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RESEARCH ARTICLE

# Wild foods from forests: Quantities collected across Zambia

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## Abstract

1. Forests provide an immense range of benefits to people, many of which are not prioritized by forest policy because they are difficult to quantify. Wild foods from forests enhance the quality of diets for those who consume them and provide income for those who sell or trade them. The quantity of wild food collected is challenging to measure because of non-standard units, seasonal differences in collection patterns and large numbers of species.
2. To provide initial estimates of collection volume in Zambia and pilot new methods, we surveyed 209 households across 14 villages randomly selected within 5 study areas covering all four agro-ecological areas between 6 August and 27 October, 2019. For each study area, we conducted a focus group to identify the most commonly collected species within each of nine food product types (mushrooms, insects, green leafy vegetables, tubers, fruits, nuts, wild meat, wild fish, and aquatic plants).
3. All but one surveyed household collected some wild foods; on average, each household collected five types of food product, most commonly mushrooms, fruits and green leafy vegetables. Volume collected varied markedly by household, product type and study area. Rural households in Zambia are estimated to collect over 380 million litres, 380,000 $m^3$, of wild foods annually. We estimate that 88% of these wild foods are collected directly from forests. Accounting for uncertainties, we estimate the volume of wild foods collected from forests to be at least 238,000 $m^3$ per year, 125% of the volume of sawnwood produced, or about 12 million large (20 L) collecting buckets.
4. Volume collected was not strongly correlated with metrics of wealth, indicating ubiquitous consumption of wild foods; however, the most food insecure collected particularly high volumes of wild food. Pilot market surveys found local value chains for wild foods, indicating a potential for economic contribution. Our results underscore the value of data that can be disaggregated locally and indicate that national estimates of quantities of wild food collected from forests would be highly useful for designing forest policy and management strategies.

**KEYWORDS**
diet, non-timber forest products, non-wood forest products, nutrition, trees

## 1 | INTRODUCTION

A clear understanding of the quantities of wild foods collected from forests and of the people collecting these foods is essential for designing forest policy and management strategies. In particular, improved data on the magnitude of the contribution of wild foods to local diets and nutrition and identification of the communities and households where these contributions are most important are needed. In this study, we define wild foods as any food not obtained by cultivation (Muir et al., 2020). Of particular interest in our study are wild foods that are collected from forest areas, including streams and rivers within, whether these areas are pristine or degraded. Quantifying the contributions of wild foods from forests can document the degree to which wild foods are sources of everyday food and nutrition or serve as safety nets for the most vulnerable peoples and communities. Despite the clear importance of this information, few studies have assessed the volume of wild foods being collected or the relationship between collection of wild foods and metrics of wealth or food security.

Globally, wild foods enhance the quality of diets for those who consume them and provide income for those who sell or trade them but the exact benefits vary widely. Powell et al. (2015) reviewed 24 studies on wild food use across the globe and identified large variation in the importance of wild food use to diets and in the food groups that mattered most. Similarly, Rowland et al. (2017) found wide variation in the importance of wild foods and type of wild food use in their study of 7569 households across 24 tropical countries; half of surveyed households consumed foods collected from forests, but the quantity of foods consumed varied markedly across sites and across households within sites. In another global review, 15 of 71 surveyed non-OECD countries reported regular use of wild foods by the majority of their populations although there was no information on quantities consumed (FAO, 2019).

In Zambia, forest area has been declining slightly over the past 30 years, but with just over 60% of land area designated as forest, it remains one of the countries with the highest proportion of forest area globally (FAO, 2020). These forested lands can and do provide a wealth of nutritious foods, from mushrooms and green leafy vegetables (leaves) to insects and wild meat, that contribute to local diets (Jumbe et al., 2007; Mofya-Mukuka & Simoloka, 2015). Jumbe et al. (2007), for example, concluded that wild foods collected from miombo woodlands are widely consumed by rural households, enriching their starch-based diets with important vitamins and minerals. The availability of wild foods in Zambia is, however, dwindling because of unsustainable harvest methods, forest degradation, and expansion of agricultural production (Muimba-Kankolongo et al., 2015). Deforestation is also a concern; it is linked both to an urbanization rate of 3.2% per year, demanding an expansion of housing, energy and transport infrastructure, and to agricultural conversion. The recent conversion of protected areas for development projects, mostly mining, has also increased the risks of overexploitation, biodiversity loss and degradation (Mabeta et al., 2018). Reductions in forest biodiversity have cascading negative effects on the provisioning of ecosystem services for the rural poor who harvest products for food and other basic needs (Ministry of Lands, Natural Resources and Environmental Protection, Republic of Zambia, 2015). A clearer understanding of the magnitude, strength and spatial patterns of these provisioning services can support policies to simultaneously guide forest management and support the rural poor.

Collection of wild foods is a potential source of income. A review of data from 7975 households across 24 developing countries found that 77% of households were engaged in wild food collection from both forest and non-forest environments (Hickey et al., 2016). Although the share of wild food income in total household income was on average only 4%, poorer households and households experiencing shocks derived higher income shares from wild foods (Hickey et al., 2016). In Zambia, collection of wild foods is a source of income for rural woman (Zulu et al., 2019). Sale of wild foods, usually collected from forest areas, has also been shown to provide income for vulnerable peoples in urban areas (Mulenga et al., 2012). Wild foods are found in many urban markets, suggesting their potential to contribute to diets of those who do not have immediate access to forests. Although wild foods are collected primarily by women (Mulenga et al., 2012), they are consumed by both men and woman across all age groups (Mofya-Mukuka & Simoloka, 2015). Some processing of wild foods, especially fruits, to create value-added products such as drinks, jams and yogurt have been documented. Masuku (*Uapaca kirkiana*), for example, is processed into a traditional drink by rural people in Eastern Province of Zambia, and *Parinari curatellifolia* is used to make a local brew in Western Province (Siangulube, 2007). Mushrooms, caterpillars and green leafy vegetables may be dried to increase storage times.

We present the first data, to our knowledge, quantifying the volume of wild forest foods collected across Zambia, describing how patterns differ across rural areas, and exploring associations with wealth and food security. We describe the data collection process and answer a set of key questions. First, we ask what proportion of households collect products from forests? How many different types of product are collected? And, are there differences between collection patterns across the five surveyed areas? Using these data as a base, we make a rough estimate of the total volume of food being supplied by forests to rural households, and estimate the degree to which wild food collection is correlated with metrics of wealth and food security. Finally, we present provisional information on whether wild foods are represented in local markets as a foundation for future work on value chains for wild forest foods. In combination, our work describes the amounts and types of wild foods being collected from Zambian forests and indicates which types of households might be most dependent. Our work tests two innovations in data collection: (1) paired focus groups and quantitative assessments and (2) direct measurement of household collecting containers. As well, we assess the value of regionally distributed study areas. An understanding of the magnitude of regional differences can support the design of targeted policies, implementation of projects with a focus on particular wild food groups and refined data collection guidelines.

## 2 | METHODS

### 2.1 | Questionnaire design

The initial questionnaire was based on instruments that had been successfully used in previous Food and Agriculture Organization of the United Nations (FAO) and Center for International Forestry Research (CIFOR) projects and was revised through three rounds of piloting to create a customized final questionnaire for this project. The first pilot took place outside Lusaka on 24 May 2019. Each enumerator informally surveyed 1–2 households to evaluate all question wording and total questionnaire length. Revisions were made in response to the experienced enumerator team's observations of what parts of particular questions were confusing or what questions took too long to complete. A pilot focus group was conducted in Kazungula District on 26 May 2019 (Figure 1). The revised questionnaire was then pre-populated with information on the most commonly collected foods in each food category, and piloted a second time in the same village on 27 May 2019. The questionnaire was revised and piloted a third time, again in Kazungula but in a new village and in combination with the graduated measuring devices described below on 28 May 2019.

Important issues in questionnaire design included agreeing on a definition of forest: 'has trees and does not belong to the respondent'. The team also agreed to define 'wild' as foods that no one had planted. We decided to quantify what was collected and what percentage of the collected material was consumed. We did not distinguish which household members consumed the food nor whether the foods were consumed as snacks or as a part of a meal. During piloting, we confirmed that a 1-year recall period would provide useful data due to the seasonality of most wild foods. Pilot respondents were able to recall with confidence the number of collection trips for a particular species as well as how many containers they were usually able to fill over the course of several collection trips.

We tested two innovations in project design. First, we designed the household survey for each area using information learned during the focus group for that area. The focus group was used to identify the most common foods collected in that area for each food type, for example fruits, green leafy vegetables, etc. We then used this information to ask about the amounts of these specific foods that were collected by the households in that area. In this way, questionnaires in all areas asked about the most commonly consumed foods of each food type but asked about locally relevant species that often differed from area to area. Second, we enabled respondents to recall volume collected in familiar units, their own collecting cups and buckets. To manage the large variability in size across household collecting containers, we equipped each enumerator with a graduated bucket (15 L), a graduated pitcher (1.75 L), and a bag of peanut shells with which to measure the collecting containers actually used by each household.

