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Reforesting BRITAIN

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Forestry for the Future

Richard St. Barbe Baker, founder of the Men of the Trees, has a maxim which he is fond of quoting. "A nation's wealth, its real wealth," he says, "can be gauged by its tree cover." By that token, Britain is almost on the poverty line. Compared with other countries of the European Community, Britain's forest mantle is threadbare in the extreme: whilst West Germany, for instance, is 30 per cent wooded, and Italy 27 per cent, Britain has only 9 per cent tree cover. Only Eire, with 4 per cent, fares worse.

Whatever view one takes of the future, those statistics bode ill — particularly for a country which imports over 90 per cent of its timber. Nor is there any 'overnight' solution to the problem. According to the Centre for Agricultural Strategy, for instance, even an immediate planting programme adding some two million hectares to our forest estate would only boost Britain's self-sufficiency to 25 per cent by 2025, assuming that demand for timber continues to rise at current rates. If demand remains static, we would still only achieve 50 per cent self-sufficiency. Nor, as Alan Grainger points out in *Reforesting Britain,* is it probable that we will be able to make up the difference by importing from abroad for, by the end of the century, the world is likely to be gripped by a timber famine.

Despite such warnings, there is considerable public hostility to the very idea of a major reforestation programme in Britain — and, ironically, much of the flak has come from environmentalists. Bird watchers, for instance, argue that reforestation will result in some birds, such as the red kite and dunlin, becoming extinct. Ramblers complain, with considerable justification, that the conifer plantations traditionally equated with reforestation will prove a slight to the landscape. Meanwhile upland farmers, conveniently forgetting the massive subsidies they receive from the government, argue that reforestation will deprive them of their livelihood and disrupt local communitites on a scale not known since the original clearances. And lowland farmers see reforestation as a threat to their yields, making mechanised farming more difficult and undermining their 'efficiency'.

By and large, the reforestation programmes proposed to date have unquestioningly assumed that our industrial society will undergo few radical changes in the near future; that our economy will continue to expand, albeit at a slower rate than in the recent past; that Britain's manufacturing industry will still be competitive enough to allow us to import those resources we lack; and that the pattern of world trade will not alter. In short that business will continue as usual. Given those assumptions, forestry is not seen as playing a radically different role in the economy to that which it plays today; indeed, the need for a reforestation programme is justified almost exclusively in terms of reducing Britain's astronomical bill — some £2,800 million a year — for imported wood and wood products. The value of planting trees for their ecological value is rarely even mentioned.

But what if those assumptions should prove ill-founded? Ten years ago, *The Ecologist* argued in its 'Blueprint for Survival' that industrial society could not be sustained much beyond the beginning of the century. Pollution, social disintegration and resource depletion would combine to bring about its demise. To avoid catastophe, it was suggested, we should adopt a programme which would move us towards a more sustainable society — a programme which would decentralise political power, concentrate economic activity at the local level and place a high premium on self-sufficiency. Nothing has happened in the last decade to alter that view: indeed events have generally confirmed it. All of which places a very different perspective on the nature of the reforestation programme we should pursue.

The move towards a more sustainable society will considerably alter present patterns of timber consumption. The decline of consumerism, with its attendent 'throwaway' mentality, for instance, will radically reduce the need for packaging materials — not least because in local markets many goods, particularly fresh food, will be sold loose. So too local production for local consumption will cut the need to transport goods around the country — a trend which will be accelerated by rising fuel costs — and again reduce the need for packaging. Nor, without the advertising that accompanies consumerism and which makes such a difference to their financial health, will many of the magazines and newspapers available today still be published. Those factors, together with the subsitition of such alternatives as hemp for wood-pulp to make paper (see *The Ecologist,* October 1980), are likely to make considerable in-roads into our present levels of demand for timber to produce paper and packaging materials — a demand which accounts for over half the wood we use each year.

Another area where demand for timber is likely to fall sharply is in the construction industry. At present, houses are built to last a mere twenty to thirty years. Inevitably such a short 'shelf-life' results in a profligate use of resources and high maintenance costs — costs which we are already finding it difficult to afford. It goes without saying that in a sustainable society, houses will be built with a view to lasting not a few decades but for centuries, thus substantially reducing the rate at which our housing stock needs to be replaced. Moreover, as the bonds of community are re-established, so the extended family will once again become the basic building block of society. Not only will that lead to greater social stability but, by increasing the number of people living under the same roof, it will reduce the number of houses needed to house our population (see 'The Ecology of Housing', *The Ecologist,* December 1973.)

Whilst the demand for timber to produce paper and packaging materials and for use in construction is likely to fall, however, the demand for wood as a fuel will undoubtedly increase. Given that some 5 acres of woodland are required each year to keep a wood-burning stove functioning on a sustainable basis, it has been argued that the development of wood as a major fuel source will not only prove an environmental disaster but also be thoroughly impractical. If, after all, every house in Britain was to have a wood-burning stove, some 100 million acres of wood would be needed each year — nearly twice the land area of the British Isles. The argument is, of course, misleading for no-one has ever suggested that wood will become a fuel for the *whole* population or that it will be the *sole* source of energy available to those who do use it. In fact, the use of wood as a fuel will largely be restricted to rural areas: other forms of energy will prove more efficient and economic in cities and small towns where concentrated housing lends itself to communal heating schemes. Moreover, even in rural areas, wood will be used to supplement other energy supplies derived from such sources as wind, solar and water power. Nonetheless, a programme aimed at producing enough wood to fuel two million houses — approximately one tenth of our present housing stock — would require planting 10 million acres.

