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Non-timber Forest Resources and Products

J L Chamberlain, US Department of Agriculture Forest Service, Blacksburg, VA, USA
M Predny, Virginia Polytechnic Institute and State University, Blacksburg, VA, USA

Introduction

Forests provide resources that are gathered from the canopy, the understory, the forest floor, and below ground level. The diversity of flora within these strata ensures forest health and productivity. Although many of the products fashioned from these resources are important for household subsistence, as well as for generating income, their ecological and economic value has not been fully appreciated nor integrated into forest management. Without management, many of these resources may be lost, reducing forest ecosystem diversity, sustainability, and greatly affecting peoples' livelihoods. To ensure that the collection is sustainable, forest management practices need to include assessments of growth, yield, and productivity, as well as inventories of the resource from which the products originate. A small body of knowledge exists that addresses resource and product inventory and assessments. In a few countries, this knowledge is being used to incorporate more prominent non-timber products into forest inventories, and these may be useful models for other less advanced countries.

Although a great deal of effort has been given to assessments of market and economic development opportunities for non-timber forest products, the primary focus of this article is biological, ethnobotanical, and social resources. Wong and others summarized much of the body of knowledge concerning inventory and resource assessments of non-timber forest resources and associated products in a seminal document published by the UN Food and Agriculture Organization. While some discussions of non-timber forest products may include wildlife and other fauna, the generally accepted definition excludes animals, and therefore they are not included in this article.

Non-Timber Forest Resources and Products

A variety of terms have been used to describe the flora collected from forests for products that are not timber based. The Food and Agriculture Organization of the United Nations describes them as 'non-wood forest products,' a term that includes food and game, fibers, resins, gums, and plant and animal products used for medicinal, cosmetic, or cultural purposes. The US Department of Agriculture Forest Service, in a recently released national strategy, uses the term 'special forest products,' which excludes sawtimber, pulpwood, cull logs, small roundwood, house logs, utility poles, minerals, animal parts, rocks, water, and soil. Recently, the US Congress, in legislation that supports improved management for these products, introduced the term 'forest botanicals' and defined them as naturally occurring mushrooms, fungi, flowers, seeds, roots, barks, leaves, and other vegetation (or portions thereof) that grow on National Forest System lands.

A more common term, non-timber forest products (NTFPs), relates to plants, parts of plants, fungi, and other flora that are collected or cultivated from within and on the edges of natural, manipulated or disturbed forests. This definition excludes animals, but embraces all flora and botanical resources. Non-timber forest resources (NTFRs) include fungi, moss, lichen, herbs, vines, shrubs, or trees. Many parts are harvested, including the roots, tubers, leaves, bark, twigs, and branches, the fruit, sap, and resin, as well as the wood. NTFPs may be marketed with little processing, such as dried roots and herbs, graded and bundled leaves and twigs, or live plants. Some are processed into finished products, such as carvings, walking sticks, jams, jellies, tinctures, or teas. The following product categories are recognized in this article: building materials, crafts, decoratives, edibles, and medicinals.

Whatever term is used to describe these products, the fact is that very little effort has been made to manage these forest resources for their sustainable production. NTFPs seldom appear as a major objective in forest management. For many of the plants, little is known about their population biology or the impact that harvesting has on population dynamics, especially on associated species. In general, silvicultural treatments that include non-timber products are lacking because insufficient information is available to address these resources adequately. Inventory and monitoring protocols for some products have been examined, but they are not fully integrated into forest management.

Inventory Methods for NTFPs

In general, inventory methods for most natural resources are well developed and utilized in the formulation of management strategies. Inventory protocols for commonly harvested timber and wildlife species are fully integrated into forest management. Vegetation inventories are now used for biodiversity conservation. Market and economic inventories have been widely used to assess current and potential contributions to community development. Much of what is known concerning these subjects is organized and consolidated into standard approaches, which are accessible to forest managers. The body of knowledge concerning inventory of non-timber forest resources does not reflect such development, but it is developing rapidly, and many of the approaches are being generated from developing countries.