In addition to asking about the nine target wild food types (mushrooms, insects, green leafy vegetables, tubers, fruits, nuts, wild terrestrial meat, e.g. mouse or boar, wild aquatic meat, e.g. fish or crayfish, and aquatic plants) for which we quantified collection and consumption, we asked each household whether or not they collected three additional products (medicinal and aromatic plants, honey, and fodder for livestock) from the forest which are more difficult to quantify in the same way. These additional products allowed a more complete assessment of all collection of non-wood forest products. At the beginning of the questionnaire, we asked a fairly standard set of questions to classify the wealth status of the household and to assess sources of income. At the end of the questionnaire, we asked the eight questions that compose the Food Insecurity Experience Scale (FIES, http://www.fao.org/3/a-i7835e.pdf).

### 2.2 | Study area and study site selection

Zambia, a landlocked country located in Southern Africa, had 459,432 km$^2$ of indigenous (natural) forests in 2014 (Central Statistics Office, 2018), with the majority of the human population living in rural areas (59%) (https://zambia.opendataforafrica.org/efhbnl/zambia-demographics-at-a-glance). The distribution of biodiversity across the country is primarily driven by patterns in rainfall (Siachoono, 2018), which ranges from 800 to 1400 mm per annum. There are three notable seasons, namely the cool dry period lasting from May to August or September, the hot and dry period from early September to late October and the hot and wet season from November through April.

Study areas were distributed across all three main agro-ecological regions in Zambia (Figure 1). Region I, a thin strip along the southern edge of Zambia and comprising approximately 12% of the country's land area, receives less than 800 mm of rainfall annually. Region II, in the middle of the country, receives between 800 mm and 1000 mm of annual rainfall, includes approximately 42% of the country and is often sub-divided into IIa (east) and IIb (west). The most rain falls in Region III, to the north of the country, which receives between 1000 mm and 1500 mm of rainfall annually and which makes up 46% of the country's total land area (https://www.wto.org/english/tratop_e/agric_e/presentation_zambia.pdf). Study areas were also distributed across five provinces (Northern, Central, Eastern, Copperbelt, and Southern) (Table 1; Figure 1).

Given the limited budget and the exploratory nature of the study, neither funds nor time were available to randomly select study areas

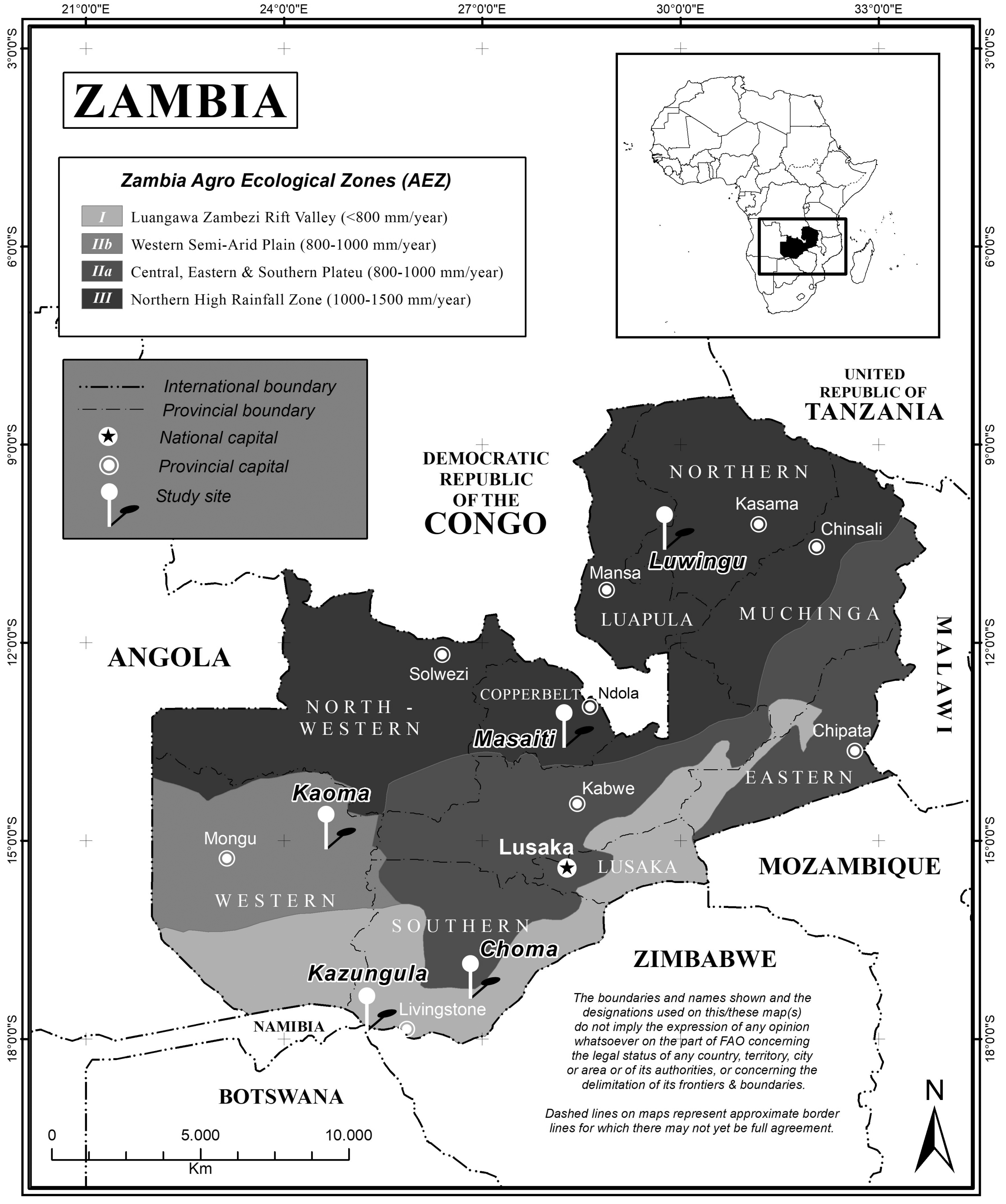


FIGURE 1 Map of Zambia including agro-ecological regions and the five study areas. Map created by Agus M. maulana. Map sources: UN 2020. Map of the world, https://www.un.org/geospatial/content/map-world; UN. 2004. Zambia https://www.un.org/geospatial/content/Zambia; ICRAF. 2015. Zambia Agro-ecological zones http://landscapeportal.org/layers/geonode: agroecological_zones. All source files accessed 24 May 2021.

**TABLE 1** Study areas by agro-ecological region, survey dates, sample size, and diversity of wild product types collected. Villages and households within villages were selected randomly from one ward within the chiefdom. Percent of sampled households with iron sheet roofs is provided as one of many possible indicators of wealth. Possible food types collected include the following: mushrooms, insects, green leafy vegetables, tubers, fruit, nuts, wild meat, wild fish and aquatic plants. HH, households; MAP, medicinal and aromatic plants

| District | Agro-ecological region | Survey dates (2019) | Number households (villages) surveyed | Mean HH size (people) | Iron sheet roofs (%) | Mean number of food types collected per HH | Households collecting each additional wild product (%) | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | MAP | Honey | Fodder |
| Nyimba | I and IIa | 6–10 Aug | 43 (2) | 6.1 | 58 | 5.3 | 65 | 42 | 79 |
| Luwingu | III Northeast | 26–31 Aug | 41 (3) | 5.8 | 71 | 4.8 | 27 | 10 | 34 |
| Masaiti | III West | 16–21 Sep | 44 (3) | 6 | 66 | 5.2 | 41 | 68 | 36 |
| Kazungula | I | 7–12 Oct | 45 (3) | 6.8 | 64 | 3.9 | 60 | 49 | 67 |
| Kaoma | IIb | 21–27 Oct | 36 (3) | 7 | 36 | 5.6 | 75 | 58 | 31 |

and to then develop a working network within each new area in advance of the survey. Instead, where possible, districts and chiefdoms within districts where CIFOR already had a working network were selected within each agro-ecological region. The five districts included (1) Nyimba, located east and slightly north of the capitol of Lusaka and which includes the Luangwa River and Luangwa Valley National Park; (2) Luwingu to the north with high rainfall, abundant streams and Lake Bangweulu, one of the biggest fresh water bodies in Zambia (Nsonga, 2015); (3) Masaiti, just north of Lusaka, with large numbers of small farms and known for informal trade in forest products; (4) Kazungula to the southwest, dominated by mopane woodlands and open grasslands and challenged by persistent droughts (Phiri & Chisonga, 2013); and (5) Kaoma, west of Kafue National Park, part of the Okavango Basin and characterized by savannah woodlands (Siangulube, 2007; Figure 1). The selected chief in each district was asked to chose a ward where the project would most likely be successful, and 2–3 villages were randomly selected from that ward using papers slips in a container. Each village headman was then asked to randomly select households, again using paper slips in a container, to be surveyed for a total of 209 households across all five study areas. Prior informed consent to conduct the research was sought from the selected chiefs and the headmen/women of the randomly-selected villages. Ethical approval for this research study was granted by the Center for International Forest Research (CIFOR, ETHCOMM_2020_006 PMO 19).

