An edited version of this essay was published in *British Wildlife* 18:4, April 2007 entitled: "Planting trees or woodlands? An ecologist's perspective".

James Merryweather

A scheme to establish more than 2,250 acres of new native oak and birch woodland.

By planting the native trees that would have originally existed here, we are helping to recreate part of the great Caledonian Forest.

An exciting initiative to create almost 1500 hectares of native woodlands … to enrich the landscape once again with native woodland.

A NEW WOODLAND IS BEING CREATED FOR YOUR ENJOYMENT

These are bold claims and worthy initiatives, but are they realistic, rational or truthful? After many years of observation, information gathering and, often-uncomfortable reflection, my opinion has changed little from what it was when I saw my first farm woodland panting. From the ecological viewpoint, it's nonsense.

I can imagine that will have enraged some readers, but my opinions keep good company: "The fallacious belief that tree-planting equals environmental protection seems impossible to eradicate" (Marren, 2006).

I'm not attacking the motives behind these schemes, but questioning their ecological validity; the truth of what they are and what they are likely to become, which is unlikely to be what is promised. Travelling around Britain, I have seen hundreds of tree plantings that make little sense, but only after exploring the evidence and my arguments thoroughly, have I come up with this considered appraisal. You might well think it unfairly attacks or fails to address some of the issues (perhaps your issues), but I will make the points that, to me, seem to be important.

Actually, I suspect quite a lot of people will feel relief that at last somebody else has noticed what they have noticed and has strayed beyond his safety zone to expose the nonsense of simply planting trees and calling the result ‘woodland’, which it will not be.

These schemes might be alright if the public were told exactly what they are rather than presented dressed up as what they are not. Most of our native woodland and forest has gone and, as the last remnants are demolished, it is widely believed that they can be replaced by planting trees. Sheer delusion. Sadly, the same ignorant judgment is applied to tropical rainforest - the assumption that it can be replaced, so chopping it all down for temporary human use will be OK. That is entirely untrue, but a convenient belief peddled by those who are likely to make that much coveted fast buck.

Unfortunately, these days a lot of people can no longer see the differences between real native woodland, forestry plantation and the new thing: mixed broadleaf plantation called ‘new woodland’. To prevent a tangle of misunderstanding I will, before proceeding further, state my definitions:

- WOODLAND Planted by Nature, in Britain since the last ice age, and developing undisturbed. Mostly man-modified, but not rendered disfunctional. Consists of trees, shrubs, herbs, mammals, birds, insects etc. and microbes above and below ground, all in interactive equilibrium.
- FOREST This seems to have at least four meanings: 1. Native woodland covering vast tracts of virtually unpopulated territory (e.g. The Taiga of northern Eurasia, the Appalachian Mountain forests and the Amazon rain forest); 2. Ancient British hunting forest, a patchwork of open common, wetland and woodland (e.g. New and Epping Forests); 3. ‘Community forests’ of broadleaved trees planted recently (e.g. The National Forest). 4. Forestry Commission conifer plantation (e.g Dalby and Thetford Forests). For the purposes of this discussion ‘forest’ will refer to case 4, unless qualified.
- PLANTATION Trees planted by man, either as a crop or for their amenity value, with little or no consideration of other flora, fauna and microbes.
- NEW WOODLAND An assortment of (mostly broadleaf) young trees planted within the past 20 years with the misguided purpose of creating woodland in the sense in which woodland is defined above.

Woodland: a word that brings to mind thoughts of biodiversity in established equilibrium; of independent productivity that requires no human assistance; of timeless permanence; of changing seasons; of the steadfast vigour of ancient oaks in a peaceful sea of bluebells, wood anemones and soft, sweet leaf litter lit in golden pools by lazily-shifting shafts of summer sunlight; of images created by Ken Russell to accompany Debussy’s *L’aprés midi d’un faune* (BBC, 1965). The reality of that powerful image is becoming diluted as the last of the old woods are felled to be reinstated somewhere more convenient because all we have to do is plant trees, which, as we are told over and over again, is “Good for the Environment - Saving the Planet”.

Rubbish. The environment does it a lot better if left to its own, highly competent, devices.

The bottom has fallen out of the softwood timber market in the UK, so now the foresters are obliged to change direction and attract the public to sport and play among the sitkas. In doing so, they have hijacked and stretched the meaning of that

special word ‘woodland’ and applied it to all sorts of tree aggregations in their care and of their devising. Similarly, the organisers of community woodland schemes apply ‘woodland’ to spare land planted with trees. People are progressively provided with a new, debased standard of woodland. Money is available to plant trees, particularly if in a worthy community cause, so people are planting trees, everywhere, whether they belong there or not, whether they will grow there or not, whether woodland will be the result or not. Just say “woodland creation” and you can get subsidy money to create woodland, whether or not that is actually what you are doing.

I may seem to have come out of my corner with guns blazing recklessly, but I am entirely prepared to stick by them or otherwise change tack and shake the hand of the most vigorous opponent who can prove I’m barking up the wrong tree. Please tell me which tree the cat is in, and I’ll bark up that one. I’ll eat my hat if there turns out to be no cat and no tree. I fully expect that aspects of my argument will not stand up to examination by those into whose fields of expertise I stray, beyond my own competence. That’s fine with me. Nobody knows everything. I just want the nation to wake up to what is being done at our vast expense throughout Britain by the under informed who have wildly optimistic (irrational) ambitions and follow simplistic thinking and methods. The result is acres and acres and acres of empty plastic tubes or straight lines of skinny trees with an understorey of weeds (and everything else between those sorry extremes). The former will become similar to set aside, a weed patch developing, if left alone, into rough scrub (mostly brambles and gorse) and the latter will literally take centuries to turn into anything like real woodland.

The problem is two-fold. Firstly, the condition of the medium into which trees are introduced, which has often been disturbed regularly for a very long time and drenched with pollutants: mostly inorganic fertiliser (specifically phosphate), but in some places, agricultural and industrial waste. Not only does it not look like a stratified natural soil but it is structurally and chemically different, and its biodiversity is at best modified, usually desperately impoverished. Secondly, would-be woodland creators pay little or no heed to how plants actually grow and what constitutes real woodland. We have in our gift the science of ecology, which made great progress during the past century. An immense store of knowledge is available to be understood and exploited, yet many conservation schemes - in particular woodland creation - seem to flout it.

Now, *that is* reckless.

Attitude and Perception

ATTITUDE 1.

In the garden, plants that were never meant to live together are forced by external management - the gardener - to grow in ecologically inappropriate combinations in soil from which they are regularly removed so that it can be routinely disrupted.

Garden soil is not sterile, but its soil organism community is highly modified and reduced, and barely in touch with the plant community.

