Research paper

Purpose, preferences and fuel value index of trees used for firewood in El Ocote Biosphere Reserve, Chiapas, Mexico

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ABSTRACT

Firewood is the main source of energy in rural communities of emerging economies. Rural people develop different strategies to select and use the available species. Analysis of the firewood consumption and its relation to the wood-energetic properties was performed in four rural villages in the El Ocote Biosphere Reserve. The relationship between the preferential use of species for firewood and wood properties (moisture, ash, volatile content and specific wood density) of 39 species was analyzed using a combination of interviews and laboratory analysis. Fuel value index (FVI) was used to rank species and compare them with a preference index obtained by 76 interviews. People recognized seven characteristics that define the choice of a species for firewood (the kind of flame, the length of the flame, the amount and duration of coal, the type of smoke produced, the ease of ignition, the flavor given to food, and the quantity of ash left). Preference criteria do not match with the FVI. Six of the preferred species have low FVI values (<60.0), 29 species have intermediate (60–300) while only four species showed the highest FVI values (>300). We conclude that the FVI is not related to the preference of the species used by people within the reserve. Availability, proximity to home and feasibility may influence the choice of species used for firewood.

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1. Introduction

The use of firewood and charcoal is the primary energy supply of the 3 billion most impoverished families in developing countries [1]. The extraction of firewood is considered a low-intensity forestry activity and can represent almost 10% of the total global energy supply [2–4]. The demand for this resource, along with other timber forest extraction activities, contributes to forest degradation, deforestation, and loss of biodiversity [5–9]. In Mexico, about 16.4 million people use firewood for cooking and heating their homes. In the State of Chiapas, half of the homes depend on firewood as their main source of energy for cooking [10]. The daily per capita consumption of firewood in rural communities ranges from 0.7 to 7 kg. This high demand negatively affects the abundance and availability of the most commonly used species. In several regions of Chiapas, firewood has become a scarce resource and Chiapas is among the five States of Mexico in critical condition in the balance between consumption, and availability of this resource [11]. The impact on the population of tree species used varies according to the selection criteria, their abundance, rules of access, and use of firewood [8,12,13].

Information on firewood use patterns in rural communities established within natural protected areas is scarce. It is supposed that the villagers may modify the selection of species due to the restrictions on access and use imposed by reserve management programs [14,16]. Some indigenous groups have a rich and complex knowledge of the wood that is used. Thanks to this experience, they select the wood they use according to the following properties: the ease of combustion, the type and duration of food being grilled, and the amount and type of smoke [14–16]. Other criteria used for the selection of useful wood species are the proximity of the source of fuel to the households and the rules of access to such sources [3,15–18].

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Abbreviations

FVI   Fuel Value Index
IVI   Importance value index
REBISO   El Ocote Biosphere Reserve

On the other hand, the main wood-energy properties measured in the laboratory are the wood caloric content, moisture content, ash, volatility, and the specific gravity of wood. These variables can help to understand the selection criteria used by people of the species preferred as fuel [16,19]. Another frequently used variable is the fuel value index (FVI), which results from a combination of the caloric content, wood density, moisture content and amount of ash. Thus, the FVI is a measure that facilitates the classification of species to determine more comprehensively their quality as fuelwood [20,21].

The aim of our research was to analyze the relationship between the preference species used for firewood with their wood properties (moisture, ash, volatile content and specific wood density). Our hypothesis is that there is a relationship between the preference of species and the properties of the wood. We expect that firewood users prefer and select species that provide the highest fuel value to maximize the energy efficiency. To test this, we first determined preference and use through interviews. Later, we assessed the domestic consumption of wood through direct measurements and took samples to the laboratory, where several wood properties were measured. Then, the fuel value index (FVI) was calculated to rank species according to its quality as fuel.

2. Materials and methods

2.1. Study area

The study was carried out in the El Ocote Biosphere Reserve (REBISO) located in the northwest part of Chiapas, Mexico. It is located between $16°45'42''$ and $17°09'00''$ North latitude and between $93°54'19''$ and $93°21'20''$ West longitude (Fig. 1). The REBISO was designated as protected area since 1997 and it extends about 101.3 km^2. It is considered of special biological and cultural importance due to its proximity to the rainforests of the Chimalapas in Oaxaca and Uxpanapa in Veracruz, which form a biological corridor called the Zoque Forest [22]. The soils are shallow, of calcareous origin, and the terrain is rugged. Under a warm sub-humid climate, the dominant vegetation is the tropical sub-deciduous forest [23]. People living in the numerous villages in the buffer zone have deforested extensive areas and affected the composition and structure of natural vegetation. The four selected communities differ in some biophysical, cultural and ethnic features (Table 1). Informed consent was obtained to carry out the study, and all inhabitants agreed to the planning and development of this research.

2.2. Criteria of preference and consumption of firewood

Fieldwork was carried out from January to March 2015. Home visits and field trips were conducted along with a guide appointed by the authorities of each locality. The guide facilitated communication with residents by acting as a Spanish-Tsotsil translator. For the determination of criteria for preference and the selection of species to be analyzed, 76 semi-structured interviews were applied (24 families in Veinte Casas, 12 in Carrizal, 18 in Emilio Rabasa and 22 in Nuevo San Juan Chamula). Families were asked first to list the species they used for fuel. Then, they were requested to mention all the species they prefer and to give the reasons for their preference. We considered a species as preferred if it was mentioned at least once as such. The preference value of each species (PV) was defined as the total number of times a good quality of the species was mentioned by interviewees.

We also asked what other criteria are applied to select the firewood, for example: where it is obtained, how abundant it is, who within the family gathers or cuts the wood, and how far he or she goes for it. We additionally recorded the size of the family and if some management is applied to favor the firewood species growing.

In a second stage of the fieldwork, we evaluated daily consumption of firewood per person. To do that, we requested each family head that had enough firewood at home separate an estimated amount of wood the family would likely consume within the next three days, and that amount was then weighed [8]. Two days later, we weighed the remnant. For the calculation of the direct consumption of firewood per person, the following formula was used:

$$FC = (Wi - Wf)/n*t$$

where FC = daily consumption of firewood ($kg \cdot day^{-1} \cdot person^{-1}$), Wi = starting weight of the sample, Wf = final weight of the sample remnant, n = the number of persons per family, t = the number of days passed between the two measurements.

2.3. Wood properties assessment

We collected samples of wood (pith) of 39 species used for firewood in the four villages. Each species was identified based on the common name, and a botanical sample of it was collected in the field and taken to the herbarium, where a botanical specialist confirmed the scientific name. From the taxonomical identification, species were classified as pioneers (soft wood), mid-successional (slightly heavy wood) or late-successional (hardwood); a classification based on the wood density. The presence, abundance, and dominance of each species were then verified in a parallel forest inventory conducted in the same region (N. Ramírez-Marcial, unpublished data).

From each sample collected in the field, a subsample of 100 g of the central core chip was obtained using a power edger. Subsequently, each sample was ground into a Tomas® model 3379-E10 electric mill. With the resulting product, the following tests were conducted. Each analysis was replicated two or three times.

2.3.1. Wood moisture content (%)

Wood moisture content affects the energy available during combustion [24]. To assess this parameter, a 3-g sample of the heartwood was placed in a melting pot and introduced into an analytical balance Sartorius BL210 untilwe obtained a constant weight.[1] Melting pots were placed in an oven model VWR 1210E at a temperature of 100 °C $\pm$ 2° for 4 h. Subsequently, the crucibles were placed in a dryer with silica gel to prevent rehydration and were left to cool for an hour before being weighed. Moisture content was obtained according to the Official Mexican Standard-116 [25]:

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[1] Standardization obtained by repetitive weight of a melting pot, heated to a temperature of 550° $\pm$ 25 °C for one hour. To obtain the constant weight variation between the last two weights should not be greater than 0.0009 g.