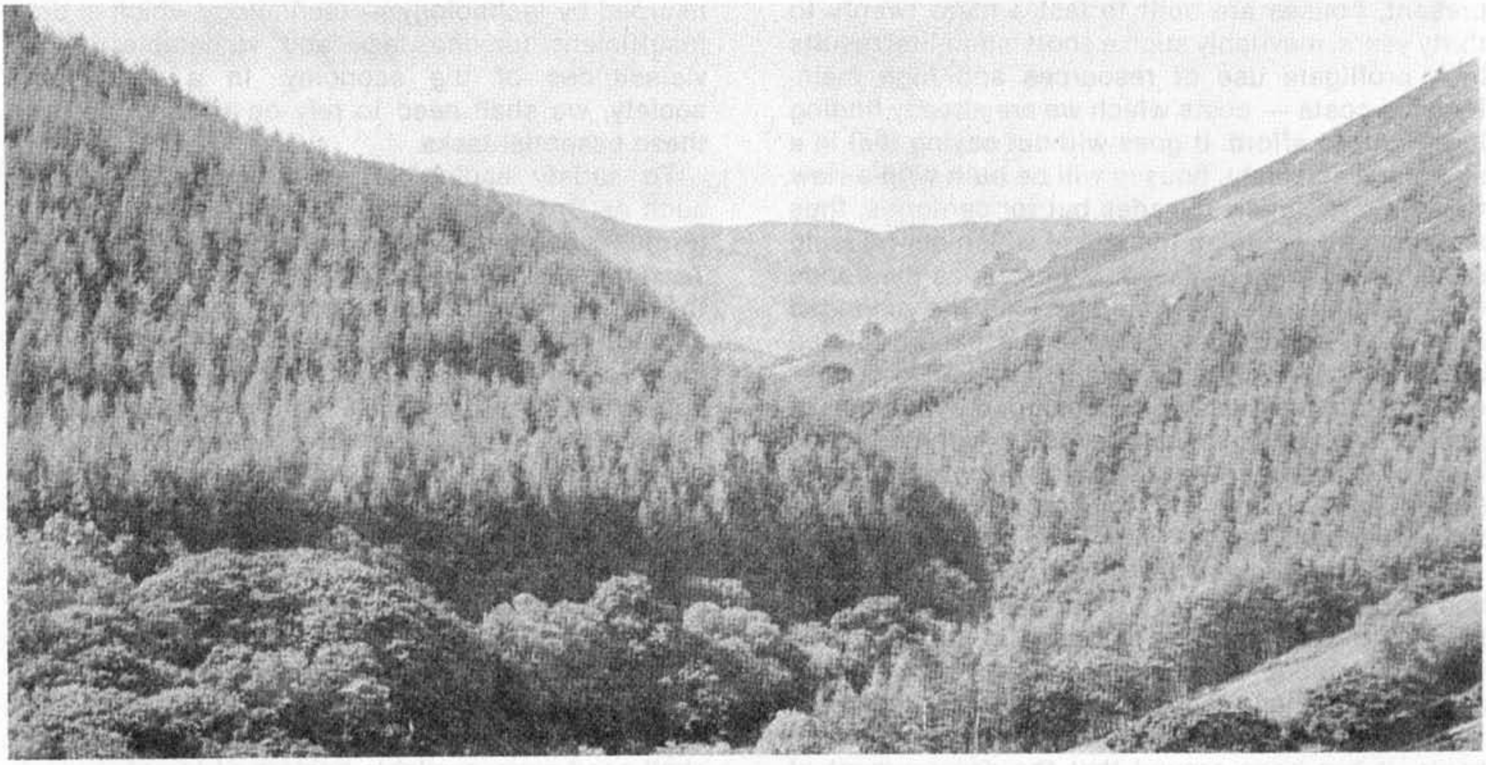
In addition to planting trees for timber, we shall also need to plant them for their ecological value. As the process of deindustrialisation gathers momentum, so the necessity of 'cashing in' on the benefits of nature will assume a new importance. Whereas today we rely on capital investment to finance technological 'solutions' to the social and environmental problems facing us, tomorrow that capital will not be forthcoming. Instead we will need to rely increasingly on ecological solutions: the substitute of natural fibres for synthetic ones; the use of natural fertilizers rather than chemical ones; natural predators to control pests rather than pesticides. Where trees are concerned, the 'free' ecological benefits are numerous — from storing water to absorbing pollutants, preventing floods, controlling soil erosion and sheltering crops. In an industrial society those functions have been usurped by technology — technology which is both insufficient for the task and vulnerable to the vicissitudes of the economy. In a sustainable society, we shall need to rely on trees to perform these essential tasks.

To satisfy ecological requirements, a country such as Britain should be at least a third wooded. (Professor Eugene Odum, of the Georgia Institute of Technology, considers 50 per cent forest cover to be the optimum). At present, political realities limit the amount of land available for reforestation. Thus, of just over 5 million hectares in the uplands capable of supporting trees, only 2.8 million are considered 'reforestable' — the rest, including 965,000 hectares of national parks and 1,350,000 hectares in the watersheds of reservoirs, are politically too sensitive to plant. As we deindustrialise, many of those sensitivities will undoubtedly evaporate in the face of the ecological crisis facing us. Indeed, if we fail to grasp the nettle of reforestation now, future generations will undoubtedly berate us not so much for 'having done too little too late' as for 'having left it too late to do even too little'. The truth is that we shall need every available hectare of forest.

The very nature of forestry — with trees taking some fifty years to mature — necessitates keeping one step ahead of the process of deindustrialisation. But vain exhortations to 'plant, plant and plant again' will come to nothing without a means to put them into practice. To that end, the government should immediately establish a Forestry Bank to encourage farmers to plant trees. The Bank would be run along much the same lines as those proposed in *The Ecologist's* World Ecological Areas Programme (see the January 1980 issue), its main function being to seek finance from corporations and the general public for reforestation schemes. The trees would be owned by the Bank and its shareholders and the farmer would be paid a percentage of the expected return from the forest each year for tending the trees and for the renting of his land. On maturity, a bonus would also be paid. Such a scheme would effectively give the farmer an annual return from his trees — a return which, without the bank, would only be realised when the forest was eventually cut down and sold. Another financial incentive to encourage planting might be to exempt woodlands from Capital Transfer Tax.

In an age where immediate solutions are expected for the most intractable problems, the failure of successive governments to face up to Britain's looming forestry crisis is perhaps inevitable. The whole issue of reforestation is too long term, too fraught with political pitfalls and vested interests. But we cannot go on forever putting off action. Certainly some groups will be antagonised by any reforestation programme, but that antagonism will be a small price to pay for the future of real ecological poverty we face if we do nothing. And the opportunity to correct the situation is rapidly slipping through our fingers.

Nicholas Hildyard



Reforesting Britain

by Alan Grainger

Britain has one of the most extensive and documented histories of deforestation of any country in the world. Indeed the story of how we lost our forests is virtually the same as the history of our island race. The first forests were felled in the uplands 5,000 years ago by Neolithic farmers, and although Julius Caesar found us still mainly a forest people, by the time William the Conqueror triumphed over Harold at Hastings most of our forests had disappeared. Some remained to make warships for Queen Elizabeth and charcoal for the early iron smelters, but we had started to import timber as early as the 14th century.

When the Great Fire razed London and the British fleet was sunk by the Dutch early in the reign of Charles II there were hardly any oak trees left with which to rebuild either our capital or our "wooden walls". The trees whose planting John Evelyn inspired helped Nelson to defeat Napoleon, and the acorns which Nelson's colleague Commander Collingwood dropped in the hedgerows sprouted to give the oaks which were used in the First World War. But when the timber ships bringing supplies from all corners of the Empire were sunk by submarines we realised that timber was still a vital strategic raw material, and thus began the programme of reforestation which the Forestry Commission is continuing to this day.

A Wreckage of a Forest

"Ours is a wreckage of a forest", says tree expert Alan Mitchell[1]. Compared with the forests of the east coast of North America which are a rich mixture of trees like white oak, butter nut, scarlet oak, sweet gum and many other species, British forests in which every other tree is an oak or a beech seem rather drab.