Garden plants require repeated supplementary feeding and constant artificial protection from pests and diseases.

A garden is soon lost when management and inputs cease.

PERCEPTION 1: Doing this leads to one sort of perception of how plants grow, driven by the erroneous notion that soil is an inert medium that must be manipulated if it is to function correctly.

ATTITUDE 2.

In the countryside, plants evolved to live together, connected by an internal self-management system that enables them to stay as together or separate as is best for them, in soil where they can remain for life where disturbance is a rare, localised occurrence.

The soil is alive with organisms that are inseparable partners of the whole plant community.

Wild plants and soil organisms feed and protect themselves and one another.

A natural community is self-sustaining.

PERCEPTION 2: Knowing this leads to very different sort of perception of how plants grow out of the understanding that soil is an intact, living 'organism' that does if not need anthropogenic intervention in order to function properly.

The safety of our environment is highly dependent upon these attitudes and perceptions. In recent times, the former has dominated the western world.

The garden is a battlefield, where the gardener wages war on natural processes, whilst wild countryside is an elegant multi-layered, intrinsically co-operative, self-sustaining partnership. Why, then, do we impose sledgehammer-to-crack-a-nut horticultural methods on our countryside when we attempt to preserve or reinstate it? Who ploughs so that the bluebells may flourish, scatters fertiliser to feed the mighty oaks or sprays the woods to banish pests and disease? Nobody. These wild habitats survive without external assistance and their productivity is high. They are self-sufficient (well, until we interfere).

With repeated reference to our conviction that we can make plants grow where ever we decide, we dictate where restored countryside ought to be and plant mixtures of more or (often) less 'growable' plants with little consideration of: 1. whether they are relevant in that particular landscape; 2. whether they belong together; 3. whether they will survive; 4. how they grow under wild conditions or 5. how they interact with the other organisms that constitute self-sustaining ecosystems. We just dig a hole and stick them in with a dollop of fertiliser. We pay no heed to the uncomfortable truth that natural soils are never ploughed or dug, and that they contain a vast army of interactive microbes and other creatures that enable communities that inhabit them to be self-sustaining. Natural soils and their vegetation function on a minimal nutrient supply, distributed with astonishing efficiency by and among the soil's inhabitants - including those we are aware of above ground. In our ignorance, we consider that plants thrive if their roots are buried in a well-dug, homogeneous, unstructured ex-soil enriched beyond natural levels with unwanted dung or excessive quantities of mostly unusable and, therefore, wasted artificial fertiliser (which then becomes a pollution problem, spoiling the countryside and requiring unnecessary expenditure on remediation).

It's rather like dumping a newborn baby in McDonald's and leaving it to get on with growing up.

Might it not be wiser to work out where our new countryside is most likely to thrive and do our best to work *with* already functioning communities of organisms? Why select an entirely un-natural starting point or, using inappropriate gardening or agricultural methods deliberately deactivate existing soils by well-meant but destructive preparation. Why not consider in advance what sort of community it is we wish to create and also how it would evolve and function under natural

circumstances? Why not hand over the task of nutrient supply to the micro-organisms that have done it so well for the past 500 million years, doing away with tillage, manures and fertilisers which inhibit, not enhance, natural processes?

The purpose of this discussion is to identify some of our environmental howlers and understand why they are mistakes. They should reveal some of the lessons we might learn from Nature *via* the science of ecology so that we might work with her, rather than use methods that damage the very countryside we treasure. We have to recognise that Nature is very, very complicated; far more complicated than we are able fully to comprehend. The knowledge we have so far gained from field research is pretty rudimentary or inconclusive, but we do have enough knowledge to be able to make informed speculation valid and decisions more likely to be the right ones – assuming we use that knowledge.

Using what I have been taught plus several decades of field observation, I am going to take two and add it to two, hoping to get a result somewhere in the region of three or five. If you can show me I have wound up with an answer of twenty-seven or minus thirteen, I will happily acknowledge a further instance of my inability to know everything. Now I have recognised and accepted the awesome complexity of Nature and my own intellectual limitations, I can welcome the challenges posed by a large amount of uncertainty. If, as I frequently discover, there is no easy answer, I can still stand and stare in contented wonder, waiting for, even hoping for, enlightenment. These days, people expect, indeed demand, easy answers to anything they don't understand. A wise contributor to *The Moral Maze* (BBC Radio 4; 30 November 2005) observed: "We're all out to lunch on bogus certainty". Can we not live with and enjoy some uncertainty in this splendid incomprehensible world? Better that than blunder forth in ignorance.

The Foundations: Symbiosis

Because it provides evidential underpinning ideal for this discussion, I will mostly make reference to a fundamental environmental mechanism, the symbiosis called mycorrhiza. Symbiosis and mycorrhiza are often presented as mere wildlife curiosities. That is far from true. They are universal and ubiquitous: the norm.

Mycorrhiza is the life-style of an estimated 90-95% of all plants, in every plant community, on every continent, including the parts of Antarctica where a few scrappy plants can eke out a living. Therefore, it can reasonably be said to be the most important symbiosis in terrestrial ecosystems. ***Symbiosis*** is a feature of the existence of every living organism and is, therefore, the most important - basic - life process in the world. Of course they are both just human words, but they and their meanings as understood by us, enable us to understand as best we can how life on Earth works. If we acknowledge how mycorrhiza works in the living world (ecology) we can try to apply what we know about it in our attempts to care for the environment in which we live. But it won't be simple or easy.

Symbiosis is a major driving force for every living organism and community of organisms on the planet. All living creatures are involved in a worldwide, multi-layered web of partnership. Symbiosis is absolutely everywhere. It is usually defined as two organisms combining for mutual benefit, a vast oversimplification. Firstly, drop the idea of mutual benefit. Profit and loss in symbiosis can vary in any temporal and spatial dimension. Benefit to partners can be more or less equal, but it is frequently a one-sided affair, at least for a while, after which benefit may swing to another member of the association; a previous consumer might become net contributor. Also, forget about involvement of just two organisms. Symbiosis can

occur between any number of organisms greater than one, at any scale from what we might look on as an individual to continent-wide organisation. Therefore, symbiosis is infinitely variable.

Mycorrhiza is a specific type of symbiotic association between specialised fungi and plants that occurs in roots. It confers a number of benefits on its immediate partners, but also contributes, through a complex mosaic of symbiotic interconnections, to community structure, health and well-being. Its original ancient, and most usual function today, is to facilitate a supply of phosphate to plants that cannot otherwise gather their own or find it easier to do so with outside assistance. This essential nutrient generally occurs at, by agricultural standards, low concentrations in natural soils and is mostly held tightly by soil particles, beyond the reach of roots, apparently unavailable. Mycorrhiza provides the remedy, making sufficient what would seem to be a very small amount of phosphate.

For instance, the roots of Britain's favourite wild flower, the bluebell *Hyacinthoides non-scripta*, operate in an environment where phosphate is available in soil solution at less than 0.1 part per million. Bluebells cannot survive if non-mycorrhizal, for their short, thick, unbranched roots are inadequate for exploring the soil for inaccessible nutrients (Merryweather & Fitter, 1995). Evolution and symbiosis have taken care of the problem. Bluebell roots are colonised by at least eleven different mycorrhizal fungi, most of which are invisible, unculturable, unidentifiable and new or unknown to science (Merryweather & Fitter, 1998; Helgason *et al*., 1999). While some help to repel pathogens, assist in drought resistance or apparently do nothing but visit roots from time to time with undiscovered purpose, others range out beyond the root system as a network (mycelium), gathering otherwise inaccessible phosphate on the behalf of their bluebell partners. In return they receive carbohydrate, a basic foodstuff they cannot produce themselves - but plants can, in abundance by photosynthesis in their leaves.

Around 500 million years ago, ancestral plants found phosphate acquisition uncomplicated in their primeval, aquatic habitat. It was not so easy when, rootless, they experimented with life on land. They collaborated with fungi as mycorrhiza, which enabled them both to live on land and diversify. From the start, co-operation with soil fungi was the normal way of life for land plants, and it still is for most plants, everywhere.

Farm and Garden

Who is getting it wrong, Nature or us? Farm and gardening practices have disastrous consequences for mycorrhiza, which was the 'organic' foundation of life on land from its origins until the very recent ascent of man.

Tillage chops up and desiccates fungi, and mycorrhizal communities decline in soils with a bare ground layer or occupied temporarily by monoculture crops or by plants that do not support mycorrhizal fungi (i.e. most commonly grown crops and weeds). Many important fungi that normally look after wild plant communities simply disappear when soils are brought into cultivation, leaving the mycorrhizal opportunists, the equivalents of plant weeds, that do best in disturbed land. This sort of repeated negative feedback leads to impoverishment of both above ground and below ground communities.

Highly managed farm and garden soils, when compared with natural soils, are therefore highly simplified. Support systems that plants might normally expect to find in the wild are not available, but that can be alright under controlled conditions. Many

plants will grow happily in soil that is much nutrient-richer than they would normally experience, so the gardener or farmer can add fertiliser for the desired result. With the gardener's assistance, competition from other plants, pests and disease can be kept to a minimum. The garden works when the gardener works. When the work stops the garden runs wild, populated by non-mycorrhizal opportunists and hangers-on rather than the microbial and botanical components of woodland, alpine ledge or flowery mead. It can take a very long time for the resulting wilderness to change from a rampant weed patch back to rich, naturalistic countryside, and without the reintroduction of laborious remedial management, it will not revert to a garden or crop field.

Hence the appearance of arable land left to Nature in set aside schemes. After crops and livestock have done their worst the plants that thrive are weeds: nettles *Urtica dioica*, *U. urens*, thistles *Cirsium arvense*, *C. vulgare*, willow herbs *Epilobium angustifolium*, *E. montanum*, docks *Rumex obtusifolius*, *R. crispus*, ragwort *Senecio jacobea*, mugwort *Artemisia vulgaris*, brambles *Rubus fruticosus* agg. and (if it's damp) soft rush *Juncus effusus* or creeping buttercup *Ranunculus repens*. Certainly some of these are the first to arrive at the start of a process of succession, but after decades of agricultural abuse, the land will be unfit to support a succession towards species rich grassland or woodland for a very long time.

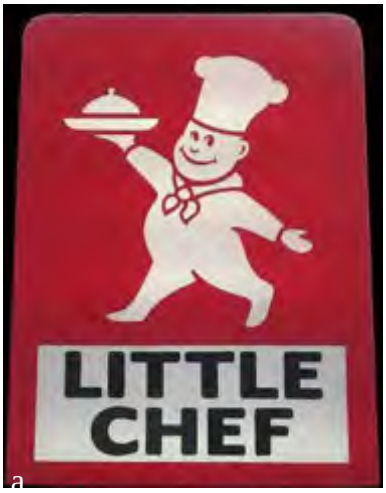
If, in spite of human assistance and the constant application of additives, plants fail to grow in the garden, we decide they are intrinsically intractable, missing the point that they might have special ecological requirements that would be readily available where they usually live. We certainly don't wonder whether they might need to live in a mixed community rather than in the solitude imposed upon them by the gardener. We do allow for, say, frost sensitivity and understand why we can't grow plants that are tender in our local climate. But we don't say: "ah, this plant needs the assistance of a special microbial partner (or indeed a whole fleet of supportive organisms) and that is why it won't grow in this disrupted, damaged, microbe deficient, nutrient overloaded medium I keep sticking it in".

The gardening gurus on TV and radio sometimes advise people to learn by observing their garden plants growing in the wild, but they don't recommend gardeners consider conditions below ground - apart from making sure the soil is well dug, moist and provided with additives well above natural levels. That is hardly surprising, because what goes on in the soil is invisible - hidden by the soil itself - and mostly microscopic, therefore very difficult to visualise and comprehend. The reaction is: what we can't see doesn't exist!

But soil processes *must* be included in our thinking because they are really happening, as they have done for the entire 500 million years of land occupation by life forms. What goes on within our vision is entirely dependent upon what goes on in the impenetrable darkness of the soil. Unfortunately, those who are in charge of the maintenance and improvement of the countryside do not know or choose to ignore what happens below ground.

Spot the Difference

Let us make some comparisons (Figure 1) and then consider the quality of man-made and natural woodland.



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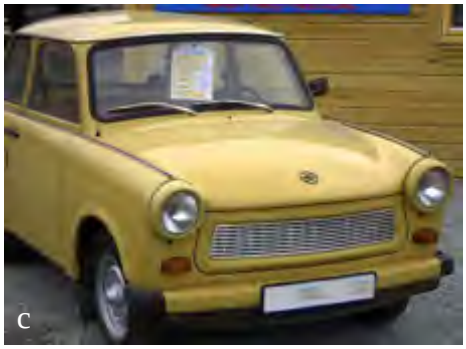
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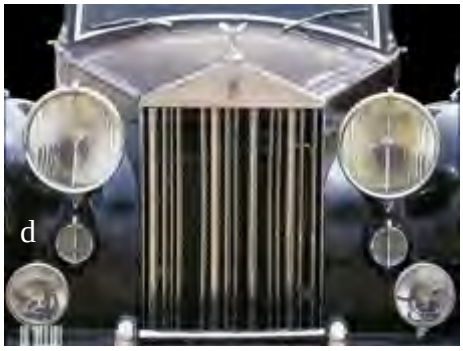
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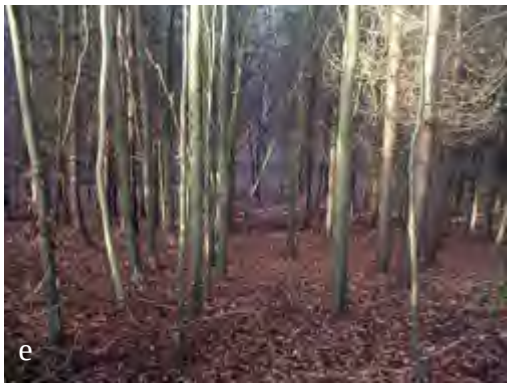
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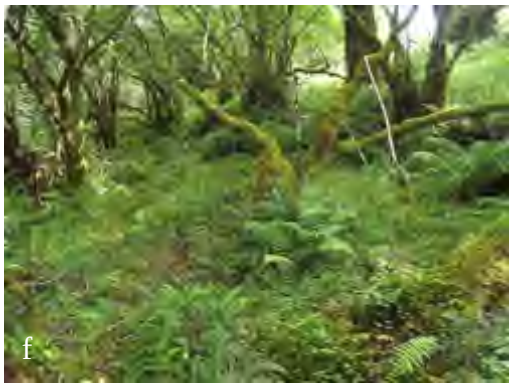
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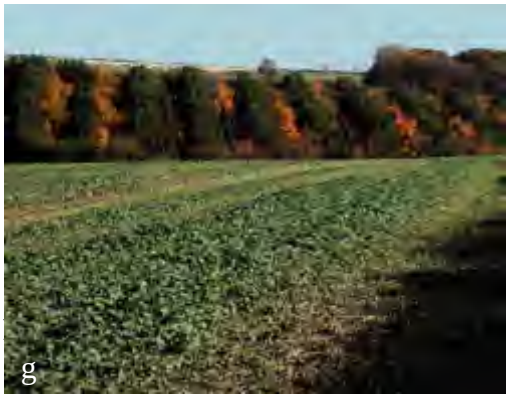
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Can you tell the difference? Of course, but if you have ever peered into the (frequently empty) plastic tubes that infest the British countryside, you will understand that it is a miracle that the ‘woodlands’ on the left (Figure 1 e, f) bear the slightest resemblance to proper woodland (Figure 1 g, h) at all. A fresh, new

plantation of native trees simply does not have the intrinsic qualities that biodiversity, complexity, evolution, heterogeneity and antiquity bestow upon true woodland.

If you could have a look below ground among the bluebells on the woodland floor you would see an apparently tangled mass of fungal hyphae. If you happened to be at Pretty Wood in North Yorkshire, you would see eleven different fungi from four families of the obscure (but ubiquitous!) mycorrhizal Glomeromycota (or Glomales, see Smith & Read, 1997; Merryweather, 2001) emerging from and harmlessly invading the bluebell roots, whilst others would be plugged into the roots of sycamores (different fungal species depending on tree age) and countless basidiomycetes ranging about through the litter, beyond the fine surface roots of the ectomycorrhizal oaks to which they are attached.

QUESTION: Why, in the past, did foresters so often choose to plant their conifer plantations in ancient woodland? Was it because the new trees would grow better there, and was that because a lot of mycorrhizal symbionts were already present?

Felling the Forests

Where I now live in the Scottish Highlands, vast areas of conifer plantation are being clear felled. The effect on the landscape of the highly publicised 'unspoilt Highlands' and the sensitive beholder's eye is extremely unpleasant. Often where alien conifers now grow there used to be mixed woodland or moorland, the latter itself perhaps having once been ancient forest, felled long ago. Fifty or more years ago, men armed only with a spade and a sack of saplings, planted millions of spruce, pine or larch. The landscape adapted. Adolescent conifers create total shade and, until they mature and thin a bit, nothing can grow beneath them. But as they grow and some of them die, light does eventually penetrate the canopy and a novel mixed understorey develops, which can become very rich. Also, as any mushroom hunter knows, as the trees mature, more and more fungi move into the forest community. Many of them are associated with the trees as mycorrhiza, whilst others participate in decomposition and nutrient cycling. Even this unwelcome change in the British landscape that conifer plantation brings eventually can have its environmental and cultural benefits.

However, the trees were planted as a crop, so they will be harvested when mature. In the past men would walk in with axes to cut down the trees, drag the trunks away aided by horse power and make good use of the other tree remains. The rest of the vegetation present would remain more or less undisturbed and the land left fit for plants to grow.

In the twenty-first century, permanent roadways are sent crashing through the forest, along which a man drives his Harvester, the big boys' Tonka toy that grasps each tree, chops its trunk just above ground level and strips away the branches in seconds. The trunks are piled to one side and *all* the branch debris left where it falls. More often than not, the collateral damage caused by this frequently claimed to be eco-friendly machine is appalling.

The Harvester's huge wheels churn the soil literally everywhere, ripping, inverting and mixing it. Where the Forwarder (collects the trunks) makes its regular journeys it digs compacted ruts up to a metre deep. All understorey plants are exposed, raked up and crushed. Virtually none survive, except perhaps preserved in seed/spore banks. At the same time, microbial communities that have built up over many decades are severely damaged as the soil is ripped and trampled (Figure 2). Surviving organisms that rely upon others become deprived of partnership. That probably means death. Such destructive effects are catastrophic, but then, adding insult to injury, the land is often blanketed with a dense layer of 'brash', not wanted by the foresters.

Figure 2. After the Harvester.

Most plants that might attempt recolonisation cannot penetrate the brash layer from above as seeds or below as seedlings and, therefore, cannot grow. It is recognised that woodland needs dead wood in order to function properly. Farmers now allow excessive numbers of cattle to destroy the ground layer in ancient woodland or poach moorland into muddy extinction with their hooves and poison it with excessive dung. Why? Because *moderate* grazing has been shown to be beneficial in carefully managed woodland. The same thinking applies here: the dead wood idea is wildly extrapolated by foresters who claim their brash acts as 'fertiliser'. That's untrue and unfair to Nature. Left in the open on land where no self-respecting lignin decomposing organisms are to be found (they are plentiful in functioning woodland), the waste remains on the surface for a very long time, unrecycled.

If plants could grow in ex-forest soil, its biota have been so severely compromised there will be little to support any relevant species that might be able to make the effort to reinstate a naturalistic community. If there is any soil exposed, only incoming weeds can make headway. A reasonably complex, interesting and attractive assemblage of early colonising mosses, liverworts, ferns and forest wildflowers is replaced by foxglove *Digitalis purpurea*, ragwort *Senecio jacobaea*, rosebay *Epilobium angustifolium*, cudweed *Gnaphalium uliginosum*, soft and toad rushes *Juncus effusus, J. bufonius*, dense brambles *Rubus fruticosus* agg. and rampant weed grasses; later on gorse *Ulex europaeus* and, worse still, Japanese knotweed *Fallopia japonica*. These are mostly not mycorrhiza-dependent plants, a further threat to the woodland succession we might like to have replaced the forest.

Observed at any distance, this landscape of wreckage provides no pleasure, serves no purpose and gives our countryside a very poor future. This sort of tree harvesting does nothing to promote ecosystem recovery no matter how eco-friendly the harvester may claim his operations are (and they do, vigorously). I have heard it said that timber prices are so low this is the only way harvesting can reasonably be done. Is that a fair excuse for landscape destruction? It reminds me of the observation that if the damage equivalent to that inflicted on the sea bed by trawlers occurred on land sea fishing would be banned forthwith. This *is* happening on land and it is mostly perpetrated by

an agency associated with our elected government! Is this a service needed or wanted by the voter, the tax payer, the tourist, the naturalist, Nature or the planet?

When the Harvester and Forwarder have done its worst and the timber has been taken away, then what? It seems there are two choices: abandon the land entirely, replant with a tree crop or bring on the plastic tubes and announce the generous creation of woodland.

Creating Woodland

When the forester has finished with the land where conifers once stood or the farmer needs to take a few acres out of food production or somebody decides woodland would be a good idea, grants are available to assist them to plant trees. Someone steps forward with the promise to create woodland. In my opinion, only Nature (God, if you are a believer) can do that. However, if man must attempt the nigh on impossible, we have the choice of taking an educated approach based on ecology, as has been done in Milton Keynes (Francis *et al.*, 2001), or we can just plant trees.

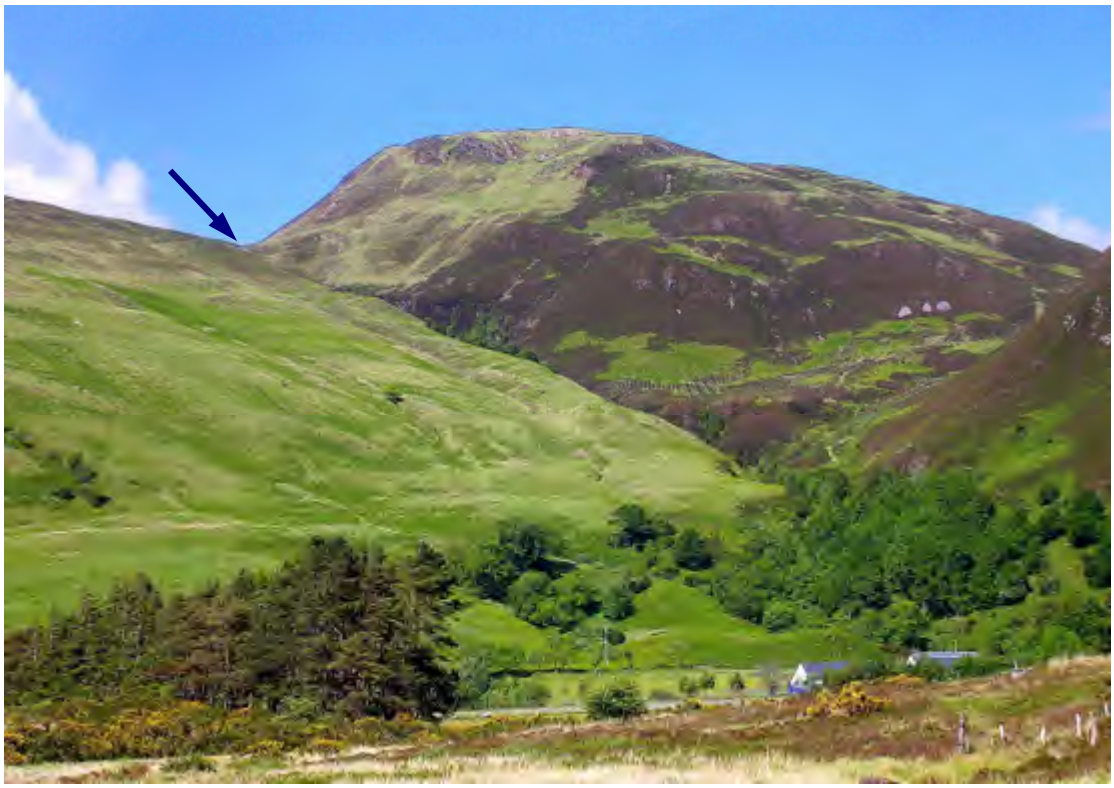

Figure 3. Ancient woodland and natural regeneration (lower right) and new 'woodland' (hillside) on either side of the Moine Thrust gully (arrow) at Auchtertyre in the Scottish Highlands.

Figure 3 shows (lower right) a small but species rich patch of ancient woodland of oak, ash, hazel, rowan, willow and birch with a rich understorey nestling around a rocky stream, the haunt of roe deer, badgers and otters. The woodland soil overlies a pocket of nutritious glacial drift. The hillside above is bracken-infested grassland overlying a shallow brown earth (left of the gully) and heather moorland on peaty podsol (right) that has been spared grazing pressure from sheep for several years. The margin of the woodland is steadfastly advancing up the hillside on both sides, not only the usual pioneer goat willows and birches, but also the occasional young rowan, hazel, hawthorn and even a proud four-metre oak tree.

To either side of the gully, the hillside plant communities are obviously very different. The stream gorge marks the line of a Precambrian upheaval that, more than 550 million years ago, pushed old rocks against and even over newer strata: the Moine Thrust. The thin hillside soils lie directly upon: left Lewisian and right Lewisian and Moinian metamorphic rocks. Both are pretty reluctant to give up nutrients by weathering, but the difference the vegetation by the plants growing on them is obvious. It seems doubtful that any of the hillside has ever been suitable for the growth of woodland, though since relieved of grazing pressure, small trees are spreading to either side of the main wood which is perhaps expanding.

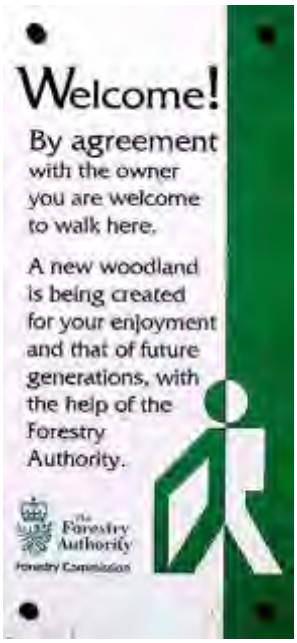

Figure 4. Welcome to Auchtertyre's new woodland.

What madness induced Forest Enterprise to "create new woodland for our enjoyment" on this hillside (Figure 4)? Striations all over the hillside (Figures 3 & 5) indicate the locations where thousands of little trees had their roots plunged into large divots of soil overturned by the woodland creators with a digger. A special treat for visitors, who are "welcome to walk here", are the thigh-deep, water-filled pitfall traps thus formed (Merryweather, personal experience, 2005). A special treat for the little trees: most are dead, and word has it that these are a second planting.

During summer 2005 a helicopter deposited white blobs all over the Auchtertyre Hill and adjoining slopes. They turned out to be large packages of sacks containing rock phosphate (Figure 6). Eventually, they disappeared and presumably their content was given to the tiny trees to help them avoid death, modifying by pollution a poor, but relatively natural moorland soil. Helping the environment!

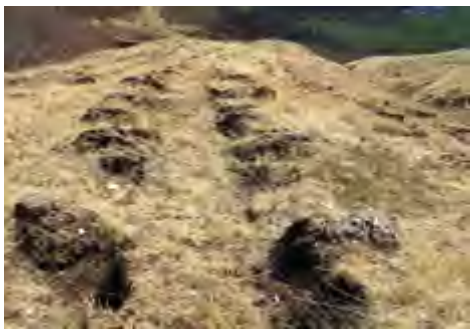

Figure 5. Rows of excavated mounds, each once planted with a sapling.

Figure 6. Rock phosphate at the ready.

Life of a Tree

What would a young tree expect when it starts out on what could be its several hundred-year life? As a seed it will have fallen or flown some distance to settle on a soft bed of moist leaf litter into which its first root will plunge and branch, finding a ready supply of all the nutrients it needs as its seed store becomes exhausted. Young rootlets make their way into the soft, warm soil where they encounter thousands of fungi and tens of thousands of bacteria, some of which attempt to take its life but most

of which offer it no harm, indeed some are waiting, ready to assist its progress. Soon, fungi gently invade its roots, and tree and invaders begin to share resources. During the summer, the tree makes carbohydrate which it exchanges with friendly fungi for nutrients it can't get easily itself, most significantly phosphorus, which is rare and does not drift rootwards in soil solution like, for instance, the various forms of nitrogen.

As it develops, the tree accumulates more and more partners and lets go some of those specialists that saw it through its infancy, replaced by other symbionts more suited to its adolescence and maturity. It accepts the service of the community within which it has found a home and, in its turn, serves that community, contributing to nutrient supply and cycling, supporting an army of symbiotic organisms and introducing new stock of its own species. The soil in which it stands rooted rarely changes suddenly and then only in local detail (due, for instance, to tree windthrow, the activity of burrowing animals or the arrival of dung, a rotting corpse or a log). The community of interactive organisms evolves slowly, and they do it together.

When it dies, our tree's remains provide sustenance for a food chain of bacteria, protozoa, algae, fungi, invertebrates, birds and mammals for several years before crashing to the woodland floor where another diverse group of organisms feed and reduce it to its components that are gradually recycled.

In striking contrast to Nature, man provides tree saplings with a variety of poor choices:

1. Ex-arable land that has suffered annual mechanical disruption and has been deprived of biodiversity for decades, intoxicated with pesticides and overloaded with phosphorus.
2. Low biodiversity, hoof-distressed, nutrient-soaked land that has been over enriched by generations of cattle or, worse still, pigs that eat everything vegetable and eliminate the rest making room for a new community of enriched-mud-loving organisms (Figure 7 a).
3. Rutted, waterlogged, topsy-turvy ex-forestry soils where huge vehicles have wrought their worst (Figure 7 b).
4. Overgrazed, low biodiversity, inhospitable moorland such as the flanks of Auchertyre Hill (Figure 3).

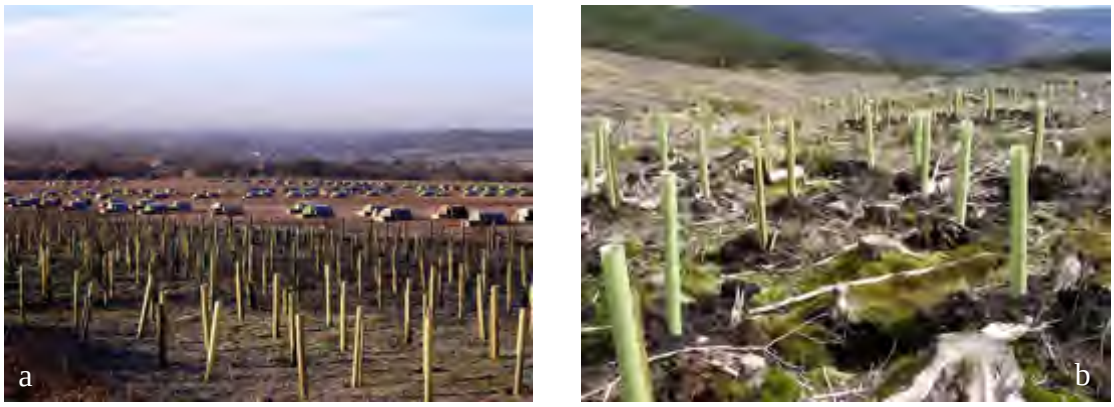

Figure 7. 'New woodland' a) after pigs and b) after forestry.

Because of his obsession with gardening, man considers that, if new woodland is to succeed, its soil should be entirely homogeneous, 'weed'-free, contain as much dung

or fertiliser as he can dump on it … and consist entirely of rows of trees that are not necessarily relevant but are relatively easy to grow (and weeds).

No account is made of the fact that real woodland is entirely different.

Imagine we wished to our son to become a member of parliament. You would think we would at least introduce our newborn at the House of Commons. But no, we take him to the stock market, and abandon him there, confident he will grow up to be an MP. Of course, we appreciate that the baby will need to be fed, and since we know that bread is a good all round foodstuff, we empty sacks of wheat in a huge pile around him and perch an extra large tin of dried yeast on top. He can get all the water he'll need in the Gents toilet. When we returned twenty-five years later, would we find our son ready for the hustings? If we had put lots of babies in the stock market with additional wheat and yeast proportional to their number, would we find a government had miraculously come into being?

Of course not, but that's essentially what the woodland creators are doing when they plant baby trees at convenient but damaged, impoverished, over enriched or inappropriate sites: dump them in a soil where something other than woodland is happening and make a simplistic gesture at supporting them before leaving them to their fate. Since, like the baby MP at the stock market, trees need to be fed, they scatter a large amount of rock phosphate around because they know phosphate is good for plants, but is not available here. Why not? Because the natural means of mobilising phosphate to plants, established nearly 500 million years ago and utilised by every healthy tree on the planet - mycorrhiza - is the wrong sort, depleted or absent.

Several words come to mind: simplistic, naïve, unrealistic, irrational and unintelligent - wrong. In any project, knowledge and understanding are useful tools if success is the desired outcome, and they should be used. Miraculously, some trees do grow, probably in spite of, rather than because of, the start they had in life, or thanks to the extraordinary resilience of Nature.

In reality, when an acorn falls from a great oak tree its parent makes provision for its life on earth. The first is the 'baby food', the cotyledons that constitute most of the acorn. It has food: not much, but enough for a while. Since it is not a flying seed, and if not carried far off by a squirrel or jay, the acorn plummets to the ground within the root/mycorrhiza spread of the parent tree and nearby plants. Its root plunges through the surface litter and heads earthwards. From the start it will 'eat' *via* fungi, its plate, knife, fork, chef and wine waiter. Here it has access to a choice of fungi, some of which will assist its nutrition further, and it will find others as it matures. Therefore, from the start, the baby oak receives a steady supply of all a seedling needs, provided by its parent, associated plants and soil microbes living in the woodland. It is likely that the parent tree will not supply all, perhaps any of the mycorrhizal fungi the youngster needs as a seedling. It might find more appropriate symbionts emanating from the roots of another species, there within the woodland community which will look after the new recruit. The 'mother' tree can take over at a later stage.

The fungal associates of a tree change as it grows from seedling into a centuries old giant. Experimental data indicate that birch or willow will have one sort of mycorrhiza as seedlings, maybe involving several different fungi, and as they pass sapling stage, they change their allegiances. Hence they are proficient pioneer colonisers. Washington State, USA, a study of fungal DNA sequences showed that a single ancient tree had an incredible 150 symbiotic fungi associated with its roots.

New Woodland in an Un-natural Landscape

Many woodland creation schemes are not just doing badly or not becoming real woodland: they are failing. Tree protection tubes often contain nothing; a vigorous grass or thistle; a 5 ft heather with a magnificent terminal tuft; on chalk a plume of *Clematis vitalba* or, at best, a struggling stunted apology for a tree. Even if the trees grow, if the starting point is wrong, woodland cannot be the rational planter's goal. The originators could call their creation 'plantation', but not woodland, which is a different thing altogether from a grove of assorted trees planted in rows.

Degenerate woodland that has not been subject to excessive abuse by agriculture or forestry can be encouraged by judicious habitat management and well thought out planting with trees that belong. Established woodland will slowly spread on its own if adjacent land is favourable and saplings are not nibbled out of existence by grazing animals. If woodland is going to be created, natural or assisted regeneration is the sensible method.

Ambitious projects are in progress in many parts of wild Scotland where there is, I would contend, an unrealistic prospect of recreating the original forests. Some aim to reproduce the old Caledonian forest (usually presumed to have been *Pinus sylvestris* Scots pine) about which Smout (2000) observed: "[L]et us begin with the Great Wood of Caledon. It is, in every sense of the word, a myth." (entirely based on a passing reference by the second-century geographer Ptolomey (Fenton, 2006)). Others hope to make communities dominated by broad-leaved trees. They should expect only what is possible from whatever the starting point might be and keep their expectations within realistic limits, based on sound history and good science rather than misinformed ambition.

Let us consider the history of these sites, not looking at the original vegetation, but at the soil biota that once used to support that original vegetation, the presence of which will be needed if the aspired end point is to be reached. In some places the ancient forests were removed a very long time ago and a treeless moorland landscape has been present ever since. The understorey of mixed shrubs and herbs, which has long gone, would have been largely arbuscular mycorrhizal (AM) whilst the trees would have supported a wide range of ectomycorrhizal (EcM) as well as AM fungi (which were very probably different species from those associated with the roots of understorey plants). The rich, stratified, partially mineral woodland soil has disappeared and been replaced by a thick (sometimes thin) blanket of peat. The mycorrhizal fungi present will be partnered with the modern above ground flora, of which the dominant species are: purple moor grass *Molinia caerulea* (weakly AM); bog cotton *Eriophorum angustifolium* (low mycorrhiza dependency), deer sedge *Scirpus caespitosus* (non-mycorrhizal); Rushes *Juncus* spp. (non-mycorrhizal); Ling *Calluna vulgaris* (ericoid mycorrhizal - EM); Heathers *Erica* spp. (EM) etc. There are few AM plants (and those present are low dependency species) and no EcM plants, so no EcM fungi. Many of the trees expected to grow there are obligately EcM plants!

EcM fungi (e.g. *Paxillus involutus*, *Suillus bovinus*, *Russula* spp., *Cantharellus* spp.) produce vast numbers of airborne spores that are readily distributed everywhere from sites where they are being produced. However, they still have to encounter and associate with a suitable tree at the right stage in its life history and there is a further complication: trees associate with a succession of different fungi as they grow and age.

AM fungi (e.g. *Scutellospora dipurpurescens*, *Acaulospora laevis*, *A. koskei*, *Archaeospora trappei*, *Glomus caledonium*, *G. hoi*) are entirely different. They do not

produce any above ground parts, and what we call ‘spores’ (subterranean, multinucleate, multi-genomic globes 50-800 μm diameter) do not travel easily and, as often as not, seem not to serve as propagules, vegetative or reproductive. Where woodland already exists, it has been there for a very long time and its component species came together by succession during that very long time. Mycorrhizal populations of plants and fungi have, therefore, spent a lot of time together, during which they have experienced relatively unchanging or gradually evolving ‘stability’.

When the archetypal British woodland plant, bluebell, produces its annual root system in late August, the roots encounter a ready-and-waiting mycelium of *Scutellospora dipurpurescens* which instantly invades them, and as is its habit of millennia, provides a reliable supply of phosphate, every year as the last. In February, when the bluebell’s attention changes from root/leaf production to photosynthesis and bulb renewal, *Scutellospora* disappears from its roots other fungi move in, but they do not provide phosphate. (Merryweather & Fitter, 1995, 1998a, 1998b) In natural communities, mycorrhizal colonisation of roots changes in space, time and species composition during a season and during the lifetime of a plant. Seen at the ecosystem or landscape scale, this is incredibly complex. [QUESTION: does the *Scutellospora* turn its attention elsewhere so that it will continue to be fed, or does it enter a period of dormancy? QUESTION: do the other bluebell fungi perform other, non-phosphate functions or do they take carbohydrate for no return or do they do nothing other than take up temporary residence? ANSWERS: in common with most aspects of soil ecology, nobody knows and it is very difficult to find out.]

So, back to Scotland and ancient forest recreation. A lot of woodland plants have requirements as special and individualistic as bluebell, and of course trees also have their specific needs, but the ecological situation in moorland (and ex-agricultural) soils is entirely different: unsuitable, inappropriate and inhospitable. According to its microbiological and nutrient status it should be unable to support woodland development. Put simply, the new woodland starting point is just plain wrong.

The British landscape is festooned with millions of plastic tubes, set in place to protect tree saplings. Some occupy unwanted farmland, whilst others line new motorways or replace, in more convenient situations, ancient woodland destroyed to improve traffic flow.

Conclusions

Why pretend that planted trees are miraculously going to turn into classic British woodland? Why pretend we know what we’re doing when we clearly do not? Why fight against Nature? Why not learn from the ecology we know and co-operate with natural forces to pursue a realistic goal?

I will not pretend that I know how to make woodland. I contend that nobody does and nobody can. The ecological succession that ends up as woodland doesn’t begin with trees. First, soils modified by man need to recover (detoxify) before they start evolving both physically and biologically, whilst opportunist pioneer plants arrive, their places to be taken by more permanent plants. The first trees to arrive are themselves pioneers such as pine, birch and willow and - if that is the route Nature wishes to take - their places will eventually be taken by the more permanent elm, oak etc., late in the woodland succession.

We knew all this a hundred plus years ago, but relatively recently it has been discovered that the mycorrhizal community, the ecological process upon which all terrestrial ecosystems depend for their nutrition and integrity, also evolves from

simple beginnings in tandem with pioneer plants. Studies of volcanic ash fields, post eruption, have provided fascinating empirical evidence of this process. As the plant assemblage develops, the number of mycorrhizal fungi gradually increases and community composition changes above and below ground. Species by species, the rampant generalist fungi that arrive first (analogous to pioneer weeds) are replaced by slower growing specialists that, along with their perennial host plants, stay longer but are more susceptible to disturbance. An extremely complicated system develops that is highly sensitive and easily unbalanced. The more it develops, the more difficult it will be to repair if it gets damaged (*viz*. tropical rain forest).

We have only one record of previous woodland creation from scratch in Britain, after the last ice age 10,000 years ago. The first pioneer birch trees arrived 550 years after the climate warmed and deciduous woodland took a further 500-1,000 years to become established (Godwin, 1975; Osborne, 1980).

Incredibly, the National Forest scheme in central England claims on its website that: "Creating a new landscape takes time and sensitivity. To date the creation of the Forest has been under way for a decade and is likely to be another 15 to 20 years in the making." and their starting point is mostly "… derelict coalfield land and mineral workings and … farmland."

I conclude that they are aiming to create something like this (Figure 8) …

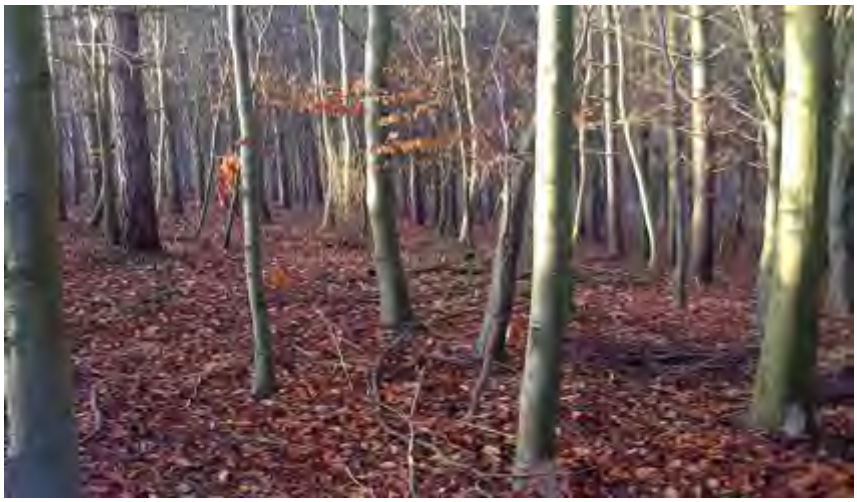

Figure 8. Modern, created 'woodland' aged 15-20 years.
[Lack of diversity made choosing a photograph easy]

… and are not expecting this (Figure 9) to happen within a couple of decades.

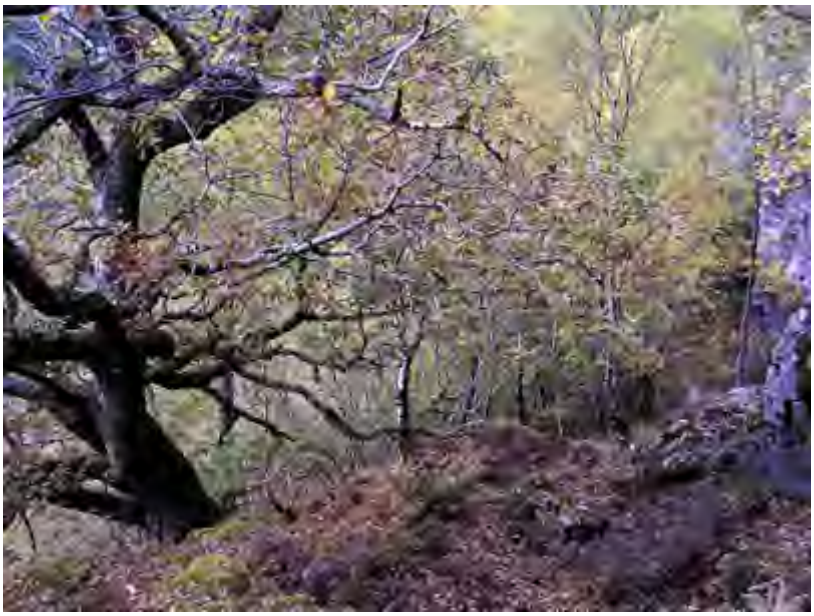

Figure 9. Ancient woodland aged up to 9,000 years. [Choosing a single photograph to represent such a varied subject was very difficult]

Biodiversity, a naturally-occurring seed source, an unpolluted starting soil, several centuries and, if they must interfere, people who understand woodland ecology, are the ingredients of woodland creation, not a patch unwanted land, a plough, a bundle of saplings, a dollop of fertiliser and a load of hogwash.

Acknowledgements

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