

## EXTRACTION OF NON-TIMBER FOREST PRODUCTS IN THE FORESTS OF BILIGIRI RANGAN HILLS, INDIA. 6. FUELWOOD PRESSURE AND MANAGEMENT OPTIONS<sup>1</sup>

UMA SHANKAR, RAVI HEGDE, AND K. S. BAWA<sup>2</sup>

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**Uma Shankar** (Tata Energy Research Institute, Ghoshpara, Hakimpara, Siliguri 734 401, India), **Ravi Hedge** (Tata Energy Research Institute, 50/7 Palace Road, Bangalore 560 052, India), and **K. S. Bawa**, (Department of Biology, University of Massachusetts, Boston, MA 02125, USA). EXTRACTION OF NON-TIMBER FOREST PRODUCTS IN THE FORESTS OF BILIGIRI RANGAN HILLS, INDIA. 6. FUELWOOD PRESSURE AND MANAGEMENT OPTIONS. *Economic Botany* 52(3):320–336. 1998. Fuelwood is a predominant source of domestic energy for the Soliga, an aboriginal tribe, and non-Soliga people inhabiting the core and the fringe of the Biligiri Rangaswamy Temple (BRT) wildlife sanctuary in Karnataka, India. Approximately 7000 Soliga and 66 000 non-Soliga people depend on the 540 km<sup>2</sup> sanctuary for fuelwood. The demand for fuelwood is estimated to be 134.7 t d<sup>-1</sup> or 49 165 t y<sup>-1</sup> against production of 66 024 t y<sup>-1</sup> for the entire sanctuary. Consumption patterns vary with the season and the altitude. The pressure for fuelwood is far greater on the fringe (85.8%) than in the core (14.2%). The fuelwood supply emanates from an activity zone of 20.1% of the total forest area which produces only 27% of the total demand. Furthermore, only selected species are preferred for fuel use, indicating that only a certain percentage of total productivity is available for extraction. Thus, the demand-supply gap is far greater than it actually appears. A wide gap between demand and supply demonstrates that the BRT forests cannot cater to the fuelwood needs sustainably with the prevailing patterns of extraction. Probable consequences of fuelwood extraction on biodiversity are discussed, and management options to meet energy requirement and to conserve biodiversity are explored.

**Key Words:** fuelwood; sustainability; consequences on biodiversity; management options; Soliga.

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India meets most of its domestic energy requirement from non-commercial fuel sources. Commercial fuels (petroleum, coal, and electricity) in the domestic sector contribute only about 25% of the total demand. Among various non-commercial fuels, fuelwood, agricultural residues, and livestock refuse contribute about 65%, 20%, and 15% respectively (NCAER 1985). No consensus exists on the current demand for fuelwood in the country. Fuelwood consumption estimates vary by a factor of 100%, i.e., from 146 to 305 million metric tons per year (Lele, Mitra, and Kaul 1994). The rural sector is estimated to share 85% of the total fuelwood consumption, and the balance (15%) is consumed by the urban sector (MEF 1987).

Standing biomass in Indian forests is estimated to be 8,357.9 million metric tons with a mean of 130.5 t ha<sup>-1</sup> (Ravindranath et al. 1992). If 1% of the standing stock is taken as annual extractable yield (Chaturvedi 1994), the total possible supply of wood from Indian forests would be 83.6 million metric tons. Clearly, a big gap exists between the demand and the supply of fuelwood in the country. The gap is steadily increasing due to burgeoning population on the one hand and depleting forest resources (supply base) on the other. The demand-supply gap can be bridged partly by expanding the fuelwood supply resource base (natural forest cover, plantations, agricultural residue, and livestock refuse) and partly by increasing production per unit area.

There is much variation in local abundance of fuelwood due to unequitable geographical distribution of the fuelwood resource supply base. Since fuelwood is a cheap commodity and trans-

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<sup>2</sup> Correspondence.

portation costs are exorbitant, fuelwood cannot be carried to a consumption center which is distant from the production center. Hence, policy formulation and planning for bridging the fuelwood demand-supply gap must be undertaken on a local basis. Consequently, there have been a number of attempts to quantify the pressures for fuelwood on specific forest areas in India (Fernandes, Menon, and Viegas 1988; Ganesan 1993; Maitra 1992; Malhotra et al. 1990a,b, 1991; PHCC 1991) as well as abroad (Gunatillake, Senaratne, and Abeygunawardena 1993; Gunatilleke, Gunatilleke, and Abeygunawardena 1993; Wall and Reid 1993).

This paper quantifies the demand for and production of fuelwood in the Biligiri Rangaswamy Temple (BRT) wildlife sanctuary. Specifically, our objectives are: 1) to estimate the extraction and production of fuelwood in the sanctuary, 2) to assess the sustainability of current fuelwood extraction and probable consequences of extraction on biodiversity, and 3) to discuss policy implications for improved management of fuelwood supply resource base.

### STUDY AREA

The Biligiri Rangaswamy Temple (BRT) wildlife sanctuary (540 km<sup>2</sup>) in the Mysore district in Karnataka State of India (Fig. 1) is the union of three reserve forests, namely, Biligiri Rangaswamy Reserve Forest (86.2 km<sup>2</sup>, henceforth referred to as BRF), Chamarajanagar Reserve Forest (234.8 km<sup>2</sup>, henceforth CRF) and Doddasampige Reserve Forest (218.5 km<sup>2</sup>, henceforth DRF). The terrain is highly undulating with altitude ranging from 600 m to 1800 m. A detailed description of the site is available in Ramesh (1989) and Hegde et al. (1996).

The sanctuary has been the home of an aboriginal hunter-gatherer tribe, the Soliga, for millennia. Currently, the tribe derives sustenance mostly from hunting and gathering of non-timber forest products (NTFPs) and partly from wage labor (Hedge et al. 1996; Uma Shankar et al. 1996). Some non-Soliga people also inhabit the sanctuary. Historical notes indicate that the non-Soligas started inhabiting these forests during late nineteenth century when coffee planting was taken up in the hills. Currently, the sanctuary houses a number of settlements in the core (i.e., within legally defined boundaries) and on the fringe (i.e., 4–6 km zone around the boundary) of the forest, which consist of either Soliga

or non-Soliga populations, or sometimes a mix of both. Both Soliga and non-Soliga people depend on forest wood for meeting domestic energy needs (cooking, water heating, and space heating). Despite a ban on the collection of wood from standing trees within the sanctuary since 1987, the forest on the fringe of the sanctuary continues to be under pressure from illicit woodcutting. Under current management practice, the forest department conducts organized collection of fuelwood from naturally dead and accidentally damaged (wind fallen and elephant broken) trees to feed the fuelwood market in surrounding villages of the sanctuary.