But it wasn't always like that. Some 50 million years ago we were clothed with the same kind of rich mantle of vegetation that graced most of Europe, Asia, and North America: a sub-tropical mixed evergreen forest[2] containing palm trees which today are only found in the humid tropics of South East Asia.[3] Global cooling and continental drift caused these evergreen broad-leaved trees to be pushed south by the deciduous and coniferous trees previously restricted to higher latitudes, and the beginning of the Ice Ages one million years ago forced even these trees to flee south in search of warmer climes.

There were four Ice Ages. After each one, the trees returned for an interglacial period of about 100,000 years before the ice caps advanced once again. But each time the number of trees that found their way back to Britain was smaller than before, the passage of many species being blocked by the great east-west barrier of the Alps and Pyrenees with only some being lucky enough to creep through the mountain passes.

When the ice retreated for the last time 10,000 years ago the trees came back to recolonise their former kingdom. After 5,000 years the land bridge to the continent of Europe was broken and the English Channel was formed. Any trees that happened to be on this side of the channel at that time we now call 'native', while others, like silver fir, European larch, Norway maple, and Norway spruce, which had not been able to make it back we call 'exotic'. Our pathetic list of 35 surviving native trees may give rise to chauvinism, but is certainly not a cause for pride.[4,5,6]

Clearing the Uplands

At about the same time that the English Channel was formed, the arrival of Neolithic agriculturalists spelt an end for the period during which Britain's impoverished flora had been able to consolidate itself into stable communities. The farmers settled on the chalk downs of Southern England and began to clear the scrubby forest of trees like oak, birch, thorn, yew, etc. for space to develop settlements, grow cereals and raise livestock. Mesolithic hunter gatherers continued to inhabit the lowland forests which were too thick and too waterlogged to be ideal for farming.[4]

The Neolithic people left behind them downs that had been shorn of trees and crowned instead with great stone circles such as Avebury and Stonehenge. Clearance continued in the Bronze and Iron Ages, and the horse drawn plough made cultivation of heavier soils much easier. Much of our upland heaths and moors date from this period, those studied in Yorkshire having been well wooded until 3,000 years ago,[7] and are just as visible reminders of early settlement as are the many Iron Age hill forts and camps still to be seen dotted about the country.

Julius Caesar, who led the first Roman expedition to Britain in 55 B.C. wrote in his *Commentaries* of the ancient Britons as being a true forest people, who would mount attacks on his legions from the cover of the forest, to which they would retreat if unsuccessful.[8] The Romans would have found most of the southern uplands under flock, herd or plough, and many of their roads followed the routes of the old Stone Age pathways along upland ridges. The Roman occupation from A.D. 43 to 407, had little effect on the thick lowland oak forests which contained plenty of bears, wolves, and deer but few people. Hunting was introduced, as were trees like the sweet chestnut (whose edible fruit was highly prized by the Romans), the walnut, and possibly the sycamore.

Assault on the Lowlands

The Saxon invasion in the 5th century A.D. brought about a dramatic change in land use. Invaders throughout history tend to impose their traditional forms of land use on the territories they acquire, regardless of what has gone before. The Saxons were no exception and, accustomed to growing crops on open fields cultivated with large ploughs pulled by teams of horses, proceeded to clear forests from the valleys and lowland plains and exterminated or expelled Celts and Britons farming the uplands. Thus began what Tansley called "the clearance which ultimately turned England from a predominantly forest covered country into a largely agricultural and predominantly pastoral country."[4]

This epoch in British history was not unlike what is happening today in Brazil's Amazon Basin. The Saxons, called by Trevelyan 'our pioneer farmers and lumbermen' started on the lighter soils of the south and east and, using boats to pierce the dense forests of the English heartland, spread gradually to the heavier soils in the north and west.[9] Beech colonised the abandoned chalk downs and further north ash established itself on limestone uplands in a similar way.

The Tragedy of the Commons

The forests were very important to the Saxons, providing the wood with which to build their houses, and giving shelter to King Alfred the Great of Wessex,[10] who waged guerilla warfare against the Danish invaders from bases in the woods and fens of Somerset. He emerged to defeat the enemy at the Battle of Ethandun in 878 and went on to unify the various English kingdoms.[11]

The Saxon Kings perpetuated the Roman sport of hunting, and set aside large areas of Royal Forests for this purpose. The word forest derives from the Latin *foris*, meaning 'outside', since any land outside settled or cultivated areas was usually covered by trees.[10] From the time of the Saxons, however, the word forest was understood to refer to a hunting preserve, although we shall be using it to describe an ecosystem dominated by woody plants.

When the Normans arrived they found Royal Forests already existing and protected by Forest Laws which prohibited peasants from killing or taking game and felling large trees. On the other hand, the peasants were given commons rights of use which they guarded jealously. Firewood could be gathered, crops grown on land traditionally cultivated by specific families, cattle, sheep, goats and geese were allowed to graze in the forests, and herds of pigs were let loose every autumn to feed on the acorns and beech mast.[11]

The rights of the commons were the kiss of death to the forests. The pigs would eat a substantial proportion of seed that would otherwise sprout into saplings, and those that were able to survive would probably be browsed by cattle or sheep. When the older trees died and fell, there were few young trees to replace them, and so the forests degenerated into scrub, and later grassland, heath, and moor.

The Normans increased the number of Royal Forests to sixty-three, William the Conqueror founding the New Forest in 1087.[11] The Forest Laws were made stricter, enforced more rigorously, and used as an instrument of repression which incited the common people to a deep hatred of their rulers. When the restrictions were extended even to encompass the lands of the Barons, who were the King's supporters, it was one of the final straws which caused them eventually to revolt against King John and force him to sign the Magna Carta in 1215.

The Kings were unable to control what happened inside the Royal Forests, because of the commons rights which the peasants would not give up. In disafforesting many of the Forests, making them the property of various nobles and thus exempt from such rights, the Crown not only relieved itself of a big headache, but gained large sums of money in return.[12] The disafforestation process continued until 1851 when Hainault Forest in Essex had its status as a Royal Forest annulled by an Act of Parliament.

The Forest Laws did not really preserve the forests, but just entrenched the rights of different people to use them. Disafforestation did not improve matters, and merely gave the go ahead for more agricultural clearance. Commons rights were a tragedy for the forests. Everybody, and his cattle, sheep and pigs, had the right to do almost everthing in the forests, and it is therefore not surprising that so little has survived the onslaught of centuries.