## 2.3 | Focus groups

The first activity conducted in each study area was a focus group consisting of 10–20 participants purposefully selected to represent the range of cultural and religious groups in the area. Both men and women were included together as each likely had distinct knowledge of which forest foods are gathered. No questions were deemed sensitive such that the presence of one gender might bias or limit the inputs of the other. Focus groups were led by the enumerator with the best knowledge of the local language.

Focus groups began with a discussion of the study purpose and of the project definitions. The focus group facilitator then led an in-depth discussion of each of the nine target wild food types. The facilitator first asked for a list of all wild foods eaten for each food type. From the list, participants were asked to determine the five most consumed foods. Participants were also asked about the season when each type of wild food is abundant; whether the food is becoming more or less abundant over time; and any reasons for changes in abundance over time.

## 2.4 | Conducting the household survey

The village headman visited selected households to explain the survey in advance of the enumeration team. In each village, each enumerator had a list of randomly selected households. At each house, they explained the survey again and requested to speak with the person who customarily prepares the meals. They checked that this respondent was over 18 years old, able to provide reliable information and willing to provide informed consent. Verbal consent was used because most women in the rural areas surveyed are not able to read and write. For those who are able to sign their name, many refuse to do so because the collection of a signature is considered the collection of sensitive information. Often, other household members stayed with the respondent to confirm responses or to provide additional details. If a suitable respondent was not available, the enumerator moved to the next house on the list. After the full questionnaire was administered, the enumerator used peanut shells and the graduated bucket and pitcher to measure the volumes of the household's large, medium, and small collecting containers. No gifts or remuneration were provided. Each enumerator was able to survey about five houses per day.

## 2.5 | Quantifying the collection of wild foods

We quantified the average volume of each type of wild food collected per household and per person in each household; the variability across households in per person collection volumes; and the proportion of households collecting each product type. Assuming collection patterns within our sample are reasonably representative of collection patterns for rural households across Zambia, we used the 2019 estimate of the rural human population in Zambia (9,989,317) (https://data.worldbank.org/indicator/SP.RUR.TOTL?locations=ZM) to estimate total volume of each product type collected by people living in rural areas. The reported confidence intervals include both the estimated error in the mean per person collection quantity (Gaussian approximation) and the estimated error around the proportion of households collecting (binomial approximation).

The estimated proportion consumed was calculated for each of the five target species within each of the nine product types at each household. These estimates (per target species and per household) were then used to calculate an average, per household and per product type, of the proportion of collected material consumed. The questionnaire asked each household if any of each product type was collected from forests rather than if any of each species within that product type was collected from forests. The estimate of collection from forested areas was therefore done by product type and should be considered a rough estimate.

### 2.6 | Wild food consumption as a function of indicators of wealth and of food security

As one indicator of wealth, our questionnaire included a list of 23 common assets worth $50 USD or more (e.g. generator, TV, mobile phone) and requested respondents to indicate how many of each asset was owned by the household. We also asked each household about chicken and livestock ownership and about the primary roof material of their house (thatch, thatch and other materials, iron sheets, or other). We explored the relationship between the collected volume of the most commonly collected product types (mushrooms, insects, leaves, fruit, and tubers) and total assets, number of chickens, and roof type. We chose number of assets and number of chickens to maximize the number of households with data and the range of data available for the analysis. While number of chickens is not commonly considered a measure of wealth, it is a measure of access to non-wild food and potentially a measure of wealth in some form.

We also graphed the relationship between the volume of these foods and the FIES score mentioned above, in this case including both whether and how often each of the 8 conditions were experienced. We chose five product types (fruit, mushrooms, leaves, insects and tubers) to maximize sample size (number of households collecting) and range of response (range of amount of product collected per household). Although trend lines are graphed for visual clarity, these were not assessed for statistical significance due to the exploratory nature of the analysis, the high number of potential tests, and the lack of a pre-existing hypothesis.

### 2.7 | Market surveys

In each area, one district market was surveyed to provide an indication of market maturity for wild foods. In each market, the total number of stalls was estimated and each was classified as (a) selling only wild foods (not primarily fish); (b) selling some wild foods (not primarily fish); (c) selling primarily fish; or (d) no wild foods. Each enumerator also went to four random vendors selling wild foods and, for all wild foods sold at the stall, interviewed the vendor to discover whether he/she had collected the food directly, purchased or bartered the food directly from the collector, or purchased the food from someone who purchased it from another vendor or the collector.

## 3 | RESULTS

A total of 209 households, relatively evenly distributed across the five study areas, were surveyed between 6 August and 27 October 2019. Mean household size ranged from 5.8 people per household in Luwingu, where 71% of the houses have roofs made of iron sheets, to 7 people per household in Kaoma, where only 36% of the houses have roofs made of iron sheets (Table 1). All but one of the households surveyed collect at least one wild food type and most collect many different wild food types. In Kazungula, for example, households collect, on average, 3.9 types of wild foods (e.g. mushrooms or nuts) and in Kaoma households collect, on average, 5.6 types, with most houses in all study areas collecting multiple species within each product type. In addition to the wild foods that are a focus of this study, 27%–75% of households collect medicinal and aromatic plants (MAP), 10%–68% of households collect honey, and 31%–79% of households collect fodder for animal feed (Table 1).

### 3.1 | Collection patterns across study areas and product types

Collection patterns differ markedly both across product types for a given study area and across study areas for a given product type (Figure 2; Table 2). Fruits are the most commonly collected wild food type with at least 90% of households collecting in every study area. Mushrooms and green leafy vegetables were also frequently collected across all study areas; at least 76% of households collected green leafy vegetables and at least 73% of households collected mushrooms with some variation between study areas. Collection patterns for insects, mostly termites and caterpillars, displayed a clear difference between Kazungula, where almost no households collected, and the other regions where a majority of households collected. Tubers were collected by only 42% of households in Nyimba, but by 92% of households in Kaoma with intermediate collection rates in the other study areas. Collecting or hunting wild meat was reported in all study regions with marked differences between Nyimba (91%) and Kazungula (8.9%). Most reports for wild meat were for bush mice but reported species also included mole, mongoose, guinea fowl, pigeon, rabbit, and warthog. We note that hunting may require special permits and is illegal for some species in Zambia; collection of wild meat is therefore likely to be under-reported, biasing our estimates downward. Fish collection

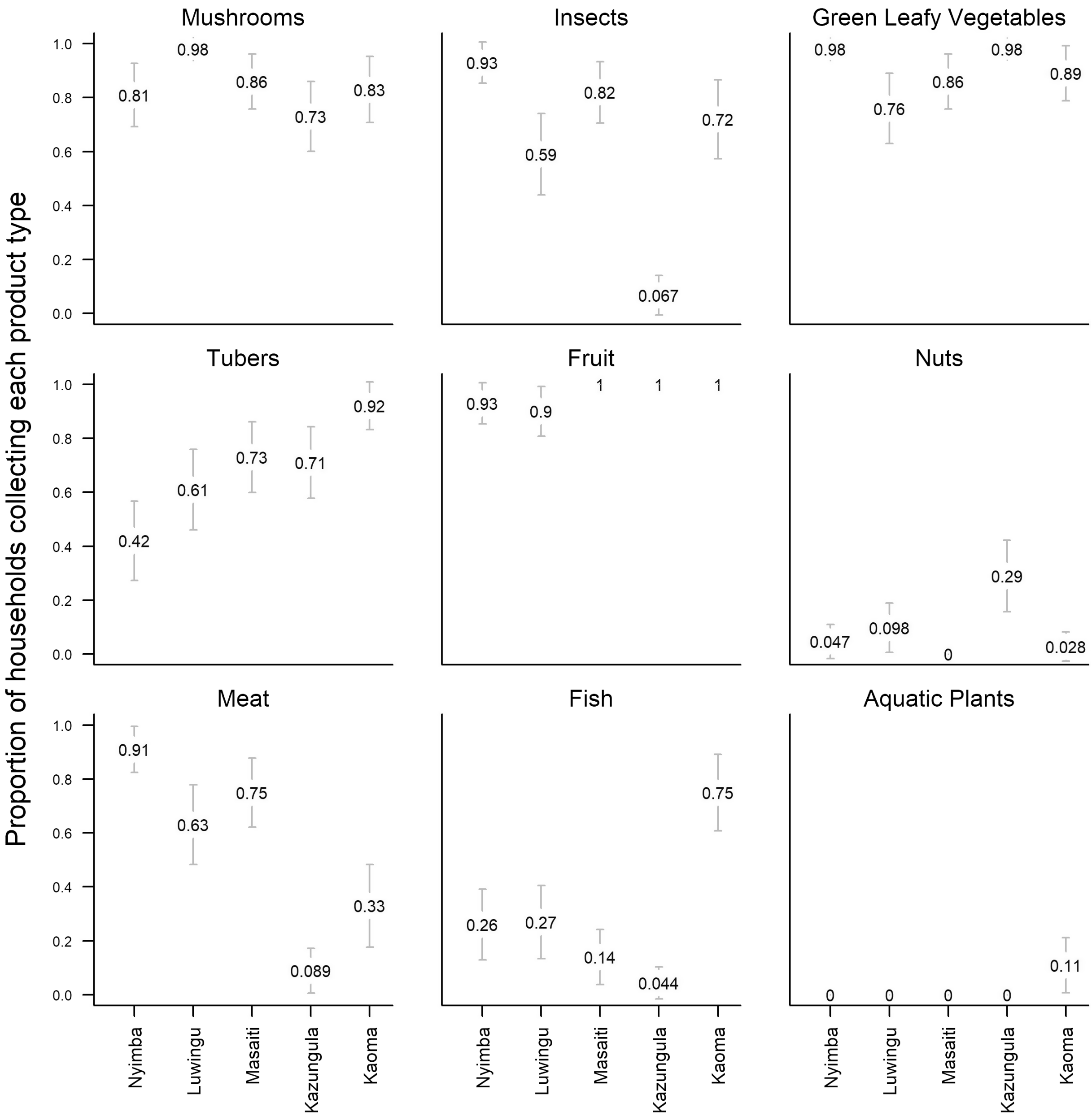


FIGURE 2 Proportion of households collecting wild products in each of 9 product types by each of the five areas studied. Whiskers display 95% confidence intervals using a normal approximation. Given small sample sizes and values close to 0 and 1, these are for qualitative, visual assessment only. Where whiskers are not visible, it indicates either a very small 95% confidence interval or the impossibility of calculating one.

varied dramatically across study areas with 75% of households in Kaoma collecting wild fish but almost no households in Kazungula collecting wild fish. Fish collection, or fishing, also requires a permit and is banned at certain times of the year, therefore, it may also be under-reported. Few households collected nuts in any study region with the exception of Kazungula. Finally, a few households in Kaoma collected a wild aquatic plant, *Mampana*, a water lily.

Almost all collection of mushrooms, tubers, fruit and nuts is from forests with slight variation across study areas. For insects, green leafy vegetables and wild meat, most collection is from forests but households also collected these foods outside of forests. Most collection of wild foods from forests is from what households described as 'degraded forest'; households in Nyimba and Luwingu also reported some collection of mushrooms, tubers and fruit from 'primary forest'. Most collection of wild fish is from rivers, with the exception of households in Luwingu which also harvest wild fish from lakes (Figure 3).

There is high variability between households and between study areas in the quantity of each product collected (Figure 4). Very large volumes of some product types are collected by some households. In several of these cases, the household survey indicated that at least a portion of these large quantities are collected for the purpose of selling although percent sold is, overall, quite small (Table 2). Extrapolating from our data, the estimated volume of wild foods collected by rural households is provided for each

**TABLE 2** Collection of wild foods across Zambia for 9 types of wild food including the percentage of households (HH) collecting that particular food type out of the 209 surveyed HH in all five study areas and the reported average percentage of the volume collected that is consumed by that reporting HH. By scaling up from the average quantity collected per HH collecting and the percentage of HH collecting, we estimate the volume of wild foods in each food type collected by rural HH across Zambia and the total volume of wild food collected across rural HH in Zambia. Incorporating both the substantial variability across HH as well as uncertainty in our estimate of the percentage of HH collecting, we also provide a 95% confidence interval for this national estimate.

| | Study data | | National estimates | | |
|---|---|---|---|---|---|
| Wild food type | Percent of HH collecting | Of material collected, percent consumed (average per HH) | Lower bound of estimate (L) | Total estimated volume of material collected by rural households (L) | Upper bounds of estimate (L) |
| Mushrooms | 86 | 95 | 54,436,704 | 74,454,436 | 96,339,157 |
| Insects | 65 | 95 | 21,814,534 | 31,984,911 | 43,708,392 |
| Leaves | 92 | 98 | 60,991,058 | 83,176,596 | 106,945,282 |
| Tubers | 67 | 98 | 28,661,792 | 44,841,952 | 63,507,927 |
| Fruit | 99 | 98 | 84,482,251 | 109,967,621 | 136,240,941 |
| Nuts | 9 | 100 | 366,143 | 1,477,030 | 3,304,841 |
| Meat | 55 | 99 | 18,158,232 | 27,298,744 | 38,058,178 |
| Fish | 23 | 96 | 2,690,902 | 6,595,393 | 11,985,170 |
| Aquatic Plants | 2 | 100 | 31,937 | 700,208 | 2,168,463 |
| Total | | | 271,633,552 | 380,496,892 | 502,258,350 |

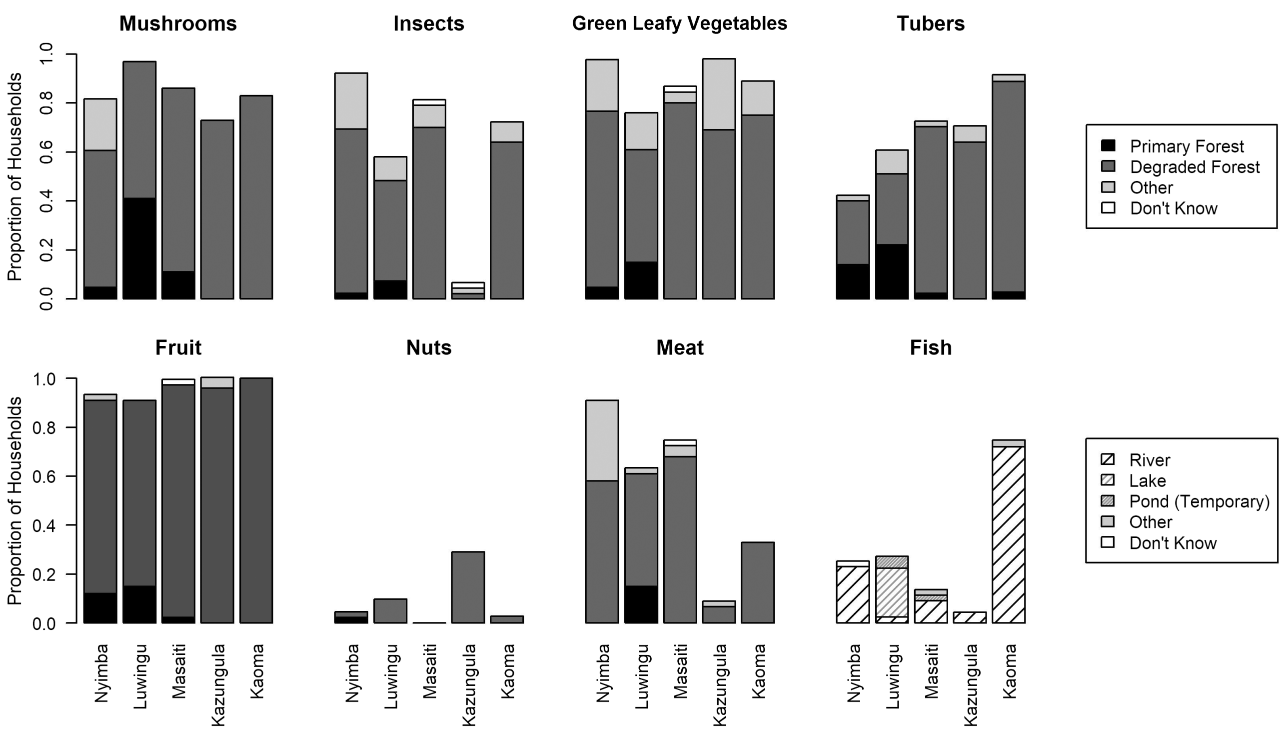


**FIGURE 3** The locations where wild foods are collected across all five study areas and the eight widely collected product types. Aquatic plants not displayed because they were collected by only four households in Kaoma; these four households collected aquatic plants from the river.

product type in litres of fresh materials; the total volume of wild foods collected across Zambia is estimated as 380, 496, 892 L with approximately 334, 657, 712 L (88%) collected from forested areas, either primary or degraded. This estimate does not include fish or aquatic plants because we only know that they were collected from rivers or lakes but not whether these were located in forested areas. Healthy freshwater systems may depend on upstream forests but, for this estimate, we included only collection of products directly from the forest.

Including uncertainty in estimating the mean across households and in estimating the proportion of households collecting wild foods, the lower bound of the 95% confidence interval is 271, 633, 552 L of wild foods collected (Table 2) with 238, 555, 870 L collected from forests. Additional uncertainties which could not be incorporated include

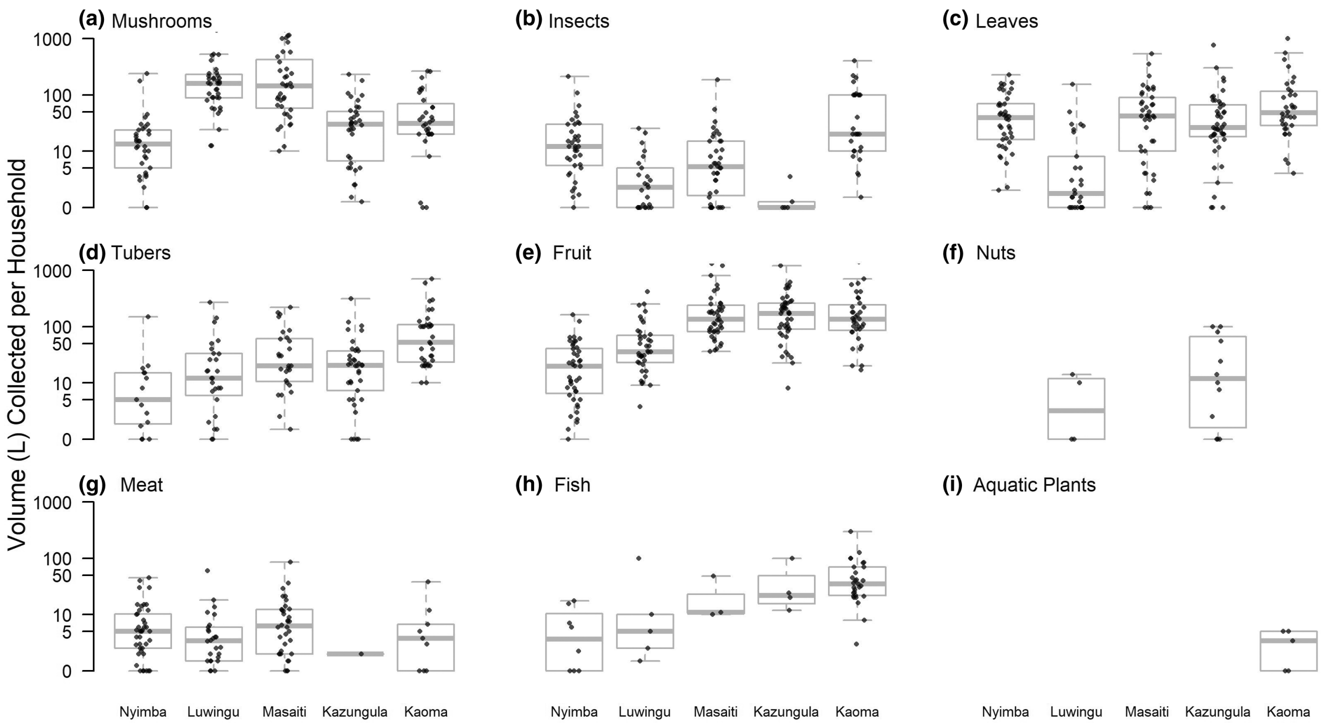


FIGURE 4 Volume of wild foods collected by those households who collect a particular product type, across all five study regions and all 9 product types. Note that the *y*-axis is the same across all product groups; it is on a log scale but labelled in original units for ease of interpretation.

(a) bias induced from selection of study areas where CIFOR already had a working relationship which are more likely to be forest-adjacent communities (biases the estimates high); (b) recall error (unknown direction of bias); (c) lack of reporting due to lack of permit (biases estimates low) (d) missing information on wild foods consumed casually such as direct snacking by children (biases estimates low) and (e) collection of data for only the five most commonly collected species in each product type in each study area (biases estimates low).

Note that for wild meat, some responses were recorded in units of whole animals. We used rough estimates where possible to convert to units of volume. We estimated that a *kote*, mongoose, and a *shakame*, rabbit, were each approximately 1 L. Although this is imperfect, it allowed us to incorporate those values into the estimates of quantity of wild foods collected. For *mbeba*, bush mouse, we were able to use water displacement to estimate the volume of 6 individuals of the most commonly consumed type (the volume of the 6 individuals was 0.175 L total) and complete the calculations. Five *puti*, duiker, were collected across three households. Common duikers weigh 12–25 kg according to Wikipedia (https://en.wikipedia.org/wiki/Duiker). Applying a simple rule-of-thumb that 1 L of meat is approximately 1 kg, we used a rough estimate of 18 L per duiker. Finally, it was reported that two households in Kaoma, collected *chishekele* (10 and 4 individual *chishekele* each). As we were unable to translate *chishekele* from the local language, these 14 animals were not included in graphs or estimates of volume of wild food collected from forests. A comparison of collection container sizes between households and study areas indicates substantial variability between households but no strong trends across study areas (Figure 5).

### 3.2 | Correlation between wild food collection and metrics of wealth and food security

Wealth was not particularly variable across study areas (Table 1) so correlations were explored across the full dataset without stratification by study area (Figure 6). We found that, overall, both the wealthiest and the poorest households surveyed collected high volumes of at least some wild food product types. There was a weak relationship between total assets and volume of wild foods collected, for example, a slight tendency for households with fewer assets to collect more mushrooms and insects and for households with a larger number of assets to collect more fruits and tubers. There were no clear patterns linking volume of collected material to number of chickens or to the roof material of the home. Forest dependence, if defined by collection of wild foods, was not correlated with indicators of wealth in our sample.

Interesting patterns were detected in the relationship between food insecurity and volume of some wild foods collected (Figure 7). For mushrooms and insects, there was no apparent trend. This may be due to the ubiquitous nature of mushroom collection in our sample and underlying correlations between insect collection and other factors. For green leafy vegetables, fruits and tubers, there was a positive correlation between food insecurity and volume of food collected, perhaps indicating a reliance of the most vulnerable on these wild foods.

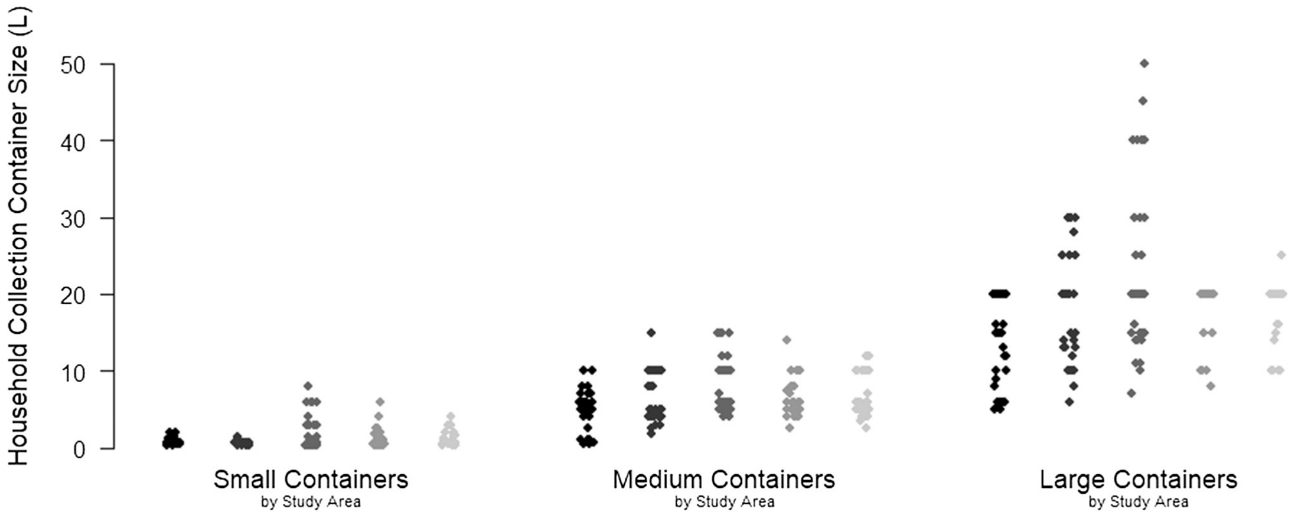


FIGURE 5 The distribution of collecting container sizes, for the small, medium, and large collection containers measured, across households within each of the five study areas.

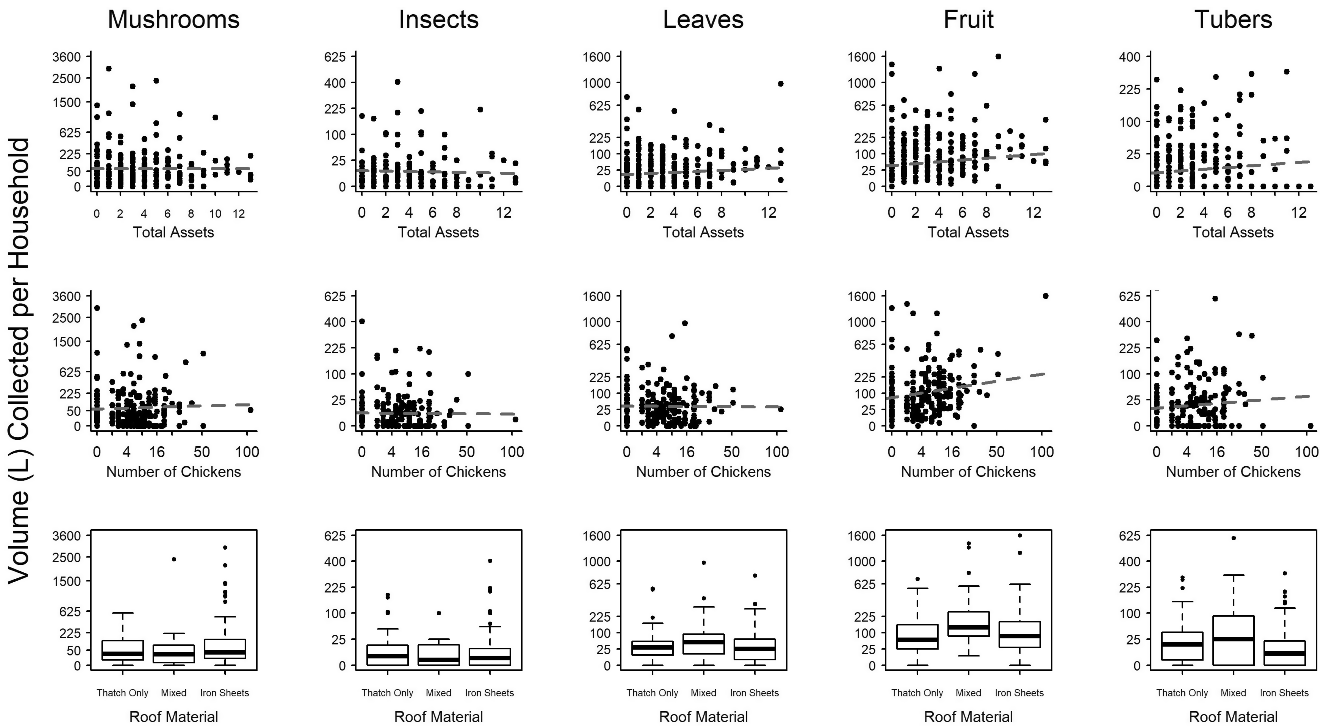


FIGURE 6 Volume of wild forest foods collected as a function of three metrics of wealth: total assets (top row), number of chickens (middle row), and roof material (bottom row). Total assets is the numerical sum of all items owned by the household from a list of items including the following: car/truck, tractor, motorcycle, bicycle, mobile phone, television, radio, CD/DVD player, computer, gas or electric stove, tablet, refrigerator/freezer, boat/canoe, chainsaw, generator, cart/wheelbarrow, water pump, gun, solar panel and private well. Mixed roof material indicates a roof that includes thatch and other materials.

## 3.3 | Representation of wild foods in local markets

All of the stalls ($n = 499$) present in five large markets, each associated with one of our five study regions, were surveyed as to whether they sold wild foods (Figure 8a). Although all five markets sold wild foods, the proportion of stalls that sold at least one wild food and those that sold fish differed markedly across markets. Less than 30% of the stalls in Nyimba and Masaiti markets sold wild foods, while over 80% of the stalls in the Kaoma market sold wild foods. In all markets, there were at least some stalls that sold only on wild foods.

Sixty vendors (four vendors × three enumerators × five markets) were randomly selected from all vendors selling wild foods and were interviewed about their wild food offerings ($n = 98$ wild food offerings) (Figure 8b). Few wild food offerings were collected by the

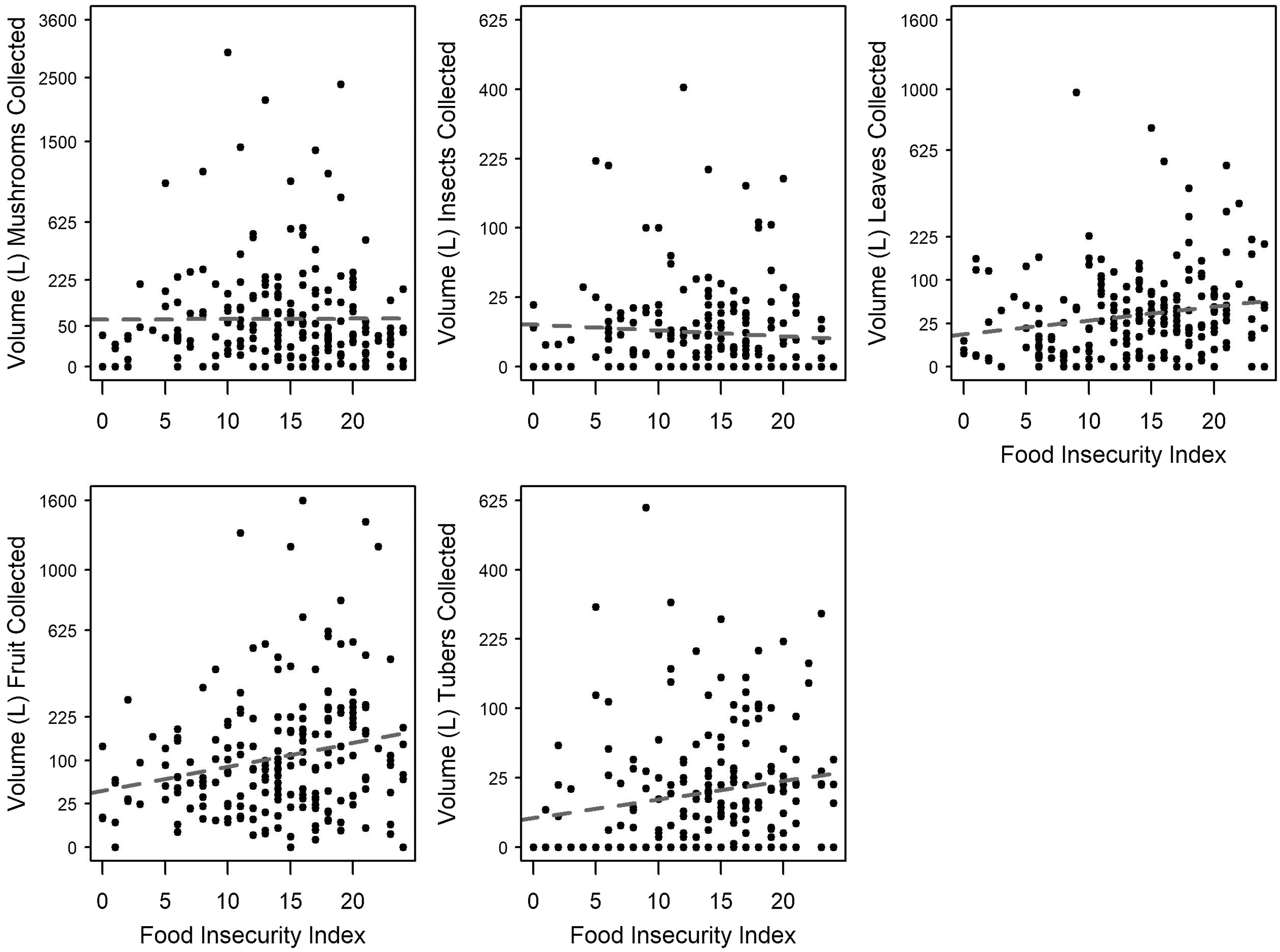


FIGURE 7 Volume of wild forest foods collected as a function of a food insecurity index, the food insecurity experience scale (FIES) (http://www.fao.org/in-action/voices-of-the-hungry/fies/en/), for the five most commonly collected wild foods. Note that y-axes differ and are on a log scale but labelled in original units for ease of interpretation.

vendors themselves; direct sales occurred only in the Luwingu and Masaiti markets. Over half of the wild food offerings were purchased directly from a collector with variability across markets; in Masaiti, all the wild food offerings assessed were purchased directly from the collector but, in Luwingu, most wild foods were purchased from a vendor rather than directly from the collector.

## 4 | DISCUSSION

We conclude that enormous quantities of wild foods are collected from forests in Zambia. With most rural households collecting wild foods and most collecting at least four different types of wild food, our results clearly demonstrate the widespread importance of forests in providing food in Zambia. Wild foods, including mushrooms, fruit, green leafy vegetables, tubers, insects, nuts and wild meat were collected from both intact and degraded forests; fish and aquatic plants were collected from rivers and lakes, habitats supported by many forest functions. Households reported use of wild foods both from plant-based production, for example fruits and nuts, as well as habitat-based production, for example mice and fish. Converting our estimated total volume of wild foods collected to cubic meters, the units commonly used for many wood products, we estimate that Zambian forests are likely producing as much as 271,633 $m^3$ and could be producing as much as 502,258 $m^3$ of wild food. For comparison, in 2019, Zambia produced 190,000 $m^3$ of sawnwood (https://www.fao.org/faostat/en/#data/FO, accessed 2 May 2021).

Collection of wild foods was substantial across gradients of wealth and of food security with an indication that collection of wild foods may be particularly important for the most food insecure. Where households depend on wild foods for diets, the sustainable management of the resources that supply those foods can be critical to ensure their food security. Although at the national level the Zambian forest area has been declining only slightly over the past 30 years, at the local level, deforestation or forest degradation can have dramatic consequences. Discussions in some focus groups revealed substantial declines in the availability of the wild foods, which were attributed to indiscriminate cutting of trees for charcoal production and increasing pressure on land for settlements and

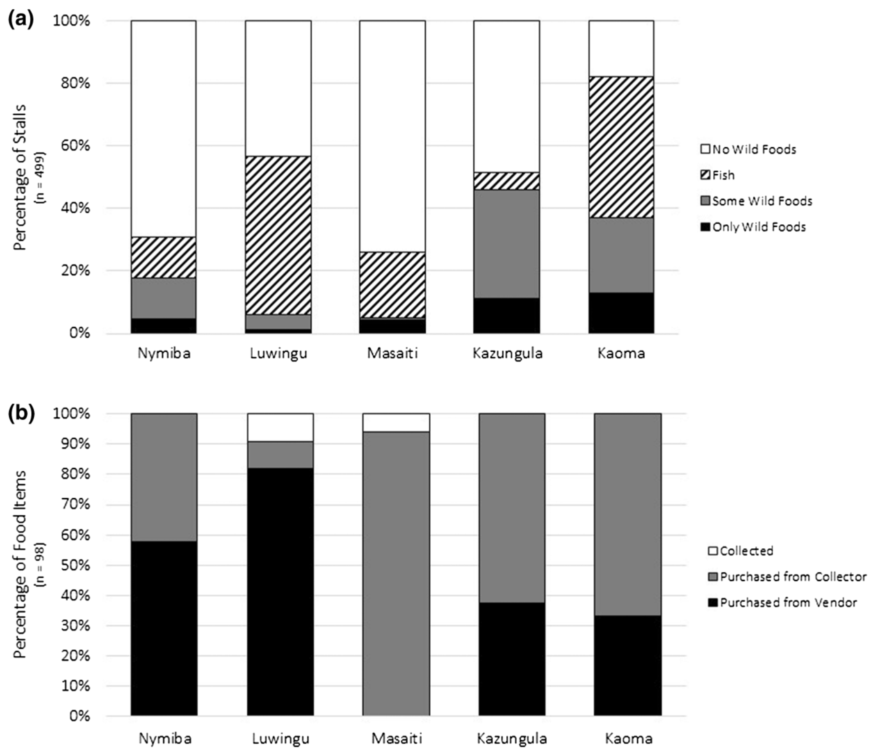


**FIGURE 8** (a) Stalls in each of five district markets ($n = 499$ stalls across five areas) categorized according to whether they sell any or all wild foods, with those focusing on fish additionally identified. (b) Source of all food items from 60 randomly selected vendors (4 vendors × 3 enumerators × 5 markets).

agricultural cultivation. In Kaoma, substantial declines in availability of wild foods were also linked to human-sparked fires.

Collection patterns varied markedly across study areas indicating both the need for a large sample size and the value of disaggregated data. Better data on the quantity of foods extracted from forests, as well as on the variation of collection patterns within countries, can inform management of both forestry and other land-use sectors and can support governments in designing effective context-based strategies for revitalizing and ensuring access to the natural production of nutritionally rich wild foods.

## 4.1 | Consistent evidence that wild foods are widely collected

Collection and consumption of wild foods are generally not captured in national statistics; the limited data that are available provide a picture that is far from comprehensive (Sorrenti, 2017). However, consistent evidence is emerging that the contribution of wild foods could be significant, particularly in forested areas. Ickowitz et al. (2014) found that across 21 African countries, children's consumption of fruits and vegetables increased with tree cover for the vast majority of over 90,000 children under 5 years old. Rowland et al. (2017) found that in forested sites across 24 countries, forests contributed up to 15% of recommended fruit and vegetable intake for the top 25% of forest users. Msola et al. (2017) studied the contribution of wild foods to local communities in the Mufindi district of the Tanzanian southern highland forests where forest foods contributed approximately 20%–40% of household food supply (by weight) and included many wild product types, for example, fruits, tubers, mushrooms, and green leafy vegetables. In that study, wild foods were predominantly collected and consumed directly in local communities; recent declines in availability and supply of wild foods were linked to deforestation and climate change.

Our results are consistent with previous work in Zambia. The Forestry Department of Zambia estimated that rural households in Zambia collected about 31 kg of wild foods (fruits, vegetables, mushrooms and tubers) (Forestry Department, 2016). A study in the Mwekera area of Zambia found that 97% of households collected wild fruits (Kalaba et al., 2009) which is similar to our estimates which range from 93% to 100% depending on site. In 2015, the government of Zambia carried out a Forest Livelihood and Economics Survey (FLES) of 5040 households that included information on the contributions of non-wood forest products to household income. The FLES results also found relatively high participation rates in wild food collection with 42% of households reporting that they collected mushrooms, and 29% reporting that they collected fruit, nuts, seed, roots, and tubers (Shakachite et al., 2016). Our results suggest even higher rates of participation (Figure 2) and collection of very large quantities of many product types (Table 2). Although there are some similarities in the data collected in the FLES with our project, there are also some important differences. First, the FLES did not collect information on specific foods, but rather on general categories of food and included all fruits, nuts, seeds, roots, and tubers in one category. Second, the FLES did not report information on green leafy vegetable consumption which is potentially an important source of wild food and nutrition. Third, the FLES used 'standard' units for conversion rather than household level units – for example, they record foods in '*meda*'—whereas we found that size of collection containers varied quite a bit by household (Figure 5).

## 4.2 | Collection of wild foods and poverty

Evidence on whether collection of wild foods is correlated with wealth remains mixed. We observed only weak relationships (Figure 6); Zulu et al. (2019) also were unable to detect a difference across wealth categories in the proportion of households collecting, consuming or selling lusala (*Dioscorea hirtiflora*), a wild yam across rural households in the Southern Province of Zambia. Woittiez et al. (2013), however, found a difference in reliance on wild foods across a gradient of wealth in the Wedza district of Zimbabwe, with indigenous fruits contributing approximately 20% of the energy intake of wealthier farmers but 40% of the energy intake of poor farmers. Discrepancies could be due to seasonal, annual, or location differences. It may also be that for smaller projects, the gradation of wealth is not strong enough to enable differences to be detected; those metrics that do have a strong gradient across households, for example number of chickens, are not particularly effective indicators of wealth. Finally, there could be multiple underlying causal mechanisms that make consistent patterns impossible to detect. For example, in some cases, collection of wild foods may be associated with poverty and lack of access to non-wild foods. In other cases, households located in close proximity to wild food resources, with experience and local knowledge or with time for collecting wild foods, may be the wealthiest households and may even grow wealthier from the collection and sale or trade of these foods.

Whether or not wild foods are collected in greater volumes by poorer or wealthier households, they are clearly collected in large quantities by households struggling with food insecurity (Figure 7). The utilization and commercialization of wild foods may be overlooked by extension agencies and in development plans because their role in contributing to rural livelihoods is not well understood. In our study, the poorest and most food insecure households were collecting wild foods. The role of wild foods and, particularly, indigenous fruits trees was recognized as a mechanism to cope with crop failure in Zimbabwe (Woittiez et al., 2013). Similar to our results, a study in the Mwekera area of Zambia in 2009 found that 97% of households collect wild fruits (Kalaba et al., 2009); they found that for some but not all types of wild foods, collected volumes were greater for the more food insecure. Implementation of policies and legal provisions, such as those that support community forestry, will benefit from a clearer understanding of the relationships between food insecurity and collection of wild foods across seasons and districts.

Wild foods may also provide a safety net during periods of drought, crop failure, or loss of income. In Zimbabwe, communities recognized wild foods as a mechanism to deal with crop failure but also reported that this buffering capacity was threatened by severe deforestation and illegal harvesting of fruits by urban traders (Woittiez et al., 2013). Kidane et al. (2015) conducted 18 focus groups and 144 interviews in southern Ethiopia and also found that wild and semi-wild leafy vegetables were consumed more frequently during periods of food shortages. In a case study from South Africa, Paumgarten et al. (2018), however, reported that the safety net value of wild foods was limited due to seasonal fluctuations in availability and to the risk that extreme events causing crop failure may also cause a reduction in availability of wild foods. They caution that further research is needed to ensure that promotion of wild foods does not induce a 'poverty trap'.

Wild foods likely contribute to dietary diversity (Ickowitz et al., 2014; Powell et al., 2015). The reported availability of nutrient-rich foods such as fruits, vegetables and pulses is low in Zambia, and has been declining over the last 50 years (Harris et al., 2019); however, the data used to make these calculations rely on international food supply data, which do not include wild foods.

## 4.3 | The value of locally disaggregated data

By stratifying data collection across disparate parts of Zambia, we provide strong evidence of heterogeneity between study areas that may reflect differences across villages, regions or agro-ecological zones even though the structure of our sampling strategy does not allow inference from study area to agro-ecological zone nor formal statistical testing of differences. We understand that there are likely some cultural and ecological reasons for differences. Seventh-Day Adventists, for example, do not eat insects based on biblical strictures and therefore only collect them for sale or trade, explaining the much lower observed collection volumes in Kazungula where the communities surveyed had a strong presence of Seventh-Day Adventists. And, of course, only households in areas with access to water collect freshwater fishes or aquatic plants. Other projects have identified similar patterns. In Malawi, Maseko et al. (2017) attributed differences across groups in consumption or avoidance of wild foods to taste, availability of particular foods and availability of alternatives, contribution to health, hunger and local taboos. The Zambian Food Composition Table (2007) also explains that ethnicity affects collection and consumption of forest-collected foods.

National estimates of the collection and consumption of wild foods are essential for awareness raising, for global monitoring, and for high-level policy dialogues. Data that can be disaggregated to local levels are also important for developing nutritional guidelines, community management of forest resources, and national forest plans that account for the heterogeneous nature of the dependence of local communities on wild foods.

We also observed large variability across households and products, with some households collecting a large amount of one product and none of another. These findings indicate that it will be difficult or impossible to infer total collection of all foods from data or information gathered about particular foods or particular food types. A complete accounting of the quantity of wild foods collected will require data across all possible food types.

