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Yield and household consumption of *Rhododendron arboreum* as a fuelwood species in Eastern Nepal

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ABSTRACT

Rhododendron arboreum Sm. is commonly used for fuelwood in mountainous regions of the Eastern Himalaya, however nothing is known about rates of extraction versus the annual increment capacity of the species in terms of biomass. In the study area, fuelwood is the major source of energy. We conducted household surveys and ecological surveys in and near two settlements to assess both fuelwood consumption and existing above ground biomass of *R. arboreum*. According to local residents, this species contributes 20–25% to household fuelwood requirements, while forest surveys and a survey of freshly cut stumps indicate that 15% of trees felled for fuelwood were *R. arboreum*. Trees were mostly young, comprised about 20% of all tree species in the forest, and accounted for $70.41 \times 10^3 \text{ kg ha}^{-1}$ biomass in average. The biomass of felled trees was calculated as $8.71 \times 10^3 \text{ kg ha}^{-1}$ at the time of study. Simulation based on the current rates of extraction and increment showed that the species will be in a critical condition in future at most of the monitored sites. In some places however, biomass was found to increase in spite of ongoing extraction. The results indicate that there is an urgent need of forest management which in a first step can be achieved through rotational harvesting that allows forest stands to regenerate and build up biomass. In addition, depletion of rhododendron stands can be reduced by economic development through ecotourism on the theme of rhododendrons, and by providing access to alternative sources of energy.

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1. Introduction

Forest biomass is an important source of energy for rural livelihoods globally as well as in Nepal. Biomass ranks fourth as an energy source worldwide, and provides about 14% of the world's energy needs [1]. Fuelwood for cooking and heating is

one of the most important products harvested from the forests of developing countries [2].

In Nepal, 68.4% of the population use wood as their main source of fuel for cooking [3]. Biomass use and especially the use of fuelwood affect the environment through deforestation, forest degradation, resource depletion, pollution, etc. In the 1970s, fuelwood use was thought to be the main cause of

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Fig. 1 – *Rhododendron arboreum* is a commonly used tree for fuelwood use in mountain settlements of Eastern Nepal a) Forest stand and cut stumps, b) Wood collected from forest (in the study area), c) Stack of *R. arboreum* wood in a village of Eastern Nepal (about 60 km from the study area).

deforestation in the Himalayas. While this one-dimensional explanation of a complex phenomenon has been largely refuted [4], fuelwood use does have a significant impact on forests, and there is still a need to better understand the links between fuelwood use and the condition of forests or of specific tree species, especially in remote locations, where so far not much research has been carried out.

This applies in particular to the high altitude regions of Nepal. People living in remote areas at high elevations consume more energy because of colder conditions. They rely more strongly on wood from the forest as an important source of energy [5–7] because other forms of energy like commercial fuel and electricity are beyond their reach due to lack of access, high prices, and low income. The proportion of people using wood as fuel is higher in the mountainous parts of Nepal (87.9%) than for the whole of the country [3].

In the mountainous areas of Nepal, local people prefer hardwoods like *Betula* and *Rhododendron* over softwood [8] as hardwood burns longer and produces a comparatively higher amount of heat. An ideal fuelwood species, according to the perspective of local people, must be heavy and dense, should have a low water content, and should not produce too much ash [9]. *Rhododendrons* meet all these requirements. Due to the presence of polyphenols and flavonoids, *rhododendrons* burn even when wet [10], which is especially important during the long and humid rainy season at high altitudes in Eastern Nepal.

Extensive use of fuelwood for domestic purposes and for the tourist sector has been exerting pressure on the forests, causing continuous decline in biomass [11]. As *rhododendrons* are also subject to these pressures, the natural populations of *rhododendrons* in the eastern Himalaya are gradually diminishing [12,13]. Among *rhododendrons*, *Rhododendron arboreum* is one of the most highly preferred and

harvested species for use as fuelwood [14–16]. It has a high calorific value (19.7 kJ g^{-1}) and high fuelwood index value [9].

In the Eastern Himalayan region, *R. arboreum* is one of the most widespread *rhododendrons*. It occurs in the understory of high altitude forests, and forms pure stands in some places. It grows to a height of 25 m, and is capable of storing a large amount of biomass. The species is under much pressure due to excessive harvesting for fuelwood (Fig. 1) and ranks within the top ten collected species in mountainous regions in Nepal and adjoining regions [17].

Efforts to conserve *rhododendrons* and especially the slow growing *R. arboreum* [14] require a better understanding of the balance of extraction of *R. arboreum* as fuelwood and of its ability to replace biomass. The present study was carried out to assess above ground biomass change of *R. arboreum* against the current rate of household fuelwood consumption in a remote and high elevation area of Nepal.

2. Materials and methods

2.1. Study site

Research was carried out in the two settlements of Ghunsa (c. 3400 masl) and Pholey (c. 3100 masl) in Lelep Village Development Committee (VDC¹) of Taplejung district (Fig. 2a) in the Kanchenjunga Conservation Area (KCA) of northeastern Nepal (Fig. 2b). The settlements are about 29 and 31 h walking distance from the headquarter of Taplejung district at *Phunling bazaar* (c. 1700 masl). Energy from gas, kerosene or electricity from the national transmission is not available because of high cost and remote location.

¹ VDC is the administrative level below district level.

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