Quantitative inventory methods for NTFRs and NTFPs must deal with enumerating the number and spatial distribution of plant populations. These inventories may describe the number of individuals of a particular species, measure various characteristics of the species of interest, and/or examine relationships between individuals and biological or ecological functions. The overall methods, including sampling designs and plot configurations, are dependent on scale of analysis, product life-form, and plant part harvested.

The sampling designs used in NTFP inventory studies vary extensively. Aerial surveys of large forest tracts have been used to measure occurrence of a single large species, such as trees or bamboo. A census, where 100% of all useful plants are measured, provides information that can be used for stock surveys to describe the abundance of species. Regularly laid out, systematic plots have been used in the Pacific Northwest of the United States and Finland to measure annual mushroom production. In India, large tracts of bamboo are stratified into smaller zones in which sampling is undertaken independently to estimate volume. Multistaged sampling techniques used for rattan entail establishing test plots within small blocks, which are nested within larger plots within a contiguous survey area.

Basic plot configurations include measured plots with fixed dimensions, plotless sampling, cluster sampling, and transect intercepts. Square, rectangular, and circular plots have been used to enumerate rattan, perennial herbs, and lianas. Plotless sampling, such as the point-centered quarter method, or 'random forest walks,' has been used to inventory particular species of trees, palms, and shrubs. A systematic group of subplots in a fixed pattern commonly referred to as cluster sampling has been used to inventory rattan. Line-plot transects of varying widths have been used to count the number of plants and percent cover for fiber and tubers. More research and development may be necessary to determine optimal and efficient designs and configurations.

Estimating Growth, Yield and Productivity

Management decisions based on information that lacks evidence of growth and regeneration rates could have serious ramifications on plant populations. To achieve sustainable management of NTFPs, data are needed on population dynamics as well as regeneration and productivity. In general, NTFP inventories require measuring certain aspects for an individual and then aggregating that to the population. Estimates of total yields can be made by sampling individuals and then using predictive models to extrapolate to the population. Estimating growth, yield and productivity are important

outcomes of NTFP inventories; yet undertaking the inventory may be problematic due to the nature of the product being harvested.

Permanent sample plots, which have been used extensively to estimate growth and yield of timber, are needed for NTFPs. Some work has been done to establish permanent plots for fruit production in tropical forests and more recently for mushrooms in the Pacific Northwest and medicinal plants in the southern Appalachian Mountains. Protocols for permanent plots of fruit tree yields include single, subjectively located plots configured in 1-ha squares which are subdivided into contiguous subplots. They call for measuring specific attributes that relate to production of fruit bearing trees and potential productivity of saplings. Configurations that include contiguous plots make statistical analysis difficult, as the plots may not be independent.

Growth and yield assessments are often undertaken using paired sites, which allow for comparisons of management approaches. One site is designated as an unharvested control, while the other is subjected to different degrees of harvesting. To achieve best results, local harvesters are used to gather the product. Alternatively, researchers simulate harvest methods based on experience. The main advantage of paired sites is that they allow for statistical testing. For better results and credibility, multiple replications and successive observations over several years are needed.

Development of methods to quantify product yields is lagging, and methods that have been developed have limitations. For example, methods for calculating yield of fruit trees may misrepresent actual yield because some fruit is inaccessible, other fruit may rot on the plant, and in general not all fruit is needed to meet market demand. Various techniques used to estimate fruit yields, such as ground level traps, repeat counting of fruit on trees, and random sampling of fruit on branches, each have their limitations. Repeat counting is good for fruit that do not fall when ripe, but requires marking fruit that have been counted. Branch counts are useful only for branches that are accessible. Litter traps only catch fruit that have dropped, which may not represent total yield for the tree.

For NTFPs where the desired products are below ground, such as tubers and roots, inventories are especially problematic as there is little or no way to correlate aboveground biomass to belowground yield. Attempts have been made to relate leaf width to bulb size, but further research is needed to find more reliable inventory methods. Understanding these limitations allow for development of improved protocols.

