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Article

Caracterización del aprovechamiento de leña en una comunidad *Me'phaa* de la Montaña de Guerrero

Characterization of the use of firewood in a *Me'phaa* community in the Mountain of *de Guerrero*

Ariadna Mozo Ocegueda[1]
Marisa Silva Aparicio[1*]

Resumen

En las comunidades de la Montaña de Guerrero, la leña es uno de los bienes más importantes que proporciona el bosque; no obstante, cada una de ellas tiene sus particularidades de empleo. El objetivo de este trabajo fue caracterizar su uso y consumo en una comunidad *Me'phaa* ubicada en dicha región. Se aplicó una encuesta en 39 hogares. Para calcular la cantidad leña usada se utilizaron métodos directos e indirectos. Los resultados indican que 100 % de los encuestados utilizan dicho recurso como combustible principal y su abastecimiento se da a través de la recolecta en terrenos propios, ubicados a una distancia media de 2 km de la vivienda al sitio de extracción. La tasa de consumo promedio obtenida con el método indirecto es de 2.11 kg persona^{-1} día^{-1}, y 2.01 kg persona^{-1} día^{-1} de manera directa. El gasto de leña es mayor en el mes agosto (2.34 kg persona^{-1} día^{-1}) y, en general, en los meses con más precipitación y bajas temperaturas. Las especies utilizadas incluyen al elite (*Alnus acuminata*), encinos (*Quercus* spp.), pino ocote (*Pinus* sp.) y el café (*Coffea arabica*); la preferida es *Q. magnoliifolia*, ya que forma brasa y no produce mucho humo. El aprovechamiento de la leña está sujeto al reglamento ejidal y al interno de la comunidad. Los resultados indican la necesidad de establecer estrategias para atender la posible pérdida de la cobertura vegetal en La Ciénega, a causa de la extracción de la leña.

Palabras clave: Brasero, combustible, especies para leña, normas comunitarias, *Quercus magnoliifolia* Née, recolecta de leña.

Abstract

In the communities of the Mountain of *Guerrero*, firewood is one of the most important goods provided by the forest; however, each of them has its own employment characteristics. The objective of this work was to characterize its use and consumption in a *Me'phaa* community located in that region. A survey was

applied in 39 households. Direct and indirect methods were used to calculate the amount of firewood used. The results indicate that 100 % of the respondents use this resource as the main fuel and its supply is through the collection on their own land, located at an average distance of 2 km from the house to the extraction site. The average consumption rate obtained with the indirect method is 2.11 kg person-1 day^{-1}, and 2.01 kg person^{-1} day^{-1} directly. The cost of firewood is higher in the month of August (2.34 kg person^{-1} day^{-1}) and generally in the months with more precipitation and low temperatures. The species used include the elite (*Alnus acuminata*), holm oaks (*Quercus* spp.), ocote pine (*Pinus* sp.) and coffee (*Coffea arabica*); the preferred one is *Q. magnoliifolia*, as it forms ember and does not produce much smoke. The use of firewood is subject to the internal regulations of the community and the ejidal. The results of this work indicate the need to establish strategies to address the possible loss of plant cover in La Ciénega, due to the extraction of firewood.

Key words: Brazier, fuel, firewood species, community standards, *Quercus magnoliifolia* Née, firewood harvesting.

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Universidad Intercultural del Estado de Guerrero. México.
*Autor para correspondencia; correo-e: marucha21048@gmail.com

Introduction

Firewood is a primary source of domestic energy for the rural population in many developing countries, and is used by approximately 2.6 billion people to meet part of their basic needs, including heating their home, cooking food, boiling water for human consumption, (Baeribameng *et al*., 2020). It is also used in small industries, such as brick kilns, pottery workshops, and bakeries (Masera and Fuentes, 2006).

In Mexico, 4 million homes (11 %) use firewood or charcoal; this consumption, by 28 million inhabitants (Díaz, 2000), accounts for 38 million cubic meters per year, representing 40 % of the total energy used in the country (Inegi, 2018). Most (66 %) of the energy produced by firewood corresponds to the states of *Campeche, Chiapas,*

Guanajuato, Guerrero, Hidalgo, Michoacán, Oaxaca, Puebla, Querétaro, Tabasco, Veracruz and *Yucatán*. The average national consumption is 2.1 to 3.0 kg inhabitant^{-1} day^{-1} (Quiroz *et al*., 2009). According to the intercensal survey of INEGI (2015), 44.4 % of households in the state of *Guerrero* used firewood or charcoal. The exclusive and mixed consumption of this fuel in 2010 amounted to 1 254 058 t (Masera *et al*., 2010), and firewood is used exclusively for cooking in 21 municipalities, among them *Malinaltepec* (in fifth place), with 95.9 % of the consumers (INEGI, 2010).

Studies on the effect of firewood extraction on forest dynamics in the Mountain of *Guerrero* region are limited; however, this effect is known to depend on such factors as the amount of biomass extracted, the relationship with the ecosystem's recovery time, the origin of the material collected, among others (Bailis *et al*., 2015). Likewise, the social repercussions of their use are complex; for example, Masera *et al*. (2005) point out the potential relationship of poverty and marginalization with the increased use of firewood. Also, important cultural elements are involved, since, according to Masera *et al*. (2010), even when families have access to other fuels, they continue to use firewood for cooking traditional dishes. The use of this resource also causes respiratory health problems, which are ranked as the third leading cause of premature deaths in developing countries (Lagunes-Díaz *et al*., 2015).

Most of the communities in the Mountain of *Guerrero* have high poverty rates, and their inhabitants are dependent on forest resources for firewood (Salgado-Terrones *et al*., 2017). However, despite the relevance of the issue, the consumption rates are still unknown, and it has not yet been determined whether or not they may represent a danger to the region's ecosystems. The objective of this study was to estimate the per capita consumption rate and determine the preference of tree and shrub species used as fuel in the community of *La Ciénega*, located in the municipality of *Malinaltepec*, in the state of *Guerrero*.

Materials and Methods

Study area

La Ciénega is located in the eastern part of the state of *Guerrero*, in the Mountain region, between 17º13'10" N and 98º37'34" W, at an 2 050 masl (Figure 1). The climate of the community is semi-warm A (C) sub-humid w (w) with rainfall in summer, a mean annual temperature between 18 and 22 °C, and an annual precipitation of 1 100 to 2 000 mm (INEGI, 2015).

The community's most important protected area is a mountain called *Tata Bègò* (*San Marcos*, or Rain Mountain), with oak-pine forests and secondary vegetation. The main economic activity of its inhabitants is agriculture, and the population is composed of 549 inhabitants belonging to the *Me'phaa* indigenous group (INEGI, 2015).

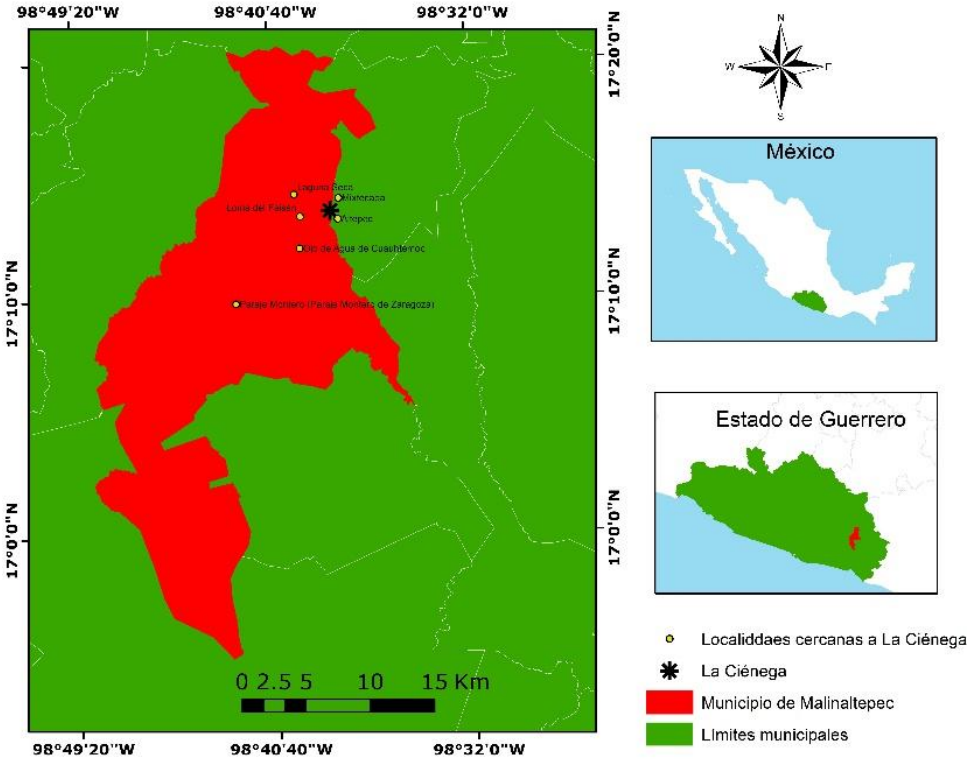


Figure 1. Location of the community of *La Ciénega*, *Malinaltepec* municipality, *Guerrero.*

Data collection

In order to learn about the use and exploitation of firewood, a questionnaire was randomly applied to 39 heads of household (32 women and 7 men), with an average age of 42 years (min 25-max 80). Of those who answered the survey, 77 % were housewives, 8 % were peasants and 15 % were employees. In addition, 35 of the respondents have communal rights, and four are *avecindados*. The questions included in this tool collected information on the family unit (number of members, occupation, schooling); type of fuel used, preferred species, method of acquisition, sites, distance traveled for collection, quantity used weekly, and exploration of the norms that regulate the use of this resource.

Estimation of firewood consumption rates

The firewood consumption rate was estimated using indirect and direct methods. For the former, the questionnaire applied in the 39 households was used, which included questions on the amount consumed (loads, truckload, rick, bundle, etc.) over a year; the conversion of the above-mentioned units was made by weighing the firewood contained in a pickup truck and a wheelbarrow (measurements used in the *La Ciénega* community). For the direct assessment, the participation of the surveyed families was requested, and the method suggested by Holz and Ramírez-Marcial was used (2011). The initial weight (with a 0.01 g Weiheng Brand digital hanging scale) of the firewood to be used during three days and the final weight were obtained to determine the amount consumed during that period; this was done

systematically during six months (starting in March). The following formula was used to measure the consumption per person per day (Holz and Ramírez-Marcial, 2011):

$$DF = \frac{(Fi - Ff)}{P * T} \qquad (1)$$

Where:

DF = Daily firewood consumption

Fi = Kilograms of firewood at initial weighing

Ff = Kilograms of firewood at final weighing

P = Number of people living in the household

T = Number of days between *Fi* and *Ff*

Taxonomic determination of species

Botanical material of the species used for firewood was collected, pressed and herborized according to the method suggested by Lot and Chiang (1986). The collected specimens were taxonomically determined based on dichotomous keys of the flora of the region (Valencia *et al*., 2002) and deposited in the botanical collections of the *Universidad Intercultural del estado de Guerrero* and the *Universidad Autónoma de Guerrero.*

Data analysis

Statistical analysis was performed with the SPSS v20 software. Mean tests (ANOVA) were applied with a significance level of *P* = 0.05 in order to verify the existence of

differences between the direct and indirect measurements of firewood. In a similar way, Tukey's test was used with a significance level of $P < 0.05$ to recognize differences between consumption rates by month.

Results and Discussion

Fuel use

La Ciénega is a town governed by customs and traditions, including those related to the preparation of food over a wood fire, which is one of the many reasons why this fuel is indispensable in most of the *Me'phaa* communities in the region. In the present study it was determined that 100 % of the respondents use firewood; also for 69 % of them, the use is exclusive, and 31 % combine it with LP gas (liquefied petroleum gas), which has a high cost ($ 568.00 per 20 kg cylinder). It is difficult for the inhabitants of the area to buy LP gas due to their low income and because the area where they live is not easily accessible.

Firewood is used to cook all types of food; however, when complemented with gas, it is used only to prepare food that requires considerable time for cooking (such as *nixtamal, tortillas, pozole,* among others), while gas is used to heat food, to prepare a sauce, or for preparations that do not demand much time on the fire. Of all the heads of household interviewed, 71.7 % use an open brazier, which is made up of three stones placed in the shape of a triangle, which, in turn, support the base for the *comal* or pan; 31.5 % use the closed brazier, and only 5.1 % use the energy-saving stove (Figure 2).

Figure 2. A) Open or three-stone brazier; B) Round or closed brazier; C) Wood-saving stove.

The results of the surveys show that firewood is the main fuel for the study community; a situation that, according to Díaz and Masera (2003), is present in various regions of the country, as it provides 80 % of the energy used in rural households. In addition, Quiroz *et al.* (2009) indicate that the decision to use this energy resource is an effect of cultural (uses and customs), social, and biological factors that influence the level of income, cost, transportation, family capacity for extraction, availability, number of species used, the heat generated, and the scarcity or abundance of smoke during combustion. Likewise, the results of this work are consistent with what was recorded in three communities in the Montaña region of *Guerrero* by Salgado-Terrones *et al.* (2017), who warn that firewood is the basic fuel for families; while, gas is complementary.

In a similar way, in other regions such as the *Zoque* region of central *Chiapas*, Escobar-Ocampo *et al.* (2009) observed that 100 % of the population consumes firewood and only 37 % combine it with gas. However, Contreras-Hinojosa *et al.* (2003) document that in a town of the state of *Oaxaca*, 18 % of their interviewees consume exclusively firewood, and 82 % alternate it with LP gas, which they attribute to the easy accessibility of the town and the purchasing power of its inhabitants.

As for the use of braziers, the open brazier was the most common in *La Ciénega*, in spite of its low efficiency, for, according to Masera *et al*. (2011), this type of stove consumes more firewood because it burns inefficiently and emits a large amount of substances that are harmful to health and to the environment, and, therefore, affects the quality of life of the families. Despite the above, its use prevails in several communities (Escobar-Ocampo *et al.,* 2009).

The inhabitants of *La Ciénega* pointed out that its construction is easy and does not imply any extra expense. On the other hand, the energy-saving stove promoted by programs such as the Special Program for Food Security (SPFS) and Integrated Ecosystem Management (IEM) has not been adopted.

In this regard, Flores (2016) indicates that the adoption of technology is a complex process, in which the economic situation is relevant, as it forces people to be extremely cautious when it comes to adopting an innovation, precisely because of the investment involved (even if it is minimal). In addition, he points out that the use of the energy-saving stove requires different handling, since it is necessary to use dry firewood (which is not always available) and the size of the piece must be small, which means more work. On the other hand, the climatic conditions of *La Ciénega* (very cold winters and abundant rainfall in summer) may limit the use of this technological alternative. Soares (2006) mentions that these stoves may not be appropriate for places with such climatic conditions, since traditional stoves, in addition to cooking food, also heat the house in winter and dry the family members when they return from their work wet from the rain in summer, a scenario present in the study community.

Acquisition of firewood

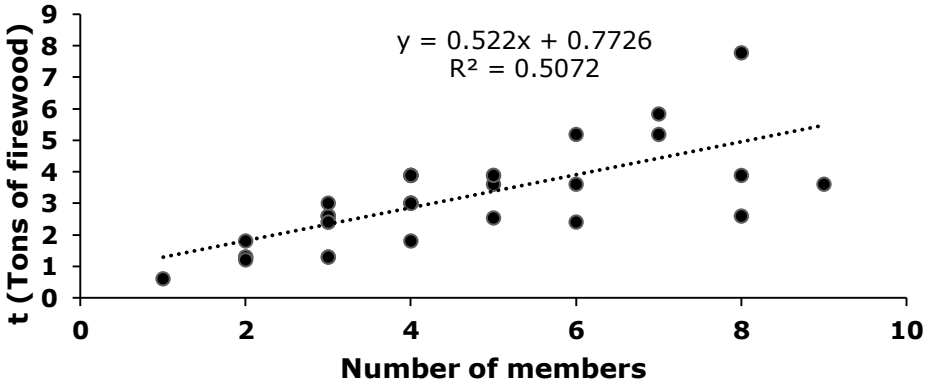
The form of firewood supply in rural communities differs according to the surrounding context (Quiroz-Carranza and Orellana, 2010). Extraction is mainly for self-supply purposes and is carried out by the users themselves; however, firewood

is also obtained through purchase from people who fix the price considering the labor for cutting and transportation (Escobar-Ocampo *et al.,* 2009).

In the *La Ciénega* community, firewood is obtained by collection (71.7 %), purchase (15.3 %), and, in some cases (12.8 %), both.

The purchase is carried out in the community itself, and the suppliers deliver it to the home. It is also available in the neighboring towns of *Loma del Faisán* and *Laguna Seca* (located at a distance of 2 and 4 km, respectively). Sellers belong to nearby communities, such as *Paraje Montero, Ojo de Agua, Mixtecapa*, and *Altepec*; they also buy from friends or relatives from *La Ciénega* who have land from which to extract it, but this is rare. The measures used locally to purchase firewood are the "wheelbarrow" and "pickup truck", at a cost of $ 50.00 and $ 800.00 pesos, respectively. Purchases are made every three months, with an average of 2.90 t year^{-1} (minimum 1.29 - maximum 5.18 t year^{-1}). The buyers, according to the surveys, are either residents or those who work outside the community; the former because they have no rights to the common areas, and the latter because they lack the time to collect the goods.

Firewood is extracted within the community; 88.2 % is obtained from their own land, and 8.8 %, from common areas. The amount collected per family, according to the interviews, is related to the number of family members (R = 0.71 and R^2 = 0.5072) (Figure 3). On average, 3.0 t of firewood are collected per year per family.



Source: interviews with 39 heads of household.

Figure 3. Correlation between the number of family members and the amount of firewood collected per family in the community of *La Ciénega*.

In this regard, Reyes-Matamoros (2016) records that in *San Nicolás Huajuapan, Puebla*, 91.42 % collect their firewood. Quiroz-Carranza and Orellana (2010) document that 39.3 % of firewood is bought from woodcutters; 53.3 % is collected from vegetated areas; 4.2 %, from the milpa area, and 3.0 %, from the plot of land.

The means of transport from the collection site to the home are the wheelbarrow (44.2 %) and pickup truck (55.8 %). In studies such as that of Quiroz-Carranza and Orellana (2010), transportation is by tricycle, bicycle, and mule-drawn cart Camou *et al.* (2006) report that in two micro-regions of the *Sierra Tarahumara*, the main means of transport are the truck, pack animals, and the back of the users. Differences in the means of transportation used in different regions are related to the social and environmental context. In *La Ciénega*, there are a large number of paths to reach the collection sites; on the main road or highway, a wheelbarrow or pickup truck is used, depending on the amount collected.

Likewise, 70.5 % of the respondents stated that harvesting is a job carried out by men, involving the search for extraction sites and the transfer to the home; 8.8 % indicated that this function corresponds to men, women and children; 12.7 % stated that women carry out this task; and 12.7 % stated that women carry out this task. Several authors (Rocheleau *et al*., 1996; Jackson, 1998) state that firewood collection is determined by the power relations within the household, the productive activities carried out by its members, the proportion of men and women in the family unit, and the physical capacity of its members; however, these conditions are specific to each region.

In *La Ciénega,* men are in charge of firewood extraction, because it is an activity

that requires physical strength for cutting (in some cases) and transportation. Ruiz-Meza (2006) cite that in households where the mother and children perform this work, this is due to the configuration of the family and coincides with the absence of the father, as in most cases he is responsible for the supply of firewood to the household.

Harvested firewood includes live and dead material, which involves pruning branches and cutting the standing tree. In *La Ciénega*, 23.5 % of respondents collect dry firewood, 26.4 % cut the tree, 17.6 % prune green branches and collect dry material, 32.3 % collect dry firewood and cut the tree. Although they say they prefer to collect it dry, it is hardly available, as the population has almost doubled due to the installation of a higher education institution in the community, increasing the demand. For this reason, its inhabitants cut live trees (mainly alders and oaks), choosing first old or pest-damaged individuals.

In the community 94.1 % of the respondents prefer to collect firewood in the dry season (December-May), since during this period the plant material is dry and lighter and can be used immediately; also, green firewood dries faster and can be stored to be used with the firewood collected during the rainy season (which is wet).

The results of the present study differ from those documented by Quiroz-Carranza and Orellana (2010), according to whom in 65 % of their cases the type of material collected are dry branches detached from the standing tree, 14.2 % are green branches and trunks, and 1.9 % corresponds to felling of the entire tree. The differences are due to the fact that in the six communities studied in *Yucatán*, 42.4 % use firewood combined with gas, 3.9 % use charcoal, and 2.6 % use other fuels (oil, cardboard, sawdust, etc.). Quiroz-Carranza and Orellana (2010) also point out that extraction is constant and, therefore, collection of dead plant material is unlikely.

The distance traveled from the home to the collection site varied, 25 % mentioned walking one kilometer, 41 % two kilometers, 23 % three kilometers and 11 % four

kilometers. The difference responds to the location of the land of each respondent; besides, the collection is not always done in the same place, so they must look for other spaces with availability of resources. The routes traveled by the inhabitants of *La Ciénega* reflect difficulties in acquiring supplies; nevertheless, they are accustomed to these routes, which is why they do not consider that they have a supply issue. Thus, the daily routine and the smooth supply dispel scarcity-related thoughts.

In other research, the effect of different social contexts is observed; thus Silva-Aparicio *et al.* (2018), point out that in the agrarian nuclei of *San Pedro Huamelula, San Marcos Arteaga* and *Unión Zapata*, located in the state of *Oaxaca*, 62 % of respondents indicate not having problems getting firewood: in the first nucleus, they have high availability; in the second, they have the purchasing power to buy LP gas. However, in the third, 44 % of those interviewed mentioned having no conflicts, while 56 % said that they have to travel long distances in order to collect good quality firewood, so that they sometimes substitute it with residues from other plants, such as agave (*Agave* spp.).

The inhabitants of *La Ciénega* also use "residues" from the pruning of coffee trees; however, this is performed only once a year. The members of the community are still selective with the species used for firewood, which may reflect the availability of the resource; however, the distance traveled for collection is increasing, and the existence of suppliers of this fuel indicates changes in the dynamics of the forests; i.e., the abundance of species used for firewood is decreasing.

Species used for firewood

The species recorded as used for firewood belong to four botanical families: Fagaceae, Pinaceae, Betulacea, and Rubiaceae. *Alnus acuminata* Kunth (Andean alder) is the most widely used species in the community, according to respondents

it is abundant and, therefore, easier to find. However, they prefer red oak (*Quercus magnoliifolia* Née), because it forms embers (Table 1).

Table 1. Species used for firewood by the inhabitants of the *La Ciénega* community.

Family	Species	Common Name	Name in the *Me'phaa* language	Frequency of use	Order of preference	Reasons for use
Betulaceae	*Alnus acuminata* Kunth	Andean alder	Íxe gro'on	1	2	It is easy to obtain
Fagaceae	*Quercus elliptica* Née	White oak	Chabun'	3	3	Generates embers
Fagaceae	*Q. magnoliifolia* Née	Red oak	Xtamaña	2	1	Generates embers
Fagaceae	*Q. martinezii* C.H. Mull.	Black oak	Íxe guku	4	4	Generates embers
Fagaceae	*Quercus* sp.	Oak	Íxe guku	6	6	Generates embers
Rubiaceae	*Cofea arabica* L.	Coffee	Íxe kafe	5	5	Availability due to pruning
Pinaceae	*Pinus* sp.	Ocote Pine	Xti' kha rondo	7	7	Easy to light

The results coincide with those reported by Contreras-Hinojosa *et al.* (2003) and Salgado-Terrones *et al.* (2017) who indicate *Quercus* spp. as the preferred ones for firewood, because their wood is "solid" and hard. Gual *et al*. (2020) note that there are 1 285 species of vascular plants that are used for fuel, but the families Fabaceae, with 257 taxa, and Fagaceae, with 94 taxa, stand out as the preferred families. The different preferences are related to the type of climate and vegetation that predominates in each place, as well as to the altitude at which they develop. In *La Ciénega,* although *Q. magnoliifolia* Née individuals are among the most preferred; the villagers mention that whether the trees are used on an occasional or a constant basis depends on their availability.

Firewood consumption rate in the community of *La Ciénega*

The firewood consumption rate estimated with the direct method was 2.01±0.003 kg person^{-1} day^{-1} ($\bar{X}$=2.0, S=0.02); whereas, with the indirect method, it was 2.11± 0.071 kg person^{-1} day^{-1} ($\bar{X}$=2.11, S=0.44). Both exhibited significant differences ($t_{(gl=38)}$ =-1.312, P<0.05) in consumption according to the method utilized. In monthly consumption (March to August), differences were also obtained in the following months (F=961.9, P<0.05); Tukey's test indicated such discrepancies for the months of May to August, when consumption increased; however, the difference was not significant between March and April (period with low rainfall) (Table 2).

Table 2. Monthly firewood consumption (person^{-1} day^{-1}) in *La Ciénega.*

Months	Average consumption (person^{-1} day^{-1})	Minimum temperatura (°C)	Average temperatura (°C)	Monthly precipitation (mm)
March	1.738	6	25.9	7.0
April	1.755	8	27.3	10.0
May	1.863	9	26.1	196.5
June	2.160	10	23.9	566.5
July	2.245	8	22.7	389.0
August	2.349	9	22.9	709.4

The consumption recorded herein differs from that cited by Quiroz-Carranza and Orellana (2010), who estimated between 1.26 and 2.89 kg person^{-1} day^{-1} in six localities in *Yucatán*. Contreras-Hinojosa *et al*. (2003) registered 1.8 kg person^{-1} day^{-1} in *Yanhuitlán, Oaxaca*. The differences in per capita firewood consumption by community are due to the particular characteristics of each region, as well as to the combination of the use of firewood and LP gas, the type of combustion device used, the availability of firewood, cultural patterns on the uses, and the customs of the

communities themselves. In addition, the amount of firewood used per family depends on the number of meals prepared during the day, the number of family members, and the time during which the stove remains lit (Del Amo, 2002; Del Amo and Yllescas, 2002; Arias-Chalico, 2002).

Masera *et al*. (2010) classify the per capita firewood consumption by exclusive users in Mexico by macro-region as follows: for the humid tropics, the consumption is 3.0 kg inhab^{-1} day^{-1}; in the dry tropics, 2.5 kg inhab^{-1} day^{-1}; in temperate zones, 2.0 to 2.5 kg inhab^{-1} day^{-1}; semi-arid zones, from 1.5 to 2.5 kg inhab^{-1} day^{-1}; in the wetlands, from 2.5 to 2.5 kg inhab^{-1} day^{-1}, and others from 1.5 to 2.5 kg inhab^{-1} day^{-1}. The community of *La Ciénega* is located in the temperate ecological microregion, and its per capita firewood consumption coincides with the most frequently cited intervals.

The per capita consumption rates estimated by the direct and indirect methods showed significant differences of 2.11± 0.071 kg of firewood person^{-1} day^{-1}; and 2.01 ±0.003 kg person^{-1} day^{-1}, respectively. These discrepancies may be related to data variation due to the uncertainty of the respondents' answers, since some of the families buy and extract firewood periodically, which complicates the estimation. However, the technique of direct weighing of firewood consumed in a given time allowed a more accurate assessment than indirect estimates (Holz and Ramírez-Marcial, 2011).

Monthly firewood consumption (March to August) in the community exhibited significant differences (F=961.9, P<0.05). Tukey's test indicated that they occur from May to August, months in which precipitation increases and temperature decreases. The values are similar to those of Camou *et al.* (2006), who estimate a per capita consumption rate of 4.85 kg person^{-1} day^{-1} in the cold season (October to February), and of 2.7 ± 1.6 kg in July, during the warm period (March to September). The decrease in firewood consumption corresponds to the increase in temperature, and the opposite occurs in the cold months. Similarly, in a study conducted in eight communities of *Chenalhó, Chiapas*, Ramírez-López *et al.* (2012) indicate that firewood

consumption for the dry season is 3.7 ±1.5 kg person^{-1} day^{-1} and 3.9 ± 2.7 kg person^{-1} day^{-1} in the rainy season, i.e. the consumption of firewood increases with the presence of rainfall, since family members stay longer in the kitchen to dry or heat themselves, as rainfall lowers the temperature. Also, in the cold season, it is necessary to use more heat to heat the home and food and, therefore, a larger amount of firewood is used.

Community standards for the use of firewood

The community of *La Ciénega* has an internal regulation, which establishes rules for the extraction of firewood. In the interviews, 92.3 % of the heads of household mentioned the prohibition of tree cutting on the Tata Bègò or Rain Mountain as the most important; 7.6 % indicated that they were not aware of any rules for the use of this resource. Other rules included in the internal regulations are:

1. The extraction or cutting of trees for firewood that are on land belonging to the community shall be based on a request for permission to the Commissariat.
2. Trees must not be removed from protected areas, such as the *Tata Bègò* Mountain.
3. It is forbidden to cut green and young trees in areas of common use.
4. Trees on other owners' land must not be removed without authorization. This includes not entering sites belonging to other communities adjacent to *La Ciénega* for the purpose of to cutting or collecting firewood.

The surveyed population also mentioned the regulations to be followed by the community and whose application is the responsibility of the Commissariat of communal goods of *Malinaltepec*, which sets out the standard for applying for a

permit to remove large or old trees.

On the other hand, 96.3 % of the inhabitants of *La Ciénega* say that they have noticed a decrease in tree resources, which they attribute to the increase in the demand for firewood extraction, which in turn causes the excessive cutting of trees, resulting in the loss of vegetation cover, which also affects the regeneration of the species collected as firewood. However, they also indicate that they have carried out reforestation of fast-growing trees useful for firewood, which helps to maintain the forests.

Conclusions

Firewood is the main fuel for the inhabitants of the community of *La Ciénega,* and they depend on the vegetation areas that exist within their territory for their supply and for meeting their daily needs. The use of the open brazier prevails, despite its low efficiency. The average per capita consumption of its inhabitants (2.01 kg person^{-1} day^{-1}) coincides with the ranges recorded for the temperate zones of Mexico (2.0 kg person^{-1} day^{-1}). The plant species used for firewood have qualities such as the generation of embers or charcoal, high fire duration and low smoke emission. *Quercus magnoliifolia* is the preferred one, although its use depends on its availability, since it is scarce; *Alnus acuminata* is the most commonly used because it is abundant. Within the community, there are norms for the use of firewood, in addition to those dictated at the agrarian nucleus level; however, attention to the guidelines is limited due to the fact that they do not have problems to obtain this fuel. The results of this work indicate that it is a good time to establish strategies to address the potential loss of vegetation cover in the study community due to firewood harvesting.

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Conflict of interest

The authors declare no conflict of interest.

Contribution by author

Ariadna Mozo Ocegueda: design, organization, data collection, data analysis, and drafting of the manuscript; Marisa Silva Aparicio: design, validation, and revision of the manuscript.

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