Biometrics and NTFP Inventory

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Abstract. Inventory for NTFPs is a rapidly growing field of considerable interest to people working across a wide range of disciplines and varied contexts. There is a growing body of experience of NTFP inventory at three scales: national policy formulation; forest management planning and as a component of community-based livelihood initiatives. A review of the biometric quality of this experience has revealed that there is a disturbing lack of statistical rigour in many of these studies. This paper highlights some of the key problems faced by practitioners designing NTFP inventories and suggests ways in which these can be addressed.

1 Introduction

For the purposes of this paper the term non-timber forest product (NTFP) is defined as "*all products derived from biological resources found on forest land, but not including timber or fuelwood*". There are many other terms that have been used for such products such as; minor, special and non-wood all of which emphases that the product is not the main objective of forest management. That is that their production is secondary in importance, at least as far as forest managers are concerned, to the production of wood. The definition is generally understood by foresters to include any part or whole plant, animal or fungi collected for human use, though the term has little currency in other disciplines (for instance it is not used by wildlife managers or agronomists). Examples of NTFPs are:

– fungi	– furs
– fruit, berries, nuts and seeds	– meat
– resins, gum, lac	– butterflies
– leaves	– insect larvae
– bark	– dung
– roots	– honey

Traditionally, many, diverse products have been harvested from forests and the archives of colonial forestry reveal that many forests were established to secure production of gum copal, rubber, oil palm and not only for timber production. However, over time such products were increasingly marginalized as the emphasis in forest management shifted to timber production. This process was fuelled by; the substitution of natural products such as rubber, gum copal and pau rosa by synthetics, the establishment of large-scale plantations for others e.g. oil palm, rubber, cocoa etc. and the increasing alienation of local people resulting from a general institutional disregard for small-scale rural industry and subsistence use. Technological substitution and plantation development are inevitable and will continue to erode the practical income generating potential of natural forest. Increased interest in NTFPs has been prompted by the rediscovery of the role of NTFPs in small-scale livelihoods and has resulted in a rapid rise in interest in NTFPs among conservationists, foresters, protected area managers, social development advisors and indigenous rights groups. This has generated a proliferation of studies into the potential of NTFPs for income generation and as a means of involving local people in forest management and benefit sharing. A basic premise of these initiatives is that the resources, be they animals or plants, should be exploited on a sustainable basis.

To be sustainable, harvest levels need to be based on a sound knowledge of the ecology, distribution and abundance of the resource species. Such information can be obtained from a number of sources including indigenous or local peoples' knowledge as well as formal scientific enquiry. Resource assessment of NTFPs in the tropics is relatively new and has received little formal study; consequently methodologies have been developed by individual researchers in response to local circumstances and the peculiarities of the resources under study. Sociologists stress that at the community level that methods need to be devised that can be carried out by the community, are sensitive to informal local knowledge and responsive to community information and management needs. It is argued that the main benefit of participation in such exercises is often awareness raising that the assessment methods used can therefore be simple and need not have a biometric basis. In the light of these developments the Forest Research Programme (FRP) commissioned a pre-project to review the status and need for biometrics in current approaches to NTFP resource assessment. This paper is based on the findings of this review [16], [16] and the subsequent workshop [2].

2 Evaluating Biometric Rigour in Current Practice

A literature review of NTFP studies was undertaken with the aim of extracting experience on the quantification of NTFP resource assessment. In all 126 studies were selected for analysis as they included as an objective the enumeration of some characteristic of a NTFP resource. The studies were drawn from a wide range of disciplines including; biodiversity inventory, social science methods (PRA etc), ethnobotany, econometrics, forest inventory, wildlife management and autecology. The protocol for each study was extracted and evaluated against a few simple biometric criteria. The first hurdle was the large number of studies in which the protocols were insufficiently reported to be able to perform the analysis. The criteria used in the evaluation were applied to the design of the studies and comprised:

- Reporting of protocols
- Objectivity in sampling design
- Level of replication

- Eliminating pseudo-replication

Overall a biometrically adequate study is one that was judged to be well reported, had an objective sampling design, had more than five plots and had plots that are at least non-contiguous. Table 1 illustrates the proportions of studies of different types that were judged to be biometrically adequate against these criteria.

2.1 Reporting of Protocols

Of the 97 quantitative studies, 14% did not give details of the sampling design and 26% did not report the exact number of plots used. This meant that the evaluation of biometric quality could only be performed on 51% of the studies.

2.2 Objective Sampling

Objectivity in sampling design is intended to reduce sampling bias and is important if the results of a study are to be generalized. A range of sampling designs were encountered as shown in Table 1. Sampling designs are intended to reduce the possibility of bias in the results. In principle, a census is the ideal as it measures the entire population but it is only practical over relatively small areas or for very high value products. Random and systematic designs with or without stratification are the norm for forest surveys. Experimental designs are used mainly for harvesting impact studies and usually used paired sites. Subjective designs cover all those where the researcher has deliberately chosen to locate a site in a specific place. Usually this is done to 'represent' a particular type of forest but runs the risk of being heavily biased by the researchers personal experience of the locality. Opportunistic samples are often not placed subjectively but are restricted to places which have easy access. Since forest close to access points i.e. rivers in Amazonia, is likely to be different than less accessible forest there is a strong possibility that the results will be biased. Table 1 therefore reveals that 35% of the studies where not designed in a manner to reduce bias.

Table 1. Sampling designs used in NTFP studies

Design	Number	%
Census	5	6
Random	18	22
Systematic	24	29
Stratified	21	25
Experimental	3	4
Subjective	18	22
Opportunistic	11	13

2.3 Replication

If the results of a study are intended to be generalized to a wider area than the study plots themselves then it is necessary for a number of plots to have been enumerated. Table 2 illustrates the range of sample sizes reported in the 90 studies which reported plot numbers. Many (12%) of the studies used only one plot. Such studies, though useful, cannot be generalized and there is a large risk of misrepresentation if data from a single plot is used to describe a larger area such as a whole forest type. However, it is difficult to say how many plots are required for results to be valid. A commonly quoted figure is 30 as the lower limit for small sample statistics. If this is taken as a threshold for the NTFP studies, almost half (48%) of the studies have inadequate replication..

Table 2. Number of plots used in NTFP studies

Type of study	Number of plots enumerated					Total
	1	2-19	20-39	40-99	<100	
Demographic	3	1		2		7
Ethnobotany	3	2		1		7
Experimental		2	1			4
Harvesting		3	2			5
Inventory	1	10	6	1	18	36
Market	1			1		2
Methodology	1	3		2		8
Monitoring	1	5	1	1		8
Social				2		2
Yield	2	6	1		2	11
Total	11	33	12	5	29	90

Table 2 reveals a range of study types which come from several disciplinary backgrounds. Not all of these will have the same requirement for quantification and should perhaps be judged on different criteria. However, there are large numbers of studies purporting to be inventory or yield studies which have used small sample sizes. The only large studies have been undertaken under the auspices of national forestry surveys

Several studies had apparently large sample sizes but closer examination revealed that the 'plots' were in fact sub-plots of a single large unit (i.e. 10x10m divisions of a 100x100m unit). This practice is termed pseudo-replication and is not desirable for hypothesis testing or for generalization outside the sampling unit.

2.4 Overall Assessment

Applying all the above criteria to the 126 reviewed studies gave the results illustrated in Table 3. The overall conclusion is that only 62% of the studies had reported their protocols in sufficient detail for the three criteria to be evaluated. Only 40% of the studies passed all four criteria.

Perhaps the greatest concern is the finding that 43% of resource inventory studies and 90% of yield studies failed in some way. These are studies that generally have quantification as a primary objective. From these results it is apparent that there are biometric concerns with the methods currently used for NTFP resource quantification.

Table 3. Overall biometric assessment of reviewed studies

Study type	Number of studies	Provided protocols (%)	Pass all biometric criteria (%)
Biodiversity	3	66	0
Population demography	9	44	22
Ethnobotany	10	50	20
Experimental studies	5	80	80
Harvesting studies	5	80	60
Resource inventory	42	69	57
Mapping	3	0	33
Inventory methodology	11	64	55
Monitoring	12	50	25
Use of secondary data	6	17	17
Yield studies	13	46	8
Other studies	7	43	14
Total	126	56	38

However, some of these studies may not need to be biometrically rigorous and several appear to be well designed but inadequately reported. As in all forms of inventory the methods used need to be matched to the information needs of the clients or management system and need not be biometrically rigorous as long as objectives are met and assumptions explicit. Nevertheless, it is contended that biometric rigour is an important consideration because it can provide reliable, good quality information. Such information is important for;

Livelihoods – giving the right advice: Decisions based on resource assessments can influence the long-term survival of species and thus livelihoods. Over-simplification of complex situations, risking giving poor recommendations, should be avoided. It is critical that community-based assessments provide useful and reliable information – advisors should see this as an ethical obligation [3], [6].

Secondary use of data – being able to generate a strategic overview: The use of NWFP data by people not involved in the inventory requires some level of standardization of what is measured and data quality. Without this it is difficult to integrate data from different sources or to place confidence in the results. This shortcoming is acutely felt by natural resource economists attempting forest valuation [5].

Credibility – avoiding political bias: Ensuring that data is biometrically sound can add weight to recommendations based on that information. Where governments have to defend their reasons for setting quotas to those who lobby for higher (industry/trade) or lower (conservationists) levels, reliable data is important.

3 Challenges in NTFP Inventory

It is evident that there is a need for increased application of biometric principles in NTFP resource assessment, however it is necessary to first understand the nature of the problem. The following is a short list of the problems encountered by practitioners working with NTFPs:

- Difficulties with traditional forestry designs
- Lack of properly tested sampling designs tailored for NTFPs
- Few NTFP mensuration techniques available - or at least not accessible to practitioners
- Little cross-disciplinary exchange of ideas or techniques
- Difficulties, conceptual and practical, in the determination of sustainable yields

3.1 Problems with Conventional Forest Inventory

The apparent deficiencies in NTFP inventory could be easily solved if it were possible to use traditional forestry methods as these are well described and understood. Unfortunately, this does not appear to be a practical solution as there are certain characteristics of NTFPs that are not easily accommodated in traditional forest inventory. The main problems being:

- Rarity - many NTFPs are rare which means that only a few plots of a conventional inventory designs will contain the species of interest. This results in very inefficient and costly inventories which often do not produce the quality of data required.
- Clumped distributions - NTFPs often occur in relatively dense patches within the landscape.
- Imperfect detectability – people dealing with trees have rarely come across the problem of searching for an elusive or moving target because trees are generally large and static. Unfortunately, many NTFPs are not so obvious (e.g. truffles and epiphytes) and these require that detectability is considered.
- Seasonality - many NTFPs are seasonal but timber accrues slowly over time consequently forest inventory methods do not cope well with seasonality.
- Mobility - animals run away, fruit falls off a tree and rolls down a hill but trees are static.
- Quantification of yield for non-destructive harvesting - most of the methods for determining timber yield from a forest are concerned with the harvesting of entire individuals. For NTFPs often only a small part of the individual is harvested. The

review suggests that there is little theoretical background for determining harvesting levels for parts of a plant.

It seems that the simple adoption of forest inventory practice is not going to meet the needs of NTFP inventory.

3.2 Practitioners Needs

These problems are considerable and there is a need to prioritize among these to ensure that future developments meet the most pressing problems. The determination of research priorities was the purpose of a workshop held in Rome in May 2000 [2]. The workshop considered the needs expressed by practitioners at three spatial scales; the macro or national scale, the local or community scale and at the level of the individual species. The results of these deliberations are summarized in Table 4.

Table 4. NTFP quantification needs as expressed by participants at the Rome workshop

Scale	Research priorities
Species	Sampling, assessment, monitoring and analysis
Community	Participatory methods Interface between local and scientific knowledge
National	Integration of data from a wide range of sources Integration of NTFPs in large-scale multi-purpose resource inventory protocols

There was general agreement at the workshop that there is a need for a better understanding of how to design biometric sampling schemes, suitable mensuration techniques, effective monitoring strategies and for analyses including the determination of sustainable yields for individual species.

At the community level (village) these technical problems are compounded by the need for protocols suitable for use by the community. Local communities also possess their own knowledge and experience of NTFP ecology and management. A key issue in promoting community management of these resources is the integration of local and scientific knowledge.

At the macro scale all of these issues are further compounded by the need to incorporate NTFPs into multi-purpose inventory designs for national-scale strategic assessments. Lastly, given that resources for commissioning NTFP assessments are always limited it is necessary to find ways to integrate knowledge across all scales.

The challenge is to develop efficient single and multi-species inventory and data analysis procedures at a range of scales from local to national level without alienating the people who will benefit from the data collected and who should be given the opportunity to participate in the proceedings.

4 Ways Ahead

The demand for better advice on NTFP resource assessment from practitioners is unequivocal. Some of the problems are such that they probably require theoretical research and field development, however, others could be addressed through the dissemination of best practice. What follows is a brief discussion of key research and development issues for NTFP resource assessment.

4.1 Provision of Biometric Advice

Optimizing an inventory for a single species is at least conceptually straightforward and it should be possible to develop efficient designs for a range of different types of population distributions and product types based on current best practice.
The sheer diversity of NTFPs means that the task of preparing resource assessment protocols has been likened to taking on the task of Sisyphus. If the intention was to prepare off-the-shelf protocols for each and every possible product this would indeed be true. However, it is proposed that it may be more efficient to provide advice in a form that assists the practitioner to design a protocol that fits the peculiarities of a particular species, product, local capacity and objectives. What is envisaged is a decision-tree approach to inventory designs based on the observation that:

1. an understanding of the distribution pattern (e.g. clumps, rare, uniform distribution) of the resource will influence the choice of sampling design (i.e. plot distribution),
2. the life form of the resource (e.g. motility, growth form, life cycle) should inform the choice and size of sampling unit (i.e. plot configuration), and
3. the nature of the harvested product (e.g. root, fruit, gall bladder, feather) should determine what is actually measured within the sampling unit or plot (i.e. mensurational technique).

Generic advice based on the characteristics of the resource can be developed at these three stages of inventory design. The FAO has initiated a small project[1] to develop NTFP inventory design support using this framework for sub-Saharan Africa. It is hoped that this initiative will be at least able to test this approach, identify gaps in knowledge and begin the task of testing alternative designs to address common problems such as clumping and rare populations.

4.2 Development of Innovative Designs

The first question is whether new designs are necessary or whether the problem can be solved with the judicious application of conventional designs. It is true that in nearly all circumstances, a conventional design, with the caveat that solutions to the problems with forestry designs listed above can be overcome by borrowing techniques from other disciplines, can give results within acceptable errors. However,

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[1] 'Sustainable forest management programme in African ACP countries' (GCP/RAF/354/EC).

doing this can become prohibitively expensive. The revenue that is available from sale of NTFPs is rarely sufficient for managers to be able to afford to invest in inventory or it is not returned into a management structure that has been designed to fund resource assessment (in most situations no royalty is collected on NTFPs). If NTFP management is to be based on sound data it is imperative that assessments are as cost-effective and efficient as possible. The next question is whether there are designs which may offer advantage for NTFPs that could be developed.
The literature suggested that there are two classes of sampling method which may offer advantages for NTFPs. These are:

- Adaptive sampling [11] which purports to be efficient and unbiased for clumped and rare populations
- Rank set sampling [7] which may offer an unbiased means of utilizing local knowledge to improve on the efficiency of small sample sizes

Of these only adaptive cluster sampling (ACS) has so far been applied to forest trees. ACS has been applied three rare trees in Nepal [1] where it was found to offer greater efficiencies for the species which occur in large clumps. The following case study presents a summary of the experience gained during a trial of ACS for *Prunus africana*[2] on Mount Cameroon.

Case study: ACS for *Prunus africana* on Mount Cameroon[3]
In 1999 the Office National de Développement des Forêts (ONADEF) of the Cameroon Government with support from DFID through the Mount Cameroon Project and GTZ undertook a trial of ACS for Prunus on Mount Cameroon [12]. ACS was applied in an area which had previously been sampling using conventional systematic strip sampling which permitted a comparison of the two methods.
The conventional sampling comprised a series of 20 m transects spaced 2 km apart running up the mountain. Each transect was divided into 250 m segments. In total 687 segments were enumerated which yielded 394 trees and the distribution pattern shown in Figure 1.

The ACS was initiated from a systematic sample of circular (0.2 ha) plots laid 100 m apart on transects. When more than a set number of *Prunus* was found in one of these plots (e.g. > or >= 2 stems over 10 cm d), identical plots were added on a 100 m rectangular grid until a predetermined stopping rule was encountered (normally the same rule, i.e. < 2 trees over 10 cm). This exercise yielded a sample of 989 sample units, 1 906 trees and revealed the distribution patterns illustrated in Figure 2.

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[2] The bark of this afro-montane tree is traded internationally as a treatment for prostate cancer. It is listed on CITES appendix 2 and harvested is supposed to be regulated by national quotas. However, there is little information available on population densities.

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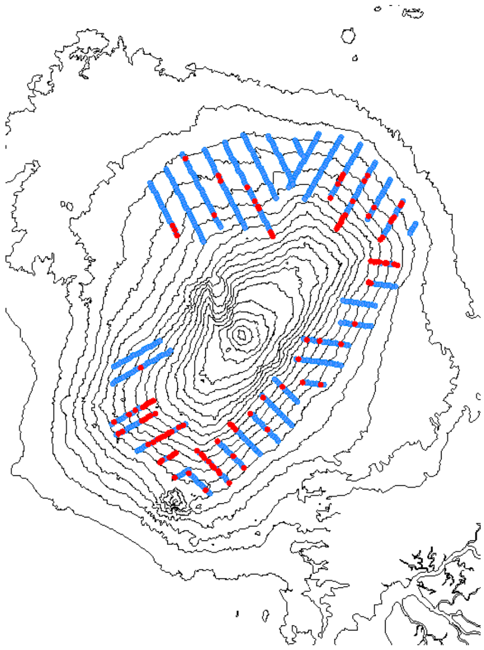

Fig. 1. Distribution of *Prunus africana* on Mount Cameroon as revealed by strip sampling

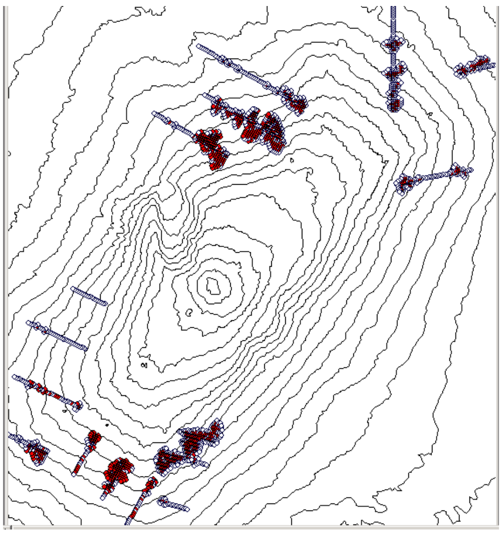

Fig. 2. Distribution of *Prunus africana* on Mount Cameroon as revealed by ACS sampling

Using the initial systematic strips as the basis of comparison, the ACS sample cost 54% more than the strip sample but had a relative efficiency of 2.64 (for trees greater than 10 cm d). The equivalent sampling effort to obtain the same precision as the ACS from strip sampling would have increased costs by 70%. The much greater number of trees enumerated (nearly 5 times more) means that ACS yielded significantly more information about population structure and health than the systematic sample. Furthermore as Figure 2 illustrates the ACS reveals the ecological footprint of the species could potentially be used to develop spatial ecological models for the species.

4.3 Determination of Sustainable Harvest Levels

This is an key issue, it will make little difference if inventories provide better data if there is no conceptual basis from which to calculate optimal harvesting regimes. At present harvest levels for plants are generally assessed using Markovian demographic matrix models [8]. For bushmeat there is a growing acceptance of the model proposed by Robinson and Redford [9] which is itself based on the maximum sustainable yield (MSY) concept. Both of these rely on either gross assumptions of fecundity, mortality and growth rates or on figures based on very limited data. An alternative approach has been developed for forecasting fruit yields for understorey shrubs based on correlations with antecedent weather conditions and forest condition (e.g. for bilberry in Finland [10]). Another development is the suggestions that population viability modeling may be a useful way to consider sustainability issues for species where range contraction is taking place (e.g. for Goldenseal in north America [4]). There is a need to test assumptions, evaluate and build on these and others ideas to place NTFP management on a sustainable footing.

4.4 Integrating Local and Scientific Knowledge

In many cases local ecological knowledge has been shown to provide important insights into sustainable harvesting practices and there is a need to evaluate and use this information. There are several approaches that could perhaps be developed to tackle this problem. The use of a formal representation of indigenous knowledge for agriculture [16] has been demonstrated to provide a means of storing and examining such information. Local knowledge can also be used to build conceptual models for use as a platform for decision-making as in FLORES.

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