The Sheep Ranchers Cometh

In the Middle Ages Cistercian monks came to northern England to establish large abbeys, such as Fountains, and clear forests (as they had already done in France) to make pastures for their huge flocks of sheep. The textile industry was very prosperous at this time, and it is estimated that there were about 8 million sheep in the country, or between three and four times the human population.[12] By the early 14th century there were between 500 and 600 monasteries in England, of which 66 were in Yorkshire. Parts of the North York Moors are still quite well wooded where steep slopes prevented grazing, but even where most of the trees have gone, the names of towns such as Oakworth and Icornshaw (wood of acorns) remind us of their presence still.[12]

The Cistercians were on Dartmoor too, rearing sheep and cattle at Buckfast Abbey since the reign of Henry II, and the high moors were used to graze ponies destined to work in the tin mines.[13] The steeper slopes of river valleys are still clothed with oak, hazel, alder and willow, and as Dartmoor expert L.A. Harvey has remarked, "Wild as the moors may be, none of their communities may be described as truly natural. All are managed to some degree or other by (burning), or stocking with sheep, cattle and ponies."[12]

The deforestation of Scotland happened much later than in England, but by the middle of the 18th century the flockmasters of the Southern Uplands needed new pastures and were able to offer considerable rents to the highland gentry who at that time required all the money they could get to subsidise their London society life.

"The coming of the sheep," said Sir Frank Fraser Darling, "finished the process of changing the face of the old Highlands." Peasants who had cultivated crops like barley, oats, and potatoes, were cleared from the land so that large scale sheep ranching could begin.

Forests become a Scarce Resource

Considerable quantities of timber were being imported into certain parts of the country as early as the 14th century,[14] and by the start of the 16th century local shortages of small timber were apparent.[12] A growing number of the remaining woodlands were therefore managed to produce wood and timber on a sustainable basis.

Coppicing, the cutting of trees near their base so that one or more shoots can spring up from the stool and be harvested as poles every ten years or so, probably started in the 12th or 13th century. The term derives from the Norman French verb *couper*, meaning 'to cut'.[15] Oak, ash, maple, and especially hazel were grown on short rotations to produce fuelwood, charcoal wood, hurdles, and poles for fencing as well as bark for tanning leather.

In Southern England and the Midlands coppicing[16] was modified to *coppice-with-standards* by allowing a minimum of 12 oaks or ashes per acre to grow into large or *standard* trees that could be harvested for timber. High forests managed exclusively for timber, planted with mixed species such as Scots pine (thinned early), oak, ash, beech, sycamore and wych elm, were known from Tudor times.

Other trees in hedgerows, parks, and forests, were *pollarded* by lopping them at least 6 feet up from the base so that the new shoots would be out of reach of deer and cattle. Willow was a popular pollard tree in the hedgerows of East Anglia, while in Epping Forest the trunks of pollarded hornbeams belonged to the Lord of the Manor and the small wood shoots to the peasants.

Wood for the Iron Masters

By the 16th century, there was a growing need for charcoal to be used in the smelting of iron, and although some iron masters were astute enough to realise that managed woodlands could supply them with the wood they needed on a continuing basis, most were content to chop down any tree they could find. The oakwoods of the Sussex Weald and the Lake District were particularly badly hit and Queen Elizabeth had to prohibit the smelting of iron in Sussex in 1556 and in the Furness district of Lancashire (near to the Lake District) in 1562 to prevent devastation of the woodlands in those areas.[11]

The iron masters transferred their activities to Scotland where, at the beginning of the 17th century, large areas of the Great Wood of Caledon, rich in pine and birch, were still intact.[14] The Scottish Parliament was quick to anticipate what could happen and in 1609 passed an Act which controlled the making of "Yrne with Wode", but it could not be enforced.[5] The big landowners were glad to sell their trees: in 1728 Sir James Grant sold 60,000 trees from his Strathspey Forest for £7,000, and in 1786 the Duke of Gordon received £10,000 for selling his Glenmore Forest to an English company.[14]

With the furnaces voraciously consuming charcoal (the large Bonawe furnace required 20 tons of wood a day)[17] it is not surprising to find that by 1812 only half a million acres of woodland remained in Scotland and John Adair could write in a contemporary account that "hardly any remains of the great and goodly forests that were of old are to be seen."[5]

The discovery in 1815 of a process by which coke rather than charcoal could be used to smelt iron served to prevent complete devestation of our forests. Those which had been managed for charcoal wood, such as the oak forests of the Calder Valley that supplied the embryonic steel industry in Sheffield, and the Wyre Forest and Forest of Arden from which wood went to the Industrial Midlands,[11] were not neglected. They were used to supply pit props to the thousands of coal mines springing up all over the place. Sessile oaks in the Lake District were coppiced to produce bobbins for the Lancashire cotton mills which were also responsible for clearing a lot of the remaining Scottish birch forests.[14,18]

The Navy and the Oaks

The rise of England as a world power depended largely on the Royal Navy, which in turn relied upon the country's oakwoods to supply it with timber for building ships. A 74 gun man-of-war required the wood from 2,300 oaks obtained from an average of 44 acres of woodland.[19] There is a story that the Spanish admirals leading the Armada were told that if they did not succeed with their first objective of invading England, they were to attempt to eliminate her as a naval power by destoying the Forest of Dean in which some of the finest oaks were to be found.[10]

But the Spanish need not have bothered about destroying our oaken wealth, for we obligingly did it ourselves, and the day of reckoning came with a cataclysm of Biblical proportions. In 1662 the people of London were struck down by the Great Plague and in the year afterwards the City was razed to the ground by the Great Fire. While Londoners were still recovering from these blows, the Dutch fleet sailed up the Thames estuary and sank the English fleet anchored off Chatham.

Samuel Pepys, then Secretary for the Navy, searched high and low for timber to rebuild the fleet, but while he found some oaks remaining in Epping Forest, generally England had run out of oak and her forests could not meet the demand at this critical time. Although in 1604 a survey of the New Forest showed that it contained more than 125,000 oaks suitable for shipbuilding, only 16 per cent of this number remained less than a century later.[20]

A New Start

The need to import timber to resurrect the Royal Navy and the City of London caused much public indignation and the time was ripe for a new initiative to conserve and expand Britain's forests. The voice of John Evelyn was listened to and heeded. His book *SILVA, or A Discourse of Forest Trees, and the Propagation of Timber within His Majesty's Dominions,* based on a lecture which he gave to the Royal Society in October 1662,[21] was published by the Society in 1664.[22]

Evelyn made a powerful plea for reforestation: "Truly the waste and destruction of our woods has been so universal that I conceive nothing less than a universal plantation of the sorts of trees as will supply and will encounter the defect. We had better be without gold than without timber."

He voiced what was in the minds of many Englishmen at the time and was able to build upon the experience and practical suggestions of other forestry enthusiasts like Smith, Yarranton and Markham.[23, 24] Charles II supported Evelyn's proposals and bought back the Forest of Dean which his father had sold to raise money to fund campaigns during the Civil War,[16] and in 1668 an Act of Parliament enabling the enclosure of 11,000 acres for tree planting established the first real forestry plantations made by an English government. An Act of 1668 also permitted the enclosure of 6,000 acres of the New Forest for the purposes of restocking but only about 1,000 acres were planted up.[21]

Evelyn also influenced many private landowners to start planting trees, and they were given an incentive by recent acts of enclosure providing them with a lot of new land. By 1679 many millions of timber trees had been planted,[19] and while the campaign for national reforestation was not as extensive as Evelyn had hoped for, England's forests were ready the next time the country was threatened. Most of the oaks planted in the time of Charles II were felled to build fleets for Nelson to scupper Napoleon's hopes of world domination.

