Zapotec and Mixe use of Tropical Habitats for securing medicinal plants in MéXicoDie Nutzung Tropischer Habitate Durch Zapoteken Und Mixe (Mexiko) Zur Sicherstellung Der Versorgung Mit Arzneipflanzen.El Uso De Ecosistemas Tropicales Por Los Zapotecos Y Mixe (MéXico) Para Asegurar El Aprovechamiento De Plantas MéDicinales.

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ZAPOTEC AND MIXE USE OF TROPICAL HABITATS FOR SECURING MEDICINAL PLANTS IN MEXICO[1]

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Frei, Barbara *(Centre for Pharmacognosy and Phytotherapy, The School of Pharmacy, University of London, 29-39 Brunswick Sq., London, WC1N 1AX, UK),* **Otto Sticher** *(Department of Pharmacy, Swiss Federal Institute of Technology (ETH) Zurich, Winterthurerstrasse 190, CH-8057 Zürich, Switzerland, and* **Michael Heinrich**[2] *(Institute of Pharmaceutical Biology, Albert-Ludwigs-University, Schaenzlestrasse 1, D-79104 Freiburg, Germany).* ZAPOTEC AND MIXE USE OF TROPICAL HABITATS FOR SECURING MEDICINAL PLANTS IN MEXICO. *Economic Botany 54(1):73–81, 2000. Medicinal plants are essential in the medical systems of the Mixe and Zapotec. In this study ethno-ecological strategies, employed by the two neighboring Indian groups in Mexico, for obtaining medicinal plants are analyzed. The indigenous classification of the environment is notably different from the Western one and distinguishes six dissimilar principal "zones" or land use types. Most ethnomedically important species are cultivated in the "house garden" or gathered in the community or its immediate surroundings. The house garden, for example, contributes 31.8% and 26.2% of all medical taxa for the Mixe and Zapotec, respectively. These ethnobotanical data on the indigenous uses indicate that anthropogenic types of vegetation yield the largest percentage of medicinal taxa.*

EL USO DE ECOSISTEMAS TROPICALES POR LOS ZAPOTECOS Y MIXE (MEXICO) PARA ASEGURAR EL APROVECHAMIENTO DE PLANTAS MEDICINALES. *Plantas medicinales son una parte esencial de los sistemas médicos de los Mixe y Zapotecos. En este estudio se analizan las estrategias etnoecológicas empleadas por los dos grupos indigenas vecinos para obtener plantas medicinales. La clasificación indigena del ambiente es notablemente diferente de la clasificación occidental y distingue seis zonas principales disimilares (o tipos de uso de la tierra). La mayoria de las especies de importancia etnomédica se cultiva en los solares o se recolecta en la comunidad o en la zona alrededor de la comunidad. El solar, por ejemplo, contribuye 31.8% y 26.2% de todas las plantas mediciniales de los Mixe y Zapotecos, respectivamente. Estos datos etnobotánicos sobre el uso indigena de la tierra indican que los tipos de vegetación antropogénica son muy importantes para la obtención de la gran mayoria de las plantas medicinales.*

DIE NUTZUNG TROPISCHER HABITATE DURCH ZAPOTEKEN UND MIXE (MEXIKO) ZUR SICHERSTELLUNG DER VERSORGUNG MIT ARZNEIPFLANZEN. *Arzneipflanzen sind ein wesentlicher Bestandteil des Medizinsystems der Mixe und Zapoteken. In dieser Untersuchung werden die ethnoökologischen Strategien, die von den beiden Indianergruppen zur Sicherstellung einer ausreichenden Versorgung mit Arzneipflanzen eingesetzt werden, untersucht. Die indigene Klassifizierung der Umwelt unterscheidet sich deutlich von der westlichen und differenziert sechs verschiedene Landnutzungszonen. Die meisten arzneilich wichtigen Taxa werden auf den Höfen angebaut oder direkt im Ort oder seiner direkten Umgebung gesammelt. Der Hof liefert beispielsweise 31.8% bzw. 26.2% aller Arzneipflanzen der Mixe bzw. der Zapoteken. Diese ethnobotanischen Informationen über die indigenen Verwendungsstrategien zeigen, dass anthropogene Landnutzungsformen den grössten Anteil an arzneilich genutzten Taxa liefern.*

Key Words: Mixe, Zapotec, Isthmus of Tehuantepec (Oaxaca, Mexico), medical ethnobotany, traditional medicine, anthropogenic vegetation, land use types, house gardens.

For centuries indigenous people have managed and modified their surrounding ecosystems for subsistence as well as for medico-pharmaceutical purposes (Alcorn 1984a,b; Frechione et al. 1989; Heinrich, Ankli, Frei et al. 1998; Heinrich, Robles, and West et al. 1998; Posey 1985; Voeks 1996). Documentation of endangered knowledge was the main goal in the early eth-

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nobotanical studies, while today many projects collect data for biodiversity conservation and community development focusing on the ecological feasibility of the indigenous management strategies (Akerele, Heywood, and Synge 1991; Cunningham 1993; Gómez-Pompa, Whitemore, and Hadley 1991; Martin, Hoare, and Posey 1996). An implicit assumption of these studies is that plants are ecologically, culturally and economically important (Bennet 1992; Grimes et al. 1994). A prerequisite of such studies is a detailed understanding of the strategies employed to grow and/or to gather plants and of the distribution of medicinal taxa along the land use types in and around a community. Hence, our study examines the indigenous land use types in one geographical area and contrasts these data with the management strategies for one specific resource, medicinal plants.

While the socio-economic potential of medicinal and other useful plants especially from primary forest has been calculated in detail (e.g., Adger et al. 1995) only very few analyses of the relative contribution of the land use zones to the indigenous ethnopharmacopeia are available (for a fascinating exception see Alcorn, 1984b). Based on two independent ethnobotanical inventories, this study analyses strategies of Mixe and Zapotec Indians plant use. The ecologically important areas of gathering and cultivating medicinal plants are discussed using six land use types, which are described based on the indigenous concepts of the environment. Mixe and Zapotecs distinguish these types based on the form of management applied and on their distance to the house. Most medicinal plants are gathered in the immediate surroundings of the community. By comparing data from two ethnic groups concerning the criteria for plant selection and management strategies, we also want to further develop the crosscultural analysis of medicinal plant use (cf. Heinrich, Ankli, Frei et al. 1998; Ankli, Sticher, and Heinrich 1999). We consciously employ the indigenous concepts of the land use types and do not attempt to correlate these with classifications of ecological or agronomic sciences. Additionally, differences and parallels in the indigenous groups' approach to plant resources are outlined. When no specific ethnic group is mentioned, the data refer to both groups, the Zapotec and Mixe.

Background and Methods

Ethnographic background

The Zapotecs (Campell et al. 1993) are the most numerous group in the state of Oaxaca (ca. 350 000). Historically, the Zapotecs settled in the highland Valley of Oaxaca where the archaeological sites of Monte Alban and Mitla give evidence of the advanced Zapotec civilization. In the middle of the fourteenth century some groups moved to the Isthmus of Tehuantepec, forced by Aztec and Mixtec invasion, settling in communities and affiliated ranchos (seasonal occupied settlements). This population dislocation was one of the major causes of the develpment of cultural and linguistic difference between the *Istmo Sierra Zapotec* people of the foothills of the Sierra Madre de Oaxaca and the highland groups. One to five percent of all inhabitants older than 5 years are Zapotec monolinguals, 50% to 70% are bilingual Indians and there are a considerable number of mestizos (ladinoized Zapotecs) in some parts (unpublished data of Mexican government agencies, INEGI 1993).

The neighboring Mixe are the fourth most numerous group (ca. 70 000) among the 15 indigenous groups in the state of Oaxaca. They extend over the central region of the state populating a well-defined area, the so-called *distrito Mixe* in the humid and cold mountains of the *Sierra de Juarez*. Only one *municipio* (subdistrict) is situated in the subtropical/tropical lowland of the *Istmo de Tehuantepec*. Under Spanish reign lowland Mixe were resettled into one central community called San Juan Guichicovi (Guichicovi = new village [in Zapotec]). A large proportion of the inhabitants live permanently in the *cabecera* (main village). Today more than 20% of all inhabitants older than 5 years are Mixe monolinguals, 75% are bilingual Indians and fewer than 5% are mestizos (unpublished data of Mexican government agencies, INEGI 1993).

Mixe and Zapotec subsistence is based on shifting and seasonal cultivation (corn), cash cropping (coffee, citrus fruits), gathering and wage labor. Today many members of both groups have migrated or have seasonal jobs in other parts of Mexico or as undocumented workers across the US border. Furthermore, the production of the Isthmus Zapotec-style women's blouses, the *huipils* (which are today part of the

Fig. 1. Mexico with the State of Oaxaca and the research area.

Mixe dress, too) by the Mixe and the widespread cultivation of *achiote* (*Bixa orellana* L., Bixaceae) by the Zapotecs used as dye and flavor, provide additional income for both of these indigenous groups.

Vegetation Types

Both research areas are situated in the southern part of the state of Oaxaca, in the Isthmus of Tehuantepec and its foothills and lowlands of the Sierra Madre de Oaxaca (Fig. 1). The area under investigation includes a small plateau 200 to 260 m.a.s.l. in the area of Matías Romero, Santo Domingo Petapa and Santa María Petapa as well as the mountainous Sierra with elevations up to 1600 m.a.s.l. The accentuated relief with its changing altitudes determines the climate and the vegetation types. In a global view, based on classifications of Köppen (Heyer 1988), the climate is defined as the As type (tropical climate, all months of the year with an average temperature above 18°C with one rainy season from June to September).

Several attempts to classify the vegetation of Mexico, including Oaxaca, have been made by Leopold (1950), Miranda and Hernández (1963), Flores and co-workers in (1972), Rzedowski (1978) and the COTECOCA (1980). The original vegetation in the area is tropical ombrophilous forest in the humid lowlands to the east and north (with *Vochysia hondurensis* Sprague, *Swietenia macrophylla* King, and *Terminalia amazonia* L.), and drought deciduous lowland (and submontane) forest in the south (with *Plumeria rubra* L., *Pithecellobium* sp., *Bursera* sp.). However most of the study area was originally covered by evergreen conifer and oak forest (with *Pinus oocarpa* Schiede and other *Pinus* spp., *Quercus* spp.) as well as (sub-)-tropical evergreen, partly submontane (broad-leaved) seasonal forest types (with *Manilkara zapota* (L.) van Royen, *Coccoloba barbadensis* Jacq., *Enterolobium cyclocarpum* (Jacq.) Griseb.). In higher elevations tropical ombrophilous forests (broad-leaved cloud and montane forests) have replaced the above mentioned vegetation types (with *Liquidambar* sp., *Podocarpus* sp., *Hymenaea courbaril* L.) (Lorence and Mendoza 1989).

This primary vegetation has been modified by indigenous manipulation for at least 600 years. Because no archaeological studies have been conducted in the area, the occupation prior to the historical record is uncertain. The current vegetation is heavily influenced by the agricultural activities of the Mixe and Zapotec. The *milpa* (cornfield) provides the culturally most important crop, maize (*Zea mays* L.), which is mostly produced with slash and burn agriculture, but along the rivers also by permanent forms of agriculture. Coffee (*Coffea* spp.) was introduced

into the area in the 1930s. It largely replaced the Zapotec cash crops *vainilla* (*Vanilla planifolia* Andr.), *añil* (*Indigofera suffruticosa* Mill.), *zarsaparilla* (*Smilax medica* Schl., *Smilax* sp.) (Brasseur 1992) and *cacao* (*Theobroma cacao* L.) as well as the Mixe root products (presumably *Colocasia esculenta* (L.) Schott, and others, indet.), *añil* and a large number of minor products (mostly fruits like *Tamarindus indica* L.).

Ethnobotanical Methods and Evaluation

The data presented on San Juan Guichicovi, the Mixe community, were collected from November 1985 to March 1986 and during several short stays since then (Heinrich 1989, 1998; Heinrich and Antonio B. 1993; Heinrich, Antonio B, and Kuhnt 1992; Heinrich, Rimpler, and Antonio B. 1992). The data from the Zapotec communities—Santo Domingo Petapa and Santa María Petapa—were collected from January 1992 to March 1993 and from October to November 1994 (Frei 1997; Frei et al. 1998). Both are based on open and structured interviews with local specialists such as traditional healers, herbalists and midwives. Additionally, observation of and participation in their daily work (plant collection, preparation and healing sessions) were made, in order to understand as fully as possible the classification of plants, their use, and the traditional way of conceptualizing and reasoning in indigenous cosmic vision (Frei 1997; Frei et al. 1998; Heinrich 1998; Heinrich, Rimpler, and Antonio B. 1992). To collect plant material, excursions were made with the informants to the different vegetation zones of the subdistrict. For each plant, detailed documentation on the area of collection, uses, preparation, application, and healing concepts were obtained. Voucher specimens were collected and identified, and complete sets have been deposited in the following herbaria: UNAM, México, D. F. (MEXU), Institute of Pharmaceutical Biology, Freiburg, Germany (collections *Heinrich and Antonio 1–320* and *Frei 1–554*) and ETH, Zurich, Switzerland (ZT; only *Frei 1–554*).

Results

Mixe and Zapotec recognize several land use zones based on two major criteria: a) distance from the house, the center of the daily life and the family and; b) the type of management applied to the respective area.

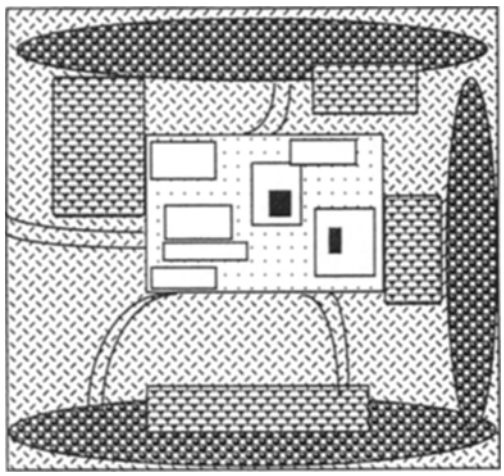
Six different zones are discussed in this paper (Fig. 2):

- *the solar* is the house garden and area directly around the house;
- *en el pueblo* refers to a land use zone within the community, mostly disturbed zones along the paths;
- *camino* on the other hand refers to the vegetation along the roads and ways leading out of the community;
- *milpa, corral, potrero* and *cafetál* are land use zones, which receive different types of management and serve the supply with specific agricultural goods;
- *the bosque* and *montañas* are those forests which are not or rarely used or which have fallen fallow after a period of use as a milpa;

Additionally medicinal plants are obtained on the weekly or daily markets (a sixth "land use zone") in the community or in nearby cities and from ambulant vendors. The plants obtained from these sources are ethnobotanically important and included, but are not discussed in detail in the context of our report.

Solar

The central and most important area according to the indigenous concept of the environment is the house garden (solar). This is the meeting place of daily life, of the family and the major sphere of activity of the healers. Housework like processing corn, drying and roasting coffee, as well as breeding animals and commercial activities take place here. It is the most important and most intensively managed zone. Usually a few (two to five) trees, either planted or spared and protected when spontaneously grown, are observed with multiple function. While giving shade and demarcating the garden, they also are sources of fresh food and medicine at special times of the year. In Mixe as well as in Zapotec house gardens the following species are found frequently: *Annona* spp., *Citrus* spp., *Crescentia alata* Kunth, *Terminalia catappa* L., *Tamarindus indica* L., and *Ficus incipida* Willd. Some of the plants typical of the primary vegetation are also grown occasionally (e.g., *Plumeria rubra* L., *Hymenaea courbaril* L.). Shrubs and herbs are also planted. These serve, for example, as ornamentals or as medicinal sources and often are transplanted from zones (e.g., the tropical ombrophilous forests) too far away for



House garden (*solar*)

Ruderals in the village (*en el pueblo*)

Roadsides and secondary vegetation, outside of the village (*camino*)

Fields, cultivated or abandoned (milpa, etc.)

Forest (*bosque*)

Markets, pedlars (*mercados, commerciantes*)

convenience or from other regions of Mexico. They receive special attention and care. The most frequent plants in both Mixe and Zapotec gardens are: *Aloe barbadensis* Miller, *Ocimum basilicum* L., *Piper* spp., *Chenopodium ambrosioides* L., *Jatropha curcas* L., *Kalanchoe pinnata* (Lam.) Persoon. Thirty-one and eight tenths percent or 67 species in Mixe gardens and 26.2% or 96 species in Zapotec gardens belong to this first zone (Table 1). Mixe cultivate a larger percentage (+5.6%) of medicinal plants in their private gardens than the Zapotecs.

En el Pueblo

Plants growing outside of house gardens, along streets and streams inside the borderlines of the village belong to the second zone. Some of these "good" or "bad" non-crops (Chacón and Gliessman 1982) growing on poor soils in the community (*en el pueblo*) are esteemed for medicinal purposes and/or as fodder for animals. Little attention is paid to these plants since they grow abundantly without special care and are only removed twice a year on the official days of the collective cleaning of the villages. *Tournefortia densiflora* Mart. & Gal. was observed to be planted by a Zapotec healer in his community—a case of intentional introduction of plants which grow too far away for convenient usage. Twenty-eight medicinal species (13.3%) in Mixe and 48 (13.1%) in Zapotec communities grow in these open spaces (Table 1). Examples are mostly herbs and little shrubs such as *Heliotropium indicum* L., *Hyptis verticillata* Jacq., *Sida* spp., *Melochia* spp., *Rauwolfia tetraphylla* L., *Capraria biflora* L., and *Plumeria rubra* L. Since the plants in this group, and plants in the *solar* are prone to be eaten and contaminated by

TABLE 1. MEDICINAL PLANTS IN THE INDIGENOUS LAND USE ZONES.

Land use zone (Mixe and Zapotec)	Number of species	%	Cumulative %	Number of species	%	Cumulative %**
	Mixe			Zapotec		
House garden/solar	67	31.8	31.8	96	26.2	26.2
In the village/en el pueblo	28	13.3	45.0	48	13.1	39.3
Outskirts/camino, monte	56	26.5	71.6	73	19.9	59.2
Fields/milpa, cafetál, corral, po-	18	8.5	80.1	57	15.5	74.7
treros	33	15.6	95.7	72	19.6	94.3
Wood/bosque	9	4.3	100.0	21	5.7	100.0
Market, peddlers/mercado*	211	100.0		367	100.0	
Total						

* Not actually an ecological zone in the sense of an area, but necessary for the complete description of Mixe and Zapotec medicinal plant use.

domestic animals, some healers prefer to have them in special home medicinal gardens (Fig. 2).

Camino

The second most important zone with 56 species (26.5%) in Mixe and 73 species (19.9%) in Zapotec areas (Table 1) are the immediate surroundings of the communities. Plants are found along the paths or roads (*camino*) which are leading out of the village to the fields, the rivers or to neighboring communities, or in places like gorges where no cultivation is possible and areas in which firewood is collected. Trees, shrubs, especially climbers and to a lesser degree herbs, are collected in this zone (e.g., *Tithonia diversifolia* (Hemsl.) Gray, *Guazuma ulmifolia* Lam., *Thevetia* spp., *Malvaviscus arboreus* Cav., *Gonolobus* spp., *Croton* spp., and *Xanthosoma robustum* Schott). This area, with the exception of the sides of the main roads, is considered to be better for collecting clean plants. Zapotec healers believe that these "wilder" plants have more healing power than cultivated plant material. Since this area is common property, everybody is allowed to gather plants. Nevertheless, places of rare species are well known among the healers and are spared when the area is cleaned. Also some woody species characteristic of the primary vegetation of the area are often spared, if they have medical importance (*Bursera* spp., *Enterolobium cyclocarpum* (Jacq.) Griseb., *Manilkara zapota* (L.) P. Royen, *Quercus* spp.). Non-healers consider this zone of lesser importance whereas medical specialists manipulate the vegetation intentionally and influence the structure of this zone.

Milpa, Corral, Potrero, Cafetál

Fields and forests with shifting cultivation, pasture land and the coffee plantations (*milpa, corral, potrero,* and *cafetál*) form a fourth and heterogeneous zone. These areas are differentiated by our informants, but in view of the low number of medicinal taxa recorded, we combined them. They are especially important for collecting timber and food. This zone is conceptually further differentiated by our informants because it includes both the sacred ground of the *milpa,* with its all-important crop maize, and zones for animals. Because the differentiation was especially made for cultivates and yielded only 18 and 57 medicinal plants (8.5% and 15.5%), respectively for the Mixe and Zapotec, these data were combined into one group. Only the owner of a plot of land or members of the ejido, who currently plant crops there are allowed to collect plants. These areas often are hours away from the village and therefore many species useful as medicinals, foods, or both, e.g., *Poiretia punctata* (Willd.) Dev., *Zebrina pendula* Schnizl., *Annona* spp., *Quercus* spp. *Theobroma cacao* L., *Coffea* sp., *Musa* spp., and *Cucurbita pepo* L., are brought into the house gardens.

Bosque, Montañas

Sometimes difficult to distinguish from the previous area is the *bosque,* which comprises the managed and unmanaged forest. It includes "primary" and secondary forest with trees up to 30 m and more in height, in gorges or on steep slopes. For the Zapotecs this zone is more important (72 species; 19.6%) than for Mixe healers (33 species; 15.6%). Plants in this area which is not managed intensively include *Dioscorea* spp., Dioscoreaceae; *Piper* spp., Piperaceae; *Psidium* spp., Myrtaceae; *Pinus oocarpa* Schiede, Pinaceae; *Critonia quadrangularis* (DC.) R. M. King & H. Rob. (syn. *Eupatorium quadrangulare* DC.), Asteraceae; *Begonia heracleifolia* Schltdl. & Cham., Begoniaceae, and *Siparuna andina* (Tul.) A.DC., Monimiaceae.

Mercado, Comerciantes

The markets (*mercados*) and peddlers (*comerciantes*) are not actually an ecological zone in the sense of an area, but are a source for Mixe and Zapotec medicinal plants. Only a few species with medicinal purposes like *Matricaria recutita* L., Asteraceae; *Capsicum* spp., Solanaceae, or *Cinnamomum ceylanicum* Sw., Lauraceae, are sold in the small shops in the villages. A larger supply is available in the nearby cities of Matías Romero, Juchitán, or Tehuantepec (one to three hours away by bus) or farther away in the state capital Oaxaca (a one day journey). Almost every week peddlers pass by the villages selling all kind of things including medicinal plants. The plants are grown all over Mexico, purchased in the Sonora market of Mexico City and redistributed in the country (Heinrich, Antonio B. and Kuhnt 1992). Nine species (4.3%) and 21 species (5.7%) were recorded for the Mixe and Zapotec, respectively.

A Statistical Analysis of the Species Numbers in the Ecological Zones

A statistical comparison of the results presented in Table 1, shows that the Mixe collect significantly more species in the first three zones closer to the house (*solar, pueblo,* and *camino,* Mixe = 151 species and Zapotecs = 217 species; *P*-value = 0.0051, $c^2 = 7.839$) as compared to the Zapotec[3]. On the other hand, the Zapotecs prefer plants from the zones which are farther away (*milpa, cafetál,* etc. and *bosque,* Zapotecs = 129 species and Mixe = 51 species). By comparing the five individual zones for general independence[4], the data shows a significantly different pattern of preference for collection by the two indigenous groups (*P*-value = 0.036, $c^2 = 10.3$). A comparison of the number of species used as medicinals with the total number of species growing in each indigenously defined zone is not possible (although desirable), since no data on the total numbers are available. The sixth "zone" (*mercado, comerciantes*) was not included in the statistical analysis.

Discussion

The Mixe and Zapotec communities under investigation are located in an area of great botanical diversity. While the indigenous inhabitants categorize their environment into at least six ecological zones (for comparative purposes some groups, such as *milpa, cafetál* etc., were reduced to a single group), based on aspects of distance and the type of management applied, ecological sciences classify the vegetation of this region into 12 different, non-corresponding, vegetation zones referring to the plant species found at a specific location (Haller 1994). Outsiders may categorize plants as wild, domesticated, or weed, while indigenous peoples view vegetation primarily as resources (Alcorn 1981). Through management, selection and other means, humans have manipulated the flora and land to create zones which yield a variety of plants which serve their needs for daily subsistence and the treatment of illness. It is noteworthy that both the Zapotec and the Mixe obtain most (59.2% and 71.6%, respectively) of their medico-botanical resources from their immediate environment. These phytotherapeutic preparations are used to treat the common illnesses of the region (Frei, Sticher, and Heinrich 1998; Heinrich, Rimpler, and Antonio B. 1992). The comparatively lower number of medicinally important species collected from the secondary and primary forest vegetation contradicts the common popular assumption (for example Haese 1998) that these vegetation types are the principal sources of indigenously used medicinal plants. Voeks (1996) reported on the relative importance of primary as compared to secondary forest vegetation in Bahia, Brazil. While primary vegetation is essential for obtaining timber, the secondary forests yielded a much larger number of medicinal plants. Since Voeks did not look at species from non-forest vegetation zones, a direct comparison is not possible. Some of the species grown near the house originate from these forest habitats, but because they have been regarded as a useful remedy, they have been brought to the *solar* of the healer or its *corral* and grown there. Having easy access to the resources is therefore a factor with much influence on the diversity of the zones closer to the house. Comerford (1996) showed in the Petén region in Guatemala that regrown forests and intensively managed zones are more important for medicinal plant gathering and therefore traditional medicine would not be seriously threatened by loss of primary forests. This conclusion is only of relevance with respect to the plant's immediate importance, because plant selection for medicinal use is an on-going process. Next to old knowledge, new findings by traditional healers are endangered as well. A comparison with the original vegetation and its characteristic taxa (see 'background') also reveals that many of the plants listed there also are important medicinal plants and now receive special attention and care or are sometimes not cut down when clearing the vegetation in and around the community. Future higher population densities will disturb and manipulate as well as explore the primary forests of today.

Historical developments and the cultural background determine the pattern of settlement and are therefore factors to be taken into consideration. While Mixe live concentrated in the

[3] Pearson's c^2 test for 2 × 2-tables with Yates' continuity correction, whereas the first three and the last two indigenous ecological zones (see Table 1) were combined into two groups (first group: "close to the house"; second group: "faraway from the house").

[4] Pearson's c^2 test without Yates' continuity correction with the data of five (not combined) indigenous ecological zones.

cabecera [principal community San Juan Guichicovi, and other populated places: El Ocotal, El Chocolate, and Río Pachiñe], the Zapotec settlements are widely dispersed over their territory. Zapotecs have more and faster access to different vegetation zones and the plant diversity is exploited in a greater variety. Mixe have a much larger proportion of plants in cultivation in their private house gardens in order to have the plants at hand when needed. This seems to be one of the major reasons for the different patterns of collecting plants in the various indigenous ecological zones (Table 1). Whether there are other socio-cultural or ecological reasons for these different preferences remains to be elucidated.

We also raise several methodological questions. While ethnobotanists and ecologists usually look at one scientifically defined vegetation zone (especially forests), we show the utility of an approach based on the indigenous concept of their environment and what resources are collected in which part of the environment. Our approach thus relies more heavily on a botanico-anthropological method as compared, for example, to the mere enumeration of useful species in one zone. Consequently, the natives' perspective of the environment is more central to our approach as to other ones. The scientific classification is based on the structure of the vegetation, while the indigenous one is based on the uses of the area. These botanico-anthropological data in combination with the scientific classification are a useful empirical basis for the further development of the area.

Simultaneously, we are interested in the empirical basis of the Zapotec plant use and have conducted several studies on the efficacy and safety of Zapotec and Mixe herbal remedies (Bork et al. 1997; Frei, Heinrich, Bork et al. 1998; Kato et al. 1996). In the long-run the approach may accordingly provide the basis for small plantations producing medicinal plants for regional use. After a systematic evaluation it may provide remote areas with inexpensive therapeutics and small scale additional income. Ethnoecology and medicinal ethnobotany in particular are therefore important links between tradition and modernization on the one hand and sustainable management, conservation and local development on the other.

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LITERATURE CITED

Adger, W. N., K. Brown, R. Cervigni and D. Moran. 1995. Total economic value of forests in Mexico. Ambio 24:286–296.

Akerele, O., V. Heywood, and H. Synge. 1991. Conservation of medicinal plants. Cambridge University Press, Cambridge, UK.

Alcorn, J. B. 1981. Huastec noncrop resource management: implications for the prehistoric rain forest management. Human Ecology 9:395–417.

———. 1984a. Development policy, forests, and peasant farms: reflections on Huastec-managed forests' contributions to commercial production and resource conservation. Economic Botany 38:389–406.

———. 1984b. Huastec Mayan ethnobotany. University of Texas Press, Austin, TX, USA.

Ankli, A., O. Sticher, and M. Heinrich. 1999. Medical ethnobotany of the Yucatec Maya: Healers' consensus as a quantitative criterion. Economic Botany 53:144–160.

Bennet, B. C. 1992. Plants and people of the Amazonian rainforests. BioScience 42:599–607.

Bork, P. M., M. Schmitz, M. Kunth, C. Escher, and M. Heinrich. 1997. Sesquiterpene lactone containing Mexican Indian medicinal plants and pure sesquiterpene lactones as potent inhibitors of transcription factor NF-kB. FEBS Letters 402:85–90.

Brasseur, Ch. 1992. Viaje por el Istmo de Tehuantepec 1859–1860. Secretaria de Educación Publica, Fondo de Cultura Economica, Mexico D.F., México.

Campell, H., L. Bindford, M. Bartolome, and A. Barabas. 1993. Zapotec struggles. Smithsonian Institution Press, Washington, London, UK.

Chacón, J. C., and S. R. Gliessman. 1982. Use of the "non-weed" concept in traditional tropical agroecosystems of South-Eastern Mexico. Agro-Ecosystems 8:1–11.

Comerford, S. C. 1996. Medicinal plants of two Mayan healers from San Andrés, Petén, Guatemala Economic Botany 50:327–336.

COTECOCA (Comisión Tecnica Consultiva para la Determinación Regional de los Coeficientes de Agostadero). 1980. Oaxaca. Impreso por las memorias de COTECOCA-SARH.V.1,2, with map of vegetation, scale of 1:500,000. pp. 295. Unpublished. (In Spanish).

Cunningham, A. B. 1993. African medicinal plants. WWF, People and Plants, United Nations Educational, Scientific and Cultural Organization, UNESCO Press, Paris, France. Working paper 1.

Flores, M. G., J. Jiménez L., X. Madrigal S., F. Moncayo R., and F. Takaki T. 1972. Mapa y descripciones de los tipos de vegetación de la República Mexicana. Secretaría de Agricultura y Recursos Hidráulicos, México D.F., México. (In Spanish).

Frechione, J., D. A. Posey, and L. Francelino da Silva. 1989. The perception of ecological zones and natural resources in the Brazilian Amazon: an ethnoecology of Lake Coari. Adv. Economic Botany 7:260–282.

Frei, B. 1997. Medical ethnobotany of the Isthmus-Sierra Zapotecs (Oaxaca, Mexico) and biological-phytochemical investigation of selected medicinal plants. Thesis. Diss. ETH Zurich No. 12324.

———, **M. Heinrich, P. M. Bork, D. Hermann, B. Jaki, T. Kato. M. Kuhnt, J. Schmitt, W. Schühly, C. Volken, and O. Sticher.** 1998. Multiple screening of medicinal plants from Oaxaca, Mexico: ethnobotany and bioassays as a basis for phytochemical investigation. Phytomedicine 5:177–186.

———, **O. Sticher, and M. Heinrich.** 1998. Medical Ethnobotany of the Zapotecs of the Isthmus-Sierra (Oaxaca, Mexico): documentation and assessment of indigenous uses. Journal of Ethnopharmacology 62:149–165.

———, **O. Sticher, C. Viesca T., and M. Heinrich.** 1998. Medicinal and food plants: Isthmus Sierra Zapotec criteria for selection. Journal of Applied Botany 72:82–86.

Gomez-Pompa, A., T. C. Whitmore, and M. Hadley, eds. 1991. Rain forest regeneration and management. MAB Series, Vol. 6. The Parthenon Pub. Group Washington, D. C., USA.

Grimes, A., S. Loomis, P. Jahnige, M. Burnham, K. Onthank, R. Alarcon, W. Palacios C., C. Cerón M., D. Neil, M. Balick, B. Bennet, and R. Mendelsohn. 1994. Valuing the rainforest: the economic value of nontimber forest products in Ecuador. Ambio 23:405–410.

Haese, A. 1998. Arzneistoffsuche im Regenwald. Pharmazeutische Zeitung 143:1196–1201

Haller, R. 1994. Zona Zapoteca de la Sierra del Istmo (mapa)/Zapotec Area of the Isthmus Sierra (map). Swiss Federal Institute (ETH), Dept. of Cartography, Zürich.

Heinrich, M. 1989. Ethnobotanik der Tieflandmixe (Oaxaca, Mexico) und phytochemische Untersuchung von *Capraria biflora* L. (Scrophulariaceae). Dissertationes Botanicae No. 144. J. Cramer, Berlin und Stuttgart, Germany.

———. 1998. Indigenous concepts of medicinal plants IN Oaxaca, Mexico. Journal of Applied Botany 72: 75–81.

———, **and N. Antonio B.** 1993. Medicinal plants in a lowland Mixe Indian community (Oaxaca, Mexico): management of important resources. Angewandte Botanik 67:141–144.

———, **N. Antonio B., and M. Kuhnt.** 1992. Arzneipflanzen in Mexiko: Der Markt von Matías Romero. Deutsche Apotheker Zeitung. 132/8, 351–358.

———, **H. Rimpler, and N. Antonio B.** 1992. Indigenous phytotherapy of gastrointestinal disorders in a lowland Mixe community (Oaxaca, Mexico): etnopharmacological evaluation. Journal of Ethnopharmacology 36:63–80.

———, **A. Ankli, B. Frei, C. Weimann, and O. Sticher.** 1998. Medicinal plants in Mexico: healers' consensus and cultural importance. Social Science and Medicine 47:1863–1875.

———, **M. Robles, J. E. West, B. R. Ortiz de Montellano, and E. Rodriguez.** 1998. Ethnopharmacology of Mexican Asteraceae (Compositae). Annual Review of Pharmacology and Toxicology 38: 539–565

Heyer, E. 1988. Witterung und Klima. 8. Auflage, BSB B.G. Teubner Verlagsgesellschaft, Leipzig, Germany.

INEGI. 1993. Region Istmo, Oaxaca, Perfil Sociodemografico, XI Censo General de Población y Vivienda, 1990. Instituto Nacional de Estadística, Geografia Informática, Aguascalientes, México.

Kato, T., B. Frei, M. Heinrich, and O. Sticher. 1996. Antibacterial hydroperoxysterols from *Xanthosoma robustum.* Phytochemistry 41:1191–1195.

Leopold, A. 1950. Vegetation zones of Mexico. Ecology 31:507–518.

Lorence, D. H., and A. G. Mendoza. 1989. Oaxaca, Mexico. Pages 253–269 *in* D. G. Campbell and H. D. Hammond, eds., Floristic inventory of tropical countries. New York Botanical Garden, Bronx, New York.

Martin, G. J., A. L. Hoare, and D. A. Posey, eds. 1996. Protecting rights. People and plants handbook Issue 2, WWF, UNESCO, RGB, Kew, Paris, France.

Miranda, F., and E. Hernández X. 1963. Los tipos de vegetación de México y su clasificación. Boletín de la Socidad Botánica de México 28:29–179.

Posey, D. A. 1985. Native and indigenous guidelines for new Amazonian development strategies: understanding biological diversity through ethnoecology. Pages 156–181 *in* Hemming, J., ed., Changes in the Amazon Basin. Vol. I. Man's impact on forests and rivers. Manchester University Press, Manchester, UK.

Rzedowski, J. 1978. Vegetación de México. Editorial Limusa, México D.F., México.

Voeks, R. A. 1996. Tropical forest healers and habitat preference. Economic Botany 50:381–400.