Chapter 22
Greece

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22.1 The Greek National Forest Inventory

22.1.1 History and Objectives

The first forest inventory conducted in Greece was in 1836. Although it was not based on scientific or statistical methods, results were published in 1842 by the consul of Bavaria and Hannover. The area of the entire country at that time was only one third of today's total area (Kontos 1921). Kontos (1929) also published the results of the inventory of 1842 but did not provide any information about the methods used.

The first National Forest Inventory (NFI) in Greece was initiated in 1963 and covered 11,377,000 ha or 86.2 % of the entire country (Ministry of Agriculture 1992). The uncovered areas were primarily agricultural lands which amounted to 1,819,000 ha or 13.8 % of the country area. This inventory was conducted as a joint project between the Hellenic Forest Service and the Food and Agriculture Organization of the United Nations (FAO).

In 1992, the entire NFI was completed, and the results were reported in a handbook titled "Results of the First National Forest Inventory" (in Greek). The results of this inventory indicated that the area occupied by forests was about 19 % of the country with approximately half of the country covered by forest and other wooded land. A characteristic feature of these forests is the uneven-aged structure of the stands with trees belonging to all diameter classes.

After Greece entered the European Union, the main objective for establishing the Greek NFI was to define and report on common forest definitions. The Greek NFI would facilitate scientific research and create results that would be comparable at European level.

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22.1.2 Sampling Methods

Although inventories were conducted in 1836, 1929 and in 1992, only the last one was based on scientific methods, while the rest are only of historic interest.

The source data for the first phase of the inventory was panchromatic black and white aerial photograph at scales of 1:30,000 (mainly), 1:20,000 and 1:42,000 from different years. In each aerial photograph, 25 photo-plots were selected, measured and classified according to their land use, forest types, canopy closure, tree height, slope, and degree of soil erosion. The field plots were located using the azimuth and the distance from characteristic points on the aerial photographs that were easy to recognise. Photo interpretation of 95,220 photo-plots was used as the basis for the stratification into three strata; non-forest, forest without volume and forest with volume. A random process was used to select 2744 field plots from among the photo-plots. In each region the ratio of field plots to photo-plots in each stratum was as follows: 1:35 for the non-forest stratum, 1:50 for the forest without volume stratum, and 1:15 for the forest with volume stratum. The interpretation of a random sample of photo plots was verified in the field. For each field plot, ten trees were measured using a systematic orientation scheme: point No. 1 was 10 m south of the centre of the field plot, and the remaining nine points were determined according to the first point. These ten sample points were separated by a distance of 20 m and covered an area of 0.5 ha. Trees were selected on each sample point using a metric angle corresponding to 10 m^2/ha. For each tree, the measured variables were basal area, diameter at breast height, total height, merchantable height, non-merchantable height, Pressler's height, radial increment and bark thickness. Also, the tree species were identified, and the tree quality, degree of damage, and percentage of the healthy merchantable volume were estimated.

22.1.3 Data Collection

The Greek NFI assesses three main categories of variables: stand, site and sample tree.

The stand data content in broad categories are:

- Administrative data: owner group, restrictions for forestry, etc.
- Site description: land use class (both national and FAO definitions), main forest type, site productivity class, soil type, soil texture, etc.
- Growing stock: crown storey, species composition, crown cover, development class, age, mean height, tree damage, etc.
- Accomplished and Proposed Management Measures: accomplished and proposed cuttings silvicultural measures, soil scarification, draining, etc.

Stand variables describe the forest stand in which the sample plot or the sub-plot is located. They include the assessment of:

- Growth classes
- Age classes
- Share of tree species in age classes
- Dominant height of even-aged conifer stands
- Forest structure: crown coverage, stand structure, development stage, coverage of shrubs in stands
- Stand stability: damages, required tending activities, factors that influence game
- Actual woodland community
- Natural woodland community
- Regeneration
- Stand layers and their coverage
- Occurrence and abundance of woody plant species with attribution to stand layers
- Deadwood.