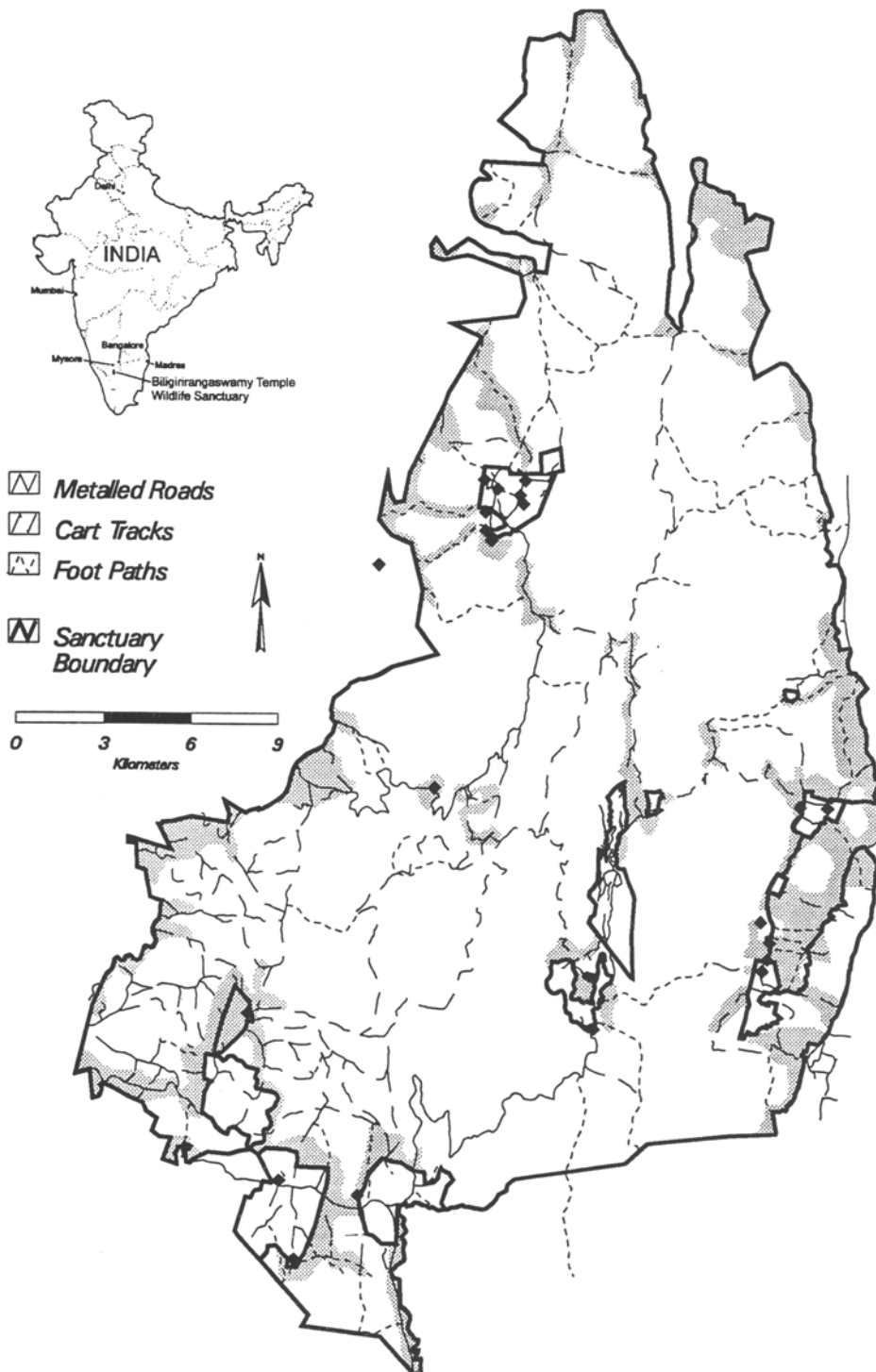
### METHODS

The fuelwood pressure on a given tract of forested land has been generally estimated by a "Questionnaire Method" or by a direct "Footpath Survey." In the following account, we discuss the limitations of these methods and the conditions in which they could be applicable. Then we propose an innovative technique to estimate the fuelwood pressure on a given forest.

#### QUESTIONNAIRE METHOD

Most preliminary inventories estimating fuelwood pressure on the forest have been conducted using a questionnaire structured according to regional needs and priorities (Fernandes, Menon, and Viegas 1988; Gunatilleke, Gunatilleke and Abeygunawardena 1993; Gunatillake, Senaratne and Abeygunawardena 1993; Malhotra et al. 1990a,b, 1991). The questionnaire is the most widely adopted method for gathering data on collection and consumption quantities of fuelwood and other non-timber forest products. The wide use of questionnaires is probably due to the limitation of time, resources and logistic facilities.

Although extensively used, the questionnaire method generates highly biased data. For example, in the case of fuelwood studies, most respondents do not generally supply accurate information for reasons such as 1) lack of interest in responding, 2) ignorance or inadequate knowledge of the subject, and 3) intentional distortion of information. Several researchers have encountered respondents who do not willingly answer the schedules simply because they do not benefit from it. Wilkie (1989) experimented with use of cash incentives to enhance recall and increase participation. He found underreporting of



**Fig. 1.** Map of the Biligiri Rangaswamy Temple (BRT) wildlife sanctuary showing settlements, non-forest land and fuelwood extraction areas. Areas of extraction are shown in gray. Settled areas, plantations, and other agricultural areas are shown as enclosures bounded by the heavy line.

killed animals by hunters when cross-checked with the other villagers. Inadequate knowledge of quantities might also lead to incorrect reporting (Malhotra et al. 1991). For example, if a respondent is asked how much fuelwood he/she requires for daily consumption for his/her family, the response could be incorrect merely because the respondent is estimating a weight that is rarely measured. The uncertainty (error) component in such an answer could be very high.

Intentional distorting of the information on a questionnaire is quite possible, especially in the case of items that are banned from collection. For instance, if a respondent is asked about the quantity of fuelwood gathered from the forest, the answer may be manipulated to a significant extent. We have noticed in the BRT sanctuary that respondents do not readily supply correct information about the quantities of fuelwood and other forest products gathered from the forest for fear of punishment. If the respondents are confederated, the answers vary greatly.

It is interesting to note in this context that most of the gatherers have adequate knowledge about the forest legislation pertaining to restrictions on gathering from the forest. However, they are unsure of the exemptions since forest officials only dictate to them about practices banned within the forest boundaries. Bernard et al. (1984) and Bernard et al. (1986) concluded that "on average, about half of what informants report is incorrect in some way." However, the questionnaire method is useful for a rapid assessment and to collect qualitative information such as the names of species used for fuelwood.

### FOOTPATH SURVEY METHOD

A few studies estimating pressure on the forest for fuelwood have relied upon the data obtained from direct observations of outgoing fuelwood (headload, bicycleload, cartload) from the "entry paths" of the forest, a technique called "footpath survey" (Appasamy 1993; Ganesan 1993). For example, the Palni Hills Conservation Council (PHCC) used the footpath survey technique for estimating fuelwood pressure on the 912 ha Kadavakurichi Reserve Forest in Tamilnadu, which is surrounded by a number of villages (Appasamy 1993). A total of 43 entry paths into the forest were identified. A vigil was kept simultaneously on each path from dawn to dusk, one day each week for 7 consecutive

weeks, and the quantity of outgoing fuelwood was recorded.

