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Community Use and Knowledge of *Algarrobo* (*Prosopis pallida*) and Implications for Peruvian Dry Forest Conservation

Uso y conocimiento comunitario del algarrobo (*Prosopis pallida*) e implicaciones para la conservación del bosque seco peruano

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Abstract

Algarrobo (*Prosopis pallida* Kunth) is the keystone species in Peru's highly threatened northern dry forests. Though uniquely adapted to thrive in arid environments, *algarrobo* extent along the Peruvian coast and particularly in La Libertad region has been drastically reduced by urban growth, agricultural expansion, and wood harvesting. Effective conservation of surviving dry forests in La Libertad will require initiatives grounded in field-based knowledge of surrounding communities' interactions with *algarrobo* and their understanding of the trees' importance. This research investigates how residents of distinct communities in or near the town of San Pedro de Lloc in La Libertad, know, use, and value *algarrobo* in three nearby dry forests. Methods include interviews with community residents and key stakeholders, as well as observation visits to local forests. Our results indicate that primary current uses of *algarrobo* include widespread domestic consumption of firewood, charcoal production for commercial use, and dependence on *algarrobo* dry forests as livestock forage. Community residents also value *algarrobo* trees for their ecological roles in producing oxygen, preventing the encroachment of sand dunes into neighborhoods, and as cultural patrimony. Building on these findings, we suggest a range of concrete ways in which local knowledge and use of *algarrobo* can support the conservation of this unique and fast-disappearing forest ecosystem.

Keywords: charcoal, dry forest management, environmental values, firewood, La Libertad.

Resumen

El algarrobo (*Prosopis pallida* Kunth) es la especie clave del bosque seco norteño de Perú, un ecosistema forestal muy amenazado. El algarrobo es únicamente adaptado para florecer en ambientes áridos, pero aun así su alcance en la costa peruana y particularmente en la región de La Libertad ha sido reducido drásticamente por la urbanización, la expansión agrícola, y la cosecha de madera. La conservación efectiva de los bosques secos sobrevivientes de La Libertad requerirá iniciativas basadas en conocimiento de la interacción de las comunidades cercanas con el algarrobo y su entendimiento de la importancia de dichos árboles. Esta investigación estudia cómo integrantes de distintas comunidades en el pueblo de San Pedro de Lloc o cerca de este, en la región de La Libertad, conocen, usan, y valoran al algarrobo en tres bosques secos locales. Los métodos de investigación incluyen entrevistas con habitantes de la comunidad y depositarios claves, además de visitas a los bosques. Nuestros resultados indican que

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los principales usos actuales del algarrobo incluyen el común empleo doméstico de la leña, la producción del carbón para fines comerciales y dependencia a los bosques secos del algarrobo como alimento para ganados. Personas entrevistadas también valoran a los algarrobos por su papel ecológico en la producción del oxígeno, la prevención de intrusión de dunas de arena a sus comunidades y como patrimonio cultural. Basadas en los resultados de esta investigación, nombramos algunas sugerencias concretas respecto a cómo el conocimiento y uso de los bosques secos por parte de la comunidad pueden ser usados para apoyar la conservación de este ecosistema único y tan amenazado.

Palabras claves: carbón vegetal, gestión del bosque seco, La Libertad, leña, valores ambientales.

1. Introduction

1.1. Context

Known in northern Peru as *algarrobo*, *Prosopis pallida* Kunth is one of the most ecologically, culturally and economically valuable trees of the Peruvian dry forest. Referred to as *algarroba, mesquite, carob, kiawe,* or *huarango* in other regions, *algarrobo* is a leguminous tree native to western South America distinctly recognizable by its strikingly contorted trunks, tiny leaflets, yellow fruit pods, spreading growth form and dense reddish-brown heartwood (Gallaher and Merlin, 2010; Pasiecznik, 2001; Whaley *et al*., 2010). Pasiecznik describes *Prosopis pallida* as one of the two "most economically and ecologically important tree species in arid and semi-arid zones of the world" (2001, p. vii). *Algarrobo* plays a crucial and primary role in Peru's dry forests, which are still recognized as "among the most threatened and least studied of the world's forested ecosystems" (Blackie *et al*., 2014, p. 1). Earlier studies of *Prosopis* include those by Griffith (1961) and Weber (1977). In the northern La Libertad region of Peru, *algarrobo* is used as a cooking fuel, source of medicinal *algarrobina* syrup, food for sheep and cattle, and nation-wide as charcoal in rotisserie chicken restaurants.

1.2. Plant description, ecological role, and national extent

Algarrobo heartwood is dense and highly resinous with a distinctly reddish-brown color, while the outer sapwood is honey-colored. Blooming in Peru during July and August, *algarrobo* produce yellow pods 13-25 cm long in December through February (Pasiecznik, 2001). Often demonstrating highly contorted and even spiraled trunks, these extremely saline-tolerant trees are believed to have a lifespan of up to 1 000 years (Pasiecznik, 2001; Whaley *et al*., 2010). *Algarrobo's* remarkable vertical taproots up to 53 m long enable it to survive in La Libertad region, which averages around 5 mm of rain in non-El Niño years (Instituto Geofísico del Perú; Gallaher and Merlin, 2010; Whaley *et al*., 2010). El Niño Southern Oscillation plays an important role in the propagation of *algarrobo*, as the intense rains every 2-7 years prompt seed sprouting and support the establishment of young plants (NOAA, n.d.). As a keystone species of the Peruvian dry forest, *algarrobo* benefits other plant species by increasing soil nitrogen and organic content (Pasiecznik, 2001; Whaley *et al*., 2010), reducing soil salinity and alkalinity, and increasing phosphorous and carbon levels (Aggarwal *et al*., 1976; Singh, 1996). In addition to its

positive effects on soil composition, *algarrobo* also affects the dry forest microclimatic through shading and humidity capture. Plant species that benefit from *algarrobo* include *cuncuno/tetillo* (*Vallesia glabra*), *sapote* (*Colicodendron scabridum*), *asote de Cristo* (*Scutia spicata*) and *vichayo* (*Capparis ovalifolia*). A diverse assortment of fauna makes it home in dry forests as well, including foxes, songbirds, woodpeckers, parrotlets and reptiles such as iguanas, snakes, and ground lizards, including the rare Peru Desert Tegu (*Dicrodon* spp.), known locally as a *cañán*.