Nelson himself visited the Forest of Dean to examine the state of the oak forests. He urged that many more trees should be planted, and had such an influence over his second in command, Commander Collingwood, that the latter was rarely to be seen without an acorn in his pocket ready to be dropped in a suitable place.[19] The oaks planted after the Battle of Trafalgar were in their prime in the late 1930s when once again Britain needed them urgently.

The Rise of the Hedgerows

The English landscape had been predominantly composed of open fields since Saxon times, but large scale enclosures of land and planting of hedgerows did not start until after the Restoration, when many of the Royalists coming back to live in this country brought with them new ideas they had acquired whilst in exile.[12]

In the more thickly wooded counties such as Kent, Essex, Devon and Yorkshire, it is likely that fields surrounded by hedgerows were created directly from forests, whilst in places where pasture was abundant and farmers could see the benefits of separate farms, open fields had been enclosed well before the Middle Ages.

However, it was in the reign of that much maligned sovereign George III (1760-1820) that most of the enclosures took place. Before 1760 only 400,000 acres had been enclosed but before the end of the 18th century this figure had risen to 2.5 million acres of arable land, not including a quarter of a million acres of wasteland. Many small farms disappeared and huge areas of heath were enclosed. Fields were surrounded with hedges of hawthorn and whitethorn, but as many trees had to be felled to produce the enormous number of new fences, posts and rails needed, enclosure was not an entirely positive change as far as the trees were concerned.

Nevertheless the estimated 180,000 miles of new hedgerows established[25] in the 18th and 19th centuries were some compensation for the lack of forest cover, providing channels of communication for wildlife between areas of woodland separated by open ground, an important new habitat for birds, and a very significant reserve of hardwood timber.

Wider Still and Wider

The inspiration which Evelyn gave to many landowners to plant trees also had not a little influence on the support which they gave to the growing number of intrepid adventurers voyaging beyond our shores to seek new traces with which to enrich our impoverished flora.

The greatest of all these must surely be David

Area of forest in the UK, 1977 (thousand ha)

Forest type	Great Britain FC	Great Britain Private	Great Britain Total	UK total
Conifer high forest	806	506	1312	1362
Broadleaved high forest, coppice and coppice-with-standards[1]	50	345	395	404
Total productive area	856	851	1707	1766
Unproductive area[2]	7	283	290	296
Bare land for planting	83	na[3]	83	88
Total	946	1134	2080	2150

[1] Coppice and coppice-with-standards make up about 12% of this category.
[2] Scrub and felled woodland.
[3] The area of bare land held ready for planting by the private sector is not known, but is probably small.
na — not available.

Sources: F.C. (1979b) modified; DANI (1978-1979).

Forest Area by Country (thousand hectares)

	ENGLAND			SCOTLAND			WALES		
Productive	252.8	490.2	733	479	318.7	798	138.4	64.85	203
Non-productive	9	179	188	11	124	135	3	30	33
Total			**931**			**933**			**236**
Forest Cover %									
(a) Productive			5.7			10.1			9.7
(b) Total			7.1			11.8			11.4

Broadleaved forests account for about a fifth of total productive forest area.

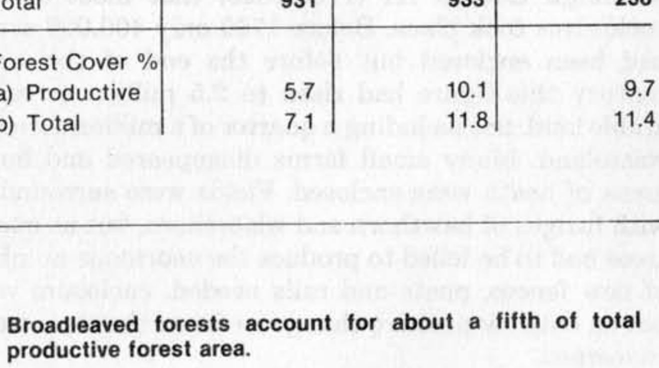


Figure 1. Distribution of high forest species groups in Great Britain (March, 1977).

Douglas who, working on behalf of the Horticultural Society of London, discovered the Douglas fir, Lodgepole pine, Ponderosa pine, Sitka spruce, and Radiata pine in the great forests on the north west Pacific Coast of North America. Four of these five species dominate timber plantations all over the world today, and however upset one may be at the vast monocultures of Sitka spruce which Douglas indirectly helped to create, surely no one would have wished upon him his terrible death in a trapper's pit in Hawaii in 1834, gored to death by a half-crazed bull who had also slipped into the pit by mistake.

The botanical name of the Douglas fir is actually *Pseudotsuga menziesii*, after Archibald Menzies who also explored the western coasts of the Americas between 1790 and 1795 and brought back for us the first seeds of the monkey puzzle tree, *Araucaria araucana.*[26]

Thanks to plant hunters like these, Britain can now boast up to 1700 species of trees, of which 700 can be said to be fairly common.[27] Most are found as ornamentals but some became the foundation of Britain's private timber plantations after being introduced in the 19th century. But the expanding Empire, with the extensive forests of Africa, India and Australia to log, meant a tendency to lapse back into old habits and neglect our own forests. Between 1850 and 1910 timber imports (mostly pine and fir woods) expanded by a factor of five.[28] A 10 per cent self sufficiency at the end of the 19th century[16] had dropped to 7 per cent at the outbreak of the First World War when the nation only had 5 per cent forest cover.[28]

Two more Wars take their Toll

The First World War brought us back to reality with a jolt. German submarines started to sink the ships bringing vital timber supplies from abroad, giving us a new awareness of our fragile reliance on imports. No less than 182,000 hectares of woodland (a third of our forest estate and most of it coniferous) had to be felled and in a very haphazard way.[29]

The Forestry Commission, established after the war with the task of making good these depredations, started off enthusiastically and by 1929 had acquired 243,700 hectares of which 56,000 had been planted[30] up. Government enthusiasm waned, and shortages of funds reduced the rate of planting so that when the next war came in 1939 only 149,400 hectares had been planted.[15] Taking into account the 51,000 hectares planted privately, this meant that we had taken 20 years to restore the forests devastated in 4 years of war.