The results obtained from the footpath survey on fuelwood collection quantity carry limited scientific value. One major factor discounting the acceptability of footpath survey data is the frequency of sampling. In case of Kadavakurichi Reserve Forest, for example, 7 days of observations comprise only 1.91% sample, a rather low sample size. Appasamy (1993) points out that seasonal variations also were not considered in the PHCC survey. Seasonal variations could be great, depending on the rainfall pattern and agricultural operations in the area. It is generally observed that during monsoon season, especially on rainy days, people may not collect fuelwood. Conversely, during pre-monsoon dry season, heavy collection might occur for storing fuelwood supplies for use during the monsoon period, when finding dry fuelwood becomes difficult. Similarly, the intensity of fuelwood collection could be much lower during the harvest than during the pre- and post-harvest seasons. Landless laborers might collect and sell fuelwood during non-labor days to generate income. Besides seasonal variations within a year, variations from year to year may also affect collection patterns.

The footpath survey could be applicable to those small areas where the boundary of the forest is well defined, and the entry paths are limited and accurately known. In large forest areas surrounded by villages, however, it is extremely difficult to precisely measure the quantity of fuelwood carried away from the forest, because of the innumerable unknown entry points. In fact, the entire forest fringe is vulnerable to the collection and transport of fuelwood and other forest products. Logistically, the footpath survey is not feasible in large forest areas because the manpower requirement for observation and the quantity of weighing instruments would be enormous. Since the survey ideally should be conducted for the whole year, it is impracticable and uneconomical.

The footpath survey is of particularly limited value when the forest area is subject to collection by the people living within the forest boundary (i.e., core of the forest) because they may not be observed at the entry paths. Also, collectors prefer to transport the fuelwood and other forest products through "loopholes" to escape from the forest vigil. Nevertheless, footpath

surveys have been tried in a large area of Mudumalai wildlife sanctuary (321 km<sup>2</sup>) and a reserve forest (200 km<sup>2</sup>) close to it in Tamilnadu by Ganesan (1993). This survey was restricted to only "key entry points" into the forest for a period of three consecutive months, and yielded useful information.

#### ESTIMATION OF FUELWOOD PRESSURE ON THE BRT SANCTUARY

We deploy a technique based on the consumption rather than the extraction patterns. The technique is particularly suitable for a very large forest land for which the accurate number of entry paths, or collection points is not known. Unlike the footpath survey which requires enormous manpower for vigilance and other logistics, our technique is comparatively simple and utilizes demographic data. The footpath survey focuses on the "collection quantity," whereas we focus on the "consumption quantity" of the fuelwood. Our assumption is that if people depend solely on the forest for fuel, and if they consume all the fuelwood which is collected (i.e., if no exports are made), then the total consumption quantity will correspond to the total collection quantity. Although this is not always the case, we first estimate the fuelwood consumption based on this assumption, and then introduce correction coefficients to account for the variability which might occur. The consumption quantity of fuelwood is a direct function of the required fuelwood for an "average person" (averaged over male, female and children of all age classes) for an "average day" (averaged over different seasons) multiplied by the number of people who depend on the forest for fuelwood.

The consumption quantity of fuelwood was estimated by the following approach. First, all settlements (Soliga as well as non-Soliga) and other institutional agencies which depend partly or exclusively on the forest for fuelwood were identified. This was done by scanning the Survey of India toposheets for the sanctuary area and listing all the settlements. The 1972 version of the toposheets (1:50 000) was used. Understandably, the settlements established after the toposheet survey in 1972 do not exist on the toposheets, and the settlements which have been abandoned after the toposheet survey remain marked on the toposheets. We updated the toposheets by deleting the abandoned settlements and marking the new settlements on the basis of

information from Soligas. A few institutional agencies that consume fuelwood from the forest, such as schools, voluntary organizations and hotels, were also identified. The census data for non-Soliga settlements were gathered from Government Taluka Offices at Yelandur, Chamara-janagar and Kollegal, and those for Soligas were obtained from the Vivekananda Girijana Kalyana Kendra, a voluntary organization active in the welfare of the Soligas in BR Hills since 1980. Second, we estimated fuelwood consumption per capita per day. A reconnaissance survey of the BRT sanctuary showed that a family consumes fuelwood typically for cooking, water heating, and space heating. The procedure for estimation of fuelwood consumption separately for cooking, and water and space heating is discussed in detail below.

#### ESTIMATION OF FUELWOOD CONSUMPTION FOR COOKING

Traditionally, a family cooks two major meals a day, one in early morning and the other in early evening. The cooking of the mid-day meal is a rare practice because the people in this area are accustomed to working in the forest or agricultural fields from morning to evening without returning home for lunch; the lunch is carried to the workplace. Therefore, breakfast and lunch are cooked together in the morning. Some households consume fuelwood in the afternoons during typhoons.

In the BRT sanctuary, three microclimatic zones can be distinguished; 1) year-round dry zone at foothills, 2) seasonally dry zone at mid altitude, and 3) cool zone at high altitude. Presumably, fuelwood consumption varies between settlements located at different altitudes primarily due to temperature variability, and secondarily due to different cooking habits. To account for this variation, we measured household fuelwood consumption for ten families each in the three climatic zones. The first household was selected as and when encountered in each zone. Each family was visited during afternoon (1600 to 1800 h) before cooking of the evening meal. The fuelwood available to each family was weighed. While selecting the families, we took care that each family had enough fuelwood for consumption and did not schedule fuelwood collection from the forest during the next 24 h, to avoid the risk of fuelwood consumption other than what has been weighed, or mixing of

TABLE 1. AVERAGE PER CAPITA FUELWOOD CONSUMPTION (KG) FOR COOKING IN DIFFERENT SEASONS AT LOW, MID, AND HIGH ALTITUDES IN THE BRT SANCTUARY.

Altitude	Summer (89 days)	Monsoon (153 days)	Winter (123 days)	Annual (365 days)	Per day
Low	1.42 ± 0.27	2.94 ± 0.77	2.22 ± 1.07	849.3	2.33
Mid	1.90 ± 0.74	3.81 ± 0.78	2.82 ± 1.29	1098.9	3.01
High	2.06 ± 0.59	4.03 ± 1.34	3.09 ± 1.18	1180.0	3.23

weighed fuelwood with that newly collected. Each family was also instructed to use the weighed fuelwood only for cooking, and not for water or space heating. These families were visited again after 24 h and the remaining fuelwood was weighed. The difference in the weight of the fuelwood was considered to be the consumption in one day. The number of the persons in each family, including children of all ages, was also recorded. When the consumption quantity of fuelwood was divided by the number of persons in the family, we got the fuelwood consumption per capita per day. Inclusion of children of young age (<2 years) might lead to an apparent error in calculation of the fuelwood consumption per capita per day, because cooking of food for this age class may not consume a significant amount of fuelwood. In our opinion, it is essential to include the young age class in the calculation because population census data also include this class. In this way, we could account for the variability due to sex and age difference of the people and obtain fuelwood consumption estimate per average person per day. The household consumption of fuelwood for cooking was estimated during all the three seasons of the year; summer (89 days, from February to April), monsoon (153 days, from May to September), and winter (123 days, from October to January).

#### ESTIMATION OF FUELWOOD CONSUMPTION FOR HEATING

In addition to cooking, fuelwood is consumed for heating water and space. A survey of the lifestyle indicates that bathing is done invariably with hot water by both Soliga and non-Soliga, and average frequency of bath is 2.5 times per week (based on interview of >50 people). Space heating is practiced by the Soligas only. Non-Soligas are not accustomed to space heating. It is generally done for 3 hours in the evening at low altitude, and is done overnight at mid and

high altitudes. Fuelwood consumption for heating water and space was measured only in summer season from four families each at the three altitudes (low, mid and high). Every family was provided a known quantity of fuelwood separately for water heating and space heating activities. The unused fuelwood was measured the next day. By taking into account the family size, consumption was calculated on per capita per day basis. For calculating consumption for water heating, the frequency of bath (2.5 times per week) was taken into account.

## RESULTS

### FUELWOOD CONSUMPTION (PER CAPITA)

A total of 10 families were studied for fuelwood consumption for cooking at all three altitudes and in all three seasons. The only exceptions to this were: 7 families at low and 13 families at mid altitude in summer. Family size varied between 2 and 6 at low altitude, 2 and 10 at mid altitude, and 3 and 8 at high altitude. The number of children in a family varied from 0 to 4 at low altitude, and 0 to 6 at mid and high altitudes. This magnitude of variability in family size and family structure allowed us to obtain a fairly good estimate of fuelwood consumption on an "average person" basis. Fuelwood consumption for water and space heating was studied in four families each at low, mid and high altitude. Family size varied between 3 and 5 at low altitude, 4 and 5 at mid altitude, and 3 and 4 at high altitude.

In all the three seasons of the year, per capita consumption of fuelwood for cooking was related to the altitudinal gradient. Two way ANOVA showed significant variations due to altitude ( $F = 6.6$ ;  $P < 0.01$ ) and season ( $F = 25.8$ ;  $P < 0.001$ ) Residents at low altitude consumed less fuelwood than those at high altitude (Table 1). At all three altitudes, per capita consumption of fuelwood for cooking increased almost 200%

TABLE 2. DAILY FUELWOOD CONSUMPTION (KG CAPITA<sup>-1</sup>) FOR COOKING, WATER HEATING, AND SPACE HEATING BY SOLIGAS AND NON-SOLIGAS AT LOW, MID, AND HIGH ALTITUDE IN THE BRT SANCTUARY.

Altitude	Cooking	Water heating	Space heating	Total by a Soliga	Total by a non-Soliga
Low	2.3	0.4	0.6	3.3	2.7
Mid	3.0	0.4	1.0	4.4	3.4
High	3.2	0.4	1.1	4.7	3.6

during monsoon and about 150% during winter as compared to that in summer (Table 1). The annual consumption was thus 849.3, 1098.9 and 1180.0 kg capita<sup>-1</sup> respectively at low, mid and high altitudes. On dividing these figures by 365 days of the year, per capita consumption of fuelwood for a day's cooking comes to 2.33 kg at low, 3.01 kg at mid, and 3.23 kg at high altitude. An appreciable increase in fuelwood consumption during winter is attributable to the relatively low temperature and an increase in the frequency of consumption of hot beverages, such as coffee and tea. A similar increase during the rainy season results not only from factors causing an increase in fuelwood consumption during winter but also from an increase in the frequency of cooking of the mid-day meal. In the absence of outdoor work during the rainy season, people stranded in their houses prefer to cook meals for morning and mid-day separately.

Per capita fuelwood consumption for water heating remained nearly constant with variation in altitude, and was 0.4 kg d<sup>-1</sup> (Table 2). Bathing habits at different altitudes seem to be similar as the frequency of bath is almost constant along the altitude (2.5 times per week). The pattern of space heating varies greatly. Space heating is practiced only by the Soliga tribe. Non-Soliga residents both within and around the forest do not practice space heating. Space heating within the Soliga community however is variable, related to altitude. At low altitude, space heating is generally done for 3 hours each day (1800 to 2100 hrs), whereas at mid and high altitudes, it is done overnight or about 10 hours. Per capita fuelwood consumption for space heating varied from 0.6 kg d<sup>-1</sup> at low altitude to 1.1 kg d<sup>-1</sup> at high altitude; it was 1.0 kg d<sup>-1</sup> at mid altitude (Table 2).

When consumption for cooking, water heating

and space heating was pooled, the fuelwood required for an average Soliga person was 3.3 kg d<sup>-1</sup> at low altitude, 4.4 kg d<sup>-1</sup> at mid altitude and 4.7 kg d<sup>-1</sup> at high altitude (Table 2). The fuelwood requirement for a non-Soliga was lower than a Soliga, because non-Soligas do not use fuelwood for space heating. Consumption by a non-Soliga was 2.7, 3.4 and 3.6 kg d<sup>-1</sup> respectively at low, mid and high altitudes (Table 2).

#### TOTAL FUELWOOD CONSUMPTION (PER DAY)

The human settlements and institutional agencies in the core and on the fringe of all the three reserve forests of the sanctuary, viz., BRF, CRF and DRF are listed respectively in appendices I, II and III. The population of each of these has been shown in Soliga and non-Soliga categories. To account for altitudinal variability, each settlement has been classified in low (<1000 m), mid (1000–1500 m) or high (>1500 m) altitudinal zones. To obtain total fuelwood consumption for a settlement, the Soliga and non-Soliga population in it was multiplied with its respective per capita fuelwood consumption for the altitudinal zone in which the settlement falls (as in Table 2). The total consumption of fuelwood is estimated to be 29391 kg d<sup>-1</sup> (14.2%) in the core and 177853 kg d<sup>-1</sup> (85.8%) on the fringe of the sanctuary (Table 3). Of the total fuelwood consumption in the core, 25.6% is in BRF, 23.0% in CRF and 51.4% in DRF. Similarly, of the total fuelwood consumption on the fringe, 20.8% is in BRF, 40.5% in CRF and 38.6% in DRF. Thus, the total consumption of fuelwood in and around the sanctuary is estimated to be 207.2 t d<sup>-1</sup> (Table 3).

#### FUELWOOD PRESSURE (PER HECTARE)

Based on our assumption that the consumption quantity corresponds to the collection quantity, the total fuelwood consumption calculated above could be regarded as the demand or pressure on the forest. If the demand per day (207.2 t) is divided by the total area of the sanctuary (53952 ha) and multiplied by 365, we get an annual pressure of 1.40 t fuelwood on each hectare of forest land. The assumption underlying this calculation is that all the fuelwood required in the core and on the fringe of the sanctuary is supplied from the forest alone. That is, no fuelwood is imported from outside.

TABLE 3. POPULATION (NUMBER OF PEOPLE DEPENDENT ON FOREST FOR FUELWOOD) AND FUELWOOD CONSUMPTION IN THE CORE AND ON THE FRINGE OF THE THREE RESERVE FORESTS OF THE BRT SANCTUARY.