## 4.4 | Presence and potential of wild foods in local markets

Pilot data on presence of wild foods in local markets suggest that short value chains already exist, with few vendors directly collecting products themselves, and high variability across markets. High variability across markets in proportion of wild food offerings or in length of value chains may be expected given differences in remoteness of the markets; the Kaoma market in Western Province, for example, is much more remote than the Masaiti market in the Copperbelt. In remote markets, there may be stronger connections between collectors and vendors and in markets closer to urban areas there may be demand for different types of products. Research on lusala in the local economy of the Southern Province of Zambia, indicated that collection and sale are, in fact, important elements of the local economy, with each market trader interviewed purchasing an average of 899 kg of product for USD 383 (Zulu et al., 2019).

Further investigation of the potential for developing value chains around wild foods is warranted, as there are many possible limiting factors, some of which may have reasonably simple solutions. In Tanzania, a pilot project looking at the potential of wild foods in markets found that wild foods were rarely sold for cash in part because of their scarcity, and in part because the market for them is badly organized and lacking in transport or storage facilities (Msola et al., 2017). The data presented here focus on the volume of product that is collected from the forest. The next step is to consider what goes to market, the structure and performance of the market, opportunities for increasing storage times, potential of value added products, and how benefits are distributed. In particular, an assessment of large urban markets as well as of collection, consumption, and demand in urban areas would be valuable.

### 4.5 | Assessment of new methodologies

Our work used two new methods in data collection, (1) paired focus groups and quantitative assessments and (2) direct measurement of household collecting containers. Both methodological innovations were successful, but future projects will benefit from further refinements. The combination of focus groups to identify the most important local wild foods allowed collection of household data at the species level that were relatively comparable across study areas in very different parts of the country. It also induced a source of bias that was not quantifiable; the importance of the top five species relative to all species collected in that product type is difficult to estimate and likely varies from study area to study area and from household to household. More in-depth questioning in the focus group about the relative importance of the top five as compared to all collected products in a particular product type would likely improve future work.

Measuring household collecting containers directly allowed study participants to provide information in units that they were familiar with, their own containers, and allowed the research team to report these data in consistent units (L). Data across households demonstrated that collection container volume varies considerably within and across study areas (Figure 5). Asking households to estimate volumes collected in anything other than the collection container actually used, for example a standard 20 L bucket, would almost certainly induce additional errors. We recommend that future studies continue to measure volumes of household collecting containers directly.

### 4.6 | Limitations of study and next steps

The two primary limitations of this pilot project were the relatively small sample sizes and the lack of a randomized sampling strategy at all stages. Although we were able to capture some of the uncertainty associated with the small sample size through the confidence intervals on our estimates, many sources of uncertainty remain. Of particular concern is the bias induced from selection of study areas where CIFOR already had a working relationship which are more likely to be forest-adjacent communities. While the study areas were distributed across agro-ecological regions, results from any one study area cannot be considered indicative of conditions across the agro-ecological region without a larger sample and a randomized design. Another minor limitation of this study is that we asked households where they collected wild foods by product type rather than by species, which added uncertainty in the quantity of wild food collected from forests. Though these issues limit the inference from this study, they can be eliminated in national surveys through a fully randomized study design and a larger sample size asking about collection area by species.

Other limitations will be more challenging to eliminate. For example, the effects of seasonality during data collection could be important if the study takes a long time. Because of travel times, there may be long time lags between surveys conducted in different study areas, causing respondents to focus on somewhat different species or product types across study areas. The magnitude of recall error, the value of missing information on wild foods consumed casually, and the quantity of foods collected beyond the top five species in each product type would best be estimated in a separate study focusing on improving methodologies for quantifying collection of wild foods.

The next steps for this research will be to conduct a nationally representative study with a much larger sample size. Using these results as a foundation, the larger study could produce a more precise estimate of national collection with a better understanding of any biases. Data using annual recall periods can be combined with information collected using shorter recall periods. A larger study could also be used to test some hypotheses developed during this work such as (a) there are important differences in quantities of wild food collected across agro-ecological zones; (b) wild foods are essential to the diets of the most food insecure; and (c) wild foods are collected similarly from poorer to wealthier households. Repeated national surveys could help governments understand trends in both availability of wild foods and in dependence on wild foods; structured research could untangle questions of mechanism such as the links between forest degradation or land-tenure and access to wild foods. Other important questions to be answered with these types of data include the degree to which proximity to forests increases dietary diversity; how access to wild foods can contribute to wealth and food security; and how forest or landscape restoration can maximize provision of wild foods. Future data on the economic value of wild foods and on their contribution to livelihoods will also be essential for valuing and enhancing the economic contributions of wild foods.

As we collected data in volumes and production of other forest products, for example sawnwood, are considered in volumes, we report our data also in volume. We chose litres because it is easy to conceptualize the collection containers and collection process. In future work, the necessary product-specific conversions to weights to edible portions and to nutrient composition will enable a clearer understanding of the value of wild foods for diets and nutrition.

## 5 | CONCLUSIONS

Across Zambia, access to old growth or primary forests and woodlands is limited. Only some respondents in our study had access to these undisturbed or less disturbed areas; yet, there were high collection volumes even in areas with access only to degraded forest areas. Similarly, Maseko et al. (2017) found that collection occurred in degraded sites but also that there was collection of a wider variety of species collected from the less degraded than from the more degraded ones. Forest loss and degradation are national concerns that also have food security and social impacts. Kalaba et al. (2009) in a study in Mwekera, Zambia reported that 85% of respondents have seen reductions in forest cover and associated biodiversity and further that, as a result of deforestation and degradation, stakeholders needed to spend more time collecting wild foods. Wild forest foods can enhance food and nutrition security under normal conditions, but can also enhance resilience in times of high economic uncertainty from a changing climate or the COVID-19 pandemic. The value of degraded forests to local communities needs strong consideration in policy development and when quantifying services provided by forests.

Results from this and similar small projects can set the stage for more systematic and wide-scale data collection efforts to quantify the value of forests. If one assumed, for example, that all 1.6 billion forest-proximate people (Newton et al., 2020) collect, on average, similar quantities of wild foods as the individuals in the 209 surveyed households in this study, we would estimate that 2.65 billion large buckets of food are carried out of forests every year, or 53 million cubic meters. For comparison, global production of industrial roundwood in 2019 was estimated at 2025 million cubic meters and global production of sawnwood was estimated at 489 million cubic meters. As we have not captured any commercial or industrial production of food from forests, our estimate is likely a dramatic underestimate. Even with the massive uncertainties in such a rough estimate, it is clear that the production of wild foods from forests is likely large. Better data would clearly contribute to a better understanding and quantification of the value of forests for health, nutrition, and livelihoods through both wood and non-wood products.

Improved data on the collection of wild foods can strengthen forest management and conservation by highlighting the importance of forests not only for biodiversity, climate change mitigation, energy and timber, but also for food and nutrition security. The Collaborative Partnership on Forests has developed a Global Core Set (GCS) of forest-related indicators to highlight the contributions that forests make to various international processes and agreements. This GCS consists of 21 indicators ranked from tier 1 to tier 3 (strongest to weakest) based on available data and methods. Indicator 14: 'Contributions of forests and trees to food security and nutrition' is currently ranked as tier 3 because of the lack of global data and agreed methods for trying to capture this information. The contribution of wild food from forests should be an essential component of such an indicator; but information is not yet systematically collected at country level. This type of global reporting process provides an additional incentive for work to improve the quantification of collection of wild foods from forests.

The 2018 Global Nutrition Report classified Zambia as a country suffering from the triple burden of malnutrition including overnutrition, undernutrition and micronutrient deficiencies. Zambian diets are reported to be relatively monotonous, consisting of large portions of maize-based staples. The nutritional importance of wild foods could be especially high if they are consumed in sufficient quantities to compensate for shortfalls in agricultural production or imports. A separate analysis of the wild fruits collected and consumed in this study indicated that consumption of wild fruits from forests comprise approximately 80% of all fruit intake across these study areas and would be enough, on average, to meet 25% of international recommendations on fruit consumption (Ickowitz et al., 2021). The loss of forest area could lead to strong negative impacts on local diet. Alternately, forest management that aims to support access to wild foods through increased forest area, reforestation and restoration including food trees and land access provisions could improve diets, particularly for rural people. Well-managed communal resources can provide a strong tool to maintain and increase the rural communities' ability to cope with an increasingly variable climate (Woittiez et al., 2013); however, clear regulations, mechanisms for enforcing compliance, and further information on best practices for regeneration, cultivation and conservation are all required. A nationally representative survey based on the methods and pilot results reported here can assist in designing forest management plans that include conservation and restoration of trees and forest habitats that provide commonly collected wild foods; assisted natural regeneration could be tailored to address species that are collected and of high nutritional value.

### AUTHORS' CONTRIBUTIONS

E.A.S. and A.I. conceived of the study question, designed the original methodology and led the writing of the manuscript; E.A.S. analysed the data; L.B., A.M., and A.L.M.S. piloted and improved the methodology, collected, entered and cleaned the data, and contributed to manuscript writing; P.B. oversaw data collection and cleaning and contributed to manuscript writing; P.B., D.G. and K.M. contributed to study design, data interpretation, and manuscript writing. All authors contributed critically to the drafts and gave final approval for publication.

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## CONFLICT OF INTEREST

The authors have no conflict of interest.

## DATA AVAILABILITY STATEMENT

Data analysed in this paper are publicly available in an anonymized form at http://www.fao.org/forestry/statistics/80577/en/

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