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Chapter 3
Archaeology of Trees, Woodland, and Wood-Pasture

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Introduction: the myth of Virgin Forest

'Virgin Forest', like 'Primitive Man', is one of those phantoms that haunt the imagination of scholars. The belief that there exist in remote parts of the world, and even in Central Europe, areas of forest that have never been affected by human activity is a powerful idea. One meets the doctrine that conservationists ought to abandon whatever else they are doing and turn all their attention to preserving virgin forests, or in countries where none is left to restoring virgin forest (Hambler and Speight, 1995). 'Unaltered' forest is sometimes used as a base-line against which to estimate the success of conservation practice.

In reality, woodland ecology is not so easily separable from human culture. The category of virgin forest recedes in the face of archaeological discoveries, which establish the antiquity and pervasiveness of people's land management almost everywhere except on remote islands. Nearly all the world's forests have been used by people and altered in some way, usually since prehistoric times. Homo sapiens, even in Palæolithic times, had the unique power to act at a distance, if only by exterminating significant animals, such as the super-elephants that lived in previous interglacials, and by altering the natural frequency of fire where fire is possible.

The last large areas of wildwood to have been affected by humanity would have been on New Zealand, which appears to have had no human contact before about 750 years ago. A few smaller forested islands seem to have had no human contact until Europeans discovered them in the eighteenth century.

The American concept of 'old growth' is not quite the same as 'virgin forest'. In practice it usually means forests that appear to have grown up without 'significant' direct human influence for a century or more, or (in America) since European settlement (Peterken, 1996). However, they often have been used and managed in earlier periods, especially by Aboriginal peoples, and may have been much changed by withdrawal of these earlier activities, even within the lifetime of existing trees.

Relations between people and trees are to be found almost everywhere; this chapter is on how to investigate them. Usually such investigations should be based on individual sites, only later (if at all) drawing generalized conclusions.

The archaeology of trees is usually a matter of the last few hundred years, sometimes extending back into prehistory, and at most to the beginning of the Holocene (the period of about 12,000 years since the last ice age). However, the inherent properties of trees are based on evolution over a much longer period, including adaptation to ecological factors that no longer operate, such as elephants.

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Tree-land: woodland (forest), savanna (wood-pasture) and maquis (trees in the form of shrubs)

Woodland

For the purpose of this chapter I shall use the terms woodland and forest more or less interchangeably to mean areas of closely set trees - what a forester would call a forest (Wood(land) and forest mean a number of

Photograph 1: A plantation, where the trees are not related to the natural vegetation and are there because someone has planted them. They are all of the same age and all of the same species. The one multi-stem tree is a coppice stool and is a relict of the ancient wood previously on the site (Borley Wood, Cambridgeshire, England, October 1999).

Photograph 2: Savanna (called dehesa) of evergreen oaks in grassland. Such ecosystems cover much of south Spain and Portugal. They involve grazing of cattle and pigs, pollarding the trees in a distinctive style, and (if the trees are *Quercus suber*) harvesting the bark to make bottle-corks. Although this is a mainly cultural savanna, and much of it modern, its antecedents go far back in the Holocene.

different things, even within the English-speaking world. 'Woodland' in Australia often means the denser kinds of savanna. 'Forest' often has to do with keeping deer). The word 'wood' means either (1) a defined area of woodland, sometimes with a name (Called in America a wood-lot), or (2) wood as a material, typically in small sizes (large sizes being timber). The term plantation implies an area of trees that some person has planted or sown, whether on the site of a wood (Photograph 1) or otherwise.

Wildwood means tree-land before it began to be affected by human activities. It may or may not still exist anywhere in the world.

A common mistake made by historians and ecologists is to equate trees with forest (that is, with closely-set trees). There are several other possibilities (Grove and Rackham, 2001). Many languages are vague about what is and what is not forest: thus in Spanish, although the word monte means 'forest', it can be used any kind of woody vegetation, as well as for 'mountain', its original meaning. Statistics of forest area are meaningless unless accompanied by a statement of how big and how close together the trees have to be to count as forest. Reported changes in a country's area of forest may result from the definition of forest becoming more or less restrictive, independently of whether there have been changes on the ground.

Savanna

This is where trees grow, but not close together to form forest (Photograph 2). Savanna is one of the world's most widespread and least understood classes of ecosystem. Trees are most often scattered in grassland, but in the Mediterranean (and in mediterraneoid climates elsewhere, such as California) they may be scattered among undershrubs (species of *Cistus*, *Salvia*, *Sarcopoterium* etc.). Trees scattered in grassland were formerly widespread in Northern Europe: they formed much of the historic 'woodland' of Scotland (Smout et al., 2005), and survive in the ancient deer-parks and royal Forests of England. They are often to be found at high altitudes, below the alpine tree-limit. The true extent of savanna, especially in Europe, is only now becoming apparent through the medium of Google Earth, in which scattered trees are easily distinguished from forest.

In this chapter, the distinction between forest and savanna is that in forest the vegetation under the trees consists of shade-bearing plants, but in savanna the trees are widely enough spaced to allow the growth of plants that do not tolerate shade. In many savannas the grassland under the trees is different from the grassland between the trees.

Savanna trees contrast with forest trees, even if both are the same species. Forest trees tend to be tall and often straight, without low branches. (Sometimes, especially in North America, they may be sny, growing in a regular curve.) Savanna trees, not having neighbours, spread sideways: they are low with sideways-spreading branches. Sometimes, as with some Acacia species in Africa and some *Eucalyptus* in Australia, there are special savanna-adapted species that branch near the base.

The difference between savanna and forest is due to one or more of a number of factors, which may be environmental (such as limited moisture), ecological (such as large herbivorous animals), or cultural (where people have decided to use the same land for pasture and trees). Savannas are often regarded as 'degraded forest', meaning forest from which some of the trees have been removed. If this is so, the remaining trees will display forest-type architecture, the shape of trees that grew up when they had neighbours (Photograph 3). In most cases, however, savanna trees are spreading in shape, showing that they have been isolated all their lives.

Photograph 3: Subtraction savanna. These trees, with their tall straight trunks, are all that is left of a forest that has been destroyed and made into a field (SW Australia, December 1996).

Photograph 4: Another classic tropical savanna, in NE Australia: Eucalyptus trees in grassland which is grazed and frequently burnt. The black objects are termite mounds (Laura, Cape York Peninsula, July 2001).

Photograph 5: Drought-determined savanna on an Ægean island. The roots of the large oak-tree on the right extend at least as far out as the red marker at bottom left (Lésbos/Midilli, September 2004).

It used to be said that in the 'classic' savannas of the tropics, such as Africa or Australia (Photograph 4), the determining factor is natural, especially drought or fire, and that wood-pastures in Mediterranean and temperate countries, such as the 'parkland' of England, are a cultural artefact and not 'real' savanna. This distinction is now difficult to uphold: most savannas have both a cultural and a natural component which are often difficult to separate. Much of the savanna of Australia and North America was maintained for most of the Holocene by burning instigated by aboriginal peoples as part of their land management. When burning stops the savanna infills into forest as new trees spring up in the gaps between the old ones. Much of the 'primæval' forest of West Africa used to be savanna maintained by indigenous peoples, and infilled into forest after slave-traders murdered or carried off the inhabitants (Fairhead and Leach, 1998). Conversely, on the Vera theory of wildwood, the vegetation of Europe in the early Holocene was not continuous forest but a dynamic equilibrium of areas of forest and areas of grassland, maintained by the grazing of wild cattle and deer.

In many savannas, especially in the Mediterranean, the main limiting factor appears to be drought. Above ground the trees appear to be scattered, but their roots extend out from beneath the canopy into the space between the trees (Photograph 5). Consequently the trees benefit from rain falling between the trees as well as on them. Browsing animals may also play a part. When large herbivores are excluded, the savanna infills, but often not into forest: once the infilling trees get beyond a few metres high they die back through drought.

Savanna is a transition zone, often a very wide transition, between forest and non-forest. The limiting factor may be drought, browsing, fire, or cold (immediately below the alpine tree-limit). It may be a more or less deliberate cultural creation (as with much of the montado and dehesa savannas of Portugal and Spain: Grove and Rackham, 2001).

In its European manifestations savanna is often termed wood-pasture (sometimes called pasture-woodland). Pasturing animals (cattle, sheep, goats, large numbers of deer) in woodland creates two problems. The shade of the trees reduces the pasture, and the animals will eat the regrowth of the trees. Combining trees and domestic livestock is a different land-use from trees only.

Hedgerow, field, and farm trees

Farmers encourage or tolerate the growth of trees for many reasons. In many countries the boundaries between fields are hedges or fence-rows, either periodically cut down low or allowed to grow up into tall trees. These may have been deliberately planted or allowed to establish themselves along fences, walls, or terrace walls. When planted, hedges are normally of only one or two species, but they may acquire other species as they age; when accidental, they are usually of a mixture of species from the start. Their function may be to mark a property boundary, to confine domestic animals within a stock-proof enclosure, to provide timber and wood, or to be a shelter from wind (Photograph 6).

