vegetation inhabits the perimeter of the lake (Rendón-López et al., 2016) and consists of 49 aquatic species. The dominant species are southern bulrush (*Schoenoplectus californicus*), southern cattail (*Typha domingensis*), common cattail (*Typha latifolia*), and chairmaker's bulrush (*Schoeno-*

Figure 2. Fully grown flowering southern cattail in De las Garzas, Pátzcuaro (photo by G. Maldonado).

plectus americanus). Submerged macrophytes mainly consist of Mexican waterlily (*Nymphae mexicana*) and Illinois pondweed (*Potamogeton illinosis*). Water hyacinth (*Eichhornia crassipes*) dominates the free-floating macrophyte populations of the lake (Lot & Novelo, 1988). Water hyacinth is known locally as "*lirio*" individually or "*camalotes*" when it grows together to create floating islands of vegetation. These islands of water hyacinth become sufficiently large that they support floating populations of southern cattail or southern bulrush.

Southern cattail is an invasive species in Lake Pátzcuaro that arrived at some unknown point in the past. It is a perennial herb that often grows 2.0 to 2.5 meters tall with flat slender-like sheaths (Figure 2). It is native to the southern United States. Known as *chuspatel* by the Purépecha, it inhabits marshes, lakes, bogs, ponds, and pristine or disturbed habitats with fluctuating water levels (Fassett & Calhoun, 1952; Hegazy et al., 2011). In order to control the species, mechanical controls are used by local authorities. Mechanical controlling occurs via third parties hired to use machinery to cut reeds routinely every few months along areas with high tourist traffic.

Southern bulrush is a 1 to 4-meter tall perennial herbaceous macrophyte with triangular stems (Jepson Flora Project, 2018). The Purépecha refer to it as *tule*. This macrophyte grows in tufts or large colonies with roots

Figure 3. Flowering southern bulrush growing on Janitzio Island, Pátzcuaro (photo by G. Maldonado).

penetrating 70 to 80 cm beneath the ground, allowing for efficient root aeration (Vymazal, 2013). The leaves are slender with V-shaped blades. The flowers are in the form of bristle spikelets that resemble orange-brown scales (Figure 3). The plant's thick rhizomes along with abundant seed production allow it to compete alongside similar plants, including invasive species. It is drought tolerant and does well in brackish to freshwater marshes, shores, perennially inundated areas, lakes, and ponds (Jepson Flora Project, 2018).

FIELD METHODS

MAPPING INVASIVE AND NATIVE REEDS

The general distribution of southern cattail and southern bulrush was determined using ENVI (Environment for Visualizing Images) to classify wetland vegetation. USGS Landsat imagery was loaded into ENVI, and each file underwent an unsupervised classification through ISODATA (Iterative Self-Organizing Data Analysis). This classification generated around 20 to 25 classes grouping different vegetation types in the ROI (region of interest). This wetland vegetation reference map was used during the first field site visit in December 2016. The results were loaded into ArcMap to create a map

of wetland vegetation that filtered out all other vegetation types, following methods set out by Carney et al. (2014). This methodology reveals the distribution and abundance of wetland vegetation but is unable to distinguish more detailed categories, such as particular species. Therefore, this method alone was useful but not sufficient to research individual exotic and native species. Nevertheless, knowing where the wetland vegetation existed before conducting fieldwork allowed for better navigation and accurate cross-referencing with existing maps.

WETLAND SPECIES FIELD SURVEY

A GPS coordinate tracking device was employed in the field for recording points and polygons of both plant species in question—southern cattail (*T. domingensis)* and southern bulrush (*S. californicus)*. It was also used to record the presence of the endemic Lake Pátzcuaro garter snake, which was frequently encountered in the wetland vegetation. GPS coordinates were recorded using the Trimble Juno SB device during the first field site visit and the Garmin device during the second visit in the form of points, polygons, and lines, if applicable. The Trimble Juno SB device loads a reference map that allows for the recording of polygons and GPS points onto the device in the field. The Garmin GPS device has existing map layers and operates similarly to the Trimble device regarding recording GPS coordinates and lines. The purpose of having two devices for data collection was that, at times, one had a better signal compared to the other. Coordinates or polygons were saved as TD (*Typha domingensis*) or SC (*Schoenoplectus californicus*). After the coordinates were uploaded to a computer, ArcMap displayed the coordinates on a base map.

The first site visit in December 2016 focused on surveying around the southwest edge of Lake Pátzcuaro. The literature suggested that although southern cattail along with other invasive species was present along different margins of the lake—southwest, west, east, and north— it was concentrated around the southwest sector (Lot & Novelo, 1988). For that reason, the first field site focused on that previously studied area. Data collection was carried out by canoeing and walking around the perimeter of the southwest side of the lake.

The second field site visit focused primarily on ethnographic data collection via interviews and participant observation, while the third site visit consisted of a month (January 2019) of vegetation surveying. The final mapping effort expanded to include a vegetation mapping survey of the entire 64 km perimeter of the lake. This included lake margins near the following towns, islands, and points of interest: Chupícuaro, Ucazanaztacua, Oponguio, San Jerónimo, Urandén, Puácuaro, Janitzio, Tzintzuntzán, De Las Garzas, Ichupio, Erongarícuaro, and Jarácuaro. Methods for the final site visit were adapted from the Invasive Plant Program (IPP) at the Catalina Island Conservancy. The IPP developed efficient ways to map abundance and presence of invasive species during field surveys on foot. Most of the lake was sectioned off based on time available for the day. Surveying the entire lake edge was scheduled to occur one town at a time. The objective of this mapping effort was to determine the geographic distribution and density of southern cattail and southern bulrush.

Figure 4. Interviewing and participant observation with a specialist weaver (photo by G. Maldonado).

Also, having been informed by local people of the negative effects of mechanical harvesting on the craft quality of southern cattail, observations and notations of mechanically harvested areas were made in the field.

ETHNOGRAPHIC METHODS

Indigenous men and women participated in interviewing sessions mainly in Ihuatzio, the town well known for using reeds to weave crafts. Aside from interviews, one of the artisans provided lessons to GM on how to weave items using both southern cattail and southern bulrush during the interviewing process. The first day of interviewing and participant observation began with basic questions on the specifics of weaving and led to more in-depth inquiry once there was a sense of trust and an established familiar relationship (Figure 4).

A small sample of informants was selected through snowball and random sampling. Randomly sampled informants were approached individually. Snowball sampling consisted of one informant recommending other knowledgeable participants (Mason, 2002). This method was useful because many weaving crafts vendors were initially hesitant to participate. Focusing on a handful of interviewees allowed for more time and effort to be put into building a trusting relationship with the artisans (Crouch & McKenzie, 2006) and yielded rich insights into the cultural significance of the two wetland species in question. A local artisan from Ihuatzio, where the center of basket weaving occurs, offered to teach GM the trade in addition to answering any questions. Thus, participant observation consisted of a daily workshop scheduled around the artisan's availability. He explained that it was necessary to learn how to actually weave crafts in order to appreciate the qualities and drawbacks of the two species. He provided

in-depth insights into the pros and cons of using one or another reed species in weaving.

Because men of the household are the weavers, whereas women focus on craft item sales, most of the interviews were conducted with men. Interviewees included three male artisans from an extended family, a woman who sells the products in town, and three more local people who provided additional insights into the political, economic, environmental, and cultural settings of Lake Pátzcuaro. The men interviewed were the heads of their households and had the trade passed down from their fathers and, in turn, have passed down the skill to their sons and grandsons.

A questionnaire consisting of economic and craft-making questions was completed by participants prior to in-depth interviews. It included a total of twenty-three questions made up of loosely structured and open-ended questions, all in Spanish. Local people speak exclusively Spanish or Tarascan, or a combination of both. Although Tarascan is the native language of the Purépecha people, all interviewees were able to speak Spanish fluently. Craft vendors and other local people were unfamiliar with the practice of weaving but were able to provide useful insights into perceptions of the impacts of southern cattail.

Verbal consent was provided by all participants. Permission to carry out the study was granted by California State University, Fullerton, IRB # HSR-17-0128.

RESULTS

SPECIES DISTRIBUTION

Although earlier literature reported that southern cattail was mainly concentrated along the southwest and upper northeast section of the lake, our results indicate that the species has expanded its aerial coverage and now dominates the lower northeast area, lower southeast region, and middle-west area (Table 1 and Figure 5). The southwest area has witnessed decreasing concentrations of southern cattail, coeval with the increase of tourism traffic in that area and, as a result, more frequent mechanical control.

Fifty percent of towns around the lake surveyed for southern cattail and southern bulrush exhibited overlap of both species (Table 1). These sympatric sections represent areas where southern cattail and southern bulrush populations grow side by side. The largest areas of overlap occurred in the middle section of the lake (Figure 5). The area of overlap in Erongarícuaro is a continuous row of southern cattail and southern bulrush around a permanent water canal that leads into the inside of the lake. Overlap areas in Uranden, Ucazanaztacua, Puácuaro, and Ichupio are publicly accessible areas along the edge of the lake. There is also a substantial amount of overlap around Janitzio Island.

Jarácuaro and De las Garzas of the south region of the lake have populations of southern cattail. De las Garzas, the area with more tourism traffic, has smaller populations spread around the area with signs of cutting and regrowth. Jarácuaro does not experience tourism traffic but is used instead for agriculture and cattle. The most extensive area of southern cattail is in Tzintzuntzán, the northeast part of the lake (Figure 5).

The populations of southern cattail in Tzintzuntzán exhibit some signs of harvest-

Town	Southern Cattail	Southern Bulrush	Overlap
Chupícuaro	-	545,674	-
Ucazanaztacua	-	-	463,975
Oponguio	-	289,931	-
San Jerónimo	-	387,690	-
Urandén	-	-	1,215,748
Puácuaro	-	-	741,253
Janitzio	-	-	119,339
Tzintzuntzán	3,241,614	-	-
De Las Garzas	364,166	-	-
Ichupio	-	-	855,453
Erongarícuaro	-	-	182,233
Jarácuaro	778,185	-	-

Table 1. Area in square meters of Southern Cattail (*T. domingensis*), Southern Bulrush (*S. californicus*), or overlap area (where they coexist).

ing, but overall, in this area they have grown taller and more massive than in any other observed area. The lake entrance in Tzintzuntzán, La Quinta Jardin de Tzintzuntzán, was covered with extremely tall *camalotes* extending past several properties. Jarácuaro and Tzintzuntzán also contained *camalotes* of southern cattail (Figure 6).

San Jeronimo, Chupícuaro, and Oponguio have large *camalotes* of southern bulrush. The overlap area in San Jeronimo grew through fences (Figure 7) and extended into private properties belonging to farmers.

Chupícuaro had large fields of *camalotes* with populations of adult growth southern bulrush and no visible signs of cutting and regrowth (Figure 8).

The *camalotes* of Oponguio were smaller than San Jeronimo and Chupícuaro with less flowering (Figure 9). These *camalotes* were spread sporadically across the edge of this town. Although Figure 9 shows the entire extent of southern bulrush distribution, the individual center points of *camalotes* are on the right side of the figure. Water hyacinth covered the area between the land and the edge of where the southern bulrush *camalotes* started.

Although the GPS coordinates do not show the impact that mechanical controlling has had on the quality of reeds, there was an obvious difference between the stage of reeds in mechanically controlled areas and those inhabiting unregulated areas. Areas with high tourist traffic via *lanchas* experience routine mechanical controlling. Regrowth in mechanically controlled areas typically does not reach the heights of *camalotes* that exist in locations that lack mechanical control, such as Tzintzuntzán. Furthermore, according to informants, southern cattail that has been mechanically cut often grows back flimsier, hindering its use for crafts.

ENDEMIC SNAKES OF PÁTZCUARO

Numerous opportunistic observations of the endemic Lake Pátzcuaro garter snake (*Tham-*

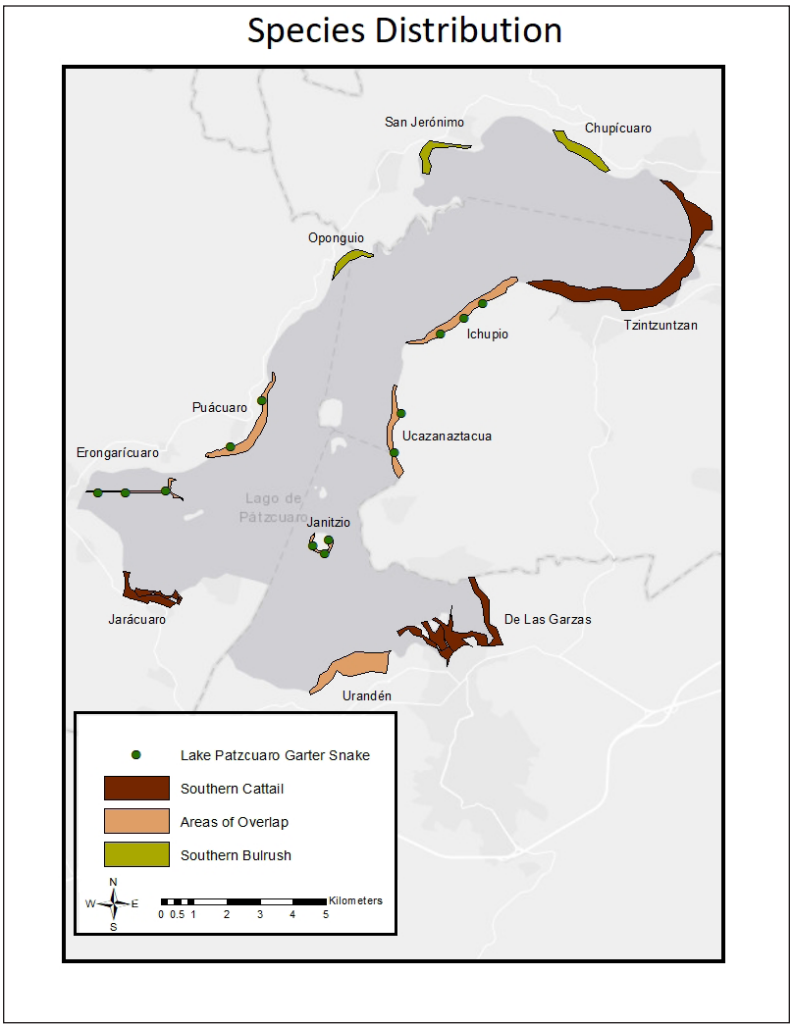

Figure 5. Overall distribution of southern cattail (*T. domingensis*) and southern bulrush (*S. californicus*) (with occurrences of the endemic Lake Pátzcuaro garter snake) throughout accessible lake areas collected via Garmin and Trimble device.

nophis eques patzcuaroensis) were made and their numbers and locations were recorded (Figure 10). The largest concentrations of ten or more snakes were recorded where the two reed species coexist in distribution. However, in these sympatric areas, the snakes appeared to cluster primarily around the invasive southern cattail reeds, leaving southern bulrush patches vacant. Areas that were dominated by southern cattail often had three to four snakes per sighting, whereas no snakes were spotted in areas populated exclusively by southern bulrush. Although this snake species is endemic to the lake and thus predates the introduction of southern cattail, today it appears to be much more abundant in areas occupied by the invasive southern cattail and where the two species overlap in distribution.

ETHNOGRAPHIC DATA

Interviews and participant observation yielded insights into the cultural use and value of the native southern bulrush and the

Figure 6. *Camalotes* of southern cattail extending across great lengths in La Quinta Jardin de Tzintzuntzán in the northeast side of Lake Pátzcuaro (photo by G. Maldonado).

Figure 7. Populations of southern bulrush in San Jeronimo, Pátzcuaro (photo by G. Maldonado).

Figure 8. Populations of southern bulrush in Chupícuaro, Pátzcuaro (photo by G. Maldonado).

invasive southern cattail. The process of weaving predated the introduction of southern cattail, and prior to its introduction into Lake Pátzcuaro the Purépecha were dependent on southern bulrush for their traditional weavings. But the inclusion of southern cattail as a weaving material has served over time to enrich the weaving process by increasing its efficiency. Although the process of weaving is the same when using either species, there are numerous situations in which artisans prefer the invasive southern cattail. According to the three artisans from Ihuatzio, they use southern cattail to make most of their craft items because its wider reed sheaths allow for faster weaving of larger items. Using the

Figure 9. Populations of southern bulrush in Oponguio, Pátzcuaro (photo by G. Maldonado).

Figure 10. The Lake Pátzcuaro Garter Snake (*Thamnophis eques patzcuaroensis*). Left: Photograph from Conant (2003). Right: Endemic snake photo taken in southern cattail on the south facing side of Janitzio, Pátzcuaro (photo by G. Maldonado).

native southern bulrush requires twice the number of reeds to make the same item. Also, southern cattail is sturdier and thicker than southern bulrush and is thus less prone to snapping in the weaving process. Southern bulrush is preferred when making small intricate items such as keychains. All of the local artisans interviewed for this study reported that they use southern cattail more often than southern bulrush.

Regarding harvest of the two species, the Purépecha that collect the material lay it out to dry before re-bundling and selling it to artisans (Figure 11). After receiving the dried reeds from material vendors, artisans wash and then allow them to dry. The drying process takes about two days. After the weaving material is dry, it is cut into a manageable size. The thicker the reed, the easier the weaving process. Reeds weaved together are tugged and tightened to secure the final product. On occasion, if a reed is too thin or flimsy, it snaps in the middle of weaving. In this case, an additional reed is placed on top of the torn one and tightened to continue. This weaving process applies to items made by both southern cattail and southern bulrush.

Although southern cattail and southern bulrush have similar uses, there are morphological distinctions between these species, and these are reflected in the ways that they are employed by artisans. Southern bulrush is thinner, circular, and smaller in comparison to southern cattail. The selection of one species over the other depends on whether a thinner, thicker, or sturdier material is needed.

Figure 11. A household in Ucazanaztacua, Pátzcuaro, lays out southern cattail material to dry after being collected and washed (photo by G. Maldonado).

To create large items that may need to withstand considerable weight, a thick broad reed, usually southern cattail, is required to complete a sturdy structure. The smaller and thinner a reed is, the longer and more of it is needed to weave the item. Artisans lean towards using southern bulrush for small intricate items, such as keychains or tiny bowls, due to its thinner structure. Southern cattail provides a broad flat look to each reed section, whereas southern bulrush looks more circular and is even more prominent when weaved into an item (Figure 12 and 13).

In addition to the morphological advantages of southern cattail, it is also more economically viable for artisans than the native southern bulrush. According to artisans and material collectors, a small bundle of southern bulrush costs about the same as a larger bundle of southern cattail. An armful of southern cattail material costs 400 pesos (about 19 USD). A small armful of southern bulrush costs about the same, since the material is sold in bundles with roughly the same number of reeds. Southern bulrush is thinner and so is more compact.

Some families rely on selling reeds as their main source of income. They prefer to sell reed material in bulk at a discounted rate. Although reed vendors sell southern cattail and southern bulrush year-round, there are peak times when it is best to stock up, when prices are low due to a more abundant harvest. According to one buyer, the peak

Figure 12. Left: A small keychain made from southern bulrush requiring a thin reed. Right: Purse made primarily of southern cattail with southern bulrush as a latch (photo by G. Maldonado).

Figure 13. Southern bulrush weaved together (left) and southern cattail weaved together (right) to make crafts (photo by G. Maldonado).

time for purchasing southern cattail and southern bulrush is in August, around or shortly after the rainy season.

The question of which of the two reed species provides more income for local crafts-persons is complicated as the income that vendors and artisans receive from selling their wares changes daily. Ihuatzio, the town that specializes in craft-making using both southern cattail and southern bulrush, does not receive major tourist traffic. Instead, it is visited intermittently by vendors from other lakeside towns that cater to large numbers of tourists in hopes of placing bulk orders. As a result, some days artisans will make little to no profit, whereas on other days they may sell out their entire inventory. Regardless, both vendors and artisans reported that crafts created by the invasive southern cattail is a central part of their tourist economy. And, importantly, by supporting tourism they are able to stay and work in their hometowns, as opposed to emigrating in search of alternative sources of income.

The demand for indigenous weaving has kept this cultural practice intact within the Purépecha community. All informants reported that the art of weaving continues to be transmitted vertically, from father or grandfather to son or grandson. All agreed that the younger generations are retaining the practice of weaving. Along with passing down the trade, this process also serves to sustain the native Tarasco language. Forty percent of informants tied the importance of retaining reed crafting to that of retaining their native language. The great grandparents of the family tend to be the generation that only speaks Tarasco, whereas younger people often used a combination of Tarasco and Spanish within the same sentence or phrase. Retaining the language and the practice of weaving can be an intertwined process, as is the case with our principal informant, who learned to weave from his grandfather who only spoke Tarasco.

DISCUSSION

Invasive organisms hold a prominent position in the ecological and environmental economic literature, and increasingly in popular publications (Baskin, 2002). Their presence can lead to major changes in the demography of native species as well as the ecological functioning of entire ecosystems (Ehrenfeld, 2010, Linders et al., 2019). They have, in extreme cases, caused billions of dollars of damage to agriculture and livestock interests as well as primary industries such as fishing and forestry (Pimentel et al., 2005). Perhaps not surprisingly, stakeholders and researchers have marshalled aggressive, even warlike language to describe the introduction of exotic organisms and the programs meant to 'eradicate' them. The ongoing and highly photogenic battle with invasive Burmese pythons in the Florida everglades is a posterchild for this process. However, according to Larson (2005), the use of militaristic language such as 'eradication,' 'beachhead,' 'targets,' 'enemy release,' and many others, attaches an immediate negative connotation to non-native species that may undermine scientific objectivity. "Nativeness," as pointed out by Davis et al. (2011, p. 153), "is not a sign of evolutionary fitness," and non-native species in many cases contribute to ecosystem function and overall biodiversity (Schlaepfer, 2018).

In the case of Lake Pátzcuaro, cartographic evidence shows that, in some cases, southern bulrush occurs alone; in others, southern cattail occurs alone; but in most cases, they share the same space. Because this study is basically a single snapshot of the lake's vegetation, no conclusions regarding the possible long-term impact of non-native southern cattail on southern bulrush's distribution and abundance can be made. As noted, however, relevant government agencies are treating the presence of southern cattail as a problem and are attempting to control its population through mechanical harvest. This is especially true in highly touristed areas and, given that areas less frequented by tourists experience no mechanical management, may be mostly for aesthetic purposes. Mechanical harvest in tourist locations keeps southern cattail in a stunted juvenile stage with very few individuals reaching the adult flowering stage. According to local artisans, this process

makes the plant unusable for weaving. And as one ruefully reported, "If you could throw all the money they've spent on cutting the plants on the lake, the lake would be covered with bills."

Both southern bulrush and southern cattail occur sporadically along the lake's margins, but, as noted, there are many areas of species overlap. It is in these sympatric areas that the highest concentrations of the endemic Lake Pátzcuaro garter snake were recorded. The snake is occasionally encountered in areas of pure southern cattail and occurs in highest densities in overlap areas but was never observed in areas purely inhabited by southern bulrush. It may be that southern cattail provides better physical conditions for the snake, as southern bulrush is much thinner and does not provide much cover compared to southern cattail. The snakes were often encountered wrapped around southern cattail reeds. Although these opportunistic observations suggest that the presence of this exotic reed species may positively influence the presence of the Lake Pátzcuar garter snake, confirmation of this phenomenon would require a proper wildlife survey.

In spite of the numerous documented examples of negative impacts associated with invasive organisms, there is a small but growing recognition that their effects on local indigenous communities and customs are not always undesirable. A recent example involves the poster child of invasive aquatic plants: water hyacinth, a species native to the Amazon Basin but now widely spread to tropical and subtropical waterways, including Lake Pátzcuaro. An ethnobotanical study from Madagascar showed that local people have learned to utilize water hyacinth to create crafts that are now sold locally and exported internationally (Rakotoarisoa et al., 2016). Similarly, in South Africa 7 out of 10 people interviewed had positive perceptions of invasive plant species, which are used locally for food, medicine, fiber, fodder, and as ornamentals (Atyosi et al., 2019). And in a survey in the Northeast of Brazil, 55 of the 56 invasive plants were considered useful by local people and, overall, non-native species were perceived to be more useful than native species (Santos et al., 2014).

Pfeiffer and Voeks (2008) established a conceptual matrix for understanding the often nuanced relationships between local people or communities and invasive plants and animals. Within this model, species are considered 'culturally impoverishing' if their presence leads to the loss or replacement of culturally important native organisms and their associated cultural practices. 'Culturally facilitating' invasives, on the other hand, provide biological continuity for migratory people and the opportunity for reformulation of traditional people-plant practices in their adopted home. Lastly, 'culturally enriching' species serve to enhance cultural traditions through their inclusion in lexicons, narratives, foods, pharmacopoeias, and other material and non-material ends.

Aquatic reeds such as bulrush and cattail represent some of the most materially useful species in the world (Balick & Cox, 2020). Many contribute to the lives and livelihoods of Indigenous people as food, medicine, fiber for crafts, fodder, and numerous other uses. And whether they are or are not native to a particular area is largely immaterial in

terms of their utility. In the case of southern bulrush, the local Purépecha people of Lake Pátzcuaro have long employed this native aquatic macrophyte as a craft item. Although elsewhere the species is used to fashion boats, houses, mats, clothing, and as a food source (Banack et al., 2004), the Purépecha limit its use to weaving small items, such as keychains, gift boxes, and the intricate details on purses, for sale to tourists. Similarly, the exotic southern cattail, which arrived at Lake Pátzcuaro at an unknown date in the past, is used worldwide as material for food, medicine, weaving, and fodder (Bansal et al., 2019). Its pollen is prepared and consumed by seven ethnic groups in Argentina and Paraguay (Arenas & Scarpa, 2003), when fruits and vegetables are scarce. In Iran, it is used to fashion fishing traps, mats, and boats (Parsapajouh & Ghahremaninejad, 2006) that are similar to the famous bulrush reed boats of Lake Titicaca. In Turkey, people fashion various items from cattail, including mats that are used to carry and bury the dead (Nedelcheva et al., 2011). The Purépecha people of Lake Pátzcuaro use southern cattail to make crafts, including animal figurines, office organizers, lampshades, baskets, chairs, and more through weaving (Hall, 2009) as well as jewelry boxes in the shape of turtles and deer figurines. Economically, the Purépecha perceive the invasive southern cattail as having expanded their craft capabilities and therefore making a significant contribution to their livelihoods. It has enhanced the dynamics of weaving since its introduction by increasing the variety of crafts produced. It allows artisans to make crafts more time-efficiently because the reeds are broader than the native southern bulrush and require less time and material to create an item. The presence of southern cattail has enriched the traditional cultural practices of the Purépecha and encouraged their retention. It is a clear example of a 'culturally enriching' invasive organism (Pfeiffer & Voeks, 2008).

Weaving is an important dimension of Purépecha culture, and the Purépecha culture in turn is a major part of what attracts tourists to Pátzcuaro. Tourists see Pátzcuaro as the home of an intact Purépecha culture and attach an indigenous narrative to the community. Furthermore, tourists are often searching for some connection to an indigenous culture that they claim or hope to be a part of distantly (Urrieta, 2017). As noted by a Purépech artisan:

> Many people say they come to Pátzcuaro because it is like coming to a place where time has stopped, and everything looks the same way as it was many years ago. They see us, indigenous people, as people who still live as if we were in the past. They like it that way. They don't want it to change. (Spears-Rico, 2015, p. 61)

The Purépecha artisans and vendors are not just peddling crafts; they are selling romanticized images of *indigenismo* to tourists. Vendors use this indigenous narrative as an advantage to market their culture through the crafts and, in effect, encourage Purépecha to retain this aspect of their culture. Thirty percent of informants stated that the practice of weaving is marketed as a widely practiced skill among Purépecha by vendors when it is

in fact limited to the Purépecha of Ihuatzio. Using this indigenous narrative encourages the retention of Purépecha weaving and is an inadvertent cultural impact of southern cattail.

Aside from cultivating and protecting their authenticity within *indigenismo*, the Purépecha reverse the traditional western Mexican gender norms regarding weaving. In areas of western Mexico, weaving is traditionally practiced by women (Schaefer, 2015). For Huichol women, for example, being a weaver is a large part of a woman's identity. Weaving reflects a Huichols' growth process through her crafts, and this practice also allows women to provide income for their family, giving them more power in their households. Indeed, the women of Lake Pátzcuaro can be found selling their crafts in markets and in towns around the lake. However, in this region weaving is carried out exclusively by the men of the household. The trade is usually passed on from father to son or from grandfather to son. Female vendors adhere to the indigenous narrative, claiming that they weave the crafts they sell and that the weaving is a widespread practice among Purépecha. This *indigenismo* narrative, fueled by the use of an invasive plant species, plays a central role in financially supporting their families.

Participants expressed that the weavings they create from these two reed species, one native, the other a non-native invasive, is not a particularly lucrative trade. But it is what they have done for generations and is the best way to support themselves and their families financially. Furthermore, allowing them to remain in the hometowns in which they have lived for so many years provides a significant cultural advantage. Employment opportunities in these small towns are limited, and the alternative is to relocate to larger towns or cities for work. Relocation, in turn, translates into the likelihood that place-based traditional practices of the Purépecha would be abandoned.

Weaving with southern cattail and southern bulrush is likewise interwoven with the language of the Purépecha community. Just as this traditional craft is passed from generation to generation, so too is the indigenous Tarasco language. And although the Spanish language has reduced the number of Purépecha speakers since colonization (Ragone & Marr, 2006), younger generations are taught weaving by older members of their household who mostly or exclusively speak Tarasco. Younger adults and children of the Purépecha community are shifting towards speaking a blend of Spanish and Tarasco, which allows them to communicate effectively with the markets outside of their hometown. But by maintaining fluency in Tarasco, the upcoming generation can continue to communicate with their grandparents and great grandparents, and thus to maintain a crucial element of their cultural identify.

CONCLUSION

This study explored the interconnecting economic, cultural, and ecosystem impacts of an invasive plant species on Lake Pátzcuaro, Michoacán. Ethnographic results demonstrate that the invasive southern cattail provides a host of cultural and economic benefits to the indigenous Purépecha. Phys-

ical properties of the plant have allowed artisans to expand their inventory of craft items. Participants did not identify any negative cultural impacts tied to southern cattail. The supply and demand for the species in the indigenous craft business encourages younger generations of Purépecha to retain an important and highly visible feature of their cultural heritage. Its presence contributes to the Purépecha's ability to provide for their families, to remain in their hometowns, and to perpetuate the Tarascan language.

Cartographic evidence suggests that the invasive southern cattail shares a geographic distribution with the native southern bulrush. Southern cattail may be providing an enhanced ecosystem service by providing habitat for the endemic Lake Pátzcuaro garter snake. Overall, our results challenge the received wisdom that invasive species are necessarily the pariahs of the plant kingdom.

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