Because trees take time to grow, very little of those planted between the wars could be harvested so soon. Some 151,000 hectares of forests, mainly in Scotland, were clear felled during and immediately after the war, while 61,000 hectares of mostly English broadleaved woodlands were stripped of their best trees. Private forests bore the brunt of war needs and the 300,000 hectares of derelict or scrubby woodland remaining today is the inevitable result.[31]

It seems as if Britain always needs a war to make it realise how much it depends upon its forests, although this bright flame of illumination dims very rapidly afterwards. We now have a national forest estate of over 2.1 million hectares, but not without a wringing of hands by Treasury civil servants which started in 1931 and has never abated. Our seeming incapacity to maintain a long term commitment to our forests says more about the limitations of human beings than it does about the profitability of forestry.

A New Threat to the Lowlands

The area of conifer plantations has substantially increased since 1945, but a considerable proportion of our hardwood trees have been lost. At least a third and maybe a half of old coppice and coppice-with-standards woodlands existing at the outbreak of World War II are no more,[32] and 140,000 miles of hedgerows (a quarter of the 1945 figure) have also gone.[33]

The Government has paid farmers to grub up their hedgerows to get bigger and "more efficient fields". the greatest change has been in East Anglia, with an 80 per cent reduction in tree numbers in the Cambridgeshire fens between 1887 and 1972 and the loss of a large number of pollarded willows. In another study area in Huntingdonshire there are now only 12 trees per 100 acres compared with 59 in 1947. A survey by Westmacott and Worthington for the Countryside Commission, found that there was a general dislike of trees amongst fen farmers, and the only area where farmers were generally interested in and knowledgeable about forestry was in Herefordshire. Here despite a 45 per cent increase in field sizes since the war, not many trees have been lost.

There were some 73 million trees in Britain's hedgerows in 1951. 70 per cent of which were in England, and altogether they contained one fifth of the nation's entire timber reserve and were equivalent in timber volume to that contained in 101,000 hectares of reasonably stocked woodland.[35,36] The elm tree accounted for 21 per cent of hedgerow and park trees, but out of an original population of about 23 million, the new and virulent strain of Dutch elm disease that swept through Britain in the 1960s and 1970s killed about 15.5 million up until 1979.[37]

While the loss of the elm has seemingly captured the hearts of many people, perhaps instead of talking about an "Epitaph for the Elm" we should look on the elm as an epitaph for our vanishing hedgerows. The tree only became so dominant because farmers increasingly neglected the maintenance and replacement of hedgerow trees and the elm was able to propagate itself by means of suckers. The green glory of the great empire of trees which once covered virtually the whole country has now finally reached its nadir.

The Effects of Deforestation

Deforestation had three major effects on Britain's ecology. It turned large areas of land into barren heaths and moorlands, and started a vicious spiral of vegetational impoverishment and soil degradation. Some species, like the wild boar, beaver and wolf became extinct in this country. Woodland birds had to adapt as best they could to the more open environment and were attracted particularly to hedgerows, while birds of prey like the golden eagle considerably expanded their distribution.

Soil Erosion and Degradation

We are for the most part completely ignorant of the extent of soil erosion which occurred after forests had been stripped from the uplands. One study in Wales, which examined sites that superficially appeared to have typical brown forest soils, found on closer investigation that they were probably no more than the very lowest part of heavily podzolised soils, most of which had been removed by erosion after the forest cover had been lost. The heavy loads of silt subsequently carried by the various rivers draining the Welsh hills could well have been the reason why ancient ports like Bristol and Chester silted up and became useless.[2]

Lowland areas such as Bagshot Heath and Breckland, which after deforestation were not much use for anything but sheep grazing because the sandy soils were so infertile, and upland areas with poor but well drained soils, were converted into heaths (known in the uplands as heather moors). These are, in Darlington's words, "arid, desert-like environments lacking easily accessible water." Rainwater drains through the soil very rapidly, and soil moisture is futher reduced by the drying effects of winds blowing over the large flat expanses of land.[38]

The vegetation on heathlands is xerophytic in character, e.g. heather has tough narrow leaves to enable it to withstand the dry conditions and many of the insects burrow into the loose soil to find shelter just like their relatives in the Sahara. Heather (ling) and bell heather are very undemanding of nutrients, and the litter being poor in bases would have made the soil humus layer more and more acid. As acidity increased the density of decay bacteria would drop, causing a layer of undecomposed dead plant matter (peat) to build up on the surface. Whatever earthworms had been present originally would leave and the soil would become even more impoverished as redistribution of nutrients between the different soil layers was greatly reduced.

The peat layer on heathlands is only a couple of inches thick, but the acids diffusing down from it with the rainfall would have leached out what bases there were in the upper soil levels. "Some brown forest soils," says Eyre, "may have been converted into podzols during the centuries. Even if the original soil was more like a podzol than a brown forest soil, podzol characteristics must inevitably have become more pronounced."[2]

The invasion of heather shaded out other plants that would have thrived even in these poor conditions. "Beneath the upper inch or so of brownish green leaves is a miniature forest of twisted dry leafless twigs, standing over a litter of dry debris. Little else can compete here and . . . other species rarely occur." R. St. Leger Gordon's most graphic description sounds more like our familiar image of a coniferous plantation than what lurks unseen beneath the heather on our heaths and moors.[13]

True moors occur in high rainfall and poorly drained upland areas in which the original forest covering prevented the accumulation of water. Each oak tree would transpire several gallons of water into the atmosphere every day during the growing season and act as what Eyre has called "one of the most efficient kinds of subsurface drainage systems that can possibly be imagined."[2]

When the trees were removed, moors were formed as the land became waterlogged and less aerated, causing the peat to build up on the surface and gleying to develop in the soil. Moors are commonly dominated by grasses such as purple moor grass *(Molinia caerulea)*, mat grass *(Nardus stricta)*, with cotton grass *(Eriphorum vaginatum)* where the land has been so saturated with water it is almost a bog.[38]

While geographers are quite clear about the distinction between a heath and a moor (one being well drained and leached and the other poorly drained and waterlogged), what we know generally as 'moors' are in practice a mosaic of true moors and heather moors. In the latter, the formation of an iron pan may have so impeded drainage that the soil is much wetter than that found on true heaths and the peat layer may have increased to more than a foot in depth, but heather moors can never match the extraordinary depth of peat layers — up to 10 metres in places — to be found under true moors.

The low fertility and sparse cover makes both heaths and moor poor habitats for wildlife, although butterflies are quite plentiful on heaths. Both may have had constant grazing for perhaps a thousand years or more, and this will have prevented the regeneration of the natural vegetation. In some places a respite from human and animal interference may have allowed trees to re-establish themselves, but elsewhere the waterlogging, and formation of peat and/or iron pans has proceeded so far that natural regeneration would be impossible.

In recent years heaths and moors have been invaded by gorse and bracken. Gorse, previously kept down by close-grazing rabbits has been able to spread relatively unhindered following their extermination by myxamatosis.[2] Periodic burning or swaling of moors is traditionally performed to get rid of the woody twigs of heather and encourage the growth of tender young shrubs to improve the pasture. When carried out indiscriminately this has weakened the heather and allowed the bracken to take over since the latter spreads by means of a fire resistant underground stem which makes it difficult to dislodge[38]. Bracken is carcinogenic to livestock and there are fears that water supplies draining from bracken covered watersheds pose a threat to human health. This is just one more cycle in the vicious spiral of ecological degeneration following the loss of forest cover.