In countries where hedges are rare, as in Ethiopia, there may be occasional big trees in fields, as well as rows

Photograph 6: Landscape of hedges and fields. The small irregular fields, massive hedges, and scattered farms are the result of centuries of piecemeal growth and alteration: their date of origin is unknown, but is at least 500 years ago. Note a few trees in fields: in the past there were more trees in fields and fewer in hedges than there are now (Border between England and Wales, June 2011).

Photograph 7: Ancient olive-tree, about 2000 years old, standing on an older terrace wall (Loutró, Crete, July 2006).

of trees along watercourses.

Another category of land-use is orchards and groves of olive, chestnut, carob, and many species of tropical fruit-trees. Many of these cultivated tree-lands do not last long enough to become archaeological, unless they are abandoned. Some trees are long-lived and continue to be productive: these include chestnut (*Castanea*), carob (*Ceratonia*), and especially olive (probably the longest-lived of all cultivated plants) (Photograph 7). In southern Europe vines in the past, and occasionally still today, vines were grown as climbers up specially-planted support trees.

Although orchards, in the sense of areas of land devoted to this type of production, are often thought of as the normal way to grow these trees, in the past fruit-bearing trees were often established on ordinary farmland. In Crete, for example, pre-1700 records usually show olive-trees not as a separate land-use but scattered among other crops. In Italy, coltura mista (mixed cultivation) involves trees mixed with perennial and annual herbaceous crops.

Maquis

This consists of trees reduced to the state of shrubs by some combination of browsing, woodcutting, drought, and fire. A classic example is *Quercus coccifera* (=*calliprinos*), one of the commonest plants of the east Mediterranean: it can exist in any form from a giant oak-tree down to a shrub a few cm high, and can change from tree to shrub or from shrub to tree according to circumstance.

North European writers think of forest as the normal state and regard maquis as 'degraded forest', meaning forest that once had tall trees which through human activities were replaced by shrubs. This claim is usually made as a generality, without demonstrating that any particular area of maquis was indeed forest in the past. (The word 'scrub' is often used for any ecosystem involving woody plants of medium stature: maquis, low trees, young forest, and the taller undershrubs such as *Phlomis* and *Cistus* species.)

Adaptations to the maquis state are widespread among Mediterranean trees: *Quercus coccifera* performs all its vital functions, including producing acorns, when less than 1 metre high. There are parallels in California and in the dwarfed mallee states of some Australian eucalypts. Maquis is really another kind of semi-natural transition from forest to non-forest. Some maquis probably goes back long before human intervention. Of the limiting factors, drought has been (so far) independent of human action; there was no lack of browsing and fire in wildwood times; even woodcutting probably has a natural parallel in the activities of elephants. One limiting factor may reinforce another: thus browsing may be more effective in places where drought limits the annual growth.

Other components of the ecosystem

Woodland, savanna, hedges, and maquis do not consist of trees alone. Shrubs, undershrubs, and herbaceous plants are an integral part of their functioning and may have archaeological significance. A third component, often overlooked, are the mycorrhizal fungi which attach themselves to the roots of all trees and most other plants and which are an essential part of the functioning of the individual host tree and of the ecosystem. There are two main groups. Ectomycorrhizæ produce visible toadstools and other fruit-bodies, like the well-known fly agaric (*Amanita muscaria*) which enables pine and birch trees to function. Glomeromycetes are invisible, except to specialists, but are essential adjuncts to many trees, like lime and ash, and to most herbaceous plants. They go back to the Palæozoic origins of land plants.

Ancient and Recent Woodland

There is a distinction between Ancient Woodland, wood-

Photograph 8: (a) Hayley Wood, Cambridgeshire, England in the Ely Coucher Book, a land register dated 1251 CE., (b) Hayley Wood in Google Earth 2009. The triangular area at the NE corner is a 20th-century addition to the wood.

lots that have been in existence for several centuries, and secondary woodland that has sprung up on land that used to be used for something else. For example Hayley Wood near Cambridge is first documented in AD 1251 and still exists. This is not by an oversight: it has been intensively used for most of the last 750 years and has been cut down many times, but it has remained as a wood and has not been made into fields. The wood has expanded on to a field abandoned in the 1920s, but this recent wood, though attached to an Ancient Wood, is very different in structure and vegetation (Photograph 8).

Ancient Woodland is not to be confused with virgin forest or old-growth. Most ancient woods have been cut down, often so many times that a felling-and-regrowth cycle has become part of their normal dynamics. What matters that they have remained as woods and have not been dug up. Trees grow again: it is a common mistake to confuse felling the trees with destroying woodland.
Forests shrink, mainly because people dig up the trees to make farmland, but they also expand whenever people abandon farmland. As North Americans know well, the easiest way to create a new woodland is to stop cultivating a field. This has happened many times in the historic and also the prehistoric past. An abandoned field is soon invaded by trees and turns into forest typically in 50 years or less; but it may be centuries before it acquires the characteristics of ancient woodland.

Woods are not necessarily stable, even without direct human action. Catastrophic events such as fires, windstorms, and avalanches can be a rare but normal part of their dynamics. In recent decades woods in many countries have been altered, and their future threatened, by events outside normal dynamics: especially the abnormal multiplication of deer, and the seemingly inexorable, global spread of foreign tree diseases subtracting tree after tree from the ecosystem. (At the time of writing all the plane-trees (*Platanus*) in Greece and Turkey and in the cities of western and southern Europe were imminently threatened by an aggressive fungal parasite, *Ceratocystis platani*) In Europe many woods have lost their lower branches (below a browse-line at 1 to 2 m depending on the species of animal) to excessive deer browsing. In North America the investigator needs to recognize the remains of chestnut (*Castanea dentata*) killed by the fungus Cryphonectria parasitica, introduced from the Far East a century ago. In Japan the pinewoods (*Pinus densiflora*), historically maintained for their mycorrhizal mushroom *Tricholoma matsutake*, are being eliminated by the parasitic eelworm *Bursaphelenchus xylophilus*, supposedly introduced from North America. Here too it is important to be able to recognize where the dead trees have been and what has filled the gaps they left.

Properties of Trees

Trees are wildlife, not environment, and are not all the same. Any ecological researcher on trees has to find out and take account of their properties and behaviour, especially the trees' reactions to what people do to them. Some of the more important properties are these.

Reproduction: trees do not necessarily reproduce by seed. Many are clonal, sending up stems called suckers from the roots (for example, most elms (*Ulmus*)). A clonal tree begins with a natural seedling or a planted individual; it then tends to grow out into a circular patch of genetically identical stems (Photograph 9). Trees that grow from seed may establish themselves tree by tree, giving rise to a forest of a mixture of ages. Alternatively they may function as areas of trees (such as pines) all of the same age, dating from the last time a disturbance occurred, such as felling or fire.

Reaction to felling. Some trees, such as most pines, are killed by being cut down. Some, such as ash (*Fraxinus*) sprout from the stump, a process called coppicing (Photograph 10); the stump develops into a stool, growing bigger and bigger with each cycle of felling and regrowth. Clonal trees sprout by suckers, shoots that arise from the roots. Pollarding is like coppicing, but the tree is cut 2-4 m above ground instead of at ground level. Coppicing and pollarding are important in woodland management over much of the world and throughout history. Trees so treated live indefinitely (often longer than trees that are not cut) and develop massive permanent bases. The ability to coppice, pollard, and sucker is an inherent genetic feature of many of the world's trees; what use (in evolutionary terms) did trees make of this capacity before people invented axes?

Adaptation to fire. The ability to burn is not a misfortune but an adaptation. Pines and eucalyptuses burn because they make flammable chemicals: they either survive the fire in various ways or begin again from fire-stimulated seed. Elms and beeches (*Fagus*) are not flammable. The business of fire-adapted trees is to catch fire from time to time (from lightning, if no other ignition is available) and burn up their non-adapted competitors.

Adaptation to browsing animals. Trees and other plants are adapted to being bitten in various ways. Some, like most grasses, readily grow again. Some defend themselves by spines or make distasteful or poisonous chemicals. These adaptations vary with the animal as well as the tree. The investigator needs to watch goats, cattle, deer etc. and see what species they prefer and which they reject. It is useful to see how the vegetation of cliffs, which animals cannot reach, differs from the rest of the landscape - this is especially instructive in Crete, with its profusion of inland cliffs (Photograph 11). Most browsing adaptations, especially in trees, are likely to result from at least hundreds of thousands of years of evolution, and will therefore be originally determined not by the present domestic livestock but by their wild predecessors, including elephants.