The site variables describe the site conditions that influence the growth and development of single trees or stands. They include the following variables:

- Elevation above sea level
- Aspect
- Slope gradient
- Relief
- Local climate situation
- Vegetation type
- Soil moisture
- Soil layer thickness
- Soil group
- Humus layer thickness
- Humus type
- Soil group.

The tree data is recorded on three categories of trees:

- standing tree data: diameter, species, quality class, crown class.
- sampled tree data: height, diameter at 6 m height, age, diameter increment, height increment, thickness of bark, etc.
- dead tree data, only on permanent plots.

Sample tree-specific assessments refer to the variables that are measured or assessed on the sample trees. Variables include:

- Species
- Diameter at breast height
- Tree height
- Height to the living crown base
- Crown radius and type of crown base
- Stem quality

- Reserved tree and trees with advanced growth
- Dead standing tree
- Forked tree
- Growth class
- Age class
- Tree class
- Crown class
- Stem damage
- Proposed removal in required tending activities
- Distorted trees.

22.1.4 *Data Processing, Reporting and Use of Results*

Areas were estimated by counting plots within strata from the total network of photo-plots on 1:50,000 maps using the following equation:

$$Area(\text{ha}) = Ai = A\sum\frac{M}{Mi} \tag{22.1}$$

where

Mi is the number of photo-plots in the survey area by stratum (Ai)
M is the number of photo-plots in the survey area and A the total land area.

Volumes were estimated using the general volume formula,

$$V = \sum\frac{U \times \pi \times (0.5 \times dbh)^2}{\pi \times R^2 \times N} \times H \times F \times A \tag{22.2}$$

where

U is the area of the land unit (m^2)
$\pi = 3.14$
dbh is the diameter at breast height (m)
H is the tree height (m)
F is the form factor for the tree
R is the maximum distance from the point to the tree (m)
N is total number of field plots in the area surveyed.

Based on the general formula, the following variables were estimated: net volume per hectare including branches, net volume per hectare of the main stem inside bark, net volume per hectare of merchantable stem and net volume per hectare of sawn timber volume.

The NFI data consists of two main categories: stand description and measured tree data. Stand description variables describe the forest stand where the field plot is located. If a field plot is divided into several stands, all stands are described. For tree measurements, the sample plot has a maximum radius of 12.65 m. which always gives us a surface of almost 500 m^2 ($\pi r^2 = 3.14 \times 12.65^2 = 502.5\ m^2$) (Dafis 1990).

The results of the first NFI in 1992 have been taken into account in formulating forest and environmental policy, forest management, and for evaluating the consequences of the decisions taken.

Reporting processes include: the Forest Resources Assessment (FRA) of the Food and Agriculture of the United Nations (FAO), the submissions on Land Use, Land-Use Change and Forestry (LULUCF) under the United Nations Framework Convention on Climate Change (UNFCCC) and under Article 3.3 of the Kyoto Protocol, the indicators and criteria for sustainable forest management for FOREST EUROPE (Ministry of Agriculture 2000; FOREST EUROPE, UNECE and FAO 2011), and on the conservation status of natural habitat types under the Habitats Directive (Council of the European Communities 1992).

22.2 Land Use and Forest Resources

22.2.1 *Classification of Land and Forests*

22.2.1.1 General Land Classification

In 1992, when the entire NFI was completed, the results of this inventory indicated that the area occupied by forests was approximately 19 % of the country with approximately half of the country covered by forest and other wooded land (Table 22.1) (Meliadis et al. 2009). Land use is divided in eight categories.

Table 22.1 Land use classes according to the national definition by area (NFI 1992)

Class name	Area (1000 ha)	Area (%)
Forest land	2512	19.0
Partially forest	3200	4.6
Phryganic land	277	2.1
Alpine areas	440	3.3
Grasslands	1756	13.3
Water (ponds, swamp)	273	2.1
Barren land	734	5.6
Agricultural land	3964	30.0
Total	13,156	100.0

In Greece forest land is defined as:

1. Land with 10 % crown cover with minimum height of trees of 5 m at maturity (in situ); areas of approximately 0.5 ha or strips with widths of 30 m (with tree canopy cover of 10 %); areas not used for any purpose other than production of wood
2. Areas from which the trees were harvested
3. Reforested areas
4. Maquis shrubland.

Other wooded land is defined as:

Land which has some forest characteristics but is not forest as defined above. It includes open woodland and shrub, shrub and brushland, whether or not used for pasture or range.

22.2.1.2 Forest Classifications by Use

The land classification system used in the Greek NFI follows a system of land management types (Table 22.2). At the highest level the land area is divided into forest and non-forest by applying the national forest definition.

22.2.1.3 Classification by Ownership Categories

In the national land use classification system, forest land includes productive forest land, forest land used for recreation, protective forest land (i.e. slopes over 50 %) and multifunctional forest land. Most forest land belongs to the state (Table 22.3) (Meliadis et al. 2009), contrary to the situation today in most of the other European Union countries.

Table 22.2 Classes within forest land and their areas according to the NFI (1992)

Class name	Area (1000 ha)	Description
Productive forest		Forests available for wood supply, and with yield
– High forest	872	
– Coppice forest	1206	
– Coppice forest with standards	434	
Total productive forest lands	2512	
Protective forest		Forest and other forest lands that are managed mainly for soil protection
– Forests and other wooded lands	6513	

Table 22.3 Forest area according to the national forest definition by ownership categories (NFI 1992)

Ownership	Area (1000 ha)	Area (%)
State	1643	65.5
Community	302	12.0
Monastery	110	4.4
Charity institution	11	0.4
Co-operative	246	9.7
Private	200	8
Total	2512	100

22.2.1.4 Forest Management and Cutting Systems

The main silvicultural systems used are:

- Coppice system (Oak (*Quercus* spp.), Chestnut (*Castanea sativa*))
- Shelterwood successive cutting system
- Edge shelterwood cuttings in strips
- Selective cuttings in groups and gaps
- Selective cuttings of single trees in all age classes of the forests.

More specifically, Greek forests consist of a large percentage of even-aged stands which are managed in the following manner:

- Establishment stage: Establishment with natural regeneration, sowing or planting, according to soil type and owners decision
- Seedling Stage: Early tending for seedling stand, no harvesting
- Sampling stage: Thinning of a seedling stand, no harvesting
- Stem stage: Two thinnings during the rotation
- Final cutting stage: Shelterwood or coppice felling to encourage regeneration.

The exact timing of these operations depend on the development stage of the tree species (Table 22.4). For example, Shade trees (Beech, Fir, Spruce) reach the Seedling stage up to 10 years, Sampling stage 10–20 years, Stem stage 20–30 years (40) while the Light trees (Pines and Oaks) reach the Pole stage at 15–20 years (Dafis 1990).

Table 22.4 Age phases and development stages according to dbh (Dafis 1990)

Age phase	Development stages	dbh (cm)
Young	Seedlings	<4
	Samplings	4–8
	Thin poles	8–10
Full growth	Thin poles	11–20
	Thick stems	21–30
Mature	Medium stems	31–50
Mature or early old growth	Thick stems	>51

22.2.1.5 Legal and Other Restrictions for Wood Use

The main body for protecting and managing the country's state forest as well as for supervising and keeping under control the private forest is the Forest Service. This body operates under the name General Secretariat of Forest and Natural Environment (GSF & NE) and constitutes an integral part of the Ministry. Also, within the framework of GSF & NE there are other institutions such as the Revisional Council for the Property of Forest, the Forest Technical Councils, the Forest Property Council and the Regional Councils and Committees (Law 300/1981). The legal restrictions impact on timber supply are summarised in Table 22.5.

Legal restrictions are designated for the following five reasons:

1. Protected areas
   Forest operations are not allowed on areas protected for biodiversity conservation. These include nature reserves, national parks and specific protection areas (such as areas for protection of herb rich forests, old growth forests, shore, etc.). In a small number of protected areas low impact management operations are permitted. Land use planning at country and municipal level may contain further restrictions. Borders of official protection areas are available in GIS database and can be taken into account in estimating statistics e.g. cutting possibilities.
2. Recreation areas
   Areas reserved for recreation including areas established by the owners decision (state forests) or land use planning at municipal or country level. These areas are managed primarily for recreation values and forestry operations must be planned accordingly. In most cases forestry is not profitable in these areas, with the aim of operations to maintain recreation values.
3. Protected biotopes, key habitats
   The forest act defines a number of biotopes that may not be managed or can be managed sensitively so that the natural elements are not endangered. These biotopes are identified if they occur in NFI plots and are identified using National, European Legislation and Natura 2000 designations.
4. Other restricted areas (e.g. monastic, military)
   This category includes military areas and other forests of specific use e.g. gene reserves or research forests.

Table 22.5 Relevance of law restrictions in Greece

Category	Relevance	Comment
Legal restrictions protected for biodiversity	Highly relevant	Forestry operations mostly not allowed
Legal restrictions protected habitats	Highly relevant	Forestry operations not allowed or restricted
Legal restrictions recreation areas	Relevant	Forestry operations restricted
Legal restrictions protective functions	Relevant	Forestry operations restricted
Legal restrictions other restricted	Relevant	Forestry operations restricted or not

5. Environmental and biodiversity conservation.
6. Protection of water resources causes limitations to forestry operations near settlement. Most of these areas are in a GIS database and can be identified in the NFI plots. Protection of forests in the high altitudes causes limitations to forestry in Greece.

Management (silviculture) and harvesting technology restrictions and logging costs also impact of the availability of wood. Due to the morphology of most of the mountainous areas, where steep slopes exist harvesting machines cannot be used. Regardless of the severity of the slope, the harvesting is conducted using mules, except in the case of plantations. The location of forests (distance from roads) is taken into account only via average hauling costs.

22.2.1.6 Further Classification of Forests

The further classification of forests in national statistics is usually by main soil type (mineral or peatland), site productivity class, dominant species, development class or age class (Table 22.6).

Table 22.6 Productive forest area according to the national definition by species (NFI 1992)

Tree species	Area (1000 ha)	Area (%)
A. Conifers		
Fir (*Abies borisii regis* & *Abies chephalonica*)	543.3	16.17
Aleppo pine (*Pinus halepensis*) and Calabrian pine (*Pinus brutia*)	567.7	16.9
Austrian pine (*Pinus nigra*)	281.7	8.39
Scots pine (*Pinus sylvestris*)	21	0.62
Bosnian pine (*Pinus leucodermis*)	8.3	0.25
Stone pine (*Pinus pinea*)	0.1	0.003
Norway spruce (*Picea abies*)	2.8	0.08
Other conifers	5.2	0.15
Conifer total	1430.1	42.57
B. Broadleaves		
Beech (*Fagus* sp.)	336.6	10.02
Sweet chestnut (*Castanea sativa*)	33.1	0.99
Oak (*Quercus humilis*)	1471.8	43.82
Oriental plane (*Platanus orientalis*)	86.6	2.58
Other broadleaves	0.8	0.02
Total broadleaves	1928.9	57.43
Total productive forest land	3359	100

22.2.2 *Wood Resources and Their Use*

22.2.2.1 Standing Stock, Increment and Drain

Estimates of standing stock, increment and drain are based on the sample tree measurements on the plots. They are calculated as volume of stemwood overbark. Stemwood according to the Greek NFI includes all stem parts above the stump. The minimum dbh is 5.0 cm measured over bark (Table 22.7). Trees below this threshold are not included. Due to the lack of periodical NFIs, increment and drain are only available in management studies for specific forest areas which are repeated every ten years. The volume of standing stock and increment, on productive forest land of the main forest species is presented in Table 22.8.

Table 22.7 Definitions for volume of standing stock, increment and drain

Variable	Definition
Standing stock	Volume of trees with dbh ≥ 5.0 cm over bark, including the bole (wood and bark), and stem top, and excluding the above-ground part of the stump
Increment	Volume increment of surviving trees with dbh ≥ 5.0 cm over bark plus the volume of ingrown trees into the small circular plot between two consecutive NFIs
Drain	Volume of living trees with dbh ≥ 5.0 cm over bark at the first measurement that were found to be harvested in the subsequent NFI

Table 22.8 The volume of standing stock and increment, on productive forest land of the main forest species (NFI 1992)

Tree species	Standing stock (overbark volume 1000 m^3)	Net annual increment (overbark volume 1000 m^3)
Conifers		
Fir	47,406	798
Aleppo Pine	14,986	1090
Black Pine	15,269	
Scotch Pine	2574	
Broadleaves		
Beech	30,437	931
Oak	26,537	695
Total	137,209	3514

22.2.2.2 Tree Species and Their Commercial Use

The main tree species are Aleppo pine and Calabrian pine, Oak and Beech. The main use of conifers is for round or structural wood and fuel wood, while the broadleaves are used for firewood (Oak and beech), round wood (Beech and Sweet chestnut) (Tables 22.9 and 22.10). The annual increment estimates are based on field measurements. The quantity of industrial volume in the Greek forest estate is presented in Table 22.11.

The categories of industrial wood are described as follows:

- Merchantable volume: Net volume of trees with dbh > 5 cm, between the stump height and the point where the stem top is 5 cm or the point where there is distortion
- Saw timber volume: Net volume of trees with dbh > 30 cm, between the stump height and the point where the top is 20 cm or the point where there is a distortion

Table 22.9 Total forest growing stock per hectare of all the forest species

Species group	Growing stock (overbark volume 1000 m^3)	Area (1000 ha)	Growing stock/ha (volume m^3/ha)
Conifers	85,012	1430	59.4
Broadleaves	66,776	1929	34.6
Total	151,788	3,359	94.0

Table 22.10 Growing stock increment of all forests

	Annual increment (volume 1000 m^3)	Increment percentage of stock (%)	Annual increment per hectare (m^3/ha)
Conifers	1918	2.26	1.34
Broadleaves	1895	2.84	0.98
Total	3813	5.11	2.32

Table 22.11 Quantity of industrial forest volume based (NFI 1992; Meliadis et al. 2009)

Industrial volume category	Volume estimate (million m^3)
Total volume of industrial forests	152
Merchantable volume	138
Sawn timber volume	139
Stem top volume	14
Desirable trees	60
Acceptable trees	59
Poor trees	21
Rejected trees	12

- Stem top volume: Net volume of trees with dbh > 5 cm between the top of the merchantable wood and the upper edge of the tree
- Desirable trees: Trees with merchantable value; trees that adapt well to a forest environment; trees that have no distortion or other damages, good shape and health
- Acceptable trees: Trees with merchantable value; trees that adapt well to a forest environment; trees whose merchantable wood has not been distorted more than 50 %, and have quite good shape and health
- Poor trees: Trees with less merchantable value; whose merchantable wood has been distorted more than 50 %
- Rejected trees: Trees with no merchantable value.

22.3 Assessment of Wood Resources

22.3.1 Forest Available for Wood Supply

22.3.1.1 Assessment of Restrictions

With regard to other restrictions and in particular to harvesting possibilities the Greek NFI assesses several relevant variables. The slope is decisive for the use of harvesting. In cases where there are steep slopes, harvesting machines cannot be used. On steep slopes, the harvesting is completed using lumberjacks and mules for transport. Another crucial factor is the distance to the nearest forest road. In field assessments the distance to the next skidding road and the distance to the nearest forest road were assessed for sample plot locations. These assessments are complemented by the analysis of aerial photographs and the determination of the shortest distance to the nearest forest road.

22.3.1.2 Estimations

The legal restrictions associated with nature protection and conservation were taken into account by excluding areas where harvest is prohibited such as national parks, and Natura 2000 areas where harvesting is limited.

NFI plots can be classified into one of three categories which is specified in the management plan, forests without any restrictions for resource use such as industrial forests, forests where cuttings are not allowed and forests where cuttings are partly limited.

22.3.2 Wood Quality

22.3.2.1 Stem Quality and Assortments

The quality of the stem is evaluated in different ways according to the local economical factors and the specifications for each tree species. In Greece three stem quality categories are used; valuable, normal and faulty. These categories are based on quality standards and wood defects which are relevant and can be incorporated in the following groups:

- Quality traits of the stem form
- Quality traits of the wood quality.

These quality traits describe "good quality wood" and include the following:

- Health, meaning the absence of the damages caused by fungus and insects
- Lack of knot
- Lack of cracks
- Rings of the same thickness
- Straightness of line wood fibers
- Presence of well formed heart or complete lack according to the silvicultural species.

22.3.2.2 Assessments and Measurements

The same quality classes are used for conifers and broadleaves. In Greece three categories of classification are used (Table 22.12).

Table 22.12 Stem quality classes as assessed by the Greek NFI

Stem quality class	Description
Valuable wood	At least 50 % of stem wood at maturity is valuable wood according to the quality standards and belongs to the IUFRO category a and aa[a]
Normal wood	At least 50 % of stem wood responds to the normal standards and belongs to the IUFRO category η[a]
Faulty wood	Less than 50 % of stem wood responds to the normal standards and belongs to the IUFRO category f[a]

[a]Leibundgut (1959), Matthews (1989) and Dafis (1990)

22.3.2.3 Estimation and Models

The volume of an individual tree is calculated using species specific volume tables:

- Black pine

$$V_\alpha = 3.9172327 \times 10^{-5} \cdot d^{1.884915} \cdot h^{1.043285} \quad (22.3)$$

$$V_\varepsilon = 0.0217237 + 1.177424 \cdot V_\alpha \quad (22.4)$$

- Oak

$$V_\alpha = 2.5182532 \times 10^{-5} \cdot d^{1.968549} \cdot h^{1.12419} \quad (22.5)$$

$$V_\varepsilon = 0.01631057 + 1.134771 \cdot V_\alpha \quad (22.6)$$

- Calabrian pine

$$V_\alpha = 3.3041044 \times 10^{-5} \cdot d^{1.790332} \cdot h^{1.181907} \quad (22.7)$$

$$V_\varepsilon = 0.01969779 + 1.195396 \cdot V_\alpha \quad (22.8)$$

where

V_α is volume without bark
V_ε is volume with bark
d is the diameter at breast height
h is height.

22.3.3 *Assessment of Change*

22.3.3.1 Estimation of Increment

Increment was estimated using the general growth formula

$$G = \sum \frac{(H \times F \times A)}{N} \times Pv \quad (22.9)$$

where

G is volume of annual increment for the survey area (m^3)
H is the tree height (m)
F is the form factor for the tree
A is the total land area
N is total number of field plots in the area surveyed

Error Estimation

The following errors are estimated for the calculations of forest area, industrial forests and growth:

- Total forest area: ±0.2 %
- Merchantable volume of industrial forests: ±2.6 %
- Growth of industrial forests: ±3.1 %.

22.3.4 *Other Wooded Land and Trees Outside Forests*

Land which has some forest characteristics but is not forest as defined above, includes open woodland and shrub, shrub and brushland, whether or not used for pasture or range. Other wooded land has very low productivity with tree resources having no economic importance and no forestry operations normally occur on other wooded land. It is estimated that OWL occupies 30 % (3,960,000 ha) of the total land area of Greece.

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