

# USE AND MANAGEMENT OF TOTORA (*SCHOENOPLECTUS CALIFORNICUS*, CYPERACEAE) IN ECUADOR<sup>1</sup>

MANUEL J. MACÍA AND HENRIK BALSLEV

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**Macía, Manuel J.** (*Real Jardín Botánico, Plaza de Murillo 2, E-28014 Madrid, Spain. Current address: Herbario QCA, Departamento de Ciencias Biológicas, Pontificia Universidad Católica del Ecuador, Apartado 17-01-2184, Quito, Ecuador*) and **Henrik Balslev** (*Department of Systematic Botany, University of Aarhus, Nordlandsvej 68, DK-8240 Risskov, Denmark.*) USE AND MANAGEMENT OF TOTORA (*SCHOENOPLECTUS CALIFORNICUS*, CYPERACEAE) IN ECUADOR. *Economic Botany* 54(1):82–89, 2000. *The New World aquatic macrophyte Schoenoplectus californicus* (= *Scirpus californicus*) is widespread along the Andes of Ecuador, where it is of great economic and cultural importance to indigenous people. Most importantly, its stems are used to make mats that are sold throughout the country with some exported to Colombia, Peru, the United States, and Italy. The estimated area of production in the Ecuadorian provinces of Imbabura, Cotopaxi, and Chimborazo is 442 hectares. One mat can be made from a 0.75 m<sup>2</sup> totora stand area. In Imbabura, 100 m<sup>2</sup> of totora stand yields 266 mats annually, bringing in a gross income of US \$251, corresponding to 22% of the official minimum salary in Ecuador. The plant also provides highly nutritional forage and is an excellent food source for cattle during periods of drought.

USO Y MANEJO DE LA TOTORA (*SCHOENOPLECTUS CALIFORNICUS*, CYPERACEAE) EN EL ECUADOR. *Schoenoplectus californicus* (= *Scirpus californicus*) es un macrófito acuático del Nuevo Mundo, que se encuentra a lo largo de los Andes en Ecuador, donde es de gran importancia económica y cultural para las comunidades indígenas. Los tallos se usan para confeccionar esteras que se comercializan por todo el país y cantidades pequeñas se exportan a Colombia, Perú, Estados Unidos e Italia. El área de producción estimada en tres provincias es de 442 hectáreas. Una estera se puede elaborar con 0.75 m<sup>2</sup> de superficie de la planta. En la provincia de Imbabura, en un área de 100 m<sup>2</sup> se produjeron 266 esteras anuales, que corresponde a un ingreso bruto de US \$251, lo que supone un 22% del salario mínimo oficial de Ecuador. Es destacable su elevado grado nutricional como planta forrajera y es un excelente recurso para el ganado durante períodos de sequía.