Annual rings: some trees produce annual layers of wood which can be counted and measured and form an independent historical record.

Gregariousness: some trees, such as many pines, tend naturally to form areas all of the same species; others are randomly scattered among other species; others tend to avoid each other's company and are rarely found two together.

Photograph 9: A clonal tree, *Populus alba*. All the stems arise from a common root system and are, in effect, all parts of the same individual (Tasmania (where Populus is exotic), July 2001).

Photograph 10: A coppice-wood less than one year after felling. The stools are of different species: *Salix caprea* commonly grows at 5 cm a day (Bradfield Woods, Suffolk, England, 15 August 1986).

Photograph 11: Thérisso Gorge, Crete, with its richly wooded cliffs. The vegetation on them has been out of reach of sheep and goats for thousands of years, and out of reach of the island's special mammals (including elephants) for 2 million years before that.

Modern Forestry and its Legacy

Human use and management of trees, for a great variety of purposes, goes back at least to the Neolithic beginnings of settled civilization. Woods and wood-pastures have often been subject to complex and interacting local rights, customs, and regulations. This began to change in the eighteenth century, as modern forestry grew up both as a science and as a philosophy. The idea got about that forests were an affair of state which governments ought to try to control and regulate. Forests came to be specialized for a narrow range of purposes, separate from other interests of rural people.

Tenets of modern forestry

- Trees should grow closely spaced in forests (Photograph 12), not scattered or mixed with other land-uses.
- Forests should belong either to the state or to private individuals (depending on which state).
- Orchards and orchard-like practices (such as rubber and palm-oil plantations) are a different land-use from forests - though some of them may be counted as forest for statistical purposes.
- Common-rights and communal land-uses are bad.
- The purpose of trees is to produce commercial timber and paper-pulp, not fuel, bark, leaves for farm animals to eat, etc. In consequence trees should be felled in early middle age, at one-tenth to one-third of their natural life-span.
- Tree growth and harvesting can be, and should be, predicted and controlled.
- Trees should be cut at ground level; the stumps should die and be replaced by a new generation of trees, either by 'natural regeneration' from seed or by being planted.
- Coppicing and especially pollarding are bad.
- Old (pre-twentieth-century) trees are bad.
- Hollow trees are bad and should be destroyed.
- Dead and decayed trees are bad (from a vague notion that they will 'infect' living trees, rather than from evidence that they promote any specific disease).
- Mixtures of tree species are bad (except for 'nurse trees' intended to be taken out when the main crop of trees has grown up).
- Grazing animals are bad.
- Fire is bad (rather than a normal part of the behaviour of certain trees) and needs to be suppressed.

Photograph 12: Modern forestry, treating trees as a farmland crop: a plantation of *Pinus sylvestris* (Norfolk, England, 1975).

Photograph 13: *Eucalyptus* plantation in Ethiopia. The trees are periodically cut to produce the many millions of poles on which Ethiopia depends for all kinds of construction and fuel. Each tree has been felled several times and has produced a stool base some 2 m in diameter. This site, near the then imperial palace, was probably one of the original plantations begun by Menelik II in the 1890s. The ground under the trees has eroded, leaving the stools perched on pedestals (Entoto, Ethiopia, September 2012).

This philosophy was most fully developed in Germany; it developed in a less rigorous form in France and (independently) in Japan. Other states took up either German or French forestry, depending on which state - regardless of whether it was appropriate for the local tree species, climate, or society. For example Britain introduced German foresters to India (to teach German forestry practices, not to learn Indian ones) and from there took the ideas to British Cyprus (in a mainly French form) and then (in the German form) to Britain itself. In countries such as Sweden and Slovakia, modern forestry has penetrated to the extent that earlier practices have almost been eliminated; in others, such as Greece and England, it has been less successful and 'traditional' tree-management, although marginalized, still continues. Ethiopia, unusually, invented its own tree-management, based on coppicing plantations of an exotic species, *Eucalyptus globulus* (Photograph 13).

Forestry philosophies have proved resistant to political upheavals. Thus the forestry of the Austro-Hungarian empire has survived the break-up of the empire, the Communist takeover of most of the successor states, the collapse of communism, and still continues in the successor states.

The mind-set of modern forestry has come to dominate much academic writing, to the extent that even natural forests have been brought within it: they should consist of young, close-set, tall, straight stems, as if they had been provided by a benevolent Providence for the north European timber market. German travellers used to reproach Greece for, in effect, not having trees like Germany's.

Foresters themselves are coming to realize that such narrow-minded ideals are unsustainable in the face of globalization of tree diseases and of the fact that trees, however fast they grow, are intended for a market that may have disappeared by the time the trees have grown. They are inconsistent with the wider significance of trees both as wildlife themselves and as habitats for other wildlife.

Archaeologists should not try to make their observations fit the agenda of modern forestry. They are dealing with a wider range of phenomena and processes, of which forestry is only a part.

Trees as Archaeological Objects

Ancient trees are not synonymous with ancient woodland. Some ancient trees are in forests, but most are either coppice stools in woodland or are in savanna and other non-woodland situations. The lives of trees are often shortened by competition: as soon as a forest tree begins to die back the space vacated is taken over by neighbouring trees. Longevity is promoted where trees have no close neighbours (at least above ground) and are able to recover from dieback periods.

Trees can be archaeological objects in themselves: they contain a record of past land-uses and of natural event occurring round them. Of particular interest are culturally modified trees, that have been used in ways that alter their structure, leaving marks that persist on the tree and outlast the use.

Old trees are a most important part of the world's tree'd ecosystems. When a tree acquires dead branches or goes hollow it provides a habitat for many specific plants and animals: hole-nesting birds, bats, fungi, insects that feed on rotten wood or on fungi, spiders that feed on such insects, lichens that require old dry bark under overhangs, mosses that live on the hard interior surface of hollow trees, and many other categories. A single oak that is 400 years old is a series of ecosystems in itself for which a hundred oaks only 200 years old are no substitute. The conservation of old trees and dead wood should be a priority for ecologists as well as archaeologists.

In England a distinction is made between veteran trees, that have outlived their utility as timber and have begun to develop cavities and dead branches (Photograph 14), and the sub-category of ancient trees that are fully developed as antiquities and as a habitat (Photograph 15). The ages at which these categories are reached varies with the species: thus a birch (*Betula*) may become a veteran tree at 50 years and an ancient tree at 100, whereas with oak these ages may be 200 and 400.

Photograph 14: A veteran tree of ash (*Fraxinus texensis*) in middle Texas. Even quite small trees are hollow and are an important habitat (January 2013).

Photograph 15: Some of the 4000 ancient oaks (*Quercus robur*) in a deer-park, where in the 13th century CE the noble Bigod family kept semi-domestic fallow deer. These are culturally modified trees: they were pollarded long ago, hence the massive short hollow trunk. This is a savanna, not forest, situation (Staverton Park, Suffolk, England, April 2004).

Ancient trees in forest

Some of the world's most famous ancient trees are now in forest and appear to have been so throughout their lives: they have tall, mostly straight trunks without low branches. Examples are the giant redwoods (*Sequoia sempervirens)* and giant sequoias (*Sequoiadendron giganteum*) in California, and the giant karri (*Eucalyptus diversicolor*) of SW Australia (though the ages of the latter are uncertain, as they do not produce good annual rings). The forest in which these trees are now may not be the same as that in which they grew up: giant redwoods are often scarred by past fires, although there is now not enough combustible material to sustain a fire.

Photograph 16: Ancient *Cupressus sempervirens* at the alpine tree-limit; it is about 3 m high (West Crete, 2011).

Photograph 17: Infilling of tropical savanna. The big trees are all eucalypts; their bases are blackened by fires. Originally they were scattered in grassland which was periodically burnt by Australian Aborigines. When Europeans came they suppressed fire, and in consequence the grassland was invaded by young trees of rain-forest species, not *Eucalyptus*. These will not burn and in time will replace the eucalypts (Kuranda, Queensland, Australia, August 2001).

Photograph 18: Coppice stool of ash (*Fraxinus excelsior*). It is thought to be about 400 years old , and has been felled many times (Hqyley Wood, Cambridgeshire, England, February 1967).

Ancient trees in savanna

The world's oldest living upstanding trees, bristlecone pine (*Pinus aristata* and *P. longæva*) are not in forest but scattered among the rocks at the alpine tree-limit of the mountains in the SW United States. Having no above-ground neighbours, they undergo cycles of dieback and recovery and can live for at least 4800 years. Similar are the cypresses (*Cupressus sempervirens*) at the alpine tree-limit in Crete (Photograph 16), among the oldest trees in Europe. Other ancient savanna trees are baobabs (*Adansonia digitata*), with their improbably massive trunks, although having no annual rings they cannot be dated.