Vanished Species

The forests were the truly wild places and rich in wildlife that was by no means friendly to man. The animals that we see around us today are mainly those which have adapted to the destruction of their original habitats. Some were not so lucky. One of the forester's greatest friends, the beaver, who very kindly obviates the need for chain saws by chopping down the trees itself, is no longer with us, having vanished from the Scottish Highlands in the 16th century.[11] The red deer is still found extensively in and around our forests, but the bucks damage many trees when rubbing against them to remove the velvet from their horns.

An old Norse Saga dating back to 1159 tells us that both red deer and reindeer were once hunted in Caithness. The reindeer's more majestic relative, the Elk (known in America as the moose), lived in Scotland from the end of the Ice Ages until 1,000 years ago. Elks were six feet high at the shoulders and half a ton in weight, but as their necks were too short for them to graze, they had to rely instead upon what they could browse from trees and shrubs. True forest dwellers, their demise was linked directly with that of the primeval forests.

The brown bear was the largest carnivorous animal ever to live in Britain. Exported back to Italy by the Romans for use in their circuses, it had been hunted since Neolithic times and finally became extinct in the 10th century. If there were still wolves in our forests, red deer (on which they prey) would not be such a nuisance to foresters. They also kept a check on the numbers of sheep grazing in the forests, which did not befriend them to farmers, and while still found in England at the time of Henry VIII, they retreated to Scotland as the English forests disappeared, and the last one was killed in the Highlands in 1743.

The wild cat — the closes thing to a tiger in Britain — was once very widespread, but had been exterminated in England and Wales by 1870. Now that Scottish gamekeepers are not so trigger-happy it is found fairly frequently north of the border. The pine marten was hunted for its fine fur, but there are still small populations in Scotland and the Lake District and in some Forestry Commission plantations in Wales.

The Auroch or wild ox was another six foot high monster which roamed around British forests from the end of the Ice Ages until the early Iron Age. The principal ancestor of our present European breeds of domestic cattle, it survived on the Continent right up to the end of the Middle Ages. The Saxons enjoyed hunting wild boars as well as deer, and King James I is recorded as having hunted them in Windsor Park in 1617, but by the end of the 17th century there were no more left in Britain.[39] Now there are only about 50 species of land mammals living in the wild in this country.[9]

The aesthetic value of trees is often overlooked. Seried rows of conifers have none of the appeal of a mixed woodland.

Changes in Birdlife

Over 200 species of birds live in Britain all through the year. Some birds, like the nightingale, cuckoo, swallow and tern just come here in the summer to breed, while others such as geese and swans visit in the winter and leave for their breeding grounds in the far north when spring arrives.[40]

Deforestation has not caused any birds to become extinct, but it has resulted in distinct changes in the character of our bird population. Some woodland birds, like the nuthatch, tree creeper, woodcock and spotted woodpecker, which could not adapt to life outside the forest are less common than before. Nightingales prefer the shrub layers of the forest and so may have become more common when coppicing brought about a more open canopy and encouraged growth of the smaller trees. However, their numbers have declined as coppicing has been discontinued.[41]

A number of other birds, like the robin, blackbird, tits, and thrushes, which used to live in the shrub layers of forests, have found hedgerows to be very adequate substitutes. As Pollard has put it: "Hedges are essentially woodland edges without the wood."[33] Also found here are seed eaters like the chaffinch, greenfinch, and yellow hammer, which are much more abundant now that there are lots of fields and farmyards where they may feast to their hearts' content. In Edlin's view: "the finches as a group probably owe their frequency to the spread of arable cultivation which has changed the forest habitat in their favour."[39] Another common hedgerow bird, the hedge sparrow, depends almost exclusively on the hedge for its food.

Hedges are essential for the survival of birds on many individual farms and in sparsely wooded areas, and might well become even more valuable refuges should the area of broadleaved woodland and scrub decline even further. The Nature Conservancy Council has estimated that if all hedgerows, field trees, and woodlands were to be cleared and all farms converted to the ultimate in 'scientific' chemical agriculture, the farming landscape would lose 85 per cent of its birds and 95 per cent of its butterflies.

Birds of prey took full advantage of the great expansion of moorland to increase the sizes of their dominions, but were often mercilessly hunted because they were a threat to sheep or game. The merlin nests beneath the heather and preys on smaller birds like the meadow pipit, linnet, and skylark. The golden eagle carries away grouse and young lambs, and praising the crofters of Aberfoyle in Perthshire in 1806, the Rev. Patrick Graham wrote of the golden eagle which "has built its eyrie from time immemorial in the cliffs of Benivenow, but by the exertions of the tenantry, who suffered much loss from his depredations on their flocks, the race is almost extirpated."[39]

The white tailed sea eagle was driven out to the islands in the 1880s and last seen in Shetland in 1918. The osprey was hunted almost to extinction but is now re-establishing itself with the encouragement of the R.S.P.B. The buzzard is the only hawk which does not hunt feathered game, concentrating mainly on rabbits, voles, frogs, and lizards, but it was hunted all the same. It too is now staging a come-back.[39]

Not so fortunate was the goshawk, which used to breed in the pine forests of Darnaway and Rothiemurcus until 1850, and is now extinct as a breeding species. The red kite, a woodland inhabitant that is the one major bird of prey remaining in Wales, has been hunted almost to the point of extinction because it likes to swoop into farmyards and take a chicken back to its nest.[39]

Will the World Run Out of Timber?

A number of recent reports, such as those from F.A.O.[42 43] and the Centre for Agricultural Strategy,[44] have predicted that world shortages of wood could develop between now and the end of the century. The C.A.S. calculates that by the year 2000, world wood consumption will have doubled from its current 2524 million m^3 and there could well be a shortfall of 410 million m^3 (ten times Britain's present annual consumption) that would increase to 3000 million m^3 by 2025. Britain, depending as it does on imports for over 90 per cent of its needs, will find that wood will become more expensive and harder to come by, especially if domestic demand rises by a fifth over the next 20 years as is forecast.

Such projections are based on assumptions about the rate of economic growth in the U.K. and other countries which may not be fulfilled (the O.E.C.D. has predicted zero growth for the developed nations in 1980[45], and numerical linkages between economic growth and the increase in consumption of wood products, which are also arguable as Charles Norman has shown[46]. Nevertheless the general trend towards scarcer timber is undeniable and all the evidence points to the fact that most of the small number of countries which dominate the world wood market will soon start to experience difficulties in maintaining production, with export levels being harder hit in a number of cases as domestic demand rises.