Forest area	Population	Fuelwood consumption (kg d <sup>-1</sup> )
Core		
Biligiri Reserve Forest	1901	7522
Chamarajanagar Reserve Forest	1729	6770
Doddasampige Reserve Forest	4212	15 099
Subtotal	7842	29 391
Fringe		
Biligiri Reserve Forest	15 604	37 043
Chamarajanagar Reserve Forest	26 470	72 085
Doddasampige Reserve Forest	25 313	68 725
Subtotal	67 387	177 853
Grand total	75 229	207 224

#### DISCOUNT FOR ADDITIONAL ENERGY SOURCES

The demand estimated above strictly assumes that fuelwood meets all the domestic energy needs. A survey within and around the BRT sanctuary revealed that the people depend primarily upon non-commercial fuel sources such as forest wood, animal refuse and agricultural residue for fuel energy. Furthermore, the people inhabiting the forest core depend on the forest solely for wood, as the pasture and agricultural land within is very limited (Rudrappa 1993). The people on the fringe of the forest partially depend on agricultural residue to meet fuel energy needs. Two major species used for fuel are coconut (rachis and pericarp of *Cocos nucifera*) and mulberry (twigs of *Morus alba*). Unlike many other parts in the country, cattle dung is not used for fuel, but is instead used as biofertilizer. Commercial energy sources like coal, petroleum and electricity are not preferred for meeting fuel energy needs for economic reasons, though kerosene and paraffin candles are used for lighting in those households that are not provided with electricity. The use of renewable energy is hardly known, although the state government recently demonstrated appliances for tap-

ping solar energy for heating water and charging batteries.

This study has not attempted to measure the alternate/additional sources of energy contributing to the total domestic consumption of energy. Agricultural residue is the major additional energy source. Its contribution varies according to the size of landholding under coconut and mulberry farming. Constrained by the lack of reliable estimates of the contribution of other sources to total energy consumption, we use national average figures of NCAER (1985) according to which agricultural residue (20%) and livestock refuse (15%) together meet about 35% of the domestic energy needs. Thus the value of fuelwood consumption is reduced to 134.7 t d<sup>-1</sup> or 0.91 t ha<sup>-1</sup> y<sup>-1</sup>.

#### WOOD PRODUCTIVITY IN THE BRT FORESTS

To our knowledge, no systematic ecological study has so far been done in the BRT forests to quantify standing crop of biomass and net primary productivity. However, it is possible to derive a fairly reliable estimate of the growing stock and annual yield if basal area and average canopy height of the forest are known. The annual yield can be estimated following Von Mantel's method described by Chaturvedi (1994). The growing stock (m<sup>3</sup> ha<sup>-1</sup>) is estimated as the product of basal area (m<sup>2</sup> ha<sup>-1</sup>) and average canopy height (m) multiplied by a crop form factor which in this forest can be presumed to be 0.5.

The growing stock in three forest types of the BRT sanctuary has been estimated in Table 4. The data on density and basal area are derived from 10 m wide and 500 to 1000 m long transects laid in deciduous (Murali et al. 1996), scrub (Uma Shankar et al. 1998) and evergreen (unpublished data) forest types. The average height of the two dbh classes (1–10 cm, and ≥10 cm) is only approximate, based on stray measurements. The transects were laid in the vicinity of the settlements to represent the floristic composition of the forest in the activity zone. The growing stock is estimated to be only 10.9 t ha<sup>-1</sup> for scrub forest, 155.9 t ha<sup>-1</sup> for deciduous forest and 316.4 t ha<sup>-1</sup> for evergreen forest. The estimate for evergreen forest is substantially lower in comparison to its counterparts in the Western Ghats in Karnataka (420–649 t ha<sup>-1</sup>), which have a comparable species composition, basal area and tree density (Rai and Proctor 1986). Similarly, the estimate for scrub forest is also

TABLE 4. ESTIMATION OF GROWING STOCK AND SUSTAINABLE YIELD OF WOOD IN THREE FOREST TYPES OF THE BRT SANCTUARY. THE ESTIMATES ARE BASED ON VON MANTEL'S FORMULA AS ELABORATED BY CHATURVEDI (1994). MEASUREMENTS OF DENSITY AND BASAL AREA ARE DERIVED FROM A SAMPLING AREA OF 2 HA FOR SCRUB, 5 HA FOR DECIDUOUS AND 2.5 HA FOR EVERGREEN FOREST. THE STOCK VOLUME HAS BEEN CONVERTED INTO DRY WEIGHT CONSIDERING  $1.5 \text{ M}^3 = 1 \text{ T}$ .

Forest type	Density (plants ha <sup>-1</sup> )	Basal area (m <sup>2</sup> ha <sup>-1</sup> )	Avg. canopy height (m)	Growing stock		Yield (t ha <sup>-1</sup> y <sup>-1</sup> )
				(m <sup>3</sup> ha <sup>-1</sup> )	(t ha <sup>-1</sup> )	
<b>Scrub</b>						
1 to <10 cm	2403	5.0	4	10.0	6.7	0.067
≥10 cm	84	2.1	6	6.3	4.2	0.042
<b>Deciduous</b>						
1 to <10 cm	564	1.1	5	2.8	1.9	0.019
≥10 cm	284	23.1	20	231.0	154.0	1.540
<b>Evergreen</b>						
1 to <10 cm	2776	3.6	6	10.8	7.2	0.072
≥10 cm	524	37.1	25	463.8	309.2	3.092

considerably lower than that calculated for tropical thorn forest (40 t ha<sup>-1</sup>) by Ravindranath et al. (1992). However, the growing stock in deciduous forest exceeds that reported for tropical dry deciduous forests (115.5 t ha<sup>-1</sup>) by Sharma, Chandra, and Singh (1990).

Annual yield of biomass is only a fraction of growing stock. Generally, the yield is 2% of growing stock for a plantation of 100 year rotation, and 4% of growing stock for a plantation of 50 year rotation (Chaturvedi 1994). For natural forests where trees of different species and ages are mixed, it is somewhat lower, i.e., 1% of growing stock. On the basis of this criterion, we get an annual yield of 0.11, 1.56 and 3.16 t ha<sup>-1</sup> respectively for scrub, deciduous and evergreen forests. On multiplying the yield values respectively with the area under these three forest types, and taking the sum of the resultant

three values, we obtain the total annual yield for the entire sanctuary (Table 5). Of the total yield (66 024 t y<sup>-1</sup>), 78.6% is in deciduous forest, 18.9% in evergreen forest and only 2.5% in scrub forest.

#### SPECIES UNDER PRESSURE

An inventory of species used for fuelwood at low, mid and high altitudes showed that the trees in immediate vicinity of the settlement, irrespective of species, have the maximum risk of wood-cutting. Nevertheless, certain species are preferred over others for fuel use because of their better burning quality (production of less smoke and ash, and ability to burn in all seasons). *Anogeissus latifolia*, *Choloroxyton swietenia*, *Dodonaea viscosa* and *Zizyphus oenoplia* are the most preferred species at low altitude (Table 6).

At mid altitude, *A. latifolia*, *Eriolaena quinquelocularis*, *Grewia tiliaefolia* and *Radermachera xylocarpa* are the preferred fuelwood species. Interestingly, the preferred species are also abundant in the community (Murali et al. 1996). For example, *A. latifolia*, which has the highest fuelwood value index (Bhatt and Todaria 1992) shares 16% and 27% importance value respectively in deciduous (mid altitude) and scrub (low altitude) forest. At high altitude where a major proportion of fuelwood consumers are the laborers for the coffee estates, fallen twigs of *Coffea arabica* and lopped branches of shade trees in coffee gardens (*Grevillea robusta* and *Eucalyptus* sp.) form a fairly large portion of fuel-

TABLE 5. ESTIMATION OF TOTAL ANNUAL YIELD OF WOOD IN THREE FOREST TYPES OF THE BRT SANCTUARY. THE FOREST AREA INDICATED FOR EVERGREEN FOREST INCLUDES THAT UNDER SHOLA FOREST TYPE (432 HA).

Forest type	Area (ha)	Annual yield (t ha <sup>-1</sup> )	Total yield (t y <sup>-1</sup> )	Total yield (%)
Scrub	15 288	0.11	1675.1	2.5
Deciduous	3326	1.56	51 891.8	78.6
Evergreen	3942	3.16	12 456.7	18.9
Grand total	52 494		66 023.6	100

TABLE 6. AN INVENTORY OF SPECIES<sup>1</sup> USED FOR FUELWOOD AT LOW, MID AND HIGH ALTITUDE IN THE BRT SANCTUARY. THE INTENSITY OF FUEL USE OF THE SPECIES IS INDICATED BY PLUS SIGNS (+); DASHES (—) INDICATE NO OR UNACCOUNTABLE INTENSITY OF USE.

Species	Low altitude	Mid altitude	High altitude
<i>Acacia sundra</i> DC.	++	—	—
<i>Albizzia lebbek</i> (L.) Benth.	—	+	—
<i>Anogeissus latifolia</i> (Roxb. ex DC) Wall. ex Guill. & Perr.	+++	+++	++
Bamboo spp.	+	—	—
<i>Bombax ceiba</i> L.	—	+	—
<i>Bridelia retusa</i> Spreng.	—	+	—
<i>Canthium parviflorum</i> Lam.	—	++	++
<i>Careya arborea</i> Roxb.	—	+	—
<i>Cassia fistula</i> L.	—	+	—
<i>Catunaregum rugulosa</i> (Thw.) Tiruv.	++	+	—
<i>Chloroxylon swietenia</i> DC.	+++	—	—
<i>Cocos nucifera</i> L. <sup>2</sup>	+++	—	—
<i>Coffea arabica</i> L. <sup>2</sup>	—	—	++
<i>Dodonaea viscosa</i> N. Jacq.	+++	—	—
<i>Phyllanthus emblica</i> L.	+	+	+
<i>Eriolaena quinquelocularis</i> (W. & A.) Cleg.	+	+++	+
<i>Grevillea robusta</i> A. Cunn. ex R. Br. <sup>2</sup>	—	—	+++
<i>Grewia tiliaefolia</i> Vahl.	+	+++	++
<i>Helicteres isora</i> L.	—	+	+
<i>Kydia calycina</i> Roxb.	+	++	+
<i>Lantana camara</i> L.	++	++	+
<i>Maeytenus emarginata</i> (Willd.) Ding-Hou.	++	—	—
<i>Mallotus philippinensis</i> (Lam.) Muell.-Arg.	—	+	++
<i>Morus alba</i> L. <sup>2</sup>	++	—	—
<i>Premna tomentosa</i> (Lam.) Willd.	+	—	—
<i>Pterocarpus marsupium</i> Roxb.	+	++	—
<i>Radermachera xylocarpa</i> (Roxb.) K. Schum.	—	++	+
<i>Schrebera swietenoides</i> Roxb.	+	+	—
<i>Terminalia chebula</i> Retz.	+	+	—
<i>Terminalia crenulata</i> Heyne.	+	++	++
<i>Terminalia paniculata</i> Roth.	+	++	—
<i>Zizyphus oenoplia</i> (L.) Mill.	+++	—	—

<sup>1</sup> See Murali et al. 1996 for authors of binomials.

<sup>2</sup> Indicates species not found in natural forest.

wood resource base. Still many species from natural forest, especially *A. latifolia* (brought from lower reaches since it is poorly distributed at high altitude), *Grewia tiliaefolia*, *Mallotus philippinensis* and *Canthium parviflorum* are cut for fuel. *Phyllanthus emblica*, *Terminalia chebula* and *T. belerica* are three major NTFP species playing a pivotal role in the economy of Soligas (Uma Shankar et al. 1996). Fruits of all three species have a variety of uses and hence are needed in large quantities. Collection of these fruits is done by the Soligas who in turn are paid collection charges. This activity is the major means of income generation for Soligas, contributing half or more of the total income

(Hegde et al. 1996). As a token of respect, the trees of these three species are generally not damaged, especially by the Soligas, for fuel use.

## DISCUSSION

### SUSTAINABILITY OF FUELWOOD EXTRACTION

The demand for forest wood for fuel use in the BRT sanctuary appears to be, at the first instance, less (49 165 t y<sup>-1</sup>) than the net wood production (66 024 t y<sup>-1</sup>). However, the gap between demand and supply is not in fact so small for the following two reasons. First, the people in the core of the forest tend to collect fuelwood repeatedly from the same patches of the forest

in their surroundings. It is most likely that the forest land in closest proximity to the settlement experiences maximum intensity of collection, with a progressive decline as one moves away from the settlement. After the supply from the closer points begins to decline, people walk further and further into the forest widening the area of the impacted zone. On the other hand, the people residing on the fringe of the forest tend to invade the forest boundary from outside to collect fuelwood. They gather fuelwood first from the outermost zone of the forest, but start intruding deeper and deeper as the supply dwindles. Supposedly, the outermost 1–2 km zone would be affected the most, since the time of stay, and with it the risk of arrest for performing illicit woodcutting would increase with the distance penetrated into the forest. Hence, while there would be continuously dilating “impacted-holes” in the core, the “impacted-periphery” of the forest would be shrinking simultaneously. It could be concluded that the forest cover under impacted-holes, and impacted-periphery, would actually be the one pressured for fuelwood cutting. Thus, if only impacted area is taken into consideration for calculating the pressure per hectare forest land (not the area of the whole forest as done above), the calculated figure of  $0.91 \text{ t ha}^{-1}$  will rise substantially.

It is hardly possible to precisely estimate the forest cover under impact-zone due to the unpredictable direction and distance travelled by a fuelwood collector. Nevertheless, we attempt here to crudely estimate the area under impact-zone by toposheet survey method. We marked on 1:50 000 scale toposheets the forest area around each settlement which is reached by the fuelwood collectors (Fig. 1). For this we visited all the settlements within the sanctuary and questioned local inhabitants about their fuelwood collection activities. The collection is done on easily accessible terrains along the roads (paved or unpaved) and footpaths. In other words, microlevel geography is an important determinant of the selection of area for fuelwood extraction. We considered this factor while marking the toposheets. Similarly, the forest area impacted by fuelwood extraction was marked along entire boundary of the forest by recognizing potential entry paths, roads, footpaths and population centers. The area under impact-zone is estimated to be 20.1% of the total sanctuary area or 10854 ha. The wood production from

activity zone would thus amount to  $13\,271 \text{ t y}^{-1}$ , or only 27% of the total demand.

The second factor which further widens the gap between demand and supply is selective use of particular species for fuel. The supply estimate takes into account the productivity of all the species occurring in the community. If the productivity of the species not preferred for fuelwood is deducted from the total, the supply estimate will go down. However, the quantum of such reduction in supply would depend upon the relative dominance of the species preferred and not preferred for fuel use. Since a quantitative conclusion is difficult to make using the data presented, it could be said that the demand-supply gap is surely more than what is calculated above, and it should be taken into consideration in policy-planning for fuelwood management.

### ECOLOGICAL IMPACTS

It is apparent that if the harvested quantity exceeds the production capacity, one would not only lose the growing stock but also biodiversity. The time taken for such a total loss would depend upon the gap between the harvest rate and production rate; the greater the harvest rate over the production rate, the smaller the time taken in ecosystem conversion. Innumerable examples of this phenomenon can be found in India (Sarin 1994) as well as other countries. Biodiversity can be influenced by fuelwood extraction activity even if the harvest rate is lower than the production rate. What matters most is the nature of material extracted. The wood for fuel is derived from live, dead and damaged trees and woody shrubs. Although dried wood is preferred from dead and damaged logs because it is ready for immediate use, branches of large standing trees are cut, and even small trees and saplings are felled whenever need arises.

Extraction of fuelwood from dead and damaged trees may disturb basic ecosystem functions in general, and biodiversity in particular. The most obvious impact of removal of dead and damaged wood is a degradation of litter supplying nutrients to the soil. Decline in supply of litter hampers not only the soil recharge with nutrients, but also eliminates the whole decomposition network. Decomposition of litter is a crucial link in nutrient recycling process in terrestrial ecosystems; the decaying wood harbors many decomposer species, including saprophytes, termites, insects etc.

Extraction of fuelwood from live plants, whether the whole plant is taken or only a part of it, poses no less serious threats than extraction from dead and damaged individuals. Lopping of twigs and branches creates openings in canopy, which in turn increases light interception, alters microhabitat on the forest floor and influences the regeneration process. Twigs and branches in most tree species are the potential sites for flower and fruit development. A reduction in these sites may lead to lower fruit and seed production in the ensuing season, and would thus affect the natural regeneration as well as populations of animals dependent upon flowers and fruits. For species that primarily depend on seeds for regeneration and in which seed mortality from factors such as predation, loss of viability, germination failure, etc. is greater, extraction of twigs and branches may be expensive to the population.

Harvest of whole plants may bring drastic changes in stand density, basal area and population structure. Species preferred for fuel use exhibit greater probability of undergoing such changes. If harvested continuously and in large amounts, the preferred species might even face local extinction. Our studies in scrub forest in the BRT sanctuary in Mysore district show that a pole (tree sapling) is most vulnerable to cutting once it attains a dbh of 5 cm (Uma Shankar et al. 1998). This hampers the establishment of newly recruited individuals in the population and causes a positive skew in the population structure. Those species which are preferred for fuel use have maximum chance of removal at the pole stage. Pole cutting also affects other ecological attributes. The density of the population declines and basal areas are reduced, which may bring changes in hydrological cycle by increasing the rate of erosion of soil and nutrients through run-off and leaching. The pole stage is the period of fastest growth in the trees' life; thus the rate of growth of the forest and in turn the rate of carbon sequestration in biomass declines if excessive numbers of poles are removed. However, removal of poles within prescribed limits can be permitted if regeneration is good and silvicultural thinning of the natural forest is required.

The method of extraction also influences biodiversity. The biomass accumulated annually in the forest through net primary productivity is apportioned to bole and small twigs and branches.

It is important to extract biomass in a way which would have the least harmful consequences on ecosystem functioning. It is also widely debated whether to permit the extraction of naturally dead trees, accidentally damaged trees, or both of these categories. Histologically, naturally dead and accidentally damaged tissues differ primarily in their moisture retaining capacity, and consequently serve as substrate for different variety of microfauna and microflora. While naturally dead tissues harbor a mostly decomposer community, damaged tissues largely support pests and borer insects which are harmful to other trees in the community.

### MANAGEMENT OPTIONS

The present practices of fuelwood extraction, if continued, may have a drastic effect on the ecosystem structure and function. Heavy extraction of fuelwood in a wildlife sanctuary, designed to protect biodiversity, is most discouraging. Even if our estimates of extraction were significantly reduced, say by half, the impact of extraction would still be substantial because much of the extraction is concentrated on the periphery. With increase in population and continuing lack of alternative fuels, the extraction is likely to increase without management interventions.

Presently, the management of the sanctuary is the responsibility of the Karnataka Forest Department (KFD), but we are not aware of any management plans that seek to address the fuelwood issue. The main concerns of the KFD management plans are the prevention of encroachments, illicit cutting of timber, curtailment of fire, eradication of weeds, and the maintenance of wild populations of large mammals. With limited human, financial, and technical resources, the ability of the KFD to monitor threats to biodiversity and to develop mechanisms that maintain biodiversity in the face of human pressures is limited.

Obvious global remedies for the "fuelwood crisis" are thought to be relatively simple: more trees in the form of energy plantations, better stoves for rural families, and alternative fuels (usually fossil fuels) for urban and industrial consumers (FAO 1990). However, implementation of the global recommendations has demonstrated that these strategies often need to be tailored to meet local conditions (Veer and Enevoldsen 1993). In this context, strategies to re-

solve the fuelwood crisis in the BRT sanctuary may be worked out at three different levels: greater productivity, efficient use, and alternative fuel sources.

Energy plantations of indigenous species in degraded lands, particularly around settlements and in the periphery of the sanctuary may provide one of the means to enhance productivity. Because the level of demand and the location of consumption centers in and around the BRT forests is known, the area that should be brought under fuelwood plantations can be calculated. Information about the choice of species, yield potential, and economics of establishing plantations is available (Chaturvedi 1985, Sharma 1992).

One way of reducing the gap between demand and supply is to harness maximum energy potential of the wood through efficient burning devices. In the BRT sanctuary, fuelwood is burnt in a highly inefficient manner in open spaces or old-fashioned mud-chulhas (stoves). There is ample scope for introduction of improved stoves. Feasibility of multi-fuel stoves such as those offered by a Philippine firm can be tested in the BRT sanctuary and similar areas (Anonymous 1993a). Impact of fuelwood extraction on biodiversity can be minimized if dependence on wood-based fuels can be reduced by promoting alternative fuel sources. Also as the era of fossil fuels such as coal, kerosene, liquefied petroleum gas is approaching its end, use of renewable and non-conventional energy sources must be promoted. This can be achieved through demonstrations of modern appliances, training consumers and providing incentives to help them afford new technology. Feasibility of some energy technologies, such as solar photovoltaic systems, windmills, biogas and briquetting should be assessed in and around the BRT sanctuary in light of the feedback provided by several researchers (Anonymous 1993b; Bagemann 1993; Nayar 1993; Tewari 1992; Venkata Ramana 1991).

Appropriate mechanisms would be required to develop energy plantations, to increase efficient use of fuels, and to introduce alternative sources of energy. Fortunately, institutions exist in the area to create such mechanisms. Moreover, these institutions have the mandate to manage natural resources and safeguard the livelihood of the Soligas. The Karnataka Forest Department (KFD) is in the process of initiating the joint forest management program, which in other parts of

the country has involved local communities in protection and regeneration of the degraded forests in exchange for the use of forest products. The non-government organization, Vivekananda Girijana Kalyana Kendra (VGKK), representing Soligas, has been engaged in a wide range of community development projects. The two organizations (KFD and VGKK) have the potential to develop a coordinated program for conservation and sustained utilization of natural resources of the area.

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APPENDIX 1. SETTLEMENTWISE POPULATION AND FUELWOOD CONSUMPTION IN THE CORE AND ON THE FRINGE OF THE BILIGIRI RANGASWAMY RESERVE FOREST (BRF) OF THE BRT SANCTUARY. LA IS LOW ALTITUDE AND MA IS MID ALTITUDE.

Settlement	Location	Soliga	Non-Soliga	Fuelwood consumption (kg d <sup>-1</sup> )
<b>Core</b>				
1. Banglepodu	MA	219	—	964
2. Hosapodu	MA	173	—	761
3. Kalyanipodu	MA	60	—	264
4. Manjeegundi	MA	43	—	189
5. Muthkadagadde	MA	271	—	1192
6. Purani	LA	329	—	1086
7. Sigebettapodu	MA	84	—	370
8. Yarakangadde	MA	236	—	1038
9. BR Temple	MA	—	12	41
10. Giridarshini*	MA	—	16	60
11. Forest Colony	MA	—	16	54
12. Sericulture	MA	—	60	204
13. Horticulture	MA	—	22	75
14. VGKK*	MA	—	280	952
15. Others	MA	—	80	272
Subtotal		1415	486	7522
<b>Fringe</b>				
1. Dasanhundi	LA	—	336	907
2. Devarahalli	LA	64	—	211
3. Gangawadi	LA	—	635	1715
4. Gowdalli	LA	—	1624	4385
5. Gumballi	LA	—	2428	6556
6. KD Halli	LA	—	70	189
7. Komaranpura	LA	—	1844	4979
8. Krishnapura	LA	—	1024	2765
9. Malaripalya	LA	—	762	2057
10. Ranganathapura	LA	4	—	13
11. T. Hosur	LA	—	726	1960
12. Vadagere	LA	—	470	1269
13. Yeragamballi	LA	—	3716	10037
Subtotal		68	13635	37043
Grand total		1483	14121	44565

\* Figures supplied by the concerned agencies based on actual measurements of fuelwood consumption.

APPENDIX 2. SETTLEMENTWISE POPULATION AND FUELWOOD CONSUMPTION IN THE CORE AND ON THE FRINGE OF CHAMARAJANAGAR RESERVE FOREST (CRF) ON THE BRT SANCTUARY. LA IS LOW ALTITUDE AND MA IS MID ALTITUDE.

Settlement	Location	Soliga	Non-Soliga	Fuelwood consumption (kg d <sup>-1</sup> )
<b>Core</b>				
1. Bedguli	MA	369	—	1624
2. Budhipadaga	LA	305	—	1007
3. Goremadu	LA	117	—	386
4. Kanneri Colony	MA	478	—	2103
5. K. Gudi	MA	115	—	506
6. Muneswara Colony	LA	163	—	538
7. Yettegowdandoddi	LA	132	—	436
8. Forest Colony	MA	—	45	153
9. Govt. School	MA	—	5	17
Subtotal		1679	50	6770
<b>Fringe</b>				
1. Attagulipura	LA	102	1623	4719
2. Banawadi	LA	196	—	647
3. Bellatha	LA	74	—	244
4. Chandakwadi	LA	—	3160	8532
5. Hittalugudda	LA	49	—	162
6. Hondrabalu	LA	—	391	1056
7. Honganur	LA	—	6245	16862
8. Irainapur	LA	—	478	1291
9. Irasawadi	LA	—	2202	5945
10. Kebbepalya	LA	33	—	109
11. Kullur	LA	87	311	1127
12. Mukanpalya	LA	—	638	1723
13. Muratipalya	LA	150	140	873
14. Nagavalli	LA	—	5628	15196
15. Nallur	LA	—	2846	7684
16. Navodaya Vidyalaya	LA	—	20	54
17. Punjur	LA	56	1200	3425
18. Puttanapur	LA	—	527	1423
19. Shanivar Muratti	LA	52	—	172
20. Srinivasapura	LA	222	40	841
Subtotal		1021	25449	72085
Grand total		2700	25499	78855

APPENDIX 3. SETTLEMENTWISE POPULATION AND FUELWOOD CONSUMPTION IN THE CORE AND ON THE FRINGE OF DODDASAMPIGE RESERVE FOREST (DRF) OF THE BRT SANCTUARY. LA IS LOW ALTITUDE, MA IS MID ALTITUDE AND HA IS HIGH ALTITUDE.

Settlement	Location	Soliga	Non-Soliga	Fuelwood consumption (kg d <sup>-1</sup> )
<b>Core</b>				
1. Arekadavu	LA	273	—	901
2. Gombegallu	MA	83	—	365
3. Gundimalam	LA	7	—	23
4. Hiriambala	MA	446	—	1962
5. Hosapodu	LA	339	343	2045
6. Jogiyuru	LA	150	—	495
7. Kanchegallu	LA	110	—	363
8. Kathekallu	LA	211	—	696
9. Kelagaluru	LA	120	—	396
10. Keredimba	MA	120	—	528
11. Mavathur	LA	113	—	373
12. Nellikadaru	MA	95	—	418
13. Udatti	LA	32	—	106
14. Uganimalai	LA	—	60	162
15. Honnamatti CE	HA	—	260	936
16. Bedguli CE	HA	—	370	1332
17. BRT CE	HA	—	100	360
18. Attikan CE	HA	—	130	468
19. Floating population*	HA	100	750	3170
Subtotal		2199	2013	15 099
<b>Fringe</b>				
1. Bailur	LA	—	485	1310
2. Basavanapura	LA	42	—	139
3. Boodhipadaga	LA	143	—	472
4. Chikkanawadi	LA	—	397	1072
5. Doddanawadi	LA	—	5310	14 337
6. Gurumallappannadoddi	LA	52	—	172
7. Kamagere	LA	—	781	2109
8. Kavalihalla Dam	LA	126	—	416
9. Kurubankatte	LA	—	84	227
10. Lokkanahalli	LA	—	4375	11 813
11. Madhuvanahalli	LA	—	7802	21 065
12. Odeyarapalya	LA	—	1160	3132
13. P.G. Palya	LA	—	2887	7795
14. Shebinakobbe	LA	170	—	561
15. Surapur	LA	96	1403	4105
Subtotal		629	24 684	68 725
Grand total		2828	26 697	83 824

\* Floating population comprises temporary laborers called for work in coffee estates (CE) during harvest season. The census figures shown for this population are one-half of the actual, because this flux of people stays in the forest for about six months only, and goes back to their native places during the other six months period.