Methods for Product Categories

One of the confounding issues that affect NTFP inventory and monitoring is the tremendous diversity of products. Many different parts of the plants are harvested to produce many different products. Vines and other climbing plants are harvested for building materials and furniture. Saps and resins extracted from palms and trees are used for medicinal and culinary products. All plant parts are harvested for medicinal uses. Edible forest products may grow above or below the ground. Parts harvested for decorative and craft products include flowers, moss, twigs, branches, and cones. Building materials, such as bamboo, rattan, poles, and thatch, require different inventory approaches. Specific inventory methods may be required for each product or plant part. With so many different products, developing and implementing standardized inventory protocols is challenging. However, commonalities exist between inventory methods that create potential for the transfer and sharing of techniques.

Building Materials

Several NTFPs, especially bamboo, rattan and palms, are useful for building materials in tropical climates. A great deal of work has been done on various aspects of bamboo, particularly in India and other South Asian countries. As bamboo is a nationalized product in India, keeping track of supply and demand is legislated. It is included in national timber surveys, and volume tables have been developed to allow for accurate estimates of density per hectare. Large-scale aerial photographs and satellite imagery have been tested as a means to inventory bamboo at the District level in India. In Central and South America, demographic studies examining population dynamics of palm species used for building materials have been undertaken in forest reserves. Studies of this nature allow for estimating potential sustainable harvest levels.

Vines collected from forest lands are used as building materials, in furniture production, and in fashioning crafts. In Southeast Asia, where rattan is a major commodity, a great deal of work has been undertaken to develop inventory protocols. Efforts in this region have determined efficient and optimal sampling techniques as well as established permanent sample plots to monitor long-term impact. Results from inventory studies concerning rattan and other vines are providing valuable information that will help management. Optimal and alternative harvest methods and sustainable yields have been developed based on statistical analysis and efficient plot layout. Methods and subsequent results for rattan could

have implications for management of other vines, such as grape (*Vitis* spp.), smoke (*Aristolochia macrophylla*), and smilax (*Smilax* spp.).

Crafts

NTFPs are used in the production of crafts for personal benefits and to augment household economies. Products such as statues, baskets, hats, and weavings are commonly fashioned from materials collected from forests. Perhaps the best-known example of an NTFP being fashioned into a craft is the tauga (*Phytelephas* spp.) nut from Ecuador that is used to produce buttons and carvings. This NTFP was one of the earliest examples of market development for conservation of a non-timber forest resource. Growth models established for the tauga nut help understand the impact of harvesting. Much of the work on craft materials has focused on harvest methods and levels. Findings from these studies provide insight into total production and optimal harvesting patterns that can aid in evaluating management alternatives. Inventory and assessments of craft materials is an area where more research is needed to address the multitude of products used to fashion these products.

Decoratives

A great many NTFPs are used to produce decorative products that provide aesthetic and spiritual benefits to people in their homes and workplaces. These products are used in churches and other places of worship to decorate altars as well as coffins and wedding tables. They decorate hotel lobbies and entranceways in offices and other buildings. Products made from gathered or cultivated forest plants decorate many different venues.

The international floral industry is full of products collected from or cultivated within forests. Moss, harvested from the Appalachian forests of the USA, is shipped throughout the world and finally consumed through retail and wholesale craft stores. Wreaths made from vines from China are available in craft markets in eastern United States. Lycopodium (*Lycopodium* spp.) pulled from the forests of northern Michigan is cleaned, dyed and turned into wreaths that grace the mantels of consumers in Germany and other European countries.

Many decorative NTFPs originate from diverse natural forests where they are gathered by hand or with simple equipment. Inventorying the resources for these products is extremely challenging due to the vast number and diversity of products and life-forms. Although work may be under way to develop inventory and monitoring protocols for many of the more common products (e.g., leaves, moss, twigs, cones) there are few fully developed approaches integrated into forest management. The inventory of twigs and branches produced through an agroforestry scheme could be readily developed and implemented.

In the USA, work is under way to develop protocols to inventory and monitor galax (*Galax urceolata*) and salal (*Gaultheria shallon*), two prominent species in the floral industy. For galax, permanent sample plots using a point-intercept approach have been established along the Blue Ridge Parkway in North Carolina to monitor harvesting impact. Within each plot, leaves that intercept the transect lines are recorded and measured for diameter.

Harvesting and exploitation inventories for decorative NTFPs provide information that may be useful in determining optimal management practices. Parallel transects, with attached circular and square plots of varying size and grid shapes, provide data that are analyzed using simple spreadsheets and more complicated statistical methods such as linear regression. These types of studies (**Figure 1**) allow for tracking changes in population densities, and provide information on long-term impact of harvests.

Edibles

A great deal of inventory and assessment work has examined NTFPs harvested for foods and other culinary products, particularly berries, mushrooms, and sap. Much of this work is based in Europe where mushrooms and berry-producing shrubs have been included in forest management inventories for several decades. At the same time, some of the early work on developing inventory methods for resins and saps has occurred in Southeast Asia.

National legislation in many European countries, including the Czech Republic, Estonia, Finland, Lithuania, Russia, Sweden, and Poland, mandates the inventory of these products. Although most of the available literature concerning inventory assessments in Europe comes from Finland, results are available from these other countries and could serve as models for other areas. The greatest impediment to this information getting wider distribution is the lack of translation services; the literature is mostly only available in the language of its country of origin.

In general, the main objective of berry and mushroom inventories in Europe has been to produce national-level production statistics. In the Czech Republic, household surveys are used to demonstrate the national importance of these edible forest products. Work in Estonia is helping to improve

Figure 1 Monitoring log-moss harvests and determining sustainable yields of this important non-timber forest product is essential to finding ways to manage for this product. Courtesy of Gary Kauffman, USDA Forest Service.

the understanding of production levels under various conditions. The mapping of berry and mushroom populations in Lithuania is mandated by law and provides the basis for sustainable management planning. In Poland, where edible forest products have been included in national inventories since the 1960s, valuable information is provided to analyze spatial distribution and to aid in development of yield tables.

A great deal can be learned from the berry and mushroom inventory assessments in Finland. Thousands of permanent sample plots have been established throughout the country. Volunteers are mobilized to enumerate berry production. Measurements are taken throughout the season to provide information on the progression of fruit production. Systems are in place that provide for regular national- and local-level yield forecasts. Product information is sent electronically to a central database for distribution through various media (e.g., newsprint, internet, radio) to aid pickers in their quest to collect berries.

Inventory efforts for forest foods in other regions are far less advanced. In Central and South America, demographic and yield studies have looked at various fruit-producing trees. This work is providing information on potential harvesting scenarios, changes in population dynamics, and the feasibility of commercial harvesting. While some studies have used small plots of less than 1 ha, others have taken a wider scope with more than 25 ha in a single plot. Lessons can be learned from these differences that may lead to improved protocols. For example, large plots may be necessary when the distribution of plant species is so thin that gatherers are forced to search greater distances. In areas where species density is

quite low, large plots may better reflect local harvesting practices. In several studies throughout this region, plots were located with the aid of local inhabitants. Certainly using local inhabitants to locate plots will better reflect what local people want the researcher to experience.

Resins and saps are used for culinary, medicinal, and lubricating purposes. In the late 1960s, an aerial survey in Papua New Guinea was used to estimate the standing volume for production of copal (*Agathis labillardieri*) gum. Protocols developed with basket makers in rural villages in Zimbabwe allowed for the inventory and monitoring of dye production from the palm *Berchemia discolor*. Multipurpose resource inventories in Sudan have been used to estimate the potential for producing gum arabic (*Acacia senegal*), fuelwood, and building materials. In South Africa, measuring the amount of sap that is collected from the palm *Hyphaene coriacea* by local tappers allowed for assessing the potential production of wine. In North America, inventory protocols for maple syrup from *Acer saccharum* will improve forest management for that delicacy.

A variety of methods, scales, and complexities have been used in resin studies. Aerial surveys and special computer software allow for tracking large distribution of species that are tapped for resin. Regional, District and plot level analysis of resin-producing species provide information to improve management at different geopolitical levels. Grid patterns for laying out plots and condition scoring of trees impacted by harvesting provide details that will aid in replicating studies and assessing impact at a tree or stand level.

Medicinals

Inventory studies on medicinal forest products span the globe. In Cameroon, average bark production for individual trees of *Prunus africana* has been determined using systematic and subjective plot layout. In South and Southeast Asia, ethnobotanical inventories have generated lists of useful medicinal plants. In Nepal, studies have developed protocols that would integrate medicinal plants into national forest inventories. Through an assessment of medicinal plants in Sri Lanka, researchers have assessed management options for commonly collected species. Other inventory studies in the region are providing insight into the responses of plant populations to other forest activities, particularly logging. Alternative inventory approaches, modified for various plant distributions, is a critical need to improve protocols.

In Central and South America, inventory studies have strived to quantify the value of managing forests for medicinal NTFPs. Studies in this region have included economic valuation inventories as well as ethnobotanical and biodiversity inventories. They have varied in scale from 10-ha forest reserves to small research plots in local forests. Transects with random plots have been used to inventory medicinal plants in the forests of Nicaragua. Interviewing local people to identify sites and species names has been integral to some studies. Data collected include a count of all plants and collection of voucher specimens, as well as volume of green and dried product prepared for sale.

The results of studies from Central and South America provide useful information for management. The value of medicinal plants to local communities can be estimated and provides for calculating the present value of sustainable harvest levels. Knowledge gained also provides insight into the impact of management practices, particularly logging, on medicinal plant populations. Methods developed in this region may be useful in other areas where medicinal plant collection is a concern.

In North America, efforts to develop inventory and monitoring protocols primarily focus on American ginseng (*Panax quinquefolius*), goldenseal (*Hydrastis canadensis*) and Pacific yew (*Taxus brevifolia*). Recent initiatives to develop inventory protocols for black cohosh (*Actaea racemosa*) and bloodroot (*Sanguinaria canadensis*) are too new to provide substantive recommendations (**Figure 2**). An inventory assessment in British Columbia, which was based on previous research by the US Department of Agriculture Forest Service to inventory Pacific yew bark, examined two alternative approaches to inventory bark production. Bark volume was estimated using linear regression, with bark thickness against tree diameter and bark shape. Protocols recommended from studies in North America are directed at ecoregional and provincial scales, and provide information to estimate minimum viable populations and growth rates. Information generated from ginseng and goldenseal protocols allow for modeling harvest at various critical life stages and aid in projecting productivity levels. All of these studies provide approaches that may be applicable to other bark and root products.

Summary

Timber is not the only flora-based product that is harvested from the forests. Many other plants and fungi are collected, and when these are included in forest management the diversity of biological material increases tremendously. In fact, more different plant parts are used to make non-timber forest products than are used to make timber products. The

Figure 2 US Department of Agriculture Forest Service field technicians install permanent plots to inventory medicinal plant populations. Volunteers also help monitor medicinal plant populations on Forest Service lands. Courtesy of Gary Kauffman, USDA Forest Service.

magnitude of this increases significantly when one considers the number of life-forms that are gathered for subsistence, spiritual, aesthetic, and economic reasons. Although it may be impossible to determine the aggregate social value of these products, the global economic benefits from NTFPs may exceed timber.

The complexity of forest management increases when NTFRs are considered. Inventory and assessment of these resources, which is essential for sustainable forest management, is not sufficiently institutionalized. Some countries, particularly in Europe and South Asia, have incorporated a few NTFPs into multipurpose resource inventories. These countries have recognized the social and economic benefits of berries, mushrooms, and bamboo, and have taken action to manage their forests for these products. Greater efforts and investments are needed to integrate fully the inventory and assessment of NTFPs into forest management.

The greatest body of knowledge concerning NTFP inventories is based on experiences in developing countries. The proportion of literature from Europe is about half that which has been generated from developing countries, but almost twice that from North America. The rest of the world is far more advanced than North America in developing NTFP inventory protocols. Certainly, there are lessons to be learned from efforts in developing countries that could help to advance efforts in more developed nations.

To ensure the sustainable management of forest for NTFRs, inventories need to be multidisciplinary, embracing social, ecological, and economic scientific methods. Local gatherers have tremendous anecdotal knowledge and need to be included in NTFR inventories. When forest management decisions might impact the lives of local inhabitants, the local people should be involved in determining resource and harvest levels. Their involvement in ecological assays and impact assessments could help to assuage the cost issues of undertaking NTFP inventories. Methods designed to inventory and assess economic and market opportunities may be more advanced, but need to be better organized and accessible to forest managers.

The choice of inventory methods depends on the purpose of the inventory, as well as the products, plant part, and life-form. Single resource inventories are less complex and require different approaches than multipurpose resource inventories. Although there are no standard methods for bark, sap, fruit, or any of the other many products, there is a solid body of knowledge from which to formalize more rigorous protocols. The many life-forms (e.g., trees, shrubs, palms, vines, grasses, and herbs) increase the challenges of developing standard methods. Inventories of NTFPs in natural forest settings are more complex than inventories set in agroforests or other planted arrangements. Optimal and efficient methods will be based on combinations of methods from these areas.

Fundamentally, there is a strong and growing body of knowledge on which to build an inventory program for non-timber forest resources and products.

But there are currently insufficient data and a lack of common reporting methods in many countries to fully integrate NTFP inventories into forest management. Efforts are further constrained by a lack of field skills, time, personnel, and fiscal resources. Until these issues are addressed, the inventory and assessment of NTFRs will remain underutilized in forest management.

See also: **Biodiversity**: Biodiversity in Forests; Plant Diversity in Forests. **Genetics and Genetic Resources**: Forest Management for Conservation. **Harvesting**: Forest Operations in the Tropics, Reduced Impact Logging. **Inventory**: Multipurpose Resource Inventories. **Medicinal, Food and Aromatic Plants**: Edible Products from the Forest; Forest Biodiversity Prospecting; Medicinal and Aromatic Plants: Ethnobotany and Conservation Status; Tribal Medicine and Medicinal Plants. **Mensuration**: Forest Measurements. **Non-wood Products**: Resins, Latex and Palm Oil; Rubber Trees; Seasonal Greenery. Bamboos and their Role in Ecosystem Rehabilitation; Managing for Tropical Non-timber Forest Products. **Sustainable Forest Management**: Definitions, Good Practices and Certification.

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Forest Change

T Krug and J R dos Santos, National Institute for Space Research, São José dos Campos, Brazil

Introduction

Forest inventories constitute the basic documentation containing data (tables, maps) and information relevant to the planning and management of forest practices. Depending on the purpose of the forest inventory, a multitude of different data and information is collected, including, for example, measurements of some tree biophysical characteristics, production assessment, the industrial and economic value of the forest, all of which may be relevant to the efficient use of the forest resources. Different types of inventories, from reconnaissance inventories (a preliminary survey of low intensity that guides the more intensive inventory) to a large area inventories exist. The identification of the areas covered by forests constitutes the first step to initiate the forest inventory.

In order to identify the areas covered by forests, the 'own' definition (see below) of forest (which is necessarily linked to other forest-related definitions, such as deforestation, afforestation, reforestation, forest degradation) needs to be agreed. Unfortunately, there is no universal definition that is used worldwide and for all purposes. An exhaustive compilation of forest definitions has been prepared and includes more than 650 different definitions.