Some time in the next twenty years the demand for industrial wood, expected to double to 2761 million m^3 by 2000 and double again by 2025, will exceed the flagging capacity of the great temperate forests, and the timber companies will turn to the tropical forests which account for half of the total world resource but provide only one tenth of wood sold on the world market. However, many of our previous activities in logging these forests, which often caused them to be sold from under the feet of their traditional inhabitants, will have contributed to forcing many of the local people to buy wood for the first time, and *they will be competing with us in the market place for their own timber.*

Average per capita wood consumption in developing nations may not differ very much from that found in developed countries. Firewood consumption (accounting for about 80 per cent of all wood used in developing nations)[47] varies between 0.35 m^3 p.c. in India to 1.3 m^3 p.c. in a forest rich country like Indonesia,[48] compared with the 0.72 m^3 of wood used by every person in Britain each year.[44] But developed countries, with only 30 per cent of the world population, consume 88 per cent of all industrial wood, so that the average person in a developing nation may only consume 5 kilos of paper per annum[49] compared with the corresponding figure of 127 kilos in Britain.[44] The increase in industrial wood consumption in developing countries will have a very significant effect on the world market, and according to C.A.S.: "the proportion of the world's industrial wood demand located in the less developed nations is expected to rise from 16 per cent in 1976 to 28 per cent in 2000 and to more than 45 per cent in 2025." This time it seems as though it will be the rich world which loses out.[44]

All is Not Well in the Temperate Forests

Just five countries — Canada, Finland, Norway, Sweden, and the U.S.S.R. — dominate the world wood market and supply 58 per cent of Britain's wood and wood panel imports. The first four alone account for 42 per cent of world forest products exports and more than three quarters of our imports of pulp and paper.[44] Add to this list South East Asia (mainly Indonesia and Malaysia) which supplies 50 per cent of our hardwood needs and we have brought global guestimates down to a manageable seven nations upon which the world depends for its wood. Europe (less than 50 per cent self sufficient), Japan (only 30 per cent self sufficient)[42], and the U.S.A. (the world's leading importer of forest products) will be competing with each other for the produce from their forests.

The United States

The U.S.A. is the largest producer of roundwood in the world, and the leading exporter of logs, even though the latter were a mere 4 per cent of the 1976 wood harvest of 400 million m^3. It is also the largest producer (and consumer) of paper and board, with mills churning out 60.4 million tonnes in 1976, but if we thought that its 202 million hectares of forests will be much use to a world in search of timber we would be mistaken. For the U.S.A. has to import over 4.5 billion dollars of forest products every year, equivalent to 107 million m^3 or 23 per cent of domestic roundwood production, and incurring a deficit on its foreign trade in wood of 800 million dollars in 1976.

The centre of the U.S. forest industry (if not the timber capital of the world) is the massive conifer forest in the north west Pacific coast states of Washington and Oregon. This is where David Douglas found trees like the Douglas fir, and where today many of the largest timber companies in the world have their headquarters. But production from the north west forests is on the decline, according to Mr John E. Wishart, vice-president of the timber and timberlands division of Georgia Pacific, the world's third largest timber corporation. The growing stock of timber is shrinking due to overcutting and lack of regeneration and replanting in the last 15 years, and up to a third of the forests have been taken out of production pending the filing of environmental impact statements. Most of the forests are owned by the federal government, and restrictions on production, supposedly because of restrictions on the budget of the U.S. Forest Service has caused an artificial shortage of wood and pushed up prices by a factor of six in the 1970s.

Consequently many timber companies like Georgia Pacific are turning to large areas of mostly privately

Exports of timber from North America are expected to cease altogether by the end of the century.

owned forests in the northern states of Georgia (which alone has 7 times as much forest as the U.K.), Alabama, Louisiana, and the Carolinas, where John Wishart expects production to double over the next 50 years.

Canada

But this is the only crumb of comfort for North America, whose exports are expected by Mr Stanley Pringle of F.A.O. to decline and even cease altogether in the next 20 years, if current trends continue. The U.S.A. will probably have to step up its imports from Canada (which already supplies up to 70 per cent of its newsprint, 8 per cent of its pulp, and about 20 per cent of total sawnwood consumption) in order to satisfy increasing home demand. To all intents and purposes Canada and the U.S.A. can be considered as if they were one country as far as forest products are concerned.

Unfortunately this close relationship even extends to a similar malaise in the 89.9 million hectares of forest in British Columbia to that which occurs in the adjacent north-west Pacific forests of the U.S.A. Only 38 per cent of the forests that were clear cut between 1974 and 1978 have been replanted, and 21 million hectares (9 per cent of Canada's productive forest and the same size as the whole of England and Scotland combined) have been described as 'inadequately stocked' with trees.

An official Review of the Canadian Forest Products Industry has predicted: "greater concern for managing the forest resource and a realisation that the physical limits to exploitation are being reached will combine to slow the pace of growth and promote rationalisation of the industry structure. Forest management initiatives on a major scale are necessary to redress the balance of a *diminishing supply through insufficient sustained yield measures in the past.*"

The state government has responded to this report, and to calls from the Canadian Lumbermen's Association for reinvestment in Canadian forests and industrial plant, with a 1.4 billion dollars "refurbishment programme" over the next five years. Nevertheless, it is going to take a lot of time to recover lost ground and production is expected to fall to 65 per cent of that expected and remain depressed for a considerable time.[51] The logs which are produced will be markedly lower in size and quality. Such a drop in production in both the U.S. and the Canadian forests means one big hole in the world timber market.[52]

Scandinavia and the U.S.S.R.

Two of the other major suppliers of softwood to the U.K., Scandinavia and the Soviet Union, are also in difficulties or will be so in the next decade, according to Dr Ted Hillis, coordinator of the International Union of Forest Research Organisations' Forest Products Division. At a conference held in Oxford in May 1980, he said that the U.S.S.R. is now cutting its permissible annual increment and is unlikely to increase output, while Sweden is already short of supplies and is having to import roundwood and chips from North America and Europe.[53] Dr Hillis's remarks confirm suspicions aired in a 1979 report of the European Commission,[54] and in an earlier study published by the United Nations Economic Commission for Europe which concluded that Swedish forests had been overcut in the last decade.[55]

The U.S.S.R. has the largest forest resource in the world: 22 per cent of all timber reserves, 66 per cent of all coniferous forests, and more than the U.S.A. and Canada combined. But production fell from 395 million m^3 in 1975 to 355 million m^3 in 1979,[56] and pulp and paper mills were starved of feedstock. Softwood shipments to the U.K. in 1980 were down by 23 per cent compared with the expected volume[57] and prices were up by 30 per cent on 1979.[58]

The Soviet forest industry has a notoriously weak and cumbersome infrastructure: low level of mechanisation, poor roads, inadequate equipment maintenance, shortage of spare parts and low labour productivity.[59] Two thirds of the forest estates are located in Siberia,[60] and as well as there being doubts about their productivity, severