3. ECONOMIC ISSUES

1. COSTS AND BENEFITS OF DOING INVENTORY
2. USING RESULTING TABLES FOR ECONOMIC ANALYSIS

3.1. COSTS AND BENEFITS OF DOING INVENTORY

A first inventory

It has been noted that first-time inventory costs will be "high" in terms of buying maps and photography or imagery, furniture and space to store them, long-lasting measurement equipment, and equipment or vehicles for fieldwork. You can calculate a cost per hectare of inventory: a GTZ-sponsored project has done this for their eastern Guinea regional inventory work, resulting in a cost estimation of 170 Guinean francs per hectare, or roughly 10 cents U.S. (Sow, personal communication 2000). Such a calculation should be associated with the number of hectares represented by the field plots, the accuracy and precision attained, and the amount and value of information gained. Such a calculation also would not include investments in training and consultancies whose effects should last far beyond a single inventory.

In the first-time inventory, precision of results (the amount by which an estimation of the average can vary) should be very relaxed. That is why the time limitation is considered more important than the precision or area limitation: for a more precise the estimate, more time is required to do plots, and the more money that must be spent on training of relief crews and fieldwork that will go into the two- and three-month range. One must be convinced that the information at this base-study stage is worth getting.

In **Appendix 6** is presented a listing of typical costs that could be incurred for a first-time inventory exercise to quantify a 20 000 - hectare forest from the Preliminary Villager Resource Assessment and the numbers-based inventory.

The time required amounts to an estimated 500 person-days, of which:

- 20% at the more highly-skilled level,
- 30% at the village resource informant level, and
- 50% at the project facilitator / forest technician level.

Equipment costs to be depreciated over many forest inventories run near

- $3500 for fieldwork equipment
- $6000 for computer equipment and software

Added to this is imagery for a forest at around $4000 (alternatives to this were presented in section 2.1); and transportation costs of fieldwork.

Costs to a project could be reduced by

- ✓ investing in upgrades of government computerized mapping units during the life of the project
- ✓ collaborating with other forestry projects in the country for equipment use and trainings
- ✓ identifying, working with, and appropriately rewarding ***only the most competent Forest Department and private sector foresters*** (consider holding competitions for project positions); no excess baggage should be allowed.

BENEFITS: It is hard to calculate a "benefit" directly due to the work of measuring forest resources that have been exploited mostly outside the law for decades. Some benefits that have been mentioned so far include:

- giving visual evidence of project and Forest Department intentions to work with communities as opposed to simply policing them

- giving foresters a chance to work in a forestry capacity and learn more about forest resource values to communities as well as organized exploiters

- providing a baseline against which to measure effects of management actions taken

- providing data for growth predictions and numbers of stems harvestable in an immediate action plan

- updating information from very old maps and reports

- providing information about potential future timber harvesting operations in a forest, which is the most profitable of forest activities for local communities and industry (this is also true of the US Forest Inventory and Analysis, the federally-funded 10-year inventory program)

- providing other information on wildlife habitat, grazing areas, and other nontimber products that can guide user groups in defining sustainable use levels for themselves

- providing data for further scientific study of the country's resources for ecological or monitoring reasons

- providing physical evidence that the Forest Department is willing to change work habits and seek new technical and cultural knowledge

Perhaps none of these benefits is quantifiable in money terms; however, they are known as "non-market benefits", or "public goods and services", usually delivered by government for the good of its people and industries.

If cost and benefit comparisons have to be made, one way to approach it is to:

(1) calculate all the costs associated with timber and nontimber product extraction in the course of a management cycle, including inventory;

(2) calculate the total timber and nonforest product revenues for the cycle;

(3) find the cost to revenue ratio; and then

(4) compare the cost of the inventory or inventories done in the cycle to the total costs, to see what percentage of them is attributable to that part of the management program.

If the cost to revenue ratio was greater than one, and inventory was a large percent of that cost, you could look for ways to improve inventory efficiency. If the ratio was less than one, you could claim that the inventory is part of a winning formula for management.

Subsequent inventories

It has been mentioned that further inventories of nontimber resources or of highly valuable timber resources might be necessary. In fact, it ends up to be the economic value of a resource that justifies, more than anything does, its detailed measurement. The present economic value of a resource is the sum of net incomes from future harvests discounted back to today. Then the amount of resource harvested, the interest rate, and labor costs influence profitability of the inventory: highest profitability is when timber prices are high, harvest cost is low, and size of the inventory compartment is large (Stahl et al. 1994). All these conditions are met in forests of certain African hardwood species, although accessibility can prove to be a major problem in some.

Subsequent inventories used to make specific harvest plans and establish sustainable use rates become more profitable as the potential economic losses due to erroneous decisions become greater. This applies especially to the decision of when to harvest a tree still putting on appreciable diameter growth.

A 1997 analysis showed the cost of pre-harvest inventory to be less than 1% of the total inputs to a timber-harvest operation in a moderately-stocked timber stand in dry tropical forest of Benin (Seko 1995, Polansky 1997). More research on the costs of detailed inventories could be carried out as part of an action-research program in jointly managed forests. Most likely, they will be carried out only when the economic advantage is an obvious net benefit.

3.2. USING INVENTORY TABLES FOR ECONOMIC ANALYSES

Once you have an idea of average or potential amount of resource that is important in the market economy, the information can be used to calculate revenues and benefit-cost ratios over the course of a management cycle. Timber is the greatest source of market income in relatively intact forests; agricultural “rents” and grazing permits can be an added important sources of revenue for forest management funds as well as local benefit.

Calculations shown are based on (yield per hectare) x (hectares managed per year). The per-hectare values have to be estimated from

- quantities found during the inventory,
- the proportion of those numbers that are allowed to be harvested each year,
- estimated costs associated with preparing a market-ready commodity from raw materials, and
- estimated revenues that can be obtained from the market-ready product.

The following examples are simplified from Seko's 1995 analyses of profitability of a 25-year cooperative-based forest management plan, using basic inventory data of trees per hectare by species and diameter class and current market prices of the product from the forest, the madrier. Additional non-timber figures come from current and local market conditions.

First is an example of the amount of money that would accumulate in an established management fund belonging to the forest, for purposes of managing that forest only.

Sawtimber: Let us say that in a stand, the plot sample has yielded an average of 12 exploitable sawtimber stems per hectare, and the management plan has directed that a conservative one-third of the stems will be harvested in the first cycle, leaving the remaining thirds as seed and future crop trees. Based on sawyers' estimations in the sample, these trees contain a total of 17.7 madriers. Other information:

- In the first year, 36 hectares of this forest type will be harvested, followed by 120, 150, and 300 hectares in the succeeding three years.
- Madriers of this species are worth 4 000 francs on the retail market.
- Costs of producing a madrier (skidding, marking, taxes to the state, contribution to management fund, sawyer, storage) average out to 3150 francs.
- Costs of administration, replanting, fire control, and one-time trainings average out to 450 francs per madrier.
- The contribution to the management fund from sawtimber is then 400 francs per madrier x 17.7 madriers per hectare x hectares exploited per year.

Fuelwood: In addition, there are 128 stems of firewood species per hectare. Adding in the unused portions of the crowns of trees cut for sawing , fuelwood volume per hectare from the 128 stems has been estimated to be 20 steres, to be split evenly between stacked firewood (steres) and sacks of charcoal. Other information:

- The contribution to the management fund per stere after subtracting costs of production, preparation, and administration (as above) is 150 francs.
- The contribution to the management fund per sack of charcoal after subtracting costs of sale (as above) is 50 francs per sack.

Other resources:

- Grazing permits for areas in the east part of the forest are sold with a net benefit to the management fund of 920 000 francs per year (to be based on a fee of 400 francs charged per head).
- A flat rate of 500 francs per hectare will be collected on almost 1000 hectares of agricultural field "rentals" per year.
- A net benefit of 405 000 will accrue to the management fund after costs of managing and marketing nuts from a 375-hectare cashew plantation within the forest.

Following is a part of the analysis showing costs of production of sawn wood, firewood, and charcoal, plus administrative costs of these elements; and revenues to the forest management fund from sales receipts of the produce.

ANNUAL CUT		COSTS	REVENUES FROM MANAGEMENT OF UNITS (FRANCS)						Revenue
YEAR	HECT	of MGMT	Sawwood	Firewood	Charcoal	Agric rent[1]	Cashew[2]	Pasture[3]	TOTALS
0	36	**216 000**	254 880	54 000	45 000	0	405 000	0	**758 880**
1	120	**2 970 000**	849 600	180 000	150 000	988 500	405 000	920 000	**3 493 100**
2	150	**3 150 000**	1 062 000	225 000	187 500	988 500	405 000	920 000	**3 788 000**
3	300	**5 050 000**	2 124 000	450 000	375 000	988 500	405 000	920 000	**5 262 500**

1, Based on a well-marked agricultural zone inside forest in which farmers pay 500 francs per year per hectare
2. Based on 375 hectare cashew plantation in forest
3. Based on collection of 400 francs per head of cattle for 2300 animals in the beginning years

The same information is then carried over to a table of discounted costs and revenues for planning purposes and sensitivity analyses:

ANNUAL CUT		Revenue	COSTS	NET	CUMUL	Disc. Rate	PRESENT NET VAL.		Ratio
YEAR	HECT	TOTALS	of MGMT	BENEFIT	BENEFIT	10%	By year	Cumul.	BENEFIT/ COST after 25 years = 1.006031
0	36	**758 880**	**216 000**	542 880	542 880	1.000	543 000	543 000	
1	120	**3 493 100**	**2 970 000**	523 100	1 065 980	1.100	476 000	1 019 000	
2	150	**3 788 000**	**3 150 000**	638 000	1 703 980	1.210	527 000	1 546 000	
3	300	**5 262 500**	**5 050 000**	212 500	1 916 480	1.331	160 000	1 706 000	

Similar analyses can be carried out to compare

- two alternative activities or interventions
- benefits from a proposed activity compared to benefits from the status quo without the activity.

An example of the latter follows. Two possible **scenarios** for revenue collections were presented for each cutting plan: SCENARIO 1 was the current system of permits and revenue collection, in which an unknown percentage of charcoal actually harvested is marketed without permits. SCENARIO 2 was a system where villagers are required to be more accountable for their harvests and share a percentage of permit and conveyance revenues with the Forest Dept.

POTENTIAL REVENUES FROM CHARCOAL HARVEST

ASSUMPTIONS:

- A cord of green wood yields 10 sacks (50-kg size) of charcoal and costs kw5400 (goes to Forest Dept)
- 1 million sacks currently on the stump, according to July 2000 inventory
- Conveyance fee of kw360 per sack (goes to Forest Dept)
- A 10-year rotation in the management plan
- All the Village Resource Management Areas will have an interest in making charcoal to raise money

BACKGROUND INFORMATION:

- There is a rough average of 100 sacks per hectare throughout the forest, including *Julbernardia globiflora* (kamponi), Brachystegia species (excluding *Brachystegia bussei*), and *Diospyros* species named by village resource informants as apt for charcoal. In total,
- **(100 sacks) x (10,000 hectares) = 1,000,000 sacks of charcoal currently standing in the forest.**
- Regeneration of charcoal in the largest stands (4 and 5) looks like it is following a classic j-shape distribution, so that future stocks of the Brachystegias and Julbernardia will not be over depleted by present harvesting if practiced with care and monitoring.
- Analysis below will assume that all village management areas (Village Resource Management Areas) of the forest will be interested in pursuing a charcoal production scheme as a means of raising household incomes.

Logically, if the forest were exclusively used for charcoal production, a 10% share of existing charcoal stocks could be removed in each of the next ten years, during which time small stems would be moving up into exploitable sizes. The following calculations will rather consider a 20-hectare-per-management area annual "coupe" area where most existing charcoal trees will be harvested.

CHARCOAL CUTTING PLAN
1st year trial cut of 20 hectares in each of 5 VgMgmtAreas in "coupe" system

- 100 sacks per hectare x 100 hectares per year = 10,000 sacks in a year from the 5 Village Mgmt Areas
- 10,000 sacks divided by 10 sacks per cord = 1,000 cords of wood
- (1,000 cords) x (kw5400 per cord) = kw 5,400,000 paid for trees
- (10,000 sacks) x (kw360 per sack) = kw3,600,000 conveyance fees

SCENARIO 1: BUSINESS AS CONDUCTED CURRENTLY

- ***TOTAL TO FOREST DEPT. UNDER CURRENT LAW = KW 9,000,000***
  - *REVENUES MAY BE USED TO SUPPORT **2 FORESTRY AGENTS** FOR A YEAR AT A SALARY OF KW 400,000 PER MONTH.*
  - *AN ADVANTAGE IS THAT THE SMALLER SCALE OF OPERATIONS WILL BE MORE MANAGE-ABLE BOTH TO FOREST DEPT AND TO VgeResourceMgmtAreaCommittees. VRMACS WILL BE ABLE TO DO MORE OF THE MONITORING THEMSELVES.*
- ***REVENUE TO CHARCOAL MAKERS: 10,000 sacks x kw5000 = KW 50,000,000***
  - ***TOTAL PROFIT** BY CHARCOAL MAKERS UNDER CURRENT LAW = (50,000,000 – 9,000,000) = KW 41,000,000 LESS MARKETING COSTS AND COSTS OF PRODUCTION*
  - *PROFIT MAY BE USED TO SUSTAIN ALMOST **70 VILLAGERS** AT A RATE OF KW 50,000 PER MONTH*
  - *THIS PLAN WILL STILL REQUIRE TRAINING OF CHARCOAL PRODUCERS IN EFFICIENCY AND MARKETING; THEY WILL REACH THIS LEVEL OF PRODUCTIVITY SOONER THAN IN CUTTING PLAN A.*

SCENARIO 2: REVENUES SHARED BETWEEN VILLAGES AND FD

- ***TOTAL CONVEYANCE PLUS CORDWOOD SALES TO BE SHARED = KW 9,000,000***
  - *IF THE PROPORTION TO VILLAGES IS 40% AND THE PROPORTION TO GOVERNMENT IS 60%, THEN GVT GETS (60% X 9,000,000) = KW 5,400,000.*
  - *REVENUES MAY BE USED TO SUPPORT **1 FORESTRY AGENT** FOR A YEAR AT A SALARY OF KW 400,000 PER MONTH.*
  - *FOREST DEPT WILL STILL BE REQUIRED TO ASSIST IN TRAINING PRODUCERS IN EFFICIENCY AND MONITORING.*
  - *CURRENT THINKING OF VILLAGERS THAT PARTICIPATED IN THE NOVEMBER MGMT PLAN WORKSHOP IS THAT THIS REVENUE-SHARING SCENARIO IS THE ONE THAT WILL BE OPERATING.*
- ***REVENUE TO CHARCOAL MAKERS: (10,000 sacks x kw5000) = KW 50,000,000***
  - *TOTAL PROFIT TO CHARCOAL MAKERS UNDER THIS SCENARIO = (50,000,000 – 9,000,000) = KW 41,000,000 LESS MARKETING, PROD. COSTS*
  - *40% OF THE KW 9,000,000 OF PERMIT AND CONVEYANCE REVENUES, OR KW 36,000,000, GOES TO THE VRMAC; the other 60% to Forest Dept*
  - *PROFIT MAY BE USED TO SUSTAIN OVER **60 VILLAGERS** AT A RATE OF KW 50,000 PER MONTH, INCLUDING THE MANDATORY 10 GUARDS*
  - *THIS SCENARIO WILL STILL REQUIRE TRAINING OF CHARCOAL PRODUCERS IN EFFICIENCY AND MARKETING*

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APPENDIX 1. SAMPLE PARTICIPATORY FIELD INVENTORY SHEET

CHIULUKIRE FOREST INVENTORY **DATE** ________

MAP OF PLOT LOCATION

NOTETAKER __________ GPS WPT REF _____________

PLOT NUMBER 1 2 3 4

SITE INFORMATION:

Grass type ___________ Soil type ______________

Rocks: gravel __ man-sized __ house-sized ____

Any other species indicators of soil potential

____

NO.	**SPECIES**	**DIAM**	**TOT HT**	**LENGTH + SAW OR OTHER PRODUCT +DIMENSIONS; LENGTH + ROTTEN; START FROM GROUND ZERO**

REGENERATION INFORMATION ***(LESS THAN 7 CM DIAMETER; USE 3 METER RADIUS)***

SPECIES	*COUNT*	*SPECIES*	*COUNT*	*SPECIES*	*COUNT*

SUNDE INFORMATION from regeneration plot

	DEAD	*NUMBER OF LIVE BUDS AS BIG AS SMALL FINGER*										TOTAL
		1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10+*	
COUNT												

PRE-PLOT TRANSECT INFORMATION *(NTFP ACTIVITY, BAMBOO, FIELDS, GALLERY, WILDLIFE SIGN)*

50 m --

100m --

150m --

200m --

250m --

300m --

350m --

400m --

450m --

500m --

550m --

600m --

650m --

700m --

750m --

800m --

850m --

900m --

950m --

1000m --

APPENDIX 2. ADDRESSES FOR SPOT IMAGERY, FAO FORESTRY, CENTRE TECHNIQUE FORESTIER TROPICAL, FAO, AND OTHER INTERNATIONAL FORESTRY ORGANIZATIONS

SPOT Images
18, Avenue Edouard-Belin
31055 TOULOUSE CEDEX (France)
Téléphone: 61 27 31 31

Permanent Plot guidelines
Intl Union of Forestry Research Organizations / IUFRO
Seckendorff-Gudent-Weg
A-1131 Vienna, Austria
Téléphone: 43 1 8770151

ITTO
8, Rue du Colonel-Moll
75017 Paris

Centre Technique Forestier Tropical/CTFT (CIRAD)
Centre de Coopération Internationale en Recherche Agronomique pour le Développement
Avenue Agropolis
34398 Montpellier Cedex 5
France

Service des Etudes Statistiques et Informatiques
Station expérimentale ITCF
Boigneville
91720 MAISSE (France)

FAO FORESTRY
Via delle Terme di Caracalla
00100 ROMA (Italie)
email: Forestry-information@fao.org

International Society of Tropical Foresters
5400 Grosvenor Lane
Bethesda, Maryland 20814, USA

APPENDIX 3. GPS AND COMPASS USED COMPLEMENTARILY

The Geographic Positioning System receiver does not have to replace the compass 100%. In fact, since the majority of foresters are more comfortable and familiar with a compass, the GPS unit should not replace the compass in inventory work, at least not at this stage in history. The most important reason for this is that there still remain certain situations when the GPS unit is inferior to the compass: (1) when tree canopy cover is too dense for a reliable reception of satellite signals, (2) when steep topography biases reception to the open-air sides of the hills, and (3) when short distances (such as 100 meters) are to be walked to a precise location. In the third case, satellite reception requires more time than is appropriate for moving such a short distance. In addition, since movement by the receiver is required for the GPS to calculate direction and distances remaining, precision of the endpoint location is itself affected.

One example of using the two apparati in a complementary fashion is to:

- ✓ Orient the 1:25 000 photo or image to the landscape in the field, using a compass with declination set according to the topo map;
- ✓ locate a definite point (house, intersection) off the image or photograph with the GPS unit in the field;
- ✓ measure distance and azimuth from the GPS point to a desired plot location, drawn on the photo, using scale and compass;
- ✓ "plug in" the measured distance and azimuth to the desired plot center using the "Create New Waypoint" feature;
- ✓ use the GPS unit to navigate to the newly-created waypoint.

Another example is to:

- ✓ locate plot center in the office on a map, photo or image with georeferencing (control points to which the document is registered);
- ✓ find the coordinates of the plot center using a digitizer on the geo-referenced photo or map;
- ✓ draw the most likely straight-line route to the chosen point that will be followed in the field;
- ✓ find magnetic azimuth of the straight line drawn (magnetic, because it is based on a magnetically-corrected map);
- ✓ in the field, use a 100-meter tape and a compass **with magnetic declination set to the reading on the topo map** to find the point as described from the office;
- ✓ while traversing to the point, use the "GO TO" waypoint function on the GPS unit to check the difference between the two methods in where your final destination ends up;
- ✓ **decide** which piece of equipment (GPS unit or compass with declination set) will be the guiding force when you are looking for plots, or which piece will be used for which part of the navigation process;
- ✓ based on your decision, use the equipment consistently for all the plot locations.

This second example should be tried in any new field operation where people are just learning use of the GPS unit. It gives confidence in its advantages and also shows where it is weak.

Two words of advice:

(1) SET THE GPS UNIT TO THE PROPER DATUM IN THE SYSTEM – NAVIGATION MENU. The datum should match the datum shown on the topographic map used for georeferencing in the GIS.

(2) SET THE COMPASS DECLINATION TO THE CORRECT MAGNETIC DECLINATION IF YOU ARE GOING BETWEEN OFFICE-LOCATED AND FIELD-LOCATED PLOT CENTERS.
The declination to set on the compass is supposed to follow the arrow indicator on the topo map: for example, if the declination is shown as 10 degrees west of magnetic north in 1970 with a 2-minute reduction per year, set the compass declination to (10 degrees west) minus (2x30=60 minutes=) 1 degree = 9 degrees west with the tiny screwdriver provided. Failure to set the declination in this case would put you way off the target point if you are walking a transect of hundreds of meters.

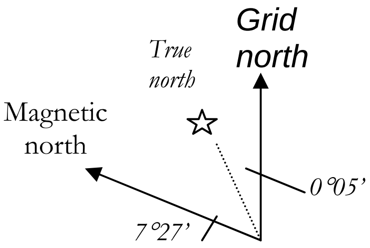
See the following Appendix for more detailed procedures.

APPENDIX 4. PROPER USE OF THE COMPASS WHEN WORKING OFF OLD TOPOGRAPHIC MAPS

COMPASS DECLINATIONS AND OLD FOREST BOUNDARIES

QUESTION: You have an old description of a gazetted forest boundary, or you have an old sketch of a boundary done with a compass with no declination set (using "magnetic north"). How should you set your compass declination today, if at all?

On the 1:50,000 topographic map that covers the forest in question, the declination at the time is written in the borders:



" Magnetic variation as at January 1972
Annual change = 01' East "

This describes a 7°27' west declination with an annual decrease by one minute (toward the east) and a further, constant rotation of 05 minutes toward the east for purposes of locating features within the map's grid system.

By January 2002, 30 years have passed, so the declination is now:

7°27' – (30 years x 01'per year)

= 6°57' WEST DECLINATION;

Subtract a further 05 minutes to the east for the map grid, and you get an effective

6° 52' west declination

to use on the compass in the field.

A west declination means that a compass with no declination set will try to pull any azimuth based on a topo map measure, or any azimuth followed on an adjusted compass, to the west of the true direction. This is because of earth's magnetic field. Therefore, the person on the ground must either
SET COMPASS DECLINATION to the amount figured as above (6° 57' WEST) AND SET THE COMPASS DIAL TO THE AZIMUTH MEASURED OFF THE MAP,

FOR A NON-REGULATED COMPASS, ADD THE NUMBER OF DEGREES AND MINUTES OF DECLINATION TO ANY AZIMUTH MEASURED OFF THE TOPOGRAPHIC MAP BEFORE SETTING THE COMPASS DIRECTION ON THE DIAL.

APPENDIX 5. FORMULAS FOR ALLOCATION OF SAMPLE PLOTS

For purposes of the baseline study, and given the restrictions of time and personnel inherent to projects, the exact precision of final estimates is relaxed in comparison to inventories done just before a timber sale. There are formulas for calculating an ideal number of plots to visit in the field to attain a predefined precision at a given level of confidence. These formulas are geared for industries who risk to lose capital and business if grave errors are made due to poor estimations of the raw materials they have to work with.

For the baseline studies of the jointly managed forests, the total number of plots to be sampled has been proposed as:

NUMBER OF FIELD TEAMS
X
NUMBER OF PLOTS EACH TEAM CAN DO EACH DAY
X
NUMBER OF DAYS AVAILABLE FOR THE INVENTORY

allowing about one field team for every 20 000 hectares of forest, and planning on no more than 30 field days for inventory work in the year. With one field crew that can do 8 to 10 plots per day, the number of sample plots (designated "n") for such a forest will end up between 100 and 200, depending on whether samples are clustered and depending on the amount of information that is to be gathered at each site.

The forest is assumed to be stratified into homogeneous stands whose boundaries indicate different potential management interventions. In each "stratum" - - forest or vegetation type which may be composed of one or of many stands - - a proportion of the n total plots to be measured will be located randomly or systematically. The following formulas are standards used to allocate n plots to different vegetation types depending on their area, variability, and accessibility.

As usual, the total number of plots possible within the entire forest is designated as capital N, the number of possible plots in each stratum as N_h. With fixed-area plots, such as circles or rectangles of a given dimension, N is simply the total hectares in the forest divided by the number of hectares in the plot size. With variable-radius plots, N can be the number of uniquely-identified intersections drawn on a uniform grid of several hundred meters falling within the forest boundary.

The number of plots that will actually be chosen and visited through the whole forest is n, and the number of those plots in each stratum is n_h. The value n could be calculated as proposed or, as described above, as in classical textbooks based on specified levels of precision and confidence. The latter method requires more statistical background than most foresters need in usual work conditions.

Assuming that we have calculated already the value for n from the formula above, there are 3 potential ways to calculate n_h, the proportion of the plots that should be located in each stratum.

(1) **PROPORTIONAL ALLOCATION:** It is simply a matter of multiplying n by N_h / N . Stated simply, N_h / N is the proportion of the total hectares in the forest that are in the given stratum. The same proportion applied to n gives n_h for that stratum. This is the easiest and most convenient method on paper, but does not help when you have a large, inaccessible stand that ends up with the bulk of the plots.

EXAMPLE: If 1 000 hectares of a 10 000 hectare forest are in stratum 1, and n was calculated at 120, then 1000/10 000 = 0.1; 120 x 0.1 = 12 plots to sample in stratum 1.

(2) **NEYMAN ALLOCATION:** For this calculation, you need an estimate of the variability in each stratum. To get the variability, go into the forest, visit each stratum, and do three or four plots in each.

- For each stratum h, calculate a standard deviation for the average being estimated. Use the usual textbook formula (sum of squares divided by degrees of freedom), or use the RANGE (= maximum minus minimum) divided by 4. The standard deviation for each stratum is S_{yh}.
- For each stratum h, calculate the total number of plots that could potentially be selected from its area. (If several stands that appear the same on the photo make up the stratum, a list procedure can be used, as in Robinson et al. 1999.) The potential number for each stratum is N_h.
- To allocate n plots among the strata, multiply n by $N_hS_{yh} / \Sigma N_hS_{yh}$ to get each stratum's n_h .

This method takes advantage of variability and area to increase number of plots allocated to those strata that are less homogeneous and larger.

(3) **OPTIMAL ALLOCATION**: The difference between this formula and the Neyman formula is that it incorporates cost differences between different strata: if it is more expensive to reach plots in a certain inaccessible area of the forest, for example, fewer plots will be allocated to it. But at the same time, variability and size of the stratum act to increase the number allocated. It is the best method to use if it is possible to get (or estimate) variability and cost.

- Calculate standard deviation and N_h as before.
- Estimate the cost of doing a plot in each stratum. You can estimate the cost in relative terms. In the case of a project and a forest of 10 000 hectares, the cost of most concern may be time; use coefficients that describe the relative amount of time required to reach the interior of the stands. For example, if one stratum takes three times as long to traverse as another, its cost would be 3 compared to the other's cost of 1. Then if cost is C_h, $C_1 = 1$ and $C_2 = 3$.
- To allocate n plots among the strata, multiply n times $[N_hS_{yh}/(C_h)^{1/2}] / \Sigma[N_hS_{yh}/(C_h)^{1/2}]$ to get each stratum's n_h .

APPENDIX 6. TYPICAL COSTS OF EXECUTING THE FIRST INVENTORY, INCLUDING PRELIMINARY ASSESSMENT

(Exclusive of project-level or Forest Department supervisors; exclusive of large training room; exclusive of specific per diems and transportation costs)

NOTE: Items in ***bold italic*** are investments that will be used many times for this and future inventories.

I. PRA OR SOCIO-ECONOMIC STUDY: 25 villages

Training in participatory tools	***10 skilled facilitators x 3 days =***	***30 man days (md)***
Field work in villages	10 skilled facilitators x 5 days =	50 md
	50 informants X 3 days =	150 md
Report writing and tabulation	2 skilled office persons x 5 days =	10 md
Presenting back to villages	10 skilled facilitators x 2 days =	20 md
Flipcharts, maps, office supplies	***$200***	
Reproduction of report	200	

SUBTOTAL
$400 + perdiems

SUBTOTAL
110 skilled man days
150 unskilled man days

II. INVESTMENTS IN EQUIPMENT ($)

Relascope (optional) or prism	***1400 (optional) or $50***
100-meter tape	***100***
Diameter tape	***50***
Height meter	***100***
Compasses (2)	***100***
Clinometer	***100***
GPS	***250***
Topofil	***100***
Noteholder	***50***
Maps (1 forest)	100
Markers, pencils, rulers…	200
Clear overaly	10

SUBTOTAL
$1210 TO $2650

Computer (large screen)	***1500***
Software	***1500***
Wide printer + paper	***2000***
Digitizer	***1500***
Satellite image	4000

SUBTOTAL
$10 500

III. INVENTORY WORK

Trainings	***6 days x 8 persons/team =***	***48 man days***
Fieldwork	30 days x 6 persons =	180 man days
Camping gear (tents, cots, cookware …)	***$800***	

SUBTOTAL
114 skilled man days
114 unskilled man days
$800 for camping

IV. DATA TREATMENT AND MAPPING

Digitizing, spreadsheets: 2 persons x 30 days = 60 man days
Presenting results: (5 vge groups x 2 presenters x 1day/gp) 10 md

SUBTOTAL
70 skilled man days