In Europe many ancient trees are in wood-pasture; typically they are pollards. Examples are the medieval deer-parks and royal Forests of England, such as Epping Forest with thousands of pollard oaks, beeches, and hornbeams (*Carpinus*); and the rare surviving examples of Hudewald wood-pasture in Germany. Mediterranean savannas often contain ancient oaks and other trees. Spanish and Portuguese dehesa and montado, with pollard trees in a distinctive style, go back at least to the middle ages, but much of what is there now was deliberately created c.1900 and its trees are not old.

Savanna was widespread in central North America, in a wide transition zone between forest to the east and prairie to the west; its almost complete destruction was a great ecological tragedy of the mid-19th century.

When savanna infills into forest, the 'savanna-shaped' trees contrast with their younger, upright neighbours; they may retain traces of their savanna history as charred bases and fire scars (Photograph 17), or evidence of pollarding. Infilling of savanna is an important cause of loss of ancient trees; savanna trees may survive by putting on an extra flush of growth in height, giving a very distinctive shape.

Coppice stools

Some trees are a self-renewing resource. They can be felled and grow again many times, forming a multi-stemmed stool which grows a little bigger at each cycle (Photograph 18). The sizes of such stools set a minimum age for the wood. They can be calibrated either from annual rings or by looking for the largest stools in a wood of known origin. Thus stools of Eucalyptus globulus at Entoto, Ethiopia, are about 2 m across, and are likely to date from the original introduction of the tree by the Emperor Menelik II c.1890 (Photograph 21); but this species is exceptionally fast-growing and stools of this size of other trees will usually be centuries old. Coppicing is widespread in Europe and Asia; it was introduced by Europeans to North America and Australia.

Occasionally coppice-like stools result from something other than woodcutting. Some trees, such as species of

Photograph 19: Ring of lime (*Tilia cordata*). The stems are all parts of an individual tree, which would be equivalent to a coppice stool thousands of years old (Westonbirt Arboretum, derived from the medieval Silk Wood, Gloucestershire, England, May 1987).

Photograph 20: The practice of plashing or laying, one of the distinctive ways of managing a hedge (Hayley Wood, Cambridgeshire, England, March 1994).

Photograph 21: The boundary of the estate of Llanteilo Pertholey, Wales, of date c.600 CE, went from left to right along the ridge of Mount Skirrid and descended at the end of the mountain through the wood that is still there (June 1999).

Tilia, *Corylus*, and *Magnolia*, self-coppice: the original stem dies and is replaced by a ring of sprouts round the base. Such rings may date from before human coppicing and be among the world's oldest trees: examples are the rings of rings of stems in Californian Redwood (*Sequoia*), the giant ring of lime (*Tilia cordata*) in what is now Westonbirt Arboretum, England (Photograph 19), and perhaps the Hundred-Horse Chestnut (Castagno di Cento Cavalli) on Mount Etna in Sicily. Periodic fires, especially in savanna, can kill trees to ground level and produce what are, in effect, coppice stools. They can also arise from avalanches when huge masses of snow slide down mountains shearing off everything in their path; avalanche tracks, however, usually have a border of uprooted or bent-over trees.

Hedgerow trees are often managed as coppice stools. In some cultures there is the practice of plashing or laying, partly cutting through stems and bending them horizontal to form a barrier to farm animals (Photograph 20), which creates a permanently distinctive shape.

Pollards

Many of the world's ancient trees are pollards, which normally arise from woodcutting, although pollard-like trees can result from fire or from breakage by wind or elephant. Pollarding, like coppicing, prolongs the life of a tree, which often goes hollow.

Pollard cycles, which may be revealed in the annual rings, may be shorter or longer depending on whether the product was leaves (for feeding domestic animals) or wood.

Pollarding requires more labour than coppicing per unit of wood produced. It tends to be used in non-forest situations, especially savanna and farmland trees, where the regrowth of a felled tree would be exposed to grazing animals. Pollards have also been used as distinctive markers for property boundaries in woodland.

There are many variants of pollarding, each creating a tree of distinctive shape. There may be one pollarding point, sometimes 10 m or more above the ground ('giraffe-pollarding'), or many points. Shredding is the practice of harvesting the side-branches of a tall tree leaving a tuft at the top (Photograph 18). Pollarding is widespread in Europe, Asia, and Africa; it is rare in North America and Australia (though it occurs in Tasmania).

Ancient cultivated trees (olive, carob, chestnut) are often pruned into a pollard-like shape, especially in conjunction with grafting to cultivated varieties.

Other practices

Many other practices leave a permanent mark on the tree. Pines have often been tapped for resin, by cutting into the bark in various styles and sometimes charring the tree to stimulate the flow of resin. Bark harvesting for food (pines in arctic Scandinavia) or roofs for beehives (cypress in Crete) creates a distinctive scar. In Australia and perhaps North America there are still marks cut into trees by surveyors to define property boundaries.

Trees and erosion

Trees are sometimes thought to prevent erosion, sometimes to promote it (especially *Eucalyptus*). Which of these (if either) is correct will vary with the climate, soil, tree species, etc. Trees undoubtedly record erosion: a tree on a site that has lost soil or soft bedrock is left on a pedestal, with its base and roots exposed; if the site has gained soil the base of the tree with its root-buttresses are buried. Roots may be somewhat exposed even if the soil has not changed, because shallow roots break through the soil surface as they grow thicker.

Pollen Analysis (Palynology)

Many trees and other plants produce large quantities of distinctive pollen grains, which in the right conditions can be preserved for thousands, indeed millions, of years. The pollen analyst looks for a place that is permanently wet, a lake-bottom or peat-bog, where there is a stratified deposit: every year a new layer of mud or peat is added on top of the previous layers. A core is taken using a suitable tool for the particular kind of sediment, divided centimetre by centimetre, and passed to a microscopist who extracts, identifies, and counts the pollen grains. The result is presented as a series of graphs, giving the amount of pollen of each type from the bottom to the top of the deposit. Dates can be provided from samples taken for radiocarbon dating, from volcanic ash fallout, or from archaeological material embedded in the deposit.

Pollen analysis is a specialized craft; archaeologists do not usually attempt it themselves, but make use of the findings of palynologists elsewhere. It can give the fluctuations of trees and other plants through the Holocene (or occasionally in previous glacial cycles or geological periods) and the effects of climate change and human activity, the advance and retreat of forest and changes of species, the beginnings of agriculture, and the introduction of new crops and new trees.

Palynology has its complications and limitations. In dry climates, such as the Mediterranean, it necessarily records the wettest spots in the landscape. Pollen grains are usually identifiable to genus (*Quercus, Tilia, Ulmus*) but often not to species: thus evergreen and deciduous oaks can be separated, but not usually single species of oak. Wind-pollinated trees and plants produce more pollen than insect-pollinated: thus *Quercus* is over-represented in pollen diagrams but Tilia is under-represented. Some pollens, such as Pinus, can be blown long distances; Tilia is unlikely to be found far from the tree.

Palynology is most useful in the prehistoric and especially the pre-Neolithic period, for which it is often the only source of evidence. In historic times pollen deposits may be absent, because drainage or peat-digging has destroyed the upper layers; they are also more difficult to interpret as the human cultural landscape becomes more complex.

One of the reasons for preserving wetlands is that they are, in effect, historic and prehistoric archives. Even if a deposit has been cored and studied, future investigators may extract further evidence from more detailed work.

Annual Rings

Many trees create their own historical record in the form of annual rings, which avoid the uncertainties inherent in other dating methods such as radiocarbon. Reading tree-rings is called dendrochronology, and has grown to be a branch of science which can be only briefly summarized here.

Caution may be needed when reading tree-rings. In temperate countries with a seasonal climate, like Britain, most tree species produce well-conditioned rings, one ring per year. Many trees elsewhere have indistinct rings or none that are visible at all. Some species produce false rings, with two or more phases of growth in a year, often detectable as a sequence of distinct rings alternating with less distinct rings. A few, such as lime (*Tilia* species) may miss one or more rings; this is detectable when rings that are distinct on one side of the stem merge on the other side.

Ideally tree-rings should be read in a slice from the base of the trunk, being counted and measured in two directions at right angles. Dendrochronologists usually work on stumps of trees that have already been cut by someone else. An alternative is to take a core with a hollow borer which leaves a hole 6 mm in diameter, not much injuring the tree. Coring tools are designed for youngish conifer trees and may not work well on trees with harder wood, or on hollow trees. A section from a branch or from higher in the trunk may be useful if nothing better is available.

These are some of the uses that dendrochronology has been put to:

- Age of the stem or of the tree. As well as the problem of false or missing rings, it may be necessary to estimate the number of rings in a missing part of the record. For example, there may be 237 rings present in a section, plus (estimated) 50 in the hollow interior of the tree, plus (estimated) 15 since the section was cut, plus (estimated) 20 years that it took the tree to grow to the height at which the section was taken; total 322 years, giving a starting date around 1690 CE. With a core, unless the operator is both skilled and lucky, the tool will miss the pith of the tree, and it will be necessary to estimate how many rings are missing from the beginning. Annual rings of trees are usually widest in the early decades of growth and diminish thereafter. Dating trees is not always an exact science, but incomplete or inexact information is often better than no information. With coppice stools and pollard trees, the age of the tree is greater (often much greater) than the age of the individual stems. Although coppice-stool bases or the bases of pollards are usually hollow, annual rings in the remaining shell of wood may give a measure of how fast the base has been expanding, from which the age of the tree itself can be estimated. It is also possible to estimate the growth-rates of stools by looking for the biggest stools in a wood of known date of origin.

- Dating events in the life of the tree. A ring count in the current generation of stems will give the date of the last time the tree was pollarded or coppiced. The dates of previous coppicings or pollardings can be ascertained from a core or section of the base. Every time the tree was cut, the growth rate suddenly falls, gradually returning to 'normal' as the tree regenerates its leafage. A more or less regular sequence, such as a fall in growth every 14 years, distinguishes this process from other events that reduce growth, such as caterpillar attack, Elm Disease, storm breakage, or bad weather. The fire history of an area can be reconstructed from sections of fire-damaged trees, counting how far back each fire scar is embedded in the subsequent annual rings. The same would apply to other events that damage the stem, such as harvesting pieces of bark.
- History of weather and climate. Trees are affected by the good and bad weather of individual years. If cold shortens the growing season, or drought weakens photosynthetic activity, the tree will make less substance to put into wood, and the annual ring will be narrower. By comparing the width of the ring of a particular year with the average of the years before and after, it is possible to identify the good and bad years, and sometimes to find out which of the possible weather variables is responsible for the difference. Climate history is different. To investigate it, the effects of weather are eliminated by taking 10- or 20-year moving averages of ring-width, to take out the variation of individual years. The result may record medium-term changes of climate, such as the phases of the Little Ice Age between 1320 and 1840 CE, or droughts in the SW United States, or (potentially) faster growth in the last few decades due to increased atmospheric carbon dioxide.
- Dating (and provenancing) archaeological timber. In principle the irregular sequence of wide and narrow annual rings, corresponding to good and bad years, should be the same for all the trees of a particular species within a particular geographical area. This gives a means of identifying the growth of individual years. For example, future dendrochronologists will recognize the two very dry years 1975 and 1976 in eastern England, followed after twelve unremarkable years by the droughts of 1989 and 1990, and then after five unremarkable years that of 1996, and so on.

The early annual rings of an old living tree can be correlated with the late rings of a piece of timber in a historic building. This method is extended back with successively older samples of timber to date archaeological wooden artefacts. Thus the famous tomb at Gordion in Turkey was built of juniper timbers within two or three years of 740 BCE (and therefore cannot be, as popularly supposed, that of King Midas) (Kuniholm et al., 2005). It is also possible to determine where a timber came from: thus in medieval English buildings some of the oak timbers fit the English dendrochronological standard, while others are imported 'Baltic oak' which fits the standard from Poland.

Dating and weather history both require the highest quality of dendrochronological data: it is essential to be sure that a particular ring is that for CE 1349, not 1348 or 1350.

Documentary Records

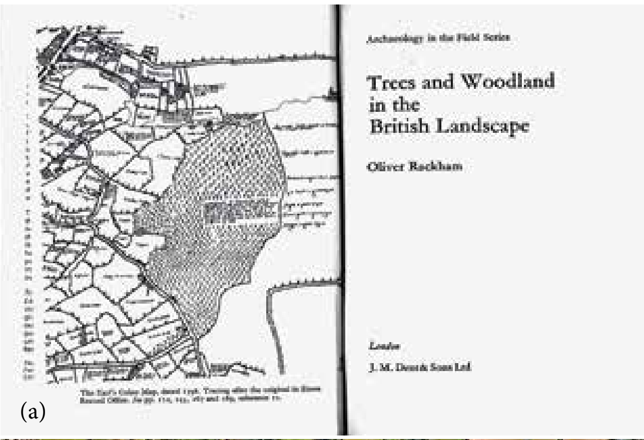
Countries vary enormously in the scope and extent of their archives. The most useful records are those that can be localized as to place. Some of the earliest are perambulations, descriptions of the boundaries of estates or political divisions which proceed from point to point describing features including trees, hedges, and the edges of woods, some of which can be identified on the modern map. The Ancient Greeks used to write even ordinary land transactions on tablets of stone or bronze, from which it appears that Hellenistic Greece (the last 3 centuries BCE) was little if any more wooded than Greece today. The Welsh perambulation of Llanteilo Pertholey, c.600 CE, which can still be followed on the ground, mentions one wood-lot, which is still there (Photograph 21). Perambulations have been especially useful in the forest history of Hungary (Szabó, 2005).

In England, Domesday Book appears to record all the woodland in most of the country in 1086 CE. England then, though it had more woodland and wood-pasture than now, was already one of the least wooded countries in Europe.

Other archives include accounts of the produce of particular estates, with details of, for instance, firewood and bark sold, the wages of men felling timber for use on the estate, or (rarely) the cost of contractors making a new boundary bank. Leases of woodland to wood-merchants or industrialists may lay down conditions as to what trees may be felled or how the regrowth is to be protected. In many countries travellers' accounts mention or describe any woodland or savanna that they encountered.

The rising cost of fuel and other woodland products has often been taken to indicate general scarcity of trees, but three other factors need to be considered: inflation (the falling value of money), and the costs of labour and transport, which often outweigh the cost of trees.

Early maps vary in quantity from country to country. As far as I know the earliest surviving map to show identifiable wood-lots, albeit sketchily, is the map of Boarstall (England) in c.1445 CE. Maps in Britain



Photograph 22: Chalkney Wood, Essex: (a) in a map dated 1598; (b) in a German aerial photograph of 1940, showing areas of felling and regrowth; (c) in Google Earth. The roads are now the same as in 1598, and most of the present hedges existed then.

become abundant from the late 16th century (Photograph 22), reaching a peak in the nineteenth century, when the Ordnance Survey produced maps at a scale of 1:2500 that portrayed every wood, and attempted to portray every non-woodland tree, in Britain and Ireland (Photograph 23). Other countries with a good map record are Italy and Sweden. Japan has immense archives of early maps which appear to have been very little studied.

Pictures and photographs

Pictures are a variable source of information. At best they are careful depictions of particular places, sometimes from exactly identifiable viewpoints, like those by John Constable in England c.1800 which can be compared with the same scene today (Photograph 24). However, trees in works of art are often sketchy and generic, mere space-fillers, not identifiable to species or individuals. Depicting a tree is an artist's most difficult task, and only a few European artists mastered it: Chinese and Japanese pictures of trees are much more convincing.

Early photographs are a valuable source, especially where the site can still be identified. Especially important are aerial photographs from World War II; the British material is now in the National Archives of Scotland, and the German material in the United States National Archive near Washington. Both cover many different countries.

Problems of interpretation

It is important, wherever possible, to go back to the original records, rather than using modern interpretations of them. What exactly did the original writer say? Was he writing from his own experience? Was he writing of events at the time, or of centuries before? What are the reasons for believing him?

Words are often used in unexpected technical senses. Many European languages draw a distinction between timber (French bois d'œuvre, Latin meremium, Italian legname), meaning tree-trunks suitable for beams and planks, and wood (bois d'industrie, lignum, legna), meaning coppice poles, tree branches, etc. suitable for light construction, fuel, or charcoal. American English does not make this distinction. The Ancient Greek drymos, which should mean a wood composed of oaks, seems in practice to have been used for coppice-woods in general. Forest may mean a place of trees or a place of deer. The investigator should be cautious in accepting other people's translations, which may often involve mere guesses at difficult words, or even be tendentious, exploiting uncertainties in the language to uphold a preconceived point of view.

Photograph 23: British Ordnance Survey map of c.1876, in the mountains of south Wales. It shows every field and every wood, distinguishing broadleaved trees and conifers. It appears to show every tree and every bush outside woodland. Similar maps cover nearly the whole of Britain and Ireland. Original scale 1:10,560. Most place-names are in the Welsh language.

Photograph 24: The famous picture The Hay Wain, painted by John Constable in 1821, and the same scene in 1998. Note the increase in trees and other vegetation (and also the artist's error in the house, which has not changed).

Place-names

Toponyms often embody woodland history, especially if they are in a previous language or an earlier form of the present language. For example Pencoed, 'End of Wood' in the Welsh language, is the name of several places in parts of Wales and western England where Welsh is no longer spoken; sometimes the wood is still there, sometimes not. Places like Penshurst embody the term hyrst, one of the many words for woodland in the Old English language: its exact meaning is uncertain.

Place-name study is a separate discipline which has its own methods and procedures. It is essential to go back to the earliest available documents. The modern form of a name may be misleading, especially if it is a misinterpretation of an earlier name in a different language.

Woods themselves have names, which may embody their history: thus in England a wood called Lound or Lownde has a name derived from lúndr in the Old Norse language of a thousand years ago. Wood-names may refer to management: thus in England Copse or Tailz, both derived from medieval Norman French, imply coppicing. A wood called Plantation is unlikely to be an ancient wood.

In England every wood, even if only a few hectares, has its own name which appears on maps. This appears to be unusual: for example on French maps only the larger woods are named, although this may be a matter of mapmakers' convention.

Wood-names may refer to trees. Sometimes the name implies a wood composed of the particular tree: thus English Oket, French Chesnaye, and German Eichat mean a tract of oak-trees (implying, perhaps, that other woods in the area were not all oak). More common, but ambiguous, are woods with names like Birkrigg ('Birch -Betula- Ridge'): does this mean a wood composed of birch-trees, or one distinguished by having a single conspicuous birch-tree?

As far as I am aware the oldest named wood in Europe is Skotitas in the Peloponnese in south Greece, described and located by Pausanias, the traveller of the 2nd century CE. It is still there and is a coppiced oakwood.

Archaeological Features in Woodland and Savanna

Features related to previous land-use

Archaeological survey - finding and mapping scatters of potsherds and other artefacts lying on the surface - is one of the most powerful methods of establishing the history of the countryside at large (as opposed to the excavation of individual sites). However, archaeologists tend to shun woodland, either because of the physical difficulty (vegetation and leaf-litter hide artefacts) or because they believe that woodland has always been woodland and will not yield evidence of people's activities.

Forests and savannas can contain almost any kind of archaeological material related to a previous non-forest land-use. Tens of thousands of square km of forest in eastern North America, from Florida to Canada, contain field boundary walls resulting from a short-lived period of agriculture in the first two centuries of European settlement. In most of the European Mediterranean, terrace cultivation has shrunk during the twentieth century, resulting in thousands of square km of abandoned terraces built at various times between the Bronze Age and the nineteenth century, much of which is now forest: the terraces may be revealed after a forest fire (Photograph 25). In England, a significant area of what is now classed as Ancient Woodland is underlain by ridge-and-furrow, the distinctive earthworks produced by medieval cultivation. In western Turkey, deserted Hellenistic and Byzantine cities are embedded in what is now forest.

Land abandonment can occur at any period. Even Hayley Wood, a classic example of Ancient Woodland

Photograph 25: Abandoned terrace cultivation, which turned into a wood of *Pinus brutia*, which then burnt, revealing the terraces. This is common in Mediterranean countries, where abandoned land is often invaded by pines, which are fire-promoting trees (West Crete, July 1988).

Photograph 26: Neolithic tomb, of about 2500 BCE, in what was then open land but has been woodland for at least 1500 years (Wychwood Forest, Oxfordshire, England, 1999).

Photograph 27: Woodbank, made about 1000 years ago by the monks who then owned the wood (Bradfield Woods, Suffolk, England, February 1973).

Photograph 28: Woodbank separating the ancient wood on the right from 19th-century woodland on the left (Cheddar Wood, Somerset, England, February 1979).

in England, is underlain by faint earthworks, thought to be of prehistoric date, which indicate that at least part of it was not woodland in the Bronze or Iron Age (1800 BCE - 40 CE). In western Europe, stone circles of the late Neolithic and Bronze Age, such as Stonehenge, indicate sites that were treeless at the time, especially as many of them have astronomical relations requiring a clear horizon. Round barrows (burial mounds, typically of the Bronze Age) commemorated the mighty dead and are in places where they were highly visible, even though some of the sites are in what has been woodland for the past thousand years or more (Photograph 26).

Some archaeological remains may be indifferent as to whether the site was wooded. In south Wales, medieval coal-mines could be as well within woodland as outside it.

Features related to woods as such

Woods, especially where they were private property, had definite limits, sometimes marked by permanent earthworks or walls. Characteristic of medieval woods, especially in England, is the woodbank, an earthwork typically 10 m in total width, with the ditch on the outside of the bank (Photograph 27): this defined the property boundary and made it easier to fence out domestic animals which would eat the young shoots. Where a woodbank is now in the interior of a wood, it may indicate a division of ownership, or may result from the wood enlarging (Photograph 28). The earliest woodbanks are thought to be Roman. They continued to be made down to the nineteenth century, but later ones (for example where part of a wood has been grubbed out, creating a new boundary) are less massive and less worn-down than early ones.

A famous example of what are interpreted as wood boundaries are the imperial boundary stones of the Forest of Lebanon, erected by the Emperor Hadrian (117-138 CE) (Abdul-Nour, 2001). However, these inscriptions mark the limit of the land on which the emperor claimed certain trees, and it would be unwise to assume that they coincided with the limit of the tree-covered area.

Wood boundaries, like other features, tend to reflect people's interest or lack of interest in geometry. The

Romans liked straight lines and regular grids and sometimes imposed them on conquered territories. For Chinese and Japanese regular orientations had a spiritual significance. In Europe, wood boundaries of the medieval period tend to run in irregular curves or zigzags. Interest in straight lines revived in the post-medieval period and was transmitted to America, where whole states are rigidly divided into sections one mile (1.6 km) square regardless of the terrain.

In England ancient roads do not normally traverse woodland: if they appear to, the road divides the wood into two woods, with a woodbank on each side. Sometimes the edge of the wood is set back from the road, with a narrow clearing, typically about 50 m wide, between. These clearings were made (and required by statute in the 13th century) to give travellers a sense of security against highwaymen hiding in the bushes. They establish that both the road and the wood existed in the middle ages. Similar roadside clearings in France are attributed to the 17th century.

Charcoal-burning sites are a common feature of forests and savannas, or of places where forest or savanna has been in the past. Charcoal has been made in various ways: the most widespread is by making a stack of logs, covering it with turf or straw and earth, and igniting it from within, after which over a period of several days it will turn into charcoal. Charcoal sites are difficult to detect in flat terrain, but if the ground is sloping a flat area had to be made. This leaves a platform, typically around 10 m in diameter, scooped into the hillside, usually with an access track and sometimes near a water source. The platform is covered with remains of charcoal, from which the species and size of wood can be determined, and (in principle) the length of the felling cycle and a radiocarbon date.

In Mediterranean countries pocket terraces can be made round individual olive or other valuable trees, especially where these are natural trees growing on rocky hillsides.

Large areas of woodland tended to attract fuel-using industries, exploiting the woods on a cycle: an area of wood would be cut each year, so that by the time the last area had been cut the first would be ready to cut again. Many of the large wooded areas of Europe have remains of furnaces and other iron-making and iron-working installations, of Roman to early-modern date: until the eighteenth century charcoal was needed to make iron because it produced a higher temperature than other fuels.

Any archaeological investigation of a wood or savanna should begin by making a map of the surface features, including distinctive trees. This may be done using the Global Positioning System, which however may not work where trees, cliffs, and other obstacles obstruct the view of satellites. If GPS is ineffective or not available, features may be mapped by the traditional method of walking along compass bearings and counting paces, starting from fixed points derived either from a large-scale map (where available) or from a Google Earth image.

Photograph 29: Compartmented wood-pasture. Hatfield Forest, Essex, is divided into coppices and plains. The coppices are ordinary woods with woodbanks round them. Each coppice was felled in turn and then fenced to keep out the cattle, sheep, and deer until the new growth was big enough not to be harmed. The plains were open to animals all the time, so the trees in them were pollarded instead of coppiced.

Savannas and wood-pastures

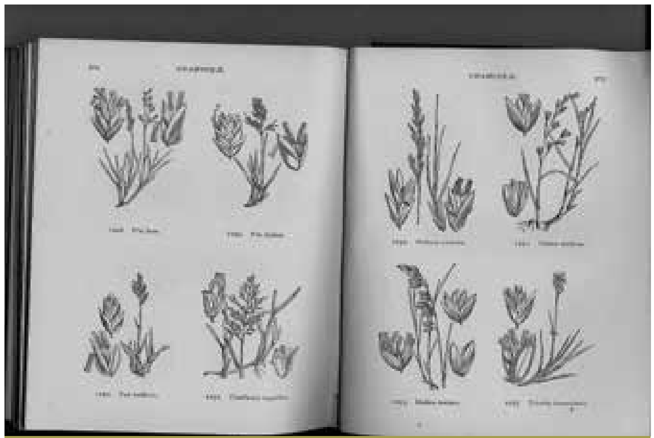
These features often have a history as common-land - that is, land on which particular persons other than the landowner have rights of pasture, woodcutting, etc. They are often diffuse in shape, with roads crossing them: any banks along the boundaries belong to the surrounding fields. Any trees will normally be pollards.

In England some wood-pastures have a history of compartmentation. Parts of the land would be maintained as woodland, surrounded by woodbanks. These would be felled in rotation and enclosed by fences on the banks for 6-9 years until the underwood had grown up again, when the fences would be removed and the commoners' animals allowed to eat the grass and other herbaceous plants between the trees. Any trees outside the enclosed coppices, exposed to livestock all the time, would be pollarded (Photograph 29).

Another form of wood-pasture was parks, places where the landowner kept deer. Keeping deer and other semi-domestic animals goes back to Roman times (Lucius Iunius Moderatus Columella) and probably to Bronze Age Crete. Parks had an expensive deer-proof perimeter fence or wall, typically of a compact shape (such as a rectangle with rounded corners), which often leaves a boundary earthwork.

In England many wood-pasture commons were designated as Royal Forests, places where the king (or some other very great magnate) kept deer - but not enclosed by a boundary fence. The term Forest does not imply woodland: many mountain Forests had few or no trees. The legal extent of the Forest (as defined by a perambulation) usually included a wide tract of

Photograph 30: *Paris quadrifolia*, a plant which in England is characteristic of Ancient Woodland. Like many such it is clonal and rarely starts from seed (Buff Wood, Cambridgeshire, England, May 1985).



Photograph 31: One of the strongest indicators of Ancient Woodland in England: the grass *Melica uniflora*. It is both clonal and has seeds dispersed by ants.

Photograph 32: A 'coppicing plant': *Primula elatior*. This is a perennial, present all the time, which flowers in abundance in the years after the wood has been cut (Hayley Wood, Cambridgeshire, England, April 1987).

surrounding farmland much greater than the physical Forest itself. Forests were not 'reserved to the king for hunting': most English medieval kings rarely hunted, but feasted on deer caught by professional hunters, and the deer in their Forests were added to whatever else was going on on the land. The various parties in a Forest were often in dispute, which is a fruitful source of records of topography and management.

In many countries deer (and bear, wild pig, and other huntable beasts) were less common than today. They and their habitat often had a special Forestal status; but the social and practical organization of hunting and deer consumption, varied widely and cannot be extrapolated from country to country. The presence of deer and pig is often taken as an indication of forest (meaning tree-land), but this need not be so: modern deer do much of their feeding outside woodland, and wild pig flourish in the semi-desert of south-east Spain.

What Trees and Plants Have to Say

When a new wood is formed, it does not suddenly acquire all the characteristic plants of woodland. Many trees behave as pioneers, rapidly taking over land that is no longer cultivated, grazed, or burnt: thus in Texas the local juniper, Juniperus ashei, is a tree that is sensitive to fire but resistant to grazing, and occupies land on which prairie fires have been suppressed. Other trees are slow to spread: thus in southern Greece the oak Quercus frainetto is characteristic of long-established woodland, as in England are lime (*Tilia cordata*) and service (*Sorbus torminalis*).

Many herbaceous plants are distinctive of woodland that has been long in existence: in English woods more than a hundred species have been so identified. Others are distinctive of recent woodland. The reason may have to do with the environment. For example, farm crops normally require higher fertility, especially in phosphate, than most wild vegetation: so woodland on former artificially-fertilized farmland may be suitable for high-fertility plants, such as nettle (*Urtica dioica*), but unsuitable for the low-fertility plants of ancient woodland - either for the plants themselves or their mycorrhizal fungi.

Another factor in ancient-woodland indicators is dispersal. Many ancient-woodland plants are clonal, growing from roots and underground stems and rarely starting from seed (Photograph 30). Or their seeds may be adapted for dispersal by some specific animal, especially ants, that is inefficient at moving them long distances (Photograph 31). Studies in a number of countries find the same two factors - clonal behaviour and ant dispersal - in plants missing from recent woodland.

Plants of ancient woodland are not the same as plants of old-growth or virgin forest. Many, perhaps all, survive periods when the wood has been cut down (but merely cut down, not converted to some other use). Some ancient-woodland indicators require the wood to be periodically felled. In England many herbaceous plants flourish in coppice-woods in the years after each felling

Photograph 33: A buried-seed plant. *Euphorbia amygdaloides* is a light-demanding plant: each time the wood is felled it comes up from seed shed after the last felling. Between fellings it is invisible. Several other Euphorbias behave in this way, including one in Greece (Bradfield Woods, Suffolk, England, June 1987).

Photograph 34: Infilled savanna on Mount Athos, the Holy Mountain of north Greece. The big spreading oaks were originally not in forest but were scattered in pasture, where the mules and bulls belonging to the Christian monks grazed. Only recently have they become embedded in forest (May 2001).

(Photograph 32). Some of these are invisible between fellings, persisting as long-lived seed in the soil from plants that flowered after the previous felling. A number of these, such as the spurge *Euphorbia amygdaloides* and others of its genus, are also ancient-woodland indicators (Photograph 33).

Listing ancient-woodland indicators can be a lengthy task, comparing species lists from many woods whose history is known. One short cut, where material is available, is to ask 'What are the plants that are found in ancient woods but not in ancient hedges?' The answer may form the nucleus of a list of ancient-woodland species.

Plants of recent woodland include nettle (see above) and the European umbellifer Anthriscus sylvestris. In North America the vast extent of recent woods is the preferred habitat for poison ivy (*Toxicodendron radicans*).

Photograph 35: A roof probably of the 14th century CE. Each timber represents one small oak-tree. Medieval woods were managed for a continuous supply of such trees (Canterbury, England).

Individual trees tell the story of their past uses and of events around them, especially those that are coppiced or pollarded. The woodland archaeologist should be on the watch for discrepancies between the form of living trees and their environment. One of the commonest changes of recent centuries is infilling of savanna. This produces a forest in which old trees of savanna shape - spreading, low-branched, often pollarded - are surrounded and hemmed in by younger, taller trees. Conversely, trees with tall, straight, branchless trunks, scattered in farmland, are likely to be relicts of a forest that has otherwise been dug up (Photograph 34).

The main dating standard for trees is annual rings: in areas such as Australia where trees seldom form good rings it may be difficult to arrive at a time-scale. In public places graffiti cut into the bark sometimes give a clue, taking into account the style of the lettering - early graffiti may be carefully and calligraphically incised - and the degree of stretching as the tree grew bigger.

Off-Site Archaeology

Archaeological excavations produce tree and plant material, preserved either in waterlogged sites (like the imperial palace of Nara, Japan) or under the sea (as in shipwrecks) or in permanently dry conditions (like tomb furniture in Egypt) or as charcoal. These can often be identified as to genus (less often to species) and give information about the use of trees for structures, fuel, or food (acorns, nuts etc.). The timbers of standing buildings, ships, waterfronts, and other structures can be dated by dendrochronology and reveal the species and many other properties of the trees that they came from.

In many cultures the custom is to fell trees when they are small enough to be handled by two men (Photograph 35). Each beam is made from the smallest tree that will serve; often the corners are waney where they intersect the curved surface of the log. Although some cultures, such

Photograph 36: An ordinary timber-framed house of c.1400 CE. The timber frame is made partly of cheaper species than oak, and of recycled timbers. The spaces between the timbers are filled with coppice poles covered with clay (Flatford, Suffolk, England).

Photograph 37: The biggest medieval buildings that could be built from ordinary trees were the great barns. This one was built c.1200 CE from some 450 mostly small oak-trees. It was a storehouse for the agri-business of the Knights Templars, military monks (Cressing Temple, Essex, England, 1989).

Photograph 38: The modern equivalent of ancient shipbuilding. The bottom of the Mediterranean is littered with thousands of ancient sunken ships, but so far these have not been much investigated for what they reveal about the origin and management of the timbers (Near Bozburun, Turkey, July 1996).

Photograph 39: If you haven't invented power tools there is one thing you can make from a giant tree (Panamá, April 1998).

as ancient Japan, subdivided trees lengthwise by sawing or splitting, this was often expensive or impracticable. Cultures without power tools tend not to make use of forest giants, except for special purposes where a big tree is essential, such as dugout boats.

Timbers of buildings, and coppice poles used as infill between the timbers, can reveal details of woodland management. For some purposes particular species are preferred. Thus oak was a high-status timber in medieval England (Photograph 37), other species being used, along with recycled oak, in less expensive buildings (Photograph 36). In cultures that build structures out of horizontal logs, as in the Alps and Scandinavia, conifers are preferred if available. For other purposes, such as the wattle-and-daub infill of medieval buildings, the species did not matter much. Annual rings reveal the felling cycle.

Most of these studies have been done on land carpentry. Another aspect is shipbuilding (Photograph 38 and 39). Although much is now known about the construction of ancient ships, investigation of the trees that went into them has not usually been given high priority by underwater archaeologists.

Timber was not always of local origin: thus much of the oak in English medieval buildings was imported -ready cut into planks- from the huge straight-grown oaks of eastern Europe. Pine was preferred in Spanish buildings, even where it had to be brought from distant mountains. Some building timber in the Ægean is pine from Turkey or larch from the south-eastern Alps.

Sacred and Civic Trees and Groves

In many religions particular species of tree or particular individual trees are objects of respect, veneration, and pilgrimage, although often by custom rather than for formal theological reasons. Examples are the ancient yews (*Taxus baccata*) around churches in England and

Wales. Many of these appear to go back to the foundation of the church 11-15 centuries ago; some are claimed (implausibly) to be older than Christianity itself.

In Japan, where there are two very different established religions (Buddhism and Shinto), both have sacred groves. Around Shinto shrines individual trees are marked with sacred ropes and ribbons as the dwelling-places of minor gods. These are usually veteran or ancient trees, but youngish trees can also be designated. Buddhist and Shinto sacred groves can range in size from a fraction of a hectare to several square kilometres, and in character from formal urban gardens to seemingly natural forest. They have often existed for many centuries. However, it is wrong to regard them as untouched natural wildwood: they show signs of past management and of fashions in tree-planting, such as the nineteenth-century vogue for sugi (*Cryptomeria japonica*). Sacred groves have their own trajectory of development, which is different from that of secular woodland.

One of the largest sacred landscapes is the peninsula of Mount Athos in Greece, which for a thousand years has been inhabited solely by Orthodox Christian monks, who (in theory) kept no female animals and thus did not have sheep, goats, or pigs. Travellers used to remark on the sudden contrast between the forested peninsula and the deforested secular mainland, inhabited by ordinary secular farmers and pastoralists. The distinction is now no longer visible as mainland agriculture has declined and the land has grown back to forest. The monks themselves have modified their forests by a thousand years of management, especially producing large coppice poles of chestnut from which they now make a living.

Ancient trees mark the centres of historic towns: probably the biggest tree in Crete is the plane-tree in the village square of Krási. One of the world's largest trees is the famous 'cypress' (*Taxodium mucronatum*) in the city of Santa María del Tule, Mexico. Other trees are associated with historic events, such as Kett's Oak near Norwich, England, associated with the rebellion of 1547, or the plane tree in Khaniá, Crete, whereon the bishops were hanged in the rebellion of 1821. In Japan are kusonoki (*Cinnamomum camphora*) and other trees planted by various emperors, which are preserved even when dead.

An Example

I write these words on the edge of a canyon (a small limestone gorge) in middle Texas. The rocky surroundings are a near-impenetrable wood of many species of little trees, 5 m or so high. The stems date mostly from the 1930s, but there remain the rot- and termite-resistant juniper stumps of a previous generation of trees, bearing the axe-marks of pioneer settlers 150 years ago. Dwarf ashes and oaks form small coppice stools and bigger clonal rings, which are probably centuries old. Interspersed among them are junipers, a few of which are big veteran trees, the specific habitat of the Golden-Cheeked Warbler (*Dendroica chrysoparia*), a rare bird endemic to Texas. The flat bottom of the canyon, reached by rare floods, is wooded with taller, mostly short-lived trees, including ash (*Fraxinus* species), pecan (*Carya illinoensis*), hackberry (*Celtis* species), bo'd'arc (*Maclura pomifera*), and elm (Ulmus crassifolia - many small hollow trees).

Photograph 40: Mott savanna, middle Texas: a cultural land-scape that has passed through at least four successive human cultures (Valley Mills, January 2013).

Above the canyon is a limestone plateau of grassland (prairie) interspersed with scattered trees (Photograph 40). It is not quite a typical savanna: the three principal trees -live-oak (*Quercus fusiformis*), elm, and soapberry (Sapota) -are all clonal, so that they occur as patches of stems, called motts, rather than single trees. Much of the grassland has become invaded by young junipers.

What is the history of this area? Settlers, some from Britain and Norway, others of European descent from other parts of North America, colonized in the 1840s and began European-style cultivation. They acquired land as their personal property, set up farms and for a time made a living, but European-style agriculture was not sustainable: the climate was harsh, the soil thin, and rainfall unreliable. Most of the farms were abandoned and are now represented by ruins with European artefacts, sometimes with a few cultivated trees. They were replaced by cattle and sheep ranches, which in turn have declined.

Local archives record the rectangles of land that were allocated to settlers by the new State of Texas or its Mexican predecessor, and the T- and L-shaped plots between them that nobody wanted until later. The boundaries were defined by perambulations, which when they came to a corner recorded the two nearest trees: Cedro as Spanish for juniper, Nogal for pecan (*Carya illinoiensis*), Encina for live-oak (*Quercus fusiformis*) etc., how many varas (a Spanish-Mexican unit of 84.7 cm) away each tree was, and in what compass direction. This reveals a landscape that in some respects has not much changed in 170 years. The trees near the corners are of much the same species, occasionally the same individuals, as the witness trees of the surveys. Where the survey found only one witness tree the site is still savanna. Where there was no witness tree -'Mound in Prairie' may be noted instead- the site is

Photograph 41: A small clonal mott of *Quercus fusiformis* (Valley Mills, Texas, December 2007).

either still prairie or overgrown with juniper.

The settlers, like all Europeans, feared fire, but did not succeed in suppressing it until about 1900; many of the old juniper stumps and fence-posts are charred by prairie fires. Previously the grazing animals had been migratory herds of buffalo (*Bison bison*) and wandering deer, but these were replaced by sedentary cattle, sheep, and goats - with disastrous effects on the native grasses and lesser effects on the trees. From c.1875 onwards, land-holdings and their many subdivisions were demarcated by barbed-wire fences, which now form a museum of successive patterns of barbed wire. There have been two main changes in the trees. Trees of all kinds have increased in the savanna, much of which has become infilled with juniper. Juniper is fire-sensitive and used to be confined to the canyons, but has now spread on to the plateau. At the same time, fenced boundaries, even in prairie, have turned into hedgerows of trees and bushes, especially as birds have sat on the fence-posts and excreted the seeds of fleshy tree fruits such as hackberry and wild plum.

The landscape that the settlers moved into, 170 years ago, was not virgin forest or natural steppe. It was already a cultural landscape maintained by a succession of Native American cultures: most recently by Tawakoni, Waco, and other nations who had acquired horses from Spanish conquistadores and settlers elsewhere, but before them by thousands of years of other cultures whose stone implements are still to be found in and near the canyons. There can be little doubt that they all managed the grasslands and savannas by burning to favour the buffalo, deer, and other animals on which they fed. Fires, noted by Euro-American travellers such as the Santa Fé expedition of 1841, then spread over nearly the whole landscape except for the fire-sheltered canyons.

A relic of ancient savanna fires are the motts. The individual stems of a *Quercus fusiformis* mott (Photograph 41) are typically 80-100 years old and are the regrowth from settlers felling the previous trees. Occasional trees, preserved because of historic links with the original settlement, may be 200 years old. But the larger motts themselves, often 50 m or more in diameter, must be thousands, rather than hundreds, of years old, periodically burnt to the ground by an unusually fierce fire but sprouting from the roots. The savanna landscape, though certainly cultural (as shown by its turning into forest when not managed), has passed through several successive human cultures during most, if not all, of the Holocene. Whether there has ever been virgin forest on this land within this interglacial is doubtful.

Conclusions

Historical ecology uses information from various sources: written records; place-names; study of pollen and other plant fossils; sizes, shapes, and ages of trees: presence of particular plants; archaeological features on and off site. It is essential to use as many as possible of these in conjunction. Even in the best-documented places, writings alone, without fieldwork, do not tell a complete story. They will not reveal what was happening in periods when people were not writing things down; and they often fail to record things, like terraces, that were commonplace and taken for granted.

The object is to study the history of particular sites, and from these to arrive at the history of a region as a whole. Ecologists should beware of generalized accounts by earlier writers, who may have been poorly informed or have drawn the wrong conclusions from their information.

How to write a false version of history?

- Do no fieldwork.
- Confine yourself to written documents.
- Use contemporary documents of a generalized nature, rather than those relating to specific sites.
- Pay plenty of attention to forest laws, and use them as direct evidence of what was or was not done.
- Rely on other people's translations from originals in other languages.
- Pay much attention to contemporary writers who had much to say for themselves.
- Assume that everything presented as 'legend' or 'oral history' is really what it claims to be.

How to write a false version of ecology?

- Confuse trees and other plants and animals with 'the Environment'; do not investigate their behaviours.
- Assume that all trees are alike.
- Confuse the history of the countryside with the history of country folk or of what people have said about the countryside.
- Copy what previous authors have said.
- Expect the history of the landscape to be simple.
- Take official statistics at face value, without reading the small print of how they were arrived at or what exactly they mean.

- Never admit you don't know something.

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