Native to western South America and found primarily in Peru and Ecuador, *P. pallida* has been introduced as widely as Hawaii and Puerto Rico. According to Peru's Instituto Nacional de Recursos Naturales (SERFOR, 2015), an estimated 3 230 263 ha of mostly-*Prosopis* dry forests survive in northern Peru, with 67 % of the forests in the Piura region, 14 % in the Tumbes region and 19 % in the Lambayeque region, immediately north of La Libertad (Schwartz, 2004). Despite the national-level recognition of *algarrobo's* critical ecological value and SERFOR's past research and reforestation projects in some northern regions, *algarrobo* harvest for charcoal consumption in Peru's urban centers continues at a staggering scale. The demand for *algarrobo* charcoal is driven by a strong cultural taste for the rich flavor *algarrobo* wood imparts to food, especially to *pollo a la brasa* ("chicken over the embers"), a nationally celebrated roast chicken dish served over potato fries at innumerable *pollerías* ("rotisserie chicken restaurants") in Trujillo, Pacasmayo, Chiclayo and throughout coastal Peru. The importance of *algarrobo* as a domestic and commercial fuelwood in Peru is difficult to overstate. A 1995 study estimated that *Prosopis* fuelwood constituted more than 70 % of domestic fuel requirements in rural Peru (Díaz-Celis, 1995). Nearly 20 years later, another study estimated that *algarrobo* dry forests in northern Peru supply 48 % of the charcoal sold in Lima, a city of 7,6 million people (Bennett-Curry *et al*., 2013), while González estimated that dry forests provide 60 % of Lima's charcoal supply (as cited in Barrena *et al*., 2010). National census data from 2007 reports that 621 683 people in La Libertad alone, or approximately 38,9 % of the region's total population, use firewood or charcoal as their primary fuel source for cooking, while nation-wide that number is estimated at 2 800 000 people (Instituto Nacional de Estadística e Informática, 2010; La Torre-Cuadros and Menton, 2016). While significant, though threatened, dry forests survive in northern regions of Piura and Lambayeque, deforestation of *algarrobo* trees and the dry forests they comprise in Peru's La Libertad region has been almost total. Information published by the Peruvian forestry service, Servicio Nacional Forestal y de Fauna Silvestre (SERFOR), on *algarrobo* production in four northern departments of Peru show that La Libertad produced only 0,1 % of national production between 2000 and 2010 (Ministerio de Agricultura, 2012). Bos's 2015 study reviewed 10 accessible *algarrobo* forest patches totaling over 1 960 ha. Of those, Bos noted that Cañoncillo, at 525 ha, is probably one of La Libertad's largest surviving dry forests, although there may also be *algarrobo* dry forest patches of unknown sizes in the Calipuy National Reserve and the Higuerón forest in the Ascope province (Bos, 2015).

1.3. Legality of woodcutting

Algarrobo is officially recognized as *patrimonio ecológico* ("ecological heritage") of Peru, and the Peruvian government, on both national and regional levels, has long expressed concern

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about unsustainable *algarrobo* wood harvesting. From 1993 to 2008, the harvesting and sale of *algarrobo* was prohibited in La Libertad, Lambayeque, Tumbes, and Piura by Law 26258 (Bennett-Curry *et al*., 2013). In 2009, Law 3543 was proposed, suggesting a total ten-year national ban on the harvesting and sale of *algarrobo* and a number of other dry forest species, but its approval is still pending (Bos, 2015). Fundamentally, *algarrobo* trees are viewed as state property, meaning that any *algarrobo* tree cutting outside of an approved management plan is generally considered a crime against the state or as a *delito contra los recursos naturales* ("crime against natural resources"). Case files housed in the provincial government office of Pacasmayo of individuals changed with illegal woodcutting illustrated this. One particular case from 2014 charged a local resident with "indiscriminate woodcutting" in Cañoncillo and instigated a preliminary investigation to determine whether the accused's actions were indeed criminal in accordance with Law 27307, "Law of Forestry and Forest Wildlife," as well as Law 28611, "General Law of the Environment." Though Cañoncillo is a private conservation area, the Peruvian State was listed as the aggrieved party.

While regulations such as Law 29763 affirm the rights of citizens to use and enjoy forests, they require tree harvesting in dry forests to meet national sustainability standards that are not procedurally defined by law, leaving their interpretation and permissibility up to local authorities. This history of protection and the current legal ambiguity around harvesting has pushed *algarrobo* harvesting into a practice which is widespread but not discussed or conducted openly; while the legality of community harvesting remains unclear to local residents, they treated *algarrobo* harvesting as an illicit activity. The 29763's Reglamento 018-2015-MINAGRI, approved while this research was being conducted, dedicates article 60 to the management of dry forests, permitting the removal of pruned branches even from low-density dry forests (SERFOR).

1.4. Research questions

The following research was conducted in partnership with national environmental non-governmental organization A Rocha Perú to assist their development of a forest conservation program around San Pedro de Lloc (UTM 17M 665 204 m E and 9 178 513 m N), a small agricultural town in northern La Libertad surrounded by significant stands of dry forest, as can be seen in **Figure 1** below. The largest of the forests is Cañoncillo, with a coverage of 525 ha, with the adjacent, smaller forest of Tronco Prieto, which is about 40 ha in size (Bos, 2015). Also significant is what is referred to here as the San Pedro de Lloc forest, approximately 40 ha in size and located less than 0,3 km from the Pan-American Highway on the southern side of San Pedro de Lloc (Bos, 2015). Forest conservation and environmental education literature have demonstrated that people's knowledge of forests gained through personal experience is an important factor in their motivation and commitment to conservation activities (Campos and Ehringhaus, 2003; Miller, 2005; Saylor *et al*., 2017). Based on the premise that the particular ways that nearby communities know, use and value *algarrobo* have specific implications for the development and implementation of effective forest conservation initiatives, our research centered around the following questions: How do community residents and representatives of key local agencies know and describe forests? Are *algarrobo* trees and dry forests seen as valuable,

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and if so, for what reasons? What drives use of *algarrobo* as firewood and as charcoal? Do different groups value *algarrobo* trees and dry forests for different reasons? How can this information be used to make local conservation initiatives more effective?