**Key Words:** *Schoenoplectus californicus*, totora, Cyperaceae, fiber, Andes, Ecuador.

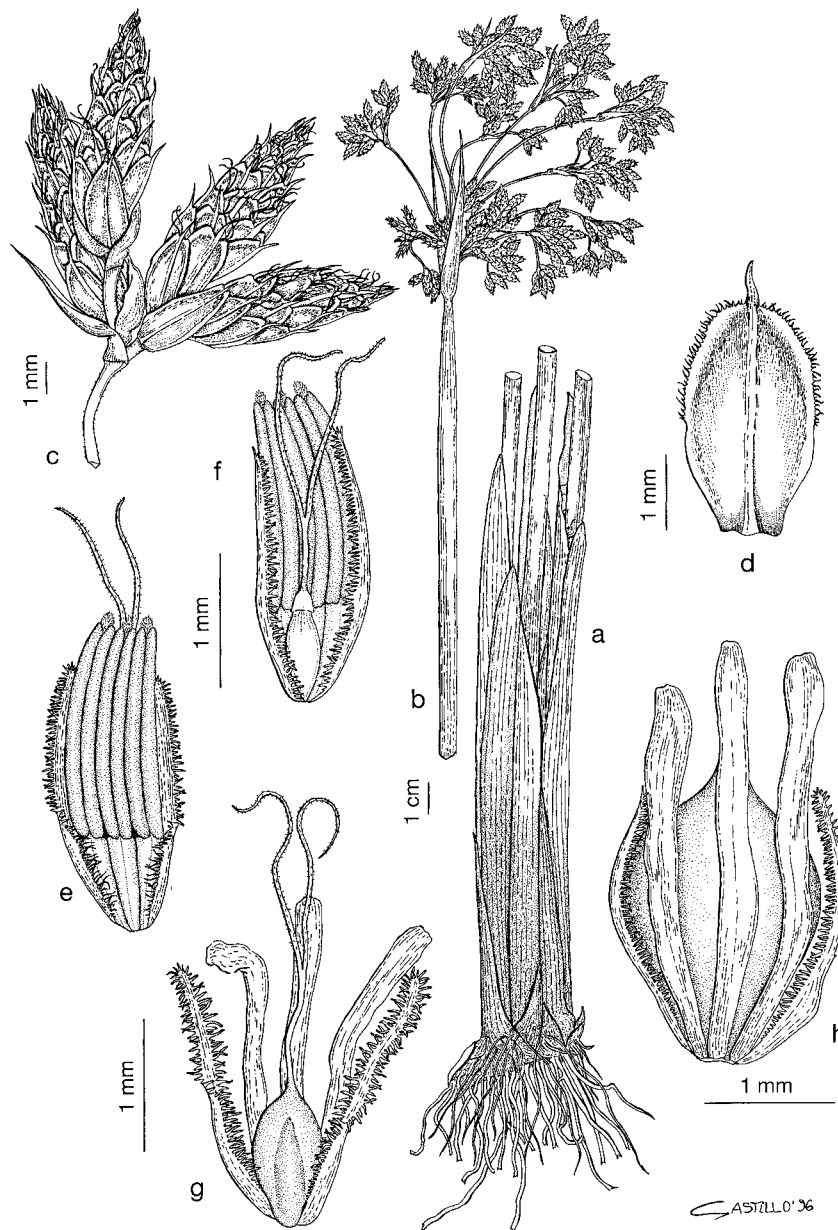
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*Schoenoplectus californicus* (C. A. Meyer) Soják (Fig. 1), often known as *Scirpus californicus* (C. A. Meyer) Steudel, is distributed along the Atlantic and Pacific Coasts of the Americas from Florida to Argentina and California to Chile, in Hawaii, the Austral Islands, and Easter Island (Adams 1994; Beetle 1941; Koyama 1963), as well as in New Zealand where it has been naturalized (de Lange et al. 1998). Its common name in Ecuador is totora, and that name will be used in this paper. Economically, totora is one of the most important Cyperaceae on the American continents. In Argentina, Bolivia, Ecuador, Guatemala, Mexico, Paraguay, Peru, and

the United States, its stems are used for weaving mats and other handicrafts, in the construction of small boats and shacks for protection against rain, as fuel, and as a substitute for string. Other uses include cattle fodder and fertilizer (Acosta-Solís 1961; Arenas 1981; Boelcke 1989; Cárdenas 1989; Estrella 1990; Heiser 1978; Levieil and Orlove 1991; Macbride 1936; Naranjo 1994; Standley and Steyermark 1958). Plant remains have been found in archaeological sites in Peru (Cárdenas 1989). In Lake Titicaca, the white submerged basal plant parts (stem base and rhizome), valued for their high carbohydrate content, had been food sources and were sometimes marketed commercially (Cárdenas 1989; Heiser 1978; Levieil and Orlove 1991). Close to Trujillo, on the northern coast of Peru, totora has

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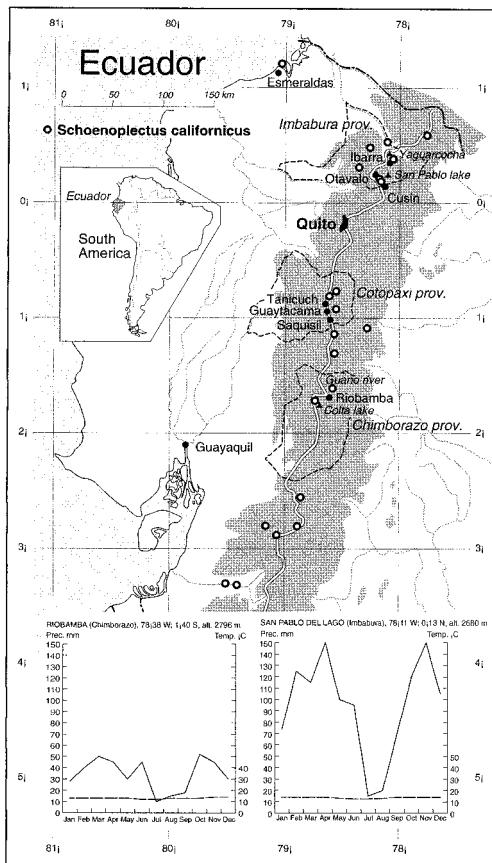


**Fig. 1.** *Totoria (Schoenoplectus californicus)*: **a**, California, Sonora County Marshes (MA 524402); **b–h**, Ecuador, San Pablo lake (Manuel J. Macía 50, MA). **a**, Basal part showing rhizome, leaves and stems; **b**, **c**, inflorescence and detail; **d**, glume; **e**, immature flower in abaxial view; **f**, immature flower in adaxial view; **g**, mature flower in adaxial view; **h**, achene in abaxial view.

been used since pre-Columbian times in the construction of seagoing fishing rafts and such boats are still made there today.

In Ecuador, totora grows mainly in the Andes above 2000 m a.s.l. where temperature ranges from 12–16°C and the annual precipitation is

400–1200 mm. In addition, it is known in a few localities below 2000 m on the west Andean slope and in the lowlands on the coastal plain near Esmeraldas (Fig. 2). Its stems were widely used in pre-Columbian Ecuador for making mats (Heiser 1978; Mardorf 1985) and this is still the



**Fig. 2.** Distribution of *Schoenoplectus californicus* in Ecuador. The occurrence in the coastal lowlands at Esmeraldas is documented by the collection *Holm-Nielsen et al.* 26062 (AAU). Climatic diagrams based on Cañadas (1983).

most important use of the plant in this country. Totora mats are marketed throughout Ecuador, with modest quantities exported to Colombia, Peru, the United States, and Italy. Quichua-speaking Indians make these mats and other totora products, and although an individual produces limited amounts, the overall economic importance of the totora is substantial; for many families, sales of totora products provide the major source of income. In some areas, totora stems are harvested from natural populations, which can be managed, while in others, it is cultivated as a crop. Heiser (1978, 1985) and Mardorf (1985) excellently described the uses of this plant in Ecuador and Peru.

In this paper, we report on the current status of totora use in Ecuador, and we quantify several aspects of its growth and harvest, as well as production and marketing of totora products.

## METHODS

We observed totora uses at seven different sites in three provinces of Ecuador (Table 1). In the province of Imbabura, it grows naturally in San Pablo Lake and Yaguarcocha (cocha = lake) and inundated areas of the Itambi River near Cusín, where it has been managed, improved, and replanted by local residents. In the province of Cotopaxi, it is cultivated in plots that are inundated with water from nearby rivers. In the province of Chimborazo, it was introduced into Colta Lake (Forman 1977; Robinson 1966), as well as into the environs of the Guano River. These sites are the most important ones concerning totora use in Ecuador, and if it is used elsewhere in the country, it is only—to our knowledge—on a minor scale.

Information on propagation, harvest, and economic value was collected in 1995 through di-

**TABLE 1.** STUDY SITES IN ECUADOR AND ESTIMATED MINIMUM AREAS OF *SCHOENOPLECTUS CALIFORNICUS* STANDS.

Province	Locality	Geogr. coord.	Alt. (m)	Area (has.)
Imbabura	San Pablo Lake	0°12'N; 78°12'W	2760	150
Imbabura	Yaguarcocha	0°22'N; 78°05'W	2190	80
Imbabura	Cusín	0°11'N; 78°11'W	2770	32
Cotopaxi	Guaytacama	0°48'S; 78°38'W	2970	35
Cotopaxi	Tanicuchí	0°46'S; 78°38'W	2980	15
Chimborazo	Colta Lake	1°44'S; 78°45'W	3340	40
Chimborazo	Guano River	1°37'S; 78°36'W	2580	90
			Total	442

rect observation and interviews with local residents. For 13 days, one of us (MJM) lived with a family of totora weavers in the community of Huayco Pungo near San Pablo Lake, participating directly in all aspects of totora production and fabrication. We visited each of the other areas for 2–7 days, where we established plots of 1 m<sup>2</sup> at each study site to determine stem densities and estimate production.

At the local markets in the towns of Ibarra, Otavalo, Riobamba, and Saquisilí, at stores in Quito, and from interviewees in Guayaquil, we gathered information about product prices. Banco Central del Ecuador, in Quito provided export statistics.

The distribution map (Fig. 2) was produced from the literature (Heiser 1978; Mardorf 1985), herbarium collections from AAU, GENT, MA, QCA, QCNE (acronyms according to Holmgren et al., 1990), and our own field collections and observations.

## RESULTS

### HARVEST AND PROCESSING

The green aerial stems of totora are harvested for weaving when the inflorescence has matured and the plant has reached maximum development. Most harvesting is done during the dry season between July and October. In Cotopaxi and Chimborazo, totora is harvested once a year, whereas in Imbabura, it is harvested every 7–8 months in San Pablo Lake and every 6–7 months in Yaguarcocha. Variation in harvest frequencies may be related to variations in altitude, water temperatures, and climatic conditions. Regular harvesting appears to promote growth of the totora stands, probably because it reduces competition from other species and increases stem density.

Harvesting is by hand and the stems are cut with serrated sickles (Fig. 3A). Usually the harvester stands in the water, but in Yaguarcocha, the plant grows in water so deep that it must be harvested from a totora raft. This raft, which is called “caballito,” is made from three large bundles of recently cut totora, firmly tied together. In Colta Lake, however, rafts for use during the harvest are made from three balsa tree (*Ochroma pyramidale*) trunks and are steered with a 3–4 m pole, usually made from *Eucalyptus globulus*.

In Imbabura, the stems are cut 15–20 cm



**Fig. 3.** Harvest and use of totora (*Schoenoplectus californicus*) in Ecuador. **A**, Harvesting by hand held sickle. **B**, Drying and bundling the harvested stems. **C**, Production of standard sized mats. **D**, Storage of mats and bundled stems. **E**, Marketing of mats. **F**, totora fans.

above the water surface and are left in place for 1–2 weeks, depending on weather conditions, to dry partially as well as to decrease their weight to facilitate transport. In the other provinces, totora is cut and taken away from the lake to dry, or it is transported immediately to the weavers' homes. The length of stems harvested varies from 1.5–4 m.

The amount of time spent harvesting varies according to the accessibility of the plant. In San Pablo Lake, a worker harvested 48 m<sup>2</sup> in 53 minutes. A week later, when the totora had partially dried, he spent 35 minutes forming bundles, tying them with the same stems, and transporting them to his home. In Yaguarcocha, in an area of approximately 900 m<sup>2</sup>, 6–7 people (men, women, and children) spent 12 days harvesting and bundling totora stems (Fig. 3B).

When the totora is totally dry, the fibers are cut in sections of various lengths, depending on their intended use (Fig. 3C). In this cut condition, they can be stored for several years without damage (Fig. 3D).

In Cotopaxi and Chimborazo, when totora's intended use is as cattle fodder, it is harvested more often, 3–4 times per year. Generally, it is cut when the stem reaches 1–2 m, usually before flowering. It makes excellent forage because, as was demonstrated at Lake Titicaca in Bolivia, it

TABLE 2. PRINCIPAL TOTORA PRODUCTS SOLD (INDICATING VARIOUS SIZES OF MATS AND FANS) AND COMPARISON OF PRICES (US\$) IN SIX ECUADORIAN MARKETS.

Product	Guayaquil	Ibarra	Otavalo	Quito	Riobamba	Saquisilí
<b>Mats</b>						
1.8 × 1.3	2.2–2.5	1.2–1.4	1.6–1.7	2.5–2.8	1.6	1.2–1.6
1.8 × 1.05	1.2–1.9	1.1–1.2	1.1	2.2–2.3	1.2	—
1.0 × 0.8	—	0.8–0.9	—	1.8–2.0	0.9	0.9–1.1
3.0 × 2.0	—	—	—	—	3.7	7.8
0.7 × 0.5	—	—	0.3–0.4	—	0.5–0.6	0.5–0.8
<b>Fan</b>						
0.35 × 0.24	—	0.2	0.2	0.2–0.3	0.2	0.2

is high in protein and easily digested (Oyanguren and Tapia 1971, cited by Levieil and Orlove 1991).

#### PROPAGATION

Wild populations of totora reproduce vegetatively or from seed (Heiser 1974), and we assume that seeds are dispersed by aquatic birds, wind, and water currents.

Cultivation begins just after harvesting ends. Rhizomes from harvested plants are uprooted and, without letting them dry, they are divided and planted in permanently wet areas at a depth of about 5 cm and 20–25 cm apart. The rate of success is generally very high. In Imbabura, plants grown in pools are said to last at least 25 years, while in Cotopaxi and Chimborazo, they will be grown for 10–20 years, depending on the care they receive. For optimal development, the plants must be inundated throughout the year. In general, we may say that the majority of totora stands in Ecuador are the result of human cultivation.

#### PRODUCTS AND APPLICATIONS

The main use for totora in Ecuador is in the production of mats. At the beginning of the century, in the villages of San Rafael near the San Pablo Lake and Guaytacama, one of the principal local industries was production of totora mats (Compañía Guía del Ecuador 1909). Currently, as in earlier times, totora mats are made almost entirely by Andean, Quichua-speaking Indians. The areas of totora cultivation are well guarded by their owners to prevent intrusion by cattle.

To produce the mats, the fiber is soaked in water overnight, which makes it more pliable and keeps it from breaking during weaving. The

mats are made indoors to prevent the sun from drying and hardening the fibers (Fig. 3C). All members of the household, both male and female, work to produce mats, usually during free periods between work in agricultural fields or early in the morning before beginning other chores.

The mats serve many purposes in indigenous life, such as: beds placed directly on the floor or to protect mattresses, seats, carpets or doormats, tablecloths, room dividers, doors and windows, and curtains. Other uses include roofs for animal shelters, fences to separate properties, for fuel, and for children's toys. In September, during the "Yamor" festival, which celebrates the grain harvest, a totora raft-rowing race takes place on San Pablo Lake. During this fiesta, baskets, hats, shirts, and bags are woven, and totora rafts are constructed for fishing.

During grain harvests, demand for mats is high, because they are used to spread grains and other crops on to dry. Mats are produced in various sizes (Table 2), the most popular one being 1.8 × 1.3 m. Although the durability of the mats varies, typically, they last about one year, after which they are replaced. Production time depends on the artisan's skill, but it usually ranges from 2–4 hours. In Cotopaxi and Chimborazo, ceilings, called "tumbados" are made to order in different sizes and used to decorate walls or roofs of houses. Totora is also traditionally used as a fan (Fig. 3F) to keep cooking fires alight. These fans are woven from 24–30 thin stems and take approximately 15 minutes to make.

Totora is important as forage for cattle, horses, and pigs, especially during times of drought. At Colta Lake, most of the totora is used for this purpose.

TABLE 3. PRICE CHANGES IN SUCRES OF  $1.8 \times 1.3$  M MATS FROM 1961 TO 1995 IN ECUADOR.

Year	Reference	Price mat ( $1.8 \times 1.3$ )
1961	Robinson, 1966	4.5–5
1971	Forman, 1977	8
1975	Heiser, 1978	15–20
1978	Mardorf, 1985	21–25
1995	Present study	4000–9000

### MARKET

Totora products are important in the national economy, and they are marketed throughout the country (Fig. 3E). A small segment of sales is dedicated to export. Table 2 shows the main totora products comparing prices in six different Ecuadorian markets. Prices are highest in cities with large populations. Totora fans are sold in local markets as well as in urban supermarkets where prices may be twice as high as in local markets. Prices of mats vary depending on the time of year; during grain harvest time, there is more demand and thus the price increases. Table 3 shows price fluctuations in local currency over the last 35 years. The large rise between 1978 and 1995 is due to inflation.

In Imbabura, mats are sold in the local food stores for 3000 Sucres (US \$0.9) apiece to both end users and intermediaries. The intermediaries sell each mat for 4000 Sucres (US \$1.25) to other Otavalo Indians to be marketed throughout the country in the coastal as well as the Andean and Amazonian regions. These vendors determine the final prices, adding in their profit (see Table 2). They sell the mats in Colombia, and from the southern border-city of Huaquillas, they sell them in Peru. Finally, during the last 15 years, small quantities of raw material of totora have been exported to the United States, Colombia, and Italy (Table 4).

### PRODUCTION

Based on our personal observations, topographic maps, and talks with interviewees, we estimate the area of totora production as 442 hectares in the three provinces studied (Table 1).

Productivity, based on the number of stems per unit area, whether wild or cultivated, varies from region to region. An area of 1 m<sup>2</sup> averages 371 stems (range 263–480, n = 30). Since it takes 271 stems (106 long ones and 165 short

TABLE 4. EXPORT DATA FOR TOTORA (*SCHOENOPLECTUS CALIFORNICUS*) PRODUCTS FROM ECUADOR: 1981 AND 1986 DATA ARE EXPORTS TO THE UNITED STATES; 1983 TO COLOMBIA; AND 1992 TO ITALY.

	Weight (tons)	Price (US\$)
1981	2.0	2000
1983	0.7	300
1986	1.8	900
1992	—	100

ones; range of 235–350, n = 35) to make one  $1.8 \times 1.3$  m mat, it follows that it takes a totora stand of 0.75 m<sup>2</sup> to produce one mat.

In Imbabura, totora is harvested between 1.8 and 2 times per year, whereas, in Cotopaxi and Chimborazo, only once. Consequently, in Imbabura, production is nearly double that of the other two areas. In Yaguarcocha, totora grows to about 4–4.5 m, over 6–7 months, while in Cotopaxi it reaches 3–3.5 m in one year; and in Colta Lake, only 2.5–3 m. By comparison, in Lake Titicaca, it reaches 3.8 m in a little more than a year (Levieil and Orlove 1991); additionally, the production of 2.9–5.5 tons of dry biomass per hectare per year, which represents a very high quantity of forage (Vacher, Brasier de Thuy, and Liberman 1991).

### SOCIOECONOMIC IMPORTANCE

In areas where totora is intensively worked, it may be the most important source of income for the indigenous community. Otherwise, it can be an extra source of revenue. In most totora growing areas, it is common for about three-fourths of all families to work with the plant, but around San Pablo Lake, practically every family profits from it. Here, all the families of the community share the totora growing area, and each family has a right to harvest a 100 m<sup>2</sup> totora stand, though some have twice this area as a result of inheritance. At Colta Lake, there is also communal ownership, but there a family usually controls a totora stand of about 42 m<sup>2</sup>, though some have as much as 126 m<sup>2</sup> also through inheritance. When a head of household or totora owner dies, his children inherit his stand, so even if the extended family maintains its area of totora stand, the areas controlled by individual farmers decrease as they are successively divided. For this reason, the Otavalo Indians from the

area near the San Pablo Lake have moved to other parts of the country in search of totora. Consequently, Colta Lake and El Salado Lake (Carchi Province) have seen an increase in the number of families working with totora.

In Imbabura, a 100 m<sup>2</sup> totora stand can produce approximately 133 mats per harvest. Two harvests yield 266 mats and bring in a gross income of US \$251 per year, which corresponds to 22% of the official minimum salary in Ecuador. It is important to realize that there are no production costs and that these estimates are conservative.

Sometimes, if the owner of the totora stand does not use his portion, it is rented out for cutting. For one such harvest, prices may vary from US \$20–33 per 100 m<sup>2</sup> depending on the region: at Yaguarcocha 900 m<sup>2</sup> were rented for US \$250; at Guaytacama 144 m<sup>2</sup> were rented for US \$47; and at Colta lake 42 m<sup>2</sup> for US \$8–9. In 1990, 25 families bought private property in Cusín with 32 hectares of totora stand for US \$2200.

### DISCUSSION

For various reasons, totora is of great interest in the modest lifestyle of Andean indigenous communities in Ecuador. On one hand, it represents an important source of cash income, and in some cases, the only source for those who produce mats. The economic benefit is small although its production and harvest require participation of all family members, regardless of sex. These same people participate in the entire process from cultivation and harvest to sale of the final product. Additionally, totora is of cultural importance, since it is used in many daily activities for a variety of domestic purposes.

It is also outstanding as a forage species. Apart from its high annual production, it provides a reliable pasture, which can be especially important during the dry season or drought periods. It is food for horses, cattle, and pigs, which are all important in the Andean indigenous economy as beasts of burden or for providing milk or meat.

In some lakes, especially in Imbabura, there are problems of pollution, as well as excessive water withdrawals, both of which affect the ecosystem and its inhabitants. In places where totora is grown in pools, there is a build up of organic matter that must be removed periodically to promote better growth. The exploitation of

totora does not appear to have had negative effects on other plant and animal life in the lakes. Totora provides a habitat for reproduction of fish and aquatic birds that serve as a food resource for lakeside communities. There are, however, no regulations controlling the harvesting of totora.

Production of totora handicrafts for sale to the tourist market has not yet developed in Ecuador. In the future, this use of totora may become important, possibly following the model established in Michoacán, México (see Cortés and Franco 1983), where there is a long tradition of totora handicraft production. There, the Purépecha communities have an important source of income from the use of totora in handicrafts.

More than 95% of the primary forest on the Ecuadorian coast has disappeared; now, it is a disturbed area that lacks natural resources (Dodson and Gentry 1991). Totora is a plant that is easy to propagate vegetatively, requiring neither special attention nor high production costs. Its presence in Esmeraldas Province suggests that it could be introduced into the coastal regions of the country as an alternative forage plant to be grown in pools near rivers or in wetlands of minor ecological importance, in the same way as it is in the highlands in Cotopaxi.

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