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Knowledge and Use Value of Plant Species in a Rarámuri Community: A Gender Perspective for Conservation

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Abstract We used a quantitative ethnobotanical approach to analyze factors influencing the use value of plant species among men and women of the Rarámuri people in Cuiteco, Chihuahua, Mexico. We constructed a use value index (UV) combining the use frequency (*U*) and the quality perception (*Q*) of useful plant species by local people. We identified all plant species used by the Rarámuri and classified them into 14 general use categories. We interviewed 34 households in the village to compare men and women's knowledge on the five main general use categories (and on their respective subcategories and specific uses), to document how they practice gathering activities and to calculate scores of plants UV. A total of 226 useful plant species were identified, but only 12% of them had high *UV* scores for the 42 specific uses defined. When the overall knowledge of plant species was examined, no significant differences were detected between men and women, but significant differences were identified in general use categories such as medicinal plants, plants for construction and domestic goods, but not in plants used as food and firewood. We identified a division of labor in gathering activities associated with gender, with women mainly gathering medicinal and edible plants and being involved in preparing medicines and food, whereas men were primarily gathering and using plants for manufacturing domestic goods, firewood, and building materials. Plant species UV associated to gender were significantly different between men and women at the level of specific uses in the general category of domestic goods and building. Frequency of use is highly associated with plant species quality perception.

Keywords Use value · Cultural significance · Traditional knowledge · Gender · Division of labor · Non-timber forest products · Rarámuri · Sierra Tarahumara

Introduction

Indigenous peoples in Mexico make use of nearly 5,000 to 7,000 plant species (Casas *et al.* 1994; Caballero *et al.* 1998) as part of a strategy called by Toledo *et al.* (2003) "multiple uses of natural resources." Plants represent direct inputs to satisfy different household needs for food, medicine, materials for construction, fuel, or fodder (Alcorn 1984; Zizumbo-Villarreal and Colunga-Garciamarin 1993; Casas *et al.* 1994; Casas *et al.* 2001; Toledo *et al.* 2003), and some plant species may also contribute to monetary incomes through commercialization of plant products (Reyes-García *et al.* 2004; Smith 2005; Farfán *et al.* 2007; Pérez-Negrón and Casas 2007). However, people in any given community do not use and value all plant species equally, and consequently some researchers have argued that identifying the more relevant groups of plant species

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for local people may help in defining and implementing priorities for conservation and sustainable management strategies (Kvist *et al.* 2001; Dalle and Potvin 2004). From a gender perspective for instance, different authors have reported that preferences for useful plant species, as well as general interest in forest resources, can be different for men and women (Fortmann and Rocheleau 1984). This circumstance requires taking into account both men's and women's priorities in the design of management plans for natural resources. But it is particularly relevant for integrating women's perspectives in these processes, since women's opinions and needs are commonly neglected in the decision-making processes of forest management, as well as an unequal distribution of forest benefits (Skutsch 1986; Siddiqi 1989; Zorlu and Lutrell 2006).

Research assessing the differential cultural significance of plant species to human cultures has increased over the last decade, and some studies have constructed quantitative indices to analyze the relative cultural importance of plant species. For instance, Phillips and Gentry (1993) developed a Use Value Index, defined as the proportion of uses of plant species within a sample of interviewed people in Tambopata, Peru, to analyze relative differential meaning of plant resources among them. Other indices have considered aspects such as knowledge of utilitarian properties, use frequency, and local perception of plant resource abundance. In a pioneering work Turner (1988) developed the Index of Cultural Significance based on plant species quality (the contribution of a taxon to people's survival) and the intensity and exclusivity of use, to analyze lexical retention of plants names in two Interior Salish groups of British Columbia. Stoffle *et al.* (1990) developed the Ethnic Index of Cultural Significance, which included the notion of contemporary use of plants, and the plant parts used, as a way to define priorities for biodiversity conservation in the Yucca Mountain area, Nevada. Pieroni (2001) proposed the Cultural Food Significance Index, which considered taste appreciation and perception on plant species availability as indicators of the importance of edible plants used in Northwestern Tuscany, Italy. More recently, Reyes-García *et al.* (2006) developed a method to value plant species based on their cultural, practical, and economic characteristics. The authors integrated a total value index considering frequency of use, economic value, and observations of households' patterns of plant species use.

Quantitative studies of the cultural significance of plant species have been considered useful tools for ethnobotanical research oriented to understanding the reasons why humans interact with plants in different ways (González-Insuasti 2006). Quantitative methods allow for testing with statistical tools whether plant species are equally useful among respondents (Gomez-Beloz 2002), and make possible the analysis of whether different sectors of a social group know and value the same plant species differently, and the factors influencing such differences.

Anthropological studies suggest that age and gender determine intracultural variations in traditional knowledge and perception of plant species. For instance, among the Caiçaras from Brazil, Begossi *et al.* (2002) found that old people possess more detailed knowledge of medicinal plants than young people, and that women are key agents in the maintenance of local knowledge of folk medicine. Similarly, Voeks and Leony (2004) reported that women from a rural community in Bahia, Brazil, were significantly better informed than men about the names and medicinal properties of plant species. Differences in knowledge and perception between men and women have been partly explained as a consequence of the sexual division of labor in traditional societies (Jackson 1994) and because learning is culturally conditioned (Garro 1986).

In this study we analyze intracultural gender variations of knowledge and cultural significance of local plant species among the Rarámuri of the Village of Cuiteco (Cuiteco), Chihuahua, Mexico, based on a use value index integrating the use frequency and quality perception of useful plant species. Following insights from previous research showing that in traditional societies gender is a key factor influencing division of labor (Ahmed and Laarman 2000), we hypothesized that Rarámuri men and women would have differences in knowledge and forms of practicing gathering of useful plant species, and these differences in turn would determine different use values of plant species between men and women. Preliminary observations in the field suggested that the people of Cuiteco relate the use frequency of a plant species with its effectiveness to satisfy a given specific use, that is, its quality. Therefore, we also tested whether the use of resources is a function of their quality.

In sum, the purposes of this study are: (1) to identify (through a use value index) those plant species perceived by the Rarámuri of Cuiteco to be the most important to satisfy their subsistence needs, (2) to determine whether men and women have different knowledge and perceptions of use values of plant species, and if they practice gathering of plant products differently, (3) to analyze if use frequency is correlated with the quality perception of plant species, and (4) to analyze these elements to construct perspectives for conservation.

Study Area

The Sierra Tarahumara

The Sierra Tarahumara is the portion of the Sierra Madre Occidental in the state of Chihuahua, Mexico. It has an extension of 53,400 km^2, including 17 municipalities distributed into the regions called the *Alta* (highlands) and *Baja* (lowlands) *Tarahumara* (Fig. 1). In these regions, the Rarámuri (or Tarahumara), the Odami (or Tepehuan), the O'óba (or Pima), and the Warijios (or Guarojío) ethnic groups coexist with mestizo people (Sariego 2002). Indigenous people are nearly 19% of the total population, the Rarámuri being the main group (85.3% of indigenous people of the area) (INEGI 2000). According to the Mexican National Commission for Conservation and Use of Biodiversity (CONABIO), the Sierra Tarahumara is a priority region for conservation because of its diversity of human cultures and ecosystems (tropical dry oak and pine forests) and because of its biogeographic importance (Arriaga *et al.* 2000). Arriaga *et al.* (2000) consider the Sierra Tarahumara has a high value as a biological corridor of the *Pinus arizonica* and *P. duranguensis* complex and as a center of origin and diversification of the genus *Pinus*. Although the flora of the Sierra Madre Occidental is still one of the most poorly documented in Mexico (Dávila and Ramírez 1991), Bye (1995) has recorded nearly 1,900 plant species of vascular plants in the Sierra Madre region.

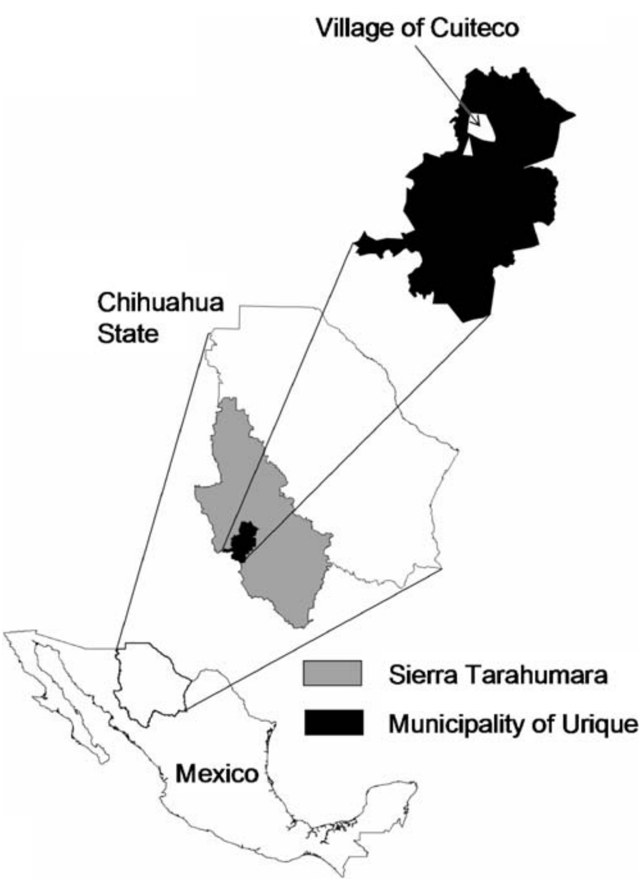

Fig. 1 Map of the study area. The Ejido Cuiteco within the context of the municipality of Urique, in the Sierra Tarahumara, Chihuahua, Northern Mexico

The Sierra Tarahumara is one of the largest forested regions in Northern Mexico (Felger and Wilson 1995), and timber extraction has been the main goal of forest management in the area (Guerrero *et al.* 2002). Industrial exploitation of forest has been conducted for at least 200 years, causing deforestation, loss of biodiversity, soil erosion, poverty, and sociocultural conflicts among indigenous communities (Felger and Wilson 1995; Lammertink *et al.* 1997; Guerrero *et al.* 2002).

According to Vatant (1990), in the Rarámuri conception "*la tierra*" (the agricultural land where the basic edible products are obtained) is the main source of resources for subsistence. However, non-crop products are commonly included in the diet, for instance Bye (1981) noted that the Rarámuri diet, based on the major crops, is complemented by nearly 120 species of wild or weedy edible plants called "*guiribá*," the traditional greens. Forests are considered the secondary source of resources by the Rarámuri (Vatant 1990), mainly plant products such as fiber, domestic goods, materials for construction, firewood, and medicines. Ethnobotanical studies by Pennington (1974), Bye (1976), and Felger and Wilson (1995) have documented that the Rarámuri of the Sierra Tarahumara use more than 1,000 plant species as food, for ceremonial use and drugs, medicine, fiber and textiles, domestic goods, and materials for construction among other uses, and that most of them are obtained from the forest.

The Village of Cuiteco

This study was conducted at Cuiteco, municipality of Urique, in the Sierra Tarahumara (Fig. 1). Cuiteco has an area of 8,561 ha, with elevations ranging from 1,700 to 2,575 m. Climate is temperate, subhumid with an annual average of 900 mm of rainfall. Vegetation types include pine forest dominated by *Pinus arizonica* var. *arizonica*, *P. ayacahuite*, and *P. chihuahuana*; oak-pine forests dominated by *Quercus coccolobifolia*, *Q. arizonica*, *Q. mcvaughii*, *Arbutus arizonica*, and *A. xalapensis*; and riparian vegetation dominated by *Cupressus lusitanica*, *Alnus acuminata* subsp. *arguta*, and *Abies* sp.

In 2001, the population of Cuiteco was 535 people, 455 Rarámuri (in 75 households) and 80 mestizo (in 15 households). The main activities of the Rarámuri households are: (1) agriculture, including seasonal cropping of maize, beans, potato, wheat, pea, and oat, and cultivation of perennial plants (mainly apple, peach, plum, quince, fig, and walnut); (2) employment on industrial farms of apple, tomato, potato, and sugar cane in the States of Cihuahua, Sinaloa and Sonora; (3) small-scale animal husbandry (mainly goats); (4) extraction of non-timber forest products, and (5) other labor such as brickwork, carpentry or seasonal migration to work in the city of Chihuahua.

Research Methods

Ethnobotanical Studies

Ethnobotanical research and collection of botanical samples were conducted between 2002 and 2004 with the collaboration of Rarámuri *campesinos* (subsistence farmers). Collecting trails were defined, covering the following vegetation types at Cuiteco: (a) secondary vegetation dominated by *Juniperus* sp., (b) pine–oak forest, (c) pine forest, and (d) riparian vegetation. Also, the following agricultural areas were sampled: (a) crop fields (mainly maize and bean fields), (b) fallow fields (locally called *barbechos*), and (3) orchards (mainly those oriented to produce apples and peaches, which are the most extensive in the village). Information about local nomenclature, use, and management of collected specimens was obtained through meetings including a workgroup comprised of 22 Rarámuri *campesinos* (12 men and 10 women) with experience and interest in traditional plant species uses. Voucher specimens under Camou collection numbers were deposited in a local community herbarium at Cuiteco, the National Herbarium of Mexico (MEXU), the herbarium of the Universidad Autónoma de Chihuahua (UACH), and the herbarium of the Instituto de Ecología, A. C., Centro Regional del Bajío (IEB), Mexico.

Interviews

We conducted structured interviews (Martin 1995; Sandoval 1996) with men and women of 34 Rarámuri households (45% of the total). The sample included 34 women and 25 men. The average male age was 51, while the average female age was 48 years old.

We classified the ethnobotanical information according to general categories of plant species uses defined by the Rarámuri *campesinos* of the workgroup referred to above (Table 1), and for the interviews we selected the main categories of medicine, food, domestic goods, fuel and building. These general categories were also classified by the Rarámuri *campesinos* of the workgroup into subcategories, which in turn were classified into specific uses (Table 2). During interviews men and women were requested separately to spontaneously name all plants more frequently used for every specific use described in Table 2. We considered the frequency of plants was mentioned to be a measure of use frequency (U). Based on this list of frequently used plants, a second set of questions was asked, including the naming of species considered to be the most effective for every specific use. Frequency of naming was considered a measure of the quality of plants (Q) as perceived by informants.

In a last section of the interview, informants were also requested to specify which of the plants mentioned they usually harvest.

Data Analysis

Knowledge

To evaluate differences in knowledge of plant species we compared the number of species cited by men and women for the five main categories of use selected (Appendix). Dependent samples t test and Wilcoxon signed rank test (StatSoft 2003) were performed. Shapiro–Wilk's W normality tests were used to analyze data distribution.

Use Value

To assess plant species use value we considered the frequency of use (U) and the local perception of quality (Q). We defined U as the proportion of positive mentions of plant species for a particular use, divided by the total number of interviews (Pieroni 2001; Ladio and Lozada 2000; Ladio and Lozada 2001; Ladio and Lozada 2004). For instance, if to the question: *which are the plants that you use to cure flu*? Seven of the 25 men interviewed mentioned "*poleo*" (*Mentha pulegium*), *poleo's* U value was calculated as: 7/25=0.28. The overall U of plant species was calculated as the total of all its U values ($U=\Sigma U_{1\ldots n}$). As in the example above, if U values of *poleo* were 0.280 (for flu) and 0.120 (for cough), overall *poleo's* U value was 0.400.

The local perception of quality (Q) of plant species was calculated as the proportion of positive mentions of quality with respect to the total number of interviews. As in the example cited above, if to the question: *which is in your opinion the best plant to cure flu*? *poleo* had ten mentions, its Q was calculated as: 10/25=0.40. The overall Q of plant species was calculated as the total of all its Q values ($Q=\Sigma Q_{1\ldots n}$).

Table 1 Useful Plants Per General Category of Use in Cuiteco, Chihuahua, Mexico

General category of use	Number of species	Percentage[a]
Medicine	116	31.1
Fodder	89	23.9
Food	56	15.0
Domestic goods	35	9.4
Firewood	31	8.3
Building materials	21	5.6
Ornamental	10	2.7
Ritual	5	1.3
Tannins	3	0.8
Colorants	2	0.5
Poisons	2	0.5
Glue	1	0.3
Resins	1	0.3
Natural fiber	1	0.3

[a] Includes species with more than one use (n=373 spp.)

Table 2 Subcategories and Specific Uses of the Main Categories of Use of Plants at Cuiteco

General category	Sub-category	Specific use
Medicine	Circulatory system	Blood pressure
		Hemorrhage
	Gastrointestinal	Diarrhea
		Indigestion
		Stomach ache
	Infectious	Dysentery
		Fever
		Malaria
		Measles
		Parasites
	Muscular	Muscular pain
		Rheumatism
		Sprain[a]
	Respiratory system	Bronchitis
		Cold
		Cough
		Flu
		Gullet pain
	Urinary system	Mal de orín[b]
Food	Food	Condiments
		Fruits
		Others[c]
		Quelites[d]
Domestic goods	Handcrafts	Guitar
		Tambourine
		Toothpick[e]
		Violin
		Wood ball
	Tools	Axe handle
		Plough
		Yoke
	Utensils	Broom
		Spoon
		Tray
		Ware[f]
Firewood	Firewood	Bread
		Charcoal
		Domestic use
		Pottery
Building materials	Building materials	Beams
		Boards
		Pole

[a] Sprain specific use includes strokes, no often they are not considered normally in biomedicine as muscular problems
[b] Urinary system illness related to a bacterial infection
[c] Includes flowers, roots and edible stems
[d] Quelites: wild edible
[e] Toothpick made of wood used in a traditional women's game
[f] Ware: basket

An index of overall use value (OUV) was calculated as the product of men and women's *U* and *Q* values of plant species, including all its specific uses (Appendix):

$$\mathrm{OUV}_{spp1} = \sum\left(\mathrm{MWU}_{spp1}\right) \times \sum\left(\mathrm{MWQ}_{spp1}\right)$$

where MWU are men's and women's values of plant species frequency of use, and MWQ are men and women values of plant species quality. We multiplied the *U* and *Q* components in order to amplify variations (Turner 1988; Stoffle *et al.* 1990; Pieroni 2001 and Reyes-García *et al.* 2006).

An overall men's (MUV) and women's (WUV) use value of plant species was calculated separately, and Wilcoxon signed rank tests were performed to test differences between them.

To find relevant plant species at the level of specific uses, a Specific Use Value index (SUV) was calculated, taking into account men's and women's *U* and *Q* values, independently for each plant species specific uses described. As above, differences between men's and women's SUV were compared through Wilcoxon signed rank tests.

Correlations

To test if use of plant species is a function of local perception of quality, pairwise correlations between MWU and MWQ were analyzed through Spearman rank order tests.

Results

Useful Plant Species Among the Rarámuri of Cuiteco

We collected a total of 812 botanical specimens that corresponded to 88 families, 227 genera and 356 species of plants. The richest families were Asteraceae with 61 plant species (17.1% of the total), Fabaceae (35 species, 9.8%), Poaceae (31 species, 8.7%), Fagaceae (15 species, 4.2%), Lamiaceae (13 species, 3.7%), and Cyperaceae and Ericaceae (9 species, 2.5%; Fig. 2). Local people used 226 plant species (nearly 63% of all plant species identified) for 14 general use categories (Table 1). A total of 122 plant species were reported as having medicinal uses (31.1% of all useful species), followed by those used as fodder (89 species, 22.7%), edible plants (66 species, 16.8%), domestic goods (38 species, 9.7%), firewood (31 species, 7.9%), and building materials (21 species, 5.4%).

Within the categories selected for the evaluation of plant species use value (medicine, food, domestic goods, firewood and building materials), a total of 12 subcategories of use and 42 specific uses were recorded (Table 2). Nearly 20.5% of medicinal plants are used to treat diseases related to the respiratory system, 16.1% for the treatment of infectious diseases (dysentery or malaria), 13.7% for the treatment of gastrointestinal diseases, and 11.2% for muscular problems. Almost 47.1% of edible plants are consumed as fresh fruit, 25.0% are used as *quelites,* the traditional greens, 7.4% are condiments, 5.9% are used to prepare beverages, and 4.4% to prepare fermented beverages. Nearly 46.8% of plant species in the domestic goods category are used for manufacturing handcrafts,

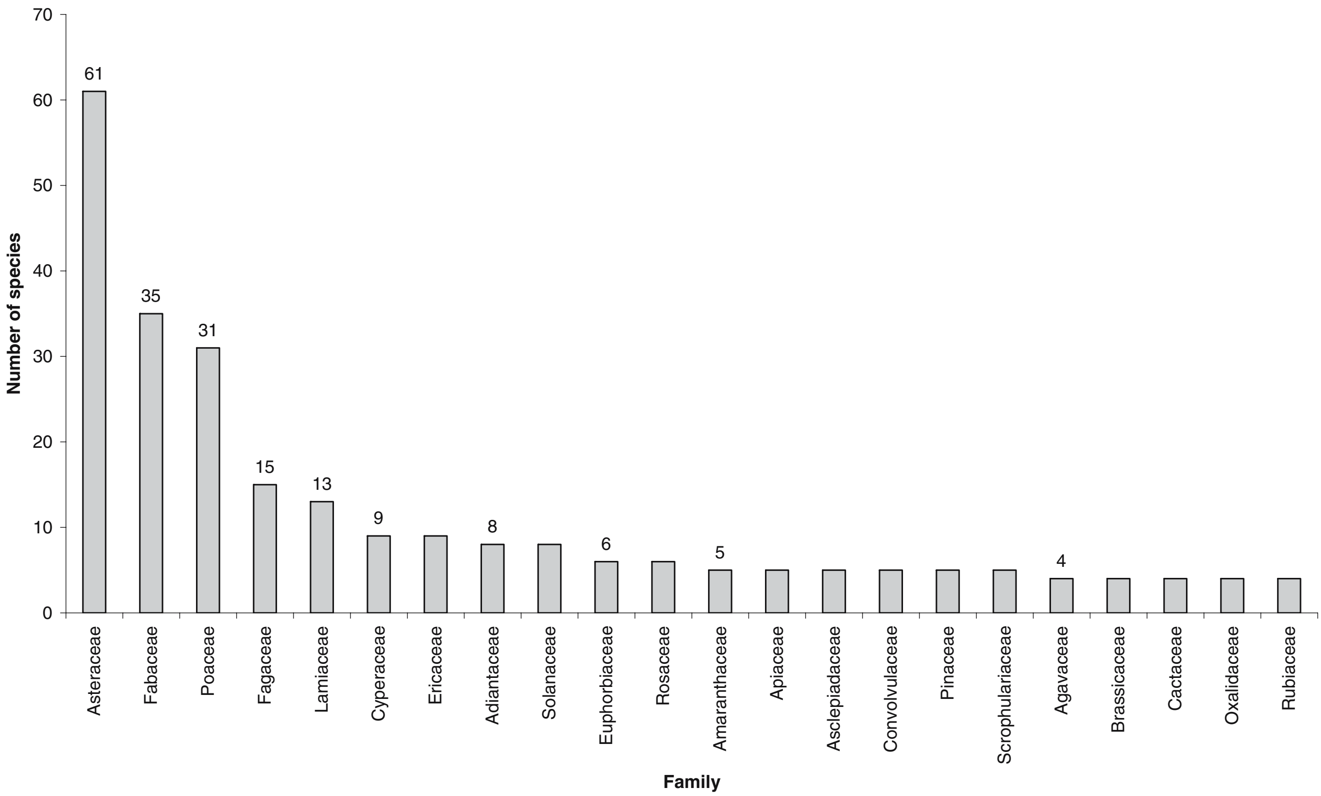

Fig. 2 Number of species by main botanic family described for Cuiteco

32.3% for making tools, and 21.0% for manufacturing utensils used in daily life. Plant species used as firewood were classified into those for domestic use (35.8%), mainly for cooking, boiling water, and heating houses during winter time, those used to craft pottery (23.5%), to produce charcoal (21.0%), and to bake bread (19.8%). Nearly 70% of plant species used as building materials is used to make poles, 16.7% for beams and 13.3% for boards.

Harvest of Plant Species

On average, Rarámuri households use 33.6±10 plant species for 17.3±4 specific uses. Men harvest an average of 20.5±7 plant species for household requirements whereas women harvest an average of 15.7±6. Men contribute 46% of medicinal plants and 47% of edible plants, whereas women contribute 54 and 53%, respectively (Fig. 3). The contribution of men is higher than that of women in the harvest of plant species used to make domestic goods (men harvest 74% of plant species for these purposes, whereas women harvest 26%), firewood (71 and 29%), and building materials (92 and 8%) respectively (Fig. 3).

Men's and Women's Knowledge of Plant Species

Table 3 summarizes the knowledge of useful plant species by men and women for the general categories of use selected. Rarámuri men mentioned an average of 23.3±7 (mean±standard deviation) useful plant species per person whereas Rarámuri women mentioned an average of 20.9±6 plant species per person, and no significant differences were found (Student's test, T_{23}=1.4, p=0.163). However, analyzing citation of plant species by general category of use, we found that women mentioned significantly more medicinal plants (10.0±5) than men (7.2±3; Student's test, T_{23}=−2.8, p=0.011). We also found that men referred to significantly more plant species (3.4±1) for building houses or fences than women (1.8±2; Wilcoxon test, n=24, z=3.2, p=0.001). Men also cited significantly more (3.0±2) plants used to craft domestic goods than women (1.4±1; Wilcoxon test, n=24, z=3.3, p=0.001). No differences were found between responses in relation to edible plants (Wilcoxon test, n=24, z=1.1, p=0.277), nor in relation to plants used as firewood (Wilcoxon test, n=24, z=1.4, p=0.162).

Overall Use Value of Plant Species (OUV)

Appendix shows the information on plant species OUV (the product of men's and women's U and Q values of plant species). A total of 87 species were referred to. The highest *OUV* scores were found in multipurpose plant species such as pines (*OUV*=9.540) and *Juniperus depeana* (*OUV*= 7.913), used in the general categories of medicine, domestic goods, firewood and building, as well as oaks (OUV=

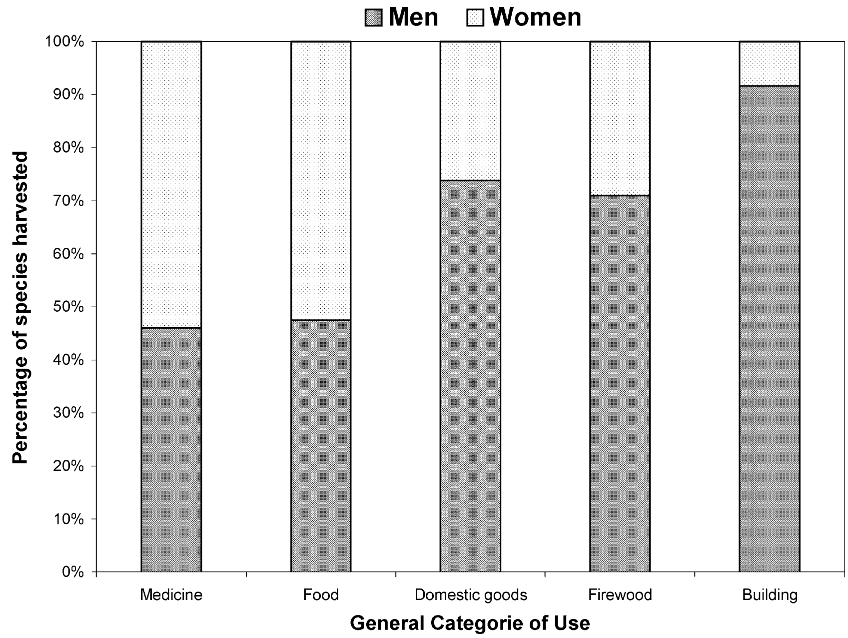

Fig. 3 Percentage of plant species harvested by men and women at household level

3.215) used in the categories of food, domestic goods, firewood, and building. However, some mono-purpose plant species had also high *OUV* scores. Among them, *Zornia reticulata* (OUV=4.078), *Ligusticum porteri* (OUV=1.498), and *Cosmos pringlei* (OUV=1.426) with a medicinal use, and *Brassica campestris* (OUV=2.495), *Lippia graveolens* (OUV=1.540), and *Amaranthus hybridus* (OUV=1.177), used as food. The remaining 89% plant species analyzed had OUV scores between 0.001 and 0.655.

Differences in Man's Use Value (MUV) and Women's Use Value (WUV) of Plant Species

No significant differences at the 95% statistical level were found when MUV and WUV were generally compared (Wilcoxon test, n=87, Z=0.6, p=0.537). However, significant differences were identified when scores for particular plant species were compared. For instance, we found that *Zornia reticulata* used for treating respiratory diseases had a higher use value for women, whereas *Cosmos pringlei* used for gastrointestinal disorders had a higher use value for men (Appendix). Edible plant species such as *Lepidium virginicum*, *Arctostaphylos pungens*, and *Nasturium officinale*, also had higher use value for women, whereas *Amaranthus hybridus* and *Portulaca oleracea* had higher use value for men. *Fraxinus uhdei*, and *Alnus acuminata* subsp. *arguta*, which are used for the elaboration of tools and utensils, had higher use value for men, whereas *Dasylirion leiophyllum*, used for crafting baskets had a higher use value for women (Appendix). *Juniperus deppeana*, used for building fences, pine species used for construction of houses, and oak species used as firewood were more valued by men (Appendix).

Specific Use Value of Plant Species (SUV)

The 28 plant species with the highest SUV scores in each specific use satisfy all the 42 specific uses described. Among the most important medicinal plant species are

Table 3 Differences in Knowledge of Plant Species Between Men and Women

	Men		Women		*T*	*Z*	*P* value
	Average	SD	Average	SD			
Medicinal	7.2	3	10.0	5	−2.8	–	0.011[a]
Food	6.1	2	5.7	2	–	1.1	0.277
Firewood	3.6	3	3.0	2	–	1.4	0.162
Domestic goods	3.0	2	1.4	1	–	3.3	0.001[a]
Building	3.4	1	1.8	2	–	3.2	0.001[a]

[a] Marked correlations are significant at p<0.05

Zornia reticulata (*chinowí*) (*SUV*=1.543) used for respiratory illnesses (flu), *Cosmos pringlei* (*asarépuri*; SUV=0.197) used for gastrointestinal disorders as diarrhea, and *Ligusticum porteri* (*wasia*; SUV=0.097) used for rheumatism problems.

The highest SUV of edible plant species used as greens (or *quelites*) were for *B. campestris* (*quelite mostaza*, SUV=2.495), *Amaranthus hybridus* (*wasorí*, SUV=1.177), *Portulaca oleracea* (*verdolaga*, SUV=0.425), and *Lepidium virginicum* (*rochiwari*, SUV=0.210). Among plants used as condiments, *Lippia graveolens* (*oregana*, SUV=1.460) had the highest SUV, followed by *Capsicum annuum* (*chiltepín*, SUV=0.058), whereas fruits of *Arctostaphylos pungens* (*iwii*, SUV=0.228) had a high SUV along with fruits of *Opuntia* sp., (*wirá*, SUV=0.205), and *Arbutus arizonica* (*urusi*, *SUV*=0.017). Edible flowers of *Agave bovicornuta* (*imé*, SUV=0.153) had a high SUV, followed by the edible stems of *Opuntia* sp. (SUV=0.130).

The most important plant species used for handcrafts is *Alnus acuminata* (*ropjgá*, SUV=0.118) used to make the "*bola*" (woody ball) for the traditional Rarámuri "ball race". The most important species used to make tools is *Fraxinus uhdei* (*uuré*, SUV=0.348), which is used for axe handles, as well as *Quercus crassifolia* (*rojá*, SUV=0.109), used for manufacturing the "*arado*" (plough) tool. *Dasylirion leiophyllum* (*repsó*, SUV=0.206), and *Nolina* sp. (*palmilla*, SUV=0.037), mainly used to craft baskets also had high SUV scores.

Species of the genus *Quercus* had in general the highest SUV for firewood. *Quercus crassifolia* (*u'turi*, SUV=0.036) and *Juniperus deppeana* (*auarí*, SUV=0.008) are the most important species for charcoal specific use. *Quercus crassifolia* (SUV=0.481) had the highest SUV for domestic firewood. *Juniperus deppeana* had the highest SUV (1.257) for poles used in fence building and pine species are in general the most important for making beams and boards.

Differences in Specific Use Value (SUV) Between Men and Women

No significant differences were found when SUV between men and women were compared in the general use categories of: (1) medicine (Wilcoxon test, n=171, z=1.6, p=0.115); (2) food (Wilcoxon test, n=29, z=0.4, p=0.681), and (3) firewood (Wilcoxon test, n=36, z=0.4, p=0.657). But differences were significant in the general category of domestic goods (Wilcoxon test, n=35, z=2.7, p=0.007), and building (Wilcoxon test, n=14, z=2.2, p=0.028). Plant species used for the elaboration of utensils, tools and handcrafts were more important for men, with the exception of plant species used for basket-making (*ware*), which were more valuable for women. Plant species included within the building category had a higher SUV for men.

Correlation Between Use Frequency (U) and Quality (Q)

We found a strong positive correlation between frequency of use and quality perception of plant species (Spearman=0.899; $t(N-2)$=18.9; p=0.000). However, in some cases plant species were frequently used but had low perceived quality. For instance, *Arbutus arizonica*, *Arbutus xalapensis*, *Arctostaphylos pungens*, *Alnus acuminata*, and *Juniperus deppeana,* are frequently used as firewood even when they are perceived as being low quality compared with oak species.

Discussion and Conclusions

Significance of Plant Species

The use value index defined through use frequency and quality perception allows identification of the relative importance of useful plant species among the Rarámuri of Cuiteco. From a total of 226 useful plant species, 87 (38.4%) were categorized using the overall use value index. We found that 28 plant species (12% of all useful plants recorded) had the highest scores of specific use value for the specific uses mentioned.

The results of this study help to identify some useful plant species that should be considered as priorities for management and conservation, as suggested by Kvist (2001). Our study identified *Zornia reticulata*, *Ligusticum porteri*, *Amaranthus hybridus*, *Portulaca oleracea*, *Alnus acuminata, Lepidium virginicum*, *Lippia graveolens* and *Cosmos pringlei* as having high overall use value but according to our field data (to be published elsewhere) these plant species have a restricted distribution and a low abundance. In the case of the edible weeds, *Amaranthus hybridus, Lepidium virginicum* and *Portulaca oleracea,* increasing their distribution and abundance could be managed by dispersing their seeds within crop fields, similar to the management of these species by the Mixtec and Nahua people from the Balsas River basin reported by Casas *et al.* (1996). LaRoche and Berkes (2003) noted that the Rarámuri of other areas practice harvest techniques of edible greens that are effective in maintaining their populations. These techniques could be used in the design of strategies for conservation of these weedy species.

For commercial harvesting *Ligusticum porteri* and *Lippia graveolens* are relatively scarce wild plant species. Their high overall use value and low availability might create high pressure on them, and these species should therefore be a priority in management plans. In these cases, their long-term maintenance would require the development of strategies of sustainable harvest based on traditional management techniques and studies of population ecology such as those developed by Olmsted and Álvarez-Buylla

(1995), Martínez-Ballesté *et al.* (2005), López-Hoffman *et al.* (2006), Pulido *et al.* (2007), and González-Insuasti and Caballero (2007). These studies have demonstrated the utility of defining harvest rates that allow maintenance of population growth, identifying cohorts of the populations to be protected and guiding practices directed at population recovery.

The hierarchy of plants found through our use value index corresponds to the criteria developed for this study, guiding questions according to particular plant species use categories that, although defined by the participants, were selected from our own perspective as researchers, and this may bias our findings. For instance, we did not consider categories such as ritual or sacred uses, or others that could be relevant in Rarámuri cosmology. Analyzing only utilitarian categories could be limiting our understanding of overall plant species significance. As Stoffle *et al.* (1990) pointed out, it is important to discern the way in which local people define their most important plants species. Further studies should address the question of use value taking categories defined as significant by the participants.

Within each category of use, a set of plant species with low use value was identified. These low values could have been so historically, but according to Stoffle *et al.* (1990) and Pieroni (2001), low values of plant species significance may also be associated with processes of losing traditional uses of plants. For instance, some plant species could have decreased their value due to generational changes of preferences, transformation of actual patterns of use, and probably the diminishing of traditional local knowledge. In our study we documented the case of *Allium longifolium* (the *cebollín*) which had the lowest specific use value score as condiment. The *cebollín* was described by Bye (1976) as an important food resource, especially when Rarámuri's cultivated supplies were low. Bye (1976) and Bye (1993) also described how the Rarámuri's gathering techniques for this plant species might increase its population numbers. This fact reinforces the idea that the *cebollín* could have had high value in the past. As has been pointed out by other authors, highly used plant species may be subject to a variety of gathering techniques designed to improve productivity (Casas *et al.* 1999). Although we did not analyze the past use of plants, we can tentatively hypothesize that the low use value recorded in this study for this plant species and the current absence of conservative gathering might be due to a decrease in the use and knowledge of *cebollín* over time. This example illustrates that use value is dynamic, changing through time in a human group or between sectors of a human group at a given time.

Other expressions of changing life needs and habits may be reflected in the disappearance of some specific uses. For instance, the manufacture of guitars, violins and drums is currently restricted to only a few families in Cuiteco. Other cases are the substitution of plant products by commercial non-plant products. For instance, domestic utensils made of wood such as spoons or trays, have now been replaced by steel or plastic utensils.

Low use value scores of plant species could also be associated in part with their scarcity. As pointed out by Benz *et al.* (1994), the use of a plant resource is a function of its abundance, with more abundant species being more extensively used. In other words, the low use value of some plant species could be related to their scarcity or the decrease of their populations. However, we documented some cases of plant species with high use value and low availability, as referred to above. This particular situation could also motivate the use of plant species with a low use value in response to the difficulty in obtaining preferred ones, as in the case of firewood. Therefore it would be relevant to conduct studies to evaluate ecological factors influencing valuation of plant species.

Intracultural Variation and Gender Perspective

Among issues of intracultural variation, documenting the local, systematic distribution of knowledge is particularly relevant since different social sectors are repositories of particular knowledge (see Boster 1985). In our study, Rarámuri men and women from Cuiteco showed differential knowledge about useful plant species, with men having more knowledge on construction and domestic goods, while women had more knowledge on medicinal plants (see Table 4). We found also that men and women had similar knowledge of plant species used as food and firewood. This appears to confirm the occurrence of intracultural variations of plant species knowledge associated with gender, as found by other authors (Boster 1985;

Table 4 Summary of Differences in Knowledge, Harvest and Specific Use Value (SUV), of Plant Species Between Men and Women

Knowledge			Harvest			SUV		
Men		Women	Men		Women	Men		Women
Medicine	<	Medicine	Medicine	<	Medicine	Medicine	=	Medicine
Food	=	Food	Food	<	Food	Food	=	Food
Domestic goods	>	Domestic goods	Domestic goods	>	Domestic goods	Domestic goods	>	Domestic goods
Firewood	=	Firewood	Firewood	>	Firewood	Firewood	=	Firewood
Building materials	>	Building materials	Building materials	>	Building materials	Building materials	>	Building materials

Begossi *et al.* 2002; Voeks and Leony 2004), and we identified the specific categories of use in which gender accounted for the differences (Table 4). However, we argue that other social conditions such as age, kin residency, and personal experience, among others (Boster 1985), should also be taken into account for further studies for a more precise characterization and understanding of the structure of knowledge among the Rarámuri.

Another important issue of intracultural variation is related to the differential roles of social sectors. Analysis of social and economic roles from a gender perspective becomes crucial to identify the function of men and women in the processes of social development (Flores 1997). In relation to the use and management of natural resources, recognition of the specific activities of men and women is particularly important in defining their specific needs and roles in the design of strategies of sustainable management and conservation of ecosystems (see Jackson 1994). In our case study, the research was focused on documenting how the division of labor determines roles in obtaining plant products. We found that for some groups of plant species, men's and women's knowledge appears to be in accord with the gender division of labor in gathering activities. For instance, women know more plants for specific medicinal uses and also they have a major responsibility in harvesting medicinal plants (Table 4). On the other hand, men are more familiar with plants used for making domestic goods (axe handles, trays, and spoons) and for construction of houses and fences, and they also have a major role in harvesting and working with these plants (Table 4).

However, it is not possible to identify the pattern referred to above in all groups of plants. Our study shows, for instance, that men and women have similar knowledge about edible plants, even when women are more involved in gathering edible plants and preparing food. Similarly, men and women have relatively equal knowledge of plants used as firewood, even when men are more involved in firewood extraction (Table 4). In part, the division of labor could be accounted for by the fact that some activities demand high physical energy, defining them as male activities (Ahmen and Laarman 2000), such as obtaining plant species used as building materials and firewood extraction.

Evaluation of plant species use priorities from a gender perspective in our case study was based on the comparison of the use value index between men and women. Statistical differences were found at the level of the specific use value index (SUV) particularly in the general categories of domestic goods and building, were men's SUV are higher than women's SUV.

Differences and similarities detected in scores of use value could be hypothetically associated with a lower or higher importance, respectively, of the household's subsistence activities. For instance, procurement of food, health and firewood constitute crucial activities in the daily life and are basic activities for the household's subsistence. Plant resources obtained from these activities are similarly valued by men and women, whereas plant resources destined to satisfy complementary or more specific needs (for instance handicraft and tool manufacturing), or important needs requiring only sporadic action (for instance house construction and repair) are differentially valued by men and women. This explanation seems to be appropriate when subsistence depends mainly on a regime of self sufficiency, but the question arises in subsistence regimes more influenced by markets as to how monetary benefits obtained through commercialization of plant products influences the valuation of plant species. In this case study, for instance, a pertinent question is whether handcrafts highly is demand in the market could influence more significantly the use value of plant species used for this purpose.

The hypotheses tested in our current analysis could be examined in further studies, using similar methods. Such an approach would provide more robust information to analyze the consistency of the patterns found in our study.

Our study accounts for the analysis of cultural variations of knowledge, harvest activities and plant species preferences associated with gender in a small rural community. Differences between men and women seem to guide complementary actions oriented to household requirements. Nevertheless, differences in the cultural meaning of plants between men and women are significant in specific groups of useful plant species. The relation between spatial availability and intensity of use associated with cultural meaning of plant species may be significant for making decisions on management and conservation. But cultural meaning is not homogeneous among social groups and therefore consensuses about what to conserve need to be constructed. Studies of gender perspectives reveal for example, which plant species are relevant for women to conserve in such processes of consensus building. Similarly, examining other factors influencing the social structure of rural communities such as age, language, economic activities, and migration among others, would allow more precise explanation of causes of intracultural variation of plant species valuation and may contribute the inclusion of the perceptions of other social sectors in decision-making on management of plant resources.

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Appendix

Table 5 Use Value of Plant Species at Cuiteco, Chiuahua Mexico

Species	Rarámuri name	Use[a]	OUV	MUV	WUV	Voucher specimens[b]
Pinus chihuahuana Engelm., *Pinus arizonica* Engelm	Oko (pino)	1, 3, 4, 5	9.540	3.040	1.800	27, 145, 269, 562, 593, 750, 759, 789, 791, 803, 804
Juniperus deppeana Steud	Auarí (Táscate)	1, 3, 4, 5	7.913	2.304	1.675	17, 37, 52, 122, 186, 226, 695, 729, 754, 802
Zornia reticulata J.E. Smith	Chinowí (h. de la víbora)	1	4.078	0.571	1.597	34, 46, 307
Quercus arizonica Sarg., *Quercus coccolobifolia* Trel., *Quercus crassifolia* Humb. et Bonpl., *Quercus pungens* Liebm., *Quercus scytophylla* Liebm., *Quercus tarahumara* Spellenb., J.R. Bacon, Breedlove., *Quercus viminea* Trel.	Rojá (encino)	2, 3, 4, 5	3.215	1.555	0.296	10, 11, 13, 19, 38, 72, 95, 153, 154, 209, 230, 405, 406, 407, 421, 447, 467, 470, 471, 564, 565, 605, 636, 637, 639, 718, 719, 720, 749, 751, 752, 753, 755, 756, 757, 760, 798
Brassica campestris L.	Quelite mostaza	2	2.495	0.640	0.606	504, 517, 555
Quercus crassifolia Humb. et Bonpl.	U'turi	1, 3, 4	2.250	1.000	0.250	637
Lippia graveolens H.B.K.	Oregana (orégano)	2	1.540	0.333	0.441	42, 60, 100, 323, 444
Ligusticum porteri Coult. and Rose	Wasia (chuchupate)	1	1.498	0.374	0.375	179, 780
Cosmos pringlei B.L. Rob. & Fernald	Asarépuri (babiza)	1	1.426	0.403	0.312	305
Amaranthus hybridus L.	Wasorí (quelite de agua)	2	1.177	0.346	0.242	290, 389, 500, 820
Opuntia sp.	Wirá (nopal)	2	0.665	0.250	0.099	344
Alnus acuminata subsp. *arguta* (Schlecht.) Furlow	Ropjgá (carnero)	3	0.530	0.432	0.004	117, 174, 677, 399
Fraxinus uhdei (Wenzig) Lingelsh.	Uuré (fresno)	3	0.476	0.435	0.001	246
Portulaca oleracea (L.) Corral –Díaz	Verdolaga	1, 2	0.472	0.144	0.090	341, 822
Iostephane heteropylla (Cav.) Hemsl.	Soili (escorcionera)	1	0.463	0.112	0.119	432
Arctostaphylos pungens Kunth.	Iwii (manzanilla)	1, 3, 4	0.450	0.019	0.283	12, 53, 155, 164, 185, 232, 730, 758, 763, 793
Mentha canadensis L.	Bahuena (hierbabuena)	1	0.342	0.072	0.099	74, 325
Quercus viminea Trel.	Achíchuri (encino negro)	3, 4	0.324	0.134	0.036	11, 639, 718, 752, 755
Mentha pulegium L.	Chopewiri (poleo)	1	0.311	0.096	0.060	401, 449
Dasylirion leiophyllum Engelm. ex Trel.	Repsó (sotol)	1, 3	0.299	0.000	0.279	494
Tagetes sp.	Manzanilla	1	0.261	0.032	0.110	81, 97
Hintonia latiflora (Sessé & Moc. Ex DC.) Bullock	Copalquín	1	0.220	0.077	0.037	n/a
Lepidium virginicum L.	Rochíhuari	2	0.210	0.013	0.103	371, 829
Agave bovicornuta Gentry	Imé (maguey)	1, 2	0.178	0.058	0.033	28
Punica granatum L.	Granada	1	0.159	0.002	0.129	Photographic register
Nasturium officinale R. Br.	Basagori (berro)	1, 2	0.148	0.006	0.088	73
Artemisa ludoviciana Nutt.	Chijpuí (estafiate)	1	0.138	0.078	0.008	89
Gnaphalium sp.	Gordolobo	1	0.132	0.010	0.071	5, 249, 873, 874
Quercus arizonica Sarg.	Mapaka	3, 4	0.130	0.086	0.004	154, 209, 230, 470, 605, 720, 751
Quercus scytophylla Liebm.	Bawitiga	3, 4, 5	0.125	0.053	0.014	72, 95, 407, 447, 564, 636
Eucalyptus sp.	Eucalipto	1	0.107	0.005	0.066	Photographic register
Chenopodium berlandieri Moq.	Chuyaca (quelite cenizo)	2	0.094	0.016	0.022	Photographic register
Pinus chihuahuana Engelm.	Sawaco	3, 5	0.070	0.064	0.000	27, 145, 269, 562, 593, 759, 791, 804

Table 5 (continued)

Species	Rarámuri name	Use[a]	OUV	MUV	WUV	Voucher specimens[b]
Berlandiera lyrata ssp. macrophylla Benth.	Kornía (coronilla)	1	0.069	0.026	0.009	333
Marrubium vulgare L.	Matranza (manrubio)	1	0.066	0.019	0.014	90, 92, 556
Prionoscidium madrense S. Wats.	Sarabiki	2	0.065	0.014	0.018	280, 349
Capsicum annuum var *glabriusculum* (Dunal) Heiser & Pickersgill	Chiltepin	2	0.058	0.016	0.013	n/a
Pinus arizonica Engelm.	Rosácame	5	0.058	0.014	0.015	750, 789, 803
Zexmenia podocephala (A. Gray) K. Becker	Rellochari (pionía)	1	0.052	0.010	0.017	45, 191, 219, 251, 228, 658, 747
Coriandrum sativum L.	Cilantro	1, 2	0.047	0.006	0.018	Photographic register
Heteroteca inuloides Cass.	Árnica	1	0.043	0.038	0.000	1, 516, 521, 324, 497
Ruta chalepensis L.	Ruda	1	0.041	0.000	0.041	Photographic register
Muhlenbergia montana (Nutt.) Hitchc.	Pichira (popote)	3	0.040	0.003	0.029	148, 259
Nolina sp.	Palmilla	3	0.037	0.002	0.023	Photographic register
Arbutus arizonica (A. Gray) Sarg.	Urusi (madroño)	2	0.036	0.000	0.025	16, 54, 469, 796
Sisymbrium wootonii Robinson	Wasaka (quelite palmito)	2	0.034	0.010	0.007	Photographic register
Packera candidissima (E.L. Greene) W. Weber & Löve	Chuká (chucaca)	1	0.033	0.006	0.009	558
Penstemon barbatus Torr	San Pedro	1	0.033	0.014	0.004	50, 162, 177, 233, 737
Iostephane madrensis (S. Wats.) Strother	Cachana	1	0.030	0.019	0.000	253
Chenopodium ambrosioides (L.)	Basote (epazote)	1	0.016	0.002	0.007	340
Arbutus arizonica (A. Gray) Sarg., *Arbutus xalapensis* H.B.K.	Madroño	3	0.028	0.000	0.018	14, 16, 54, 55, 236, 258, 463, 469, 640, 641, 761, 762, 796
Psacalium decompositum (A. Gray) H. Robins & Brett.	Matarike	1	0.026	0.019	0.000	85, 570
Equisetum sp.	Cola de caballo	1	0.022	0.003	0.008	Photographic register
Cupressus arizonica Greene.	Wa'a	1, 3, 4	0.020	0.003	0.007	83, 111, 396, 427
Phoradendum sp.	Guchoy	1	0.019	0.019	0.000	56, 68, 102
Loeselia mexicana (Lam.) Brand.	San Antonio	1	0.017	0.003	0.006	Photographic register
Quercus tarahumara Spellenb. J.R. Bacon. Breedlove	Rocua	3, 4	0.014	0.014	0.000	19, 405, 757, 760, 798
Prunus serotina var. *capuli* (Cav.) McVaugh	Usabi (capulín)	1, 2, 3,	0.014	0.003	0.004	116
Arbutus xalapensis H.B.K.	Rocró	3	0.012	0.010	0.000	14, 55, 236, 258, 463, 640, 641, 761, 762
Quercus coccolobifolia Trel.	Amawi	4	0.012	0.000	0.003	13, 38, 153, 421, 565, 753, 756
Haematoxylon brasiletto Karst.	Palo brazil	1	0.010	0.002	0.004	n/a
Persea sp.	Aguacate	1	0.008	0.000	0.008	n/a
Unidentified	Chuales	2	0.008	0.003	0.001	140
Physalis phyladelpica Lam.	Romate (tomatillo)	1	0.007	0.002	0.002	377, 503, 520, 810, 812
Quercus pungens Liebm.	Epéchuri	4	0.007	0.005	0.000	10, 406, 467, 471, 719, 749
Litsea glaucescens L.	Laurel	1	0.007	0.002	0.002	Photographic register
Cinnamomum zeilaniccum Ness.	Canela	1	0.006	0.000	0.006	n/a
Chimaphila maculata (L.) Pursh	Cayetano	1	0.006	0.006	0.000	18, 40, 143, 165, 238, 722
Juglans sp.	Nogal	1	0.004	0.000	0.004	345
Allium scaposum Benth.	Richihui (cebollín)	2	0.004	0.003	0.000	Photographic register
Cucurbita foetidissima H.B.K.	Calabacilla	1	0.004	0.000	0.004	36
Piper nigrum L.	Pimienta	1	0.003	0.000	0.002	n/a
Anoda cristata (L.) Schlecht.	Rewé (Malva)	1	0.003	0.000	0.002	351, 378, 518
Salix sp.	Wactosí (sauce)	4	0.003	0.003	0.000	93, 357
Tagetes micrantha Cav.	Anísi (anis)	1	0.003	0.000	0.002	98, 373
Bursera grandifolia Engl.	Palo mulato	4	0.002	0.000	0.001	n/a
Echinocereus sp.	Pitaya	1	0.002	0.002	0.000	n/a

Table 5 (continued)

Species	Rarámuri name	Use[a]	OUV	MUV	WUV	Voucher specimens[b]
Abies durangensis Martínez	Mateó (pinabete)	3	0.002	0.002	0.000	120, 525
Yucca schottii Engelm.	Socó	3	0.002	0.000	0.002	124
Rumex acetosella L.	Acasií (lengua de vaca)	1	0.002	0.002	0.000	84, 321, 478, 824
Chenopodium graveolens Willd.	Sorío (h. del zorrillo)	1	0.002	0.002	0.000	91, 336
Alternanthera caracasana H.B.K.	Gaichokri	1	0.001	0.000	0.001	79, 819
Baccharis thesioides Kunth	Hierba del pasmo	1	0.001	0.000	0.001	63, 166, 606
Larrea tridentata (DC.) Coville	Gobernadora	1	0.001	0.000	0.001	n/a
Eryngium heterophyllum Engelm.	Remó (hierba del sapo)	1	0.001	0.000	0.001	4, 274, 304
Buddleia sp.	Mjtói (tepozán)	1	0.001	0.000	0.001	33, 329
Solanum rostratum Dunal.	Satre muki (mala mujer)	1	0.001	0.000	0.001	395, 831

[a] Medicinal (1); food (2); domestic goods (3); firewood (4); building (5)
[b] Voucher specimens under Camou collection numbers
[c] No available at Cuiteco. This plant species are not found in the area of Cuiteco and are obtained by local households trough commercial relations whit other regions
OUV: Overall Use Value; MUV: Men Use Value; WUV: Women Use Value. The Table is Arranged from the Highest to the Lowest Species OUV

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