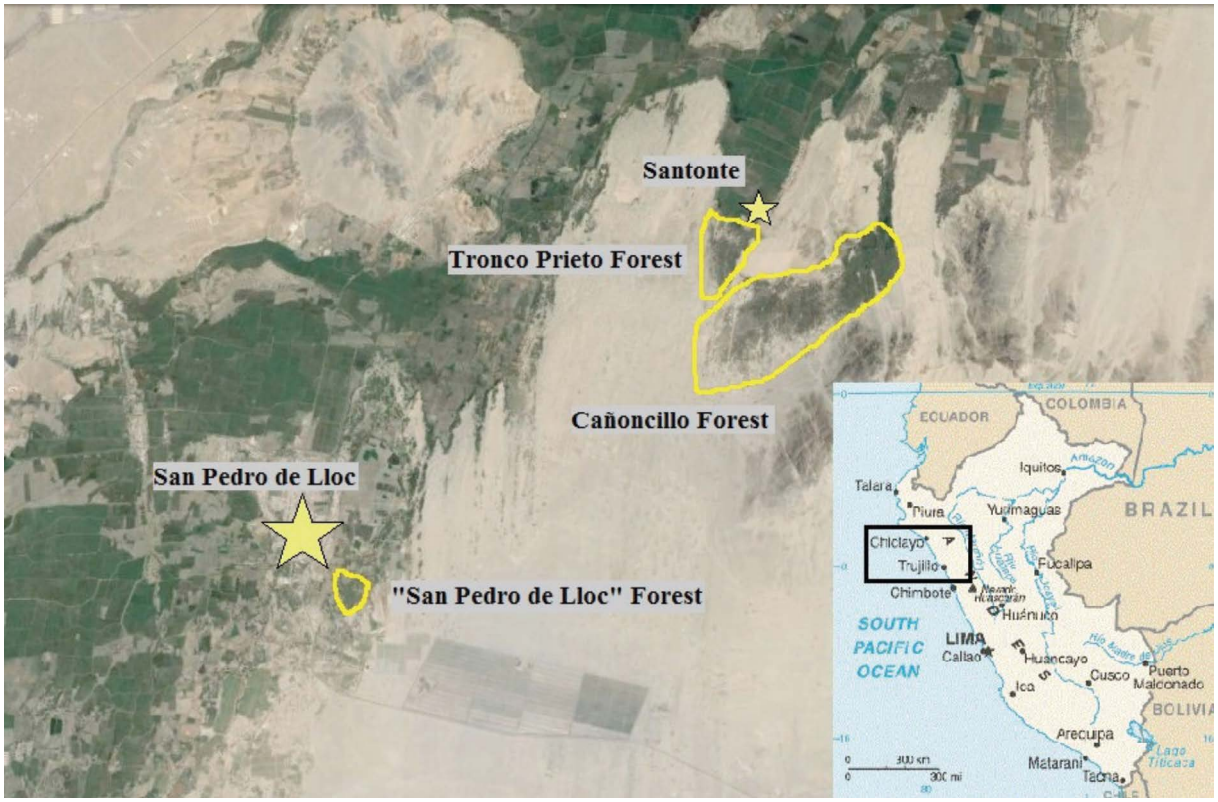

Figure 1. Map of San Pedro de Lloc and key dry forests among sand dunes. Inset: map of Peru. (Image credits: CIA World Factbook, Google Earth)

2. Methodology

2.1. Methods

Between July and November of 2015, I (Johanna Depenthal) made 16 visits to San Pedro de Lloc and the surrounding area to gather qualitative and quantitative data using three research methodologies: 22 structured interviews conducted with community residents, eight semi-structured group interviews with representatives of prominent community organizations such as the provincial government and the peasant-farmers' association and seven observation visits to local dry forests, often accompanied by community residents residing nearby. Together, information gathered from these various methodologies conveys a complex situation in which *algarrobo* trees are valued even as they are exploited for multiple uses.

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2.2. Interviews with residents of adjacent communities

A total of 22 forty-five-minute interviews were conducted during October-November 2015: 13 in San Pedro de Lloc in three distinct neighborhoods (Amauta, El Rázuri, and La Venturosa), eight in the village of Santonte, and one with a resident of San José. Respondents included 16 women and eight men from 29-85 years old, with 13 of them under 50 years of age. Interviews were conducted in five to ten percent of households in a community. They were recruited both randomly by going door-to-door and by referral of other respondents using the "snowball" sampling strategy.

The village of Santonte functions as the gateway to the dry forest of Tronco Prieto and is the home of local forest conservation group La Asociación Muchik. The Amauta and El Rázuri neighborhoods are both adjacent to the San Pedro de Lloc forest, as can be seen in **Figure 2**, but have distinctive histories and demographics. Amauta, with approximately 50 brightly painted, two-story cement block houses, was established about 30 years ago by the municipal government as housing for school teachers. El Rázuri, divided from Amauta by a sand lane and composed of single-story earthen brick buildings, originated approximately six years ago when the people who became inhabitants cleared the trees and staged an overnight group occupation of government land. Residents of Amauta refer to this event as "the invasion." Before this occupation, El Rázuri was a forested lot known as *El Algarrobal* ("place of the Algarrobos").

During the first part of the interview respondents were asked to describe how their communities valued, used, and had knowledge of local dry forests, while later questions focused specifically on firewood and charcoal harvesting and use. All potential respondents were presented with and read a consent form before being invited to participate in an interview. Because of the ambiguous legality of cutting *algarrobo*, no questions were asked about individuals' wood collecting habits, and no potentially self-indicting responses were recorded. This research was conducted with the approval of the Institutional Review Board (IRB) of Wheaton College, IL.

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Figure 2. Proximity of the Amauta and El Rázuri communities to the San Pedro de Lloc forest

2.3. Semi-structured interviews with representatives of the local government and community organizations

The municipal government of San Pedro de Lloc and the provincial government of Pacasmayo are key actors in the area, as are the Cooperativa Agraria de Usuarios Tecapa (CAU-Tecapa) which manages the forest of Cañoncillo, and the Comunidad Campesina de San Pedro de Lloc (or Peasant Farmers' Association of San Pedro de Lloc, hereafter referred to as the CCSPLL), which reportedly manages 73 000 hectares of land. During the course of research, several meetings and interviews were held between A Rocha Perú staff, representatives of the municipal and provincial government (as San Pedro de Lloc is the capital of the province of Pacasmayo, the municipal and provincial governments overlap significantly), and leadership of the CCSPLL to discuss potential partnership in forest conservation initiatives. These conversations provided an important glimpse into regional stakeholders' perspectives on the value of forests.

2.4. Forest visits

Research included five observation visits to the San Pedro de Lloc forest and guided visits to Tronco Prieto and Cañoncillo. Observations included animal and plant identification,

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descriptions of ecological relationships, signs of fuelwood harvesting and charcoal production pits (**Figure 3**), forest uses such as livestock pasturing, conversations with individuals encountered in forests, and locations of largest *algarrobo* trees (**Figure 4**). Global Positioning System (GPS) mapping of forest borders and of brush fences within the forest was also conducted in the San Pedro de Lloc forest.

Figure 3. A Rocha Perú personnel inspecting *algarrobo* fuelwood piles next to a charcoal pit

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Figure 4. One of the largest *algarrobo* trees in the San Pedro de Lloc forest, with author Johanna Depenthal for scale. (Photo credit: Hugo Marcos Loyola)

3. Results

3.1. Community knowledge

While almost every interview respondent professed familiarity with local dry forests, respondents' ways of knowing the forest differed markedly. Respondents' knowledge stemmed either from personal experience in the forest or "mythology," a way of knowing and evaluating the forest based on hearsay, stories, and legends. Two respondents from Santonte actively engaged in forest conservation work expressed great personal familiarity with the forest of Tronco Prieto: one mentioned that growing up, it was as if the forest was part of the respondents' home, while the other expressed that he was practically raised in the forest. In contrast, where personal experience of the San Pedro de Lloc forest was apparently low, sentiment towards the forest

was more ambivalent. Several respondents living in the Amauta and El Rázuri neighborhoods adjacent to the forest stated they did not know if the forest had a name, and while a few of them told us that they had walked in the forest in the past, no one said they did so now. This lack of personal experience with the forest may both result from and cause fear of the forest, as multiple people mentioned that the body of a murdered woman had been discovered in the forest a few years before. Despite this, we did encounter multiple people, most commonly sheep herders and their flocks, during visits to the San Pedro de Lloc forest who spend time in the forest. Interview respondents' knowledge of the forest of Cañoncillo was also largely based on hearsay, especially surrounding the locally prominent mythology of a "gringa" siren character who is said to live in one of the forests' lagoons and to lure the unsuspecting to death by drowning.

3.2. Community and commercial uses

Respondents provided multiple uses for various *algarrobo* parts, as seen in **Table 1**. Some uses listed by respondents are still part of the daily lives of communities in and around San Pedro de Lloc, while others were largely historic or were products used but not necessarily produced within the community. Uses of *algarrobo* in San Pedro de Lloc correlate with those described for other *Prosopis* species in northern and southern Peru (Whaley *et al*., 2010; Rodríguez and Uhlenbrock, 2002). The following sections detail each category of *algarrobo* use, beginning with those most frequently mentioned by respondents.

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Table 1. Local uses for *algarrobo* (*Prosopis pallida*) named by interview respondents

	Fuel	*Medicinal*	*Animal food*	*Material*	*Other*
Trunk	Firewood Charcoal			Construction Furniture Lintels Benches	Gates
Branches	Firewood Candles				Fences Corrales
Bark	Firewood	Unspecified			
Sap		Lip sores Toothache Tooth extraction		Colors wood	
Leaves	Burned with trash		Livestock		
Flowers			Bees Birds Lizards		Produce fruit Honey
Fruit		Algarrobina used to treat anemia	Cows Pigs Horses Guinea pigs Lizards		Algarrobina Chicha Algarrobo honey Molasses Sold
Seeds			Cows		Coffee substitute New plants Sold for planting
Roots	Firewood	Aphrodisiac		Agricultural tools Ax handles	Small roots smoked

3.2.1. Fuelwood

Of the variety of uses for *algarrobo* mentioned by respondents in **Table 1**, *algarrobo*'s role as fuelwood was mentioned in every interview and was highly valued by many of them. It was clear in every interview that *algarrobo* is an important fuelwood resource in and around San Pedro de Lloc. Yet respondents' descriptions of the ways *algarrobo* firewood and charcoal are harvested, used, and traded also made it clear that local domestic use and national commercial use of *algarrobo* are two distinct issues which should not be conflated if they are to be effectively addressed in conservation initiatives.

Despite its ambiguous legality, harvesting *algarrobo* for charcoal production is a flourishing underground trade. Though it is uncertain whether wood cut from Cañoncillo and Santonte was mostly destined to be processed into charcoal or sold as firewood, several respondents in Santonte mentioned trucks loaded with wood leaving the forest early in the morning. Our walks through the San Pedro de Lloc forest passed two active *algarrobo* charcoal-production pits. Our guide at Cañoncillo told us that *algarrobo* is "loved by the [wood] cutters because its charcoal is very expensive," probably because *algarrobo* is "very, very, very loved by *pollerías* (rotisserie chicken restaurants) and bakeries." Charcoal price as reported by respondents varied between S/. 0,80 to S/. 1,00 (about $0,30 USD) per kilogram, and between S/. 80 to S/. 100 (about $25-30 USD) per sack. Though several small stores in San Pedro de Lloc advertised

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charcoal, respondents predominantly described *algarrobo* charcoal as being sold outside San Pedro de Lloc to large urban centers such as Pacasmayo and even Trujillo and Chiclayo for use in *pollerías* and bakeries, as well as for brick-production, metalworking and grilling *anticuchos* ("meat kebabs").

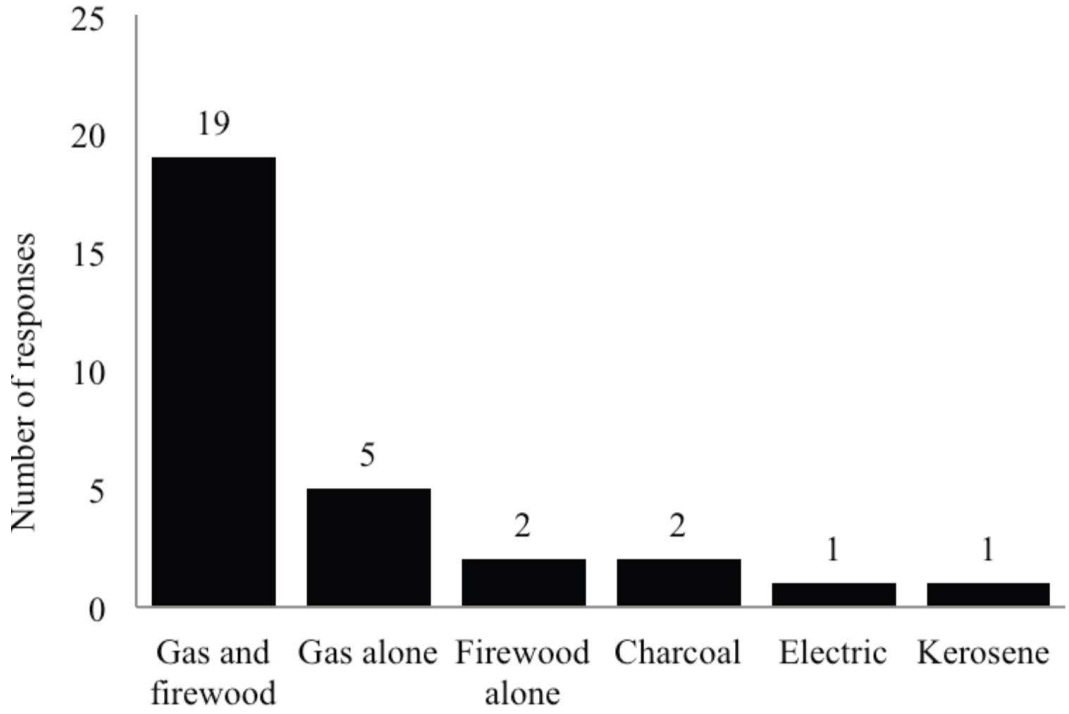

Figure 5. Respondents' household cooking fuels by type (n = 26, multiple answers permitted)

In contrast to charcoal, respondents frequently described *algarrobo* firewood as being used locally, mostly in homes but also in some bakeries and restaurants. As seen in **Figure 5**, while only 7,7 % of respondents cooked solely using firewood, 73,1 % reported cooking over both gas and firewood, meaning 80,8 % of respondents cooked at least occasionally with *algarrobo* firewood. Use of firewood is driven by both cultural and economic factors, and relatively low availability of alternative tree species. Cultural and flavor preferences lead gas stove-owning households to continue cooking with firewood on some occasions. *Algarrobo* firewood was repeatedly praised for the rich flavor the smoke imparts to food, and several respondents stated that gas-cooked food had a very unpleasant flavor by contrast. "[*Algarrobo* firewood] results in a richer flavor in the food," said one respondent, while another asserted that "*Algarrobo* firewood is essential for good food!"

Several trends for *algarrobo* wood use emerged across communities. Respondents preferred cooking over *algarrobo* firewood for dishes such as stewed duck or rotisserie chicken, and also for special occasions involving large numbers of people, such as birthdays, weddings, and family dinners. As one respondent from La Venturosa put it, "When cooking a cow, you must use

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firewood. But for a chicken, just use gas." My hosts in Santonte used a gas stove to rapidly heat up water for breakfast and to prepare a small late-night meal, but used *algarrobo* firewood to prepare a meal of pan-fried fish and rice Sunday afternoon when time permitted and flavor was more important (**Figure 6**).

Figure 6. Cooking over *rajas* of *algarrobo* on an open hearth in Santonte

Financial status is also a significant factor in cooking fuel choice. *Algarrobo* wood was praised by respondents for its dense hardness, "powerful temperature," and long-lasting heat. The high caloric value of *algarrobo* wood, reported as 4 216 to 4 800 kcal/kg (Khan *et al*., 1986; NAS, 1980 cited in Pasiecznik, 2001), made it the preferred fuel for food items such as lentils and beans, which are both time consuming and expensive to cook on a gas stove. Two respondents in El Rázuri directly correlated their finances and firewood use: "When there's money I cook with gas, but the food turns out tasting richer with firewood," and "When one wants to save on gas, one lights the firewood." But while financial status dictates whether individuals can afford to buy a gas stove or how often they can afford to use it, the flavor preferences and cultural factors discussed above counteract a direct inverse relationship between economic status and firewood use. The cost of gas canisters also varies: in roadside Amauta and El Rázuri gas canisters cost S/. 34.50-35 ($11.04-$11.20 USD), while in remote Santonte, the prices increased to S/. 35-39 ($11.20-12.50 USD).

Three respondents named negative health effects of cooking with firewood as a reason for using gas. While several asserted that *algarrobo* firewood smokes relatively little, one wealthier elderly person in La Venturosa stated that she only cooks with gas "because the smoke makes

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the lungs bad." During a different interview a middle-aged woman in El Rázuri commented that she did not like to cook with firewood because it is "bad for vision." A man also participating in the interview agreed, and added, "[and] cancer." An elderly respondent in Santonte also mentioned that the smoke from *algarrobo* firewood is bad for the eyes and said her doctor had warned her against cooking with it. The respondent continued to do so, however, because she feared burning herself with the gas stove and depended on others to light it. Another respondent mentioned that she preferred using charcoal over firewood because it produces less smoke, but did not explicitly connect firewood smoke to health effects.

Terminology for units of firewood differed between communities, with significant implications. In the San Pedro de Lloc neighborhoods, firewood was generally described as sold in *palos*, rounded branches typically about the length and width of an adult's forearm. Respondents from Santonte, however, only described firewood as being sold by the *raja*, a split piece of wood about 80 cm long and up to 10 cm in diameter, or by the *carga*, the equivalent of a donkey load's worth of wood. Respondents frequently told us that the woodcutters went to Cañoncillo or other dry forests early in the morning, cut wood (including green wood, which reportedly produces a denser, higher quality charcoal) using hatchets, and then transported the wood to San Pedro de Lloc or the surrounding villages by donkey. The exact size of a *carga* is unknown. Oudman (2004) states that donkeys can typically carry a 40-80 kg load, and Pasiecznick (2001) reports *algarrobo* density ranging from 710-910 kg/m^3 for dry wood to 1 050-1 250 kg/m^3 for green wood. One source mentions a *carga* containing about 14 *palos* (Guerrero, 2010), although a donkey loaded with *algarrobo* wood being harvested from Cañoncillo in a photo published by a Peruvian news agency appears to be carrying 11 *palos* on only one side of its saddle, for an estimated 22 *palos* total per trip (Anonymous, 2010). Quantifying rates of *algarrobo* fuelwood use in homes was difficult, but three respondents indicated using two to four *rajas* or *palos* for domestic cooking use on an average day.

3.2.2. Forage

The second most common use mentioned was of *algarrobo* as livestock forage, which supports Rodríguez and Uhlenbrock's (2002) observation that *algarrobo* is critically important for goat farmers in northern Peru. Respondents told us that herds of goats, sheep, and even cattle graze in local dry forests, especially when the *algarrobo* are in fruit. One respondent descriptively reminisced how *vacas flacas* ("thin cattle") get fat during *algarrobo* fruiting seasons. In addition to allowing livestock to graze on fallen, raw pods, *algarrobo* fruit is fed to livestock in two other forms: as dried pods, and as sugary molasses mixed into dry feed. Four respondents specifically described the sale of *algarrobo* pods (typically dried on hot sand and sold by the sackful), while a retired respondent stated that sale of *algarrobo* pods significantly supplements his small government pension.

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3.2.3. Historic or largely discontinued uses: algarrobina, building material, and seed

Although this use is now largely abandoned, *algarrobo* pods were used to make a sweet syrup known as *algarrobina*. *Algarrobina* is still often used in Peru as a sweetener or as cocktail ingredient, but this was not mentioned by interviewees in our region. Instead, several mentioned *algarrobina* as a medicinal tonic, and two explained that *algarrobina*'s usefulness for treating anemia in women and children (sometimes mixed into a drink with egg and honey) was due to its high vitamin B5 content. While generally familiar with *algarrobo* products such as *algarrobina* and animal feed, respondents generally stated that *algarrobo* pods were not harvested in their community anymore. When asked why *algarrobina* was no longer produced in Santonte, one elderly answered: "Because they don't know how to make [it]." The lack of local *algarrobina* production from adjacent forests may be due in part to lack of knowledge and equipment, but is also likely due to the fact that *algarrobina* is now produced commercially further north around Piura and is inexpensively available.

Other medicinal uses of *algarrobo* products mentioned by interviewees included dabbing *algarrobo* sap on lip sores and chewing *algarrobo* gum to numb toothache or even to extract rotten teeth. One middle-aged person with a bright if somewhat toothless smile stated that she had removed a molar using *algarrobo* gum. A group of male respondents mentioned smoking small *algarrobo* roots as teenagers. They reported that the roots produce drug-like effects and *da valor* (lit., "give bravery") at night, which an A Rocha Perú field officer interpreted as a euphemism for aphrodisiac properties. It was also used in *chicha*, a term for traditional Peruvian fermented drinks. *Miel del algarrobo* literally translates to "algarrobo honey," but it was unclear whether this referred to the honeybee product or was sometimes conflated with *algarrobina*.

Several houses where interviews were conducted featured *algarrobo* beams or lintels, but respondents said that use of *algarrobo* in home construction has largely been abandoned with the advent of modern construction materials.

3.2.4. Tourism

The forest of El Cañoncillo is a private conservation area locally billed as a tourist attraction. Renowned for its rare feature of three small lagoons set in an *algarrobo* forest, Cañoncillo charges a small fee for entry and offers both private tours of the natural features of the forest and sports such as sandboarding. It was clear that Cañoncillo's use as a tourist attraction was well known by respondents. Two respondents from Santonte commented negatively on the way in which access to Cañoncillo (and the resulting income) is controlled by the managing cooperative, while one also mentioned that tourism was part of a proposed forest management plan for Tronco Prieto. Another respondent in San Pedro de Lloc mentioned that he had unsuccessfully petitioned to protect a small forest he owned as a tourist attraction. Beyond these comments, however, respondents did not mention tourism as a "use" for Cañoncillo or other local dry forests.

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3.3. Value of dry forests to community residents and government officials: ecological role and cultural patrimony

"Why are dry forests valuable to you and your family?" "Thanks to these plants, we breathe pure air!" exclaimed one village respondent who lives in a forest-adjacent community. Many of our respondents shared their enthusiasm: all but one of the 22 community residents readily stated that local dry forests are valuable for one reason or another, and a total of eight respondents named *algarrobo's* role in producing oxygen or purifying air as a key reason for valuing local dry forests, as shown below (**Figure 7**).

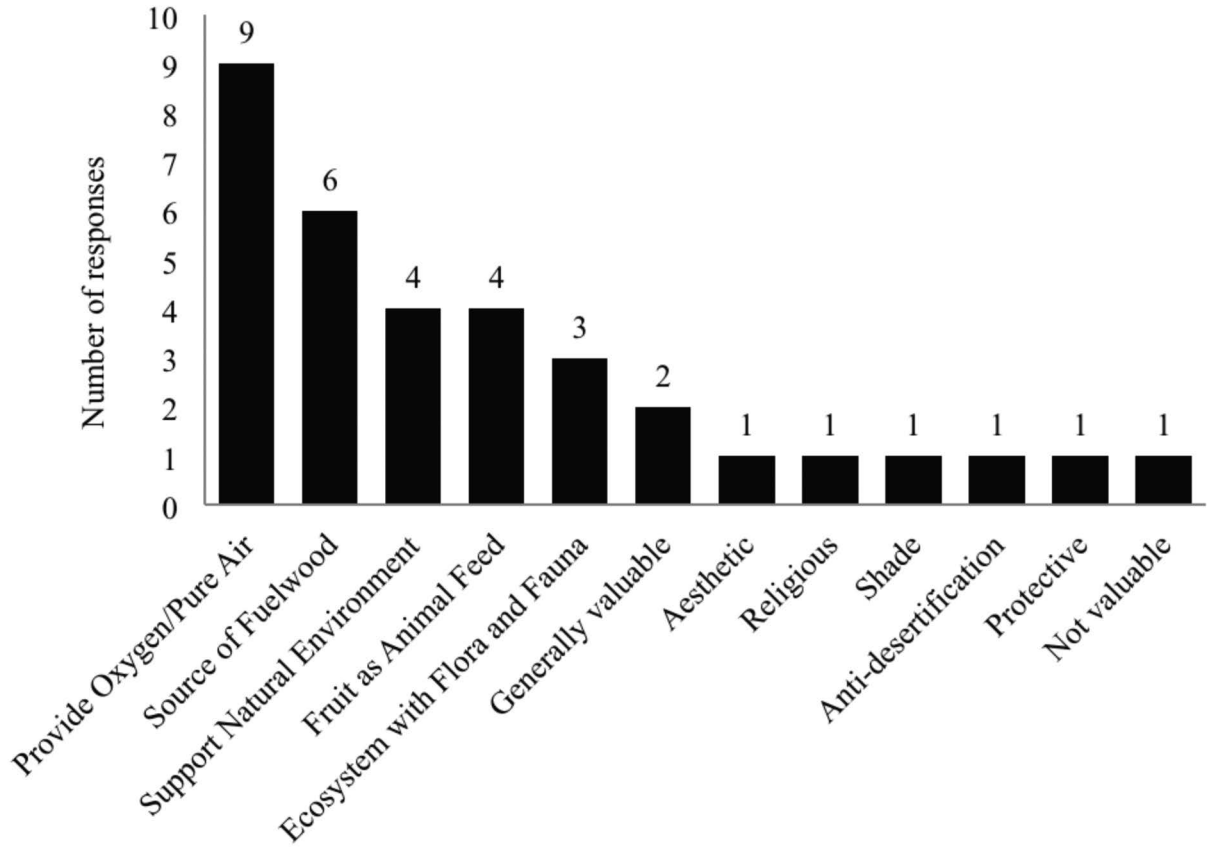

Figure 7. Community residents' reasons for valuing *algarrobo* and local dry forests (n = 22, multiple answers permitted)

Government officials and representatives of the CCSPLL also emphasized *algarrobo*'s role in oxygen production, often referring to the dry forests as the region's "lungs," a term popular media often applies to forests (ironically forests have the inverse ecological function of lungs, which take in oxygen and give off carbon dioxide). Other reasons government officials and CCSPLL leadership gave for valuing forests diverged widely from each other and from interview respondents, however, demonstrating that rhetoric about forests changes with direct proximity and familiarity.

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Officials from the provincial government of Pacasmayo especially stressed the importance of forests as national or cultural *patrimonio*, a word roughly equivalent to common or national heritage, inheritance, patrimony, and wealth. This situates the forests squarely within the domain of the nation-state, rather than acknowledging oversight by adjacent communities. When discussing the illegal sale of land, one government official lamented the loss of what he considered Peru's heritage, stating ironically, "Heritage cannot be sold but we're in Peru!" Yet, it is striking that none of the 22 community residents used the term *patrimonio*. Instead, community residents valued the forest for both ecological and utilitarian reasons, with the trees' roles in oxygen production and as a source of fuelwood as the respective first and second most frequently mentioned reason for valuing dry forests; the third most mentioned reasons is a tie between its value as livestock forage and its value as natural environment and home for flora and fauna. Less frequently, community residents also indicated that dry forests and *algarrobo* had cultural, intrinsic, sentimental or aesthetic value. Two respondents placed nature in a religious framework, implying that trees and forests had intrinsic worth because they were created by God: one of them, a former schoolteacher living in Amauta, used to remind her Catholic schoolgirls during fieldtrips to Cañoncillo that the forest was "the nature that God has given us, and we have to care for her."

The president of the CCSPLL also assured us that it was "very, very clear" to them that *algarrobo* has value as cultural *patrimonio*, but demonstrated more concern with the potential economic value of *algarrobo*. This was especially evident during meetings with representatives of A Rocha Perú. While A Rocha Perú personnel's focus was on the conservation of existing forests and reforestation for ecological purposes, CCSPLL officers repeatedly proposed ideas for *algarrobo* production on a large scale, such as an *algarrobo* plantation with a built-in irrigation system. This is yet another vision for *algarrobo* forest ownership and use: not a natural forest on state-claimed land, or community-managed forest, but an industrial-scale commercial plantation containing permanent infrastructure.

A recent land use conflict between the CCSPLL and the provincial government of Pacasmayo demonstrated this difference in their institutional positioning. According to an official in the provincial government of Pacasmayo who is largely responsible for local forest conservation, the CCSPLL had planned to cut down "several thousand" *algarrobo* trees near Jatanca, a small town of about 200 people between San Pedro de Lloc and Santonte, in order to plant avocado trees. The provincial government had shut down the project, purportedly on the grounds of dry forest conservation, stating that while the land may belong to private owners, trees are state patrimony. While the CCSPLL expresses interest in dry forest conservation, they may value economic development over forest conservation when the interests conflict.

Notably overlooked in any interviews about *algarrobo's* value, however, was substantive discussion of the ecological roles *algarrobo* roots play in preventing erosion and desertification or trees' role in regulating hydrologic cycles. Sand nets along the Pan-American highway near San Pedro de Lloc testify to the constant dune migration caused by winds in the desert surrounding town. Several large dunes near San Pedro de Lloc are crowned by *algarrobo* trees, whose deep roots stabilize the dune even as their foliage intercepts airborne sand particles. Without these

trees, the dunes could migrate into nearby farmers' fields. Though mentioned by a provincial government official, the only local resident to hint at this valuable service performed by *algarrobo* was an elderly woman in Santonte, a town overshadowed by a massive bare sand dune. After mentioning that trees on the opposite side of the street had recently been cut down, she commented, "The wind carries the sand." To clarify her intent, I asked, "If they cut the trees, what happens?" "Well," she said, "[the sand] comes."

4. Discussion

This study aims to understand community dry forest use and knowledge that can help shape conservation initiatives. Most interview respondents, including those dependent on *algarrobo* fuelwood, expressed a desire to protect the forests. In one memorable instance, our interview with a respondent who expressed great enthusiasm for the value of trees and forest conservation was interrupted when a man towing a wagon piled high with *algarrobo* firewood pulled up in front of the house and loudly asked where he should put the firewood. Flustered, our respondent ran to the open doorway and with much arm-waving, quickly shooed the man away before returning to continue the interview without explanation.

While this incident could be interpreted as a respondent attempting to give the "right answer" to an interviewer regardless of the respondents' true beliefs and typical behaviors, we recognize this vignette as an illustration of the classic problem of conservation shared among peasant farmers and environmentally conscious people from diverse walks of life the world over: how individuals desire to preserve a resource, such as a highly threatened forest or fast-vanishing ecosystem, while simultaneously act in ways that may damage or destroy it. Yet, people who live in close proximity to forest resources and whose livelihoods are directly dependent on the adjacent forest's use are in a special situation regarding conservation. They have most ready access to resource use, and yet are also they those who can most easily witness and experience resource decline. Different types of actors value forests differently, and more abstract reasons for valuing forests reflected lack of familiarity with and direct dependency on forests. For these reasons, respondents whose concern for the forest resulted from their direct use of the forest through fuelwood or livestock pasturing are potentially stronger partners in conservation than respondents who gave abstract responses such as oxygen production as reasons for forests' value. Use of *algarrobo* firewood is driven not only by considerable cultural preference for *algarrobo* smoke flavor in food, but also by the relative low cost of firewood when compared with natural gas, especially for community residents who can harvest wood personally. Recognizing this is important for national conservation organizations such as A Rocha Perú, as it means that conservation-desire does exist in adjacent communities. Proper incentives or community pressure may tip the scales for individuals and lead them to adopt behaviors that result in forest conservation and sustainable growth for forested regions. The interviews with government officials and CCSPLL leaders also point to other potential initiatives, such as planting *algarrobo* trees to expand forested areas specifically for production of wood, forage, or other products that are of highest value to the adjacent residential communities.

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Though adjacent community residents also valued the forests for ecological and use-based reasons, they never mentioned the forests as belonging to the nation as a whole, as provincial officials did through the language of *patrimonio*. Referring to local forests as national patrimony relocates the trees' purpose from being a resource for concrete local use to an abstract national benefit, an action which elevates the ownership of the forests to a national level while diminishing the role and rights of local actors. Conservation organizations should be deliberate in deciding which reasons for conservation and rhetorical strategies they choose to employ; for example, responding to nearby residents' top concerns for fuelwood and forage production is more likely to resonate with those communities than projecting government approaches that identify forests as an abstract national patrimony under theoretical guardianship of the state.

5. Conclusions

How do people in and around San Pedro de Lloc know, use and value *algarrobo* trees and dry forests? More respondents knew local forests more through secondhand accounts and legends than through personal experience. Firewood is regularly used alongside gas stoves in 73 % of respondents' households, and exclusively in eight percent of households. Flavor preferences, cultural factors, and economic reasons all influence why and when *algarrobo* firewood is used. Community respondents valued local forest stands first for their role in producing oxygen, second as a source of fuelwood and third as a place for pasturing livestock and for its role as a natural environment and home to plant and animal species. Terminology used for units of firewood in different communities reflects distinct ways of harvesting wood, some of which may be more sustainable than others. Conversations with government officials and representatives of the CCSPLL demonstrated that abstract terms with forests often indicate lack of dependency on forests. Visits to local forests, especially to the San Pedro de Lloc forest, revealed a unique and ecologically rich ecosystem still in active use by nearby community residents as a livestock pasture and as a charcoal production site. Further research is needed to determine whether harvesting *algarrobo* firewood for domestic use, though widespread, is less detrimental to local dry forests than the *algarrobo* charcoal trade. Perhaps most significantly, the majority of community residents interviewed value forests and are in favor of conserving them, even as their use of *algarrobo* fuelwood may be detrimental to the forests.

What are the implications of this research for forest conservation initiatives in La Libertad? Based on our findings, we recommend a conservation plan that emphasizes increasing familiarity and personal exposure to dry forests for government and CCSPLL officials, children, and other citizens through guided tours and outings. This conservation plan could work closely with community residents who depend on *algarrobo* wood, forage and pods daily and emphasize sustainable harvesting and reforestation, while at the same time working with community leaders and government authorities to disincentivize and check charcoal production and trade. Rather than assuming that making gas or other alternative stove types available would eliminate firewood use, the organization could promote more fuel-efficient wood stove designs, teach community residents how to use them safely and promote awareness of the negative health effects of cooking over open fires. In addition to providing insight into how individuals in and

around San Pedro de Lloc, Peru know, use and value *algarrobo*, this study provides a case study for how research on community knowledge can contribute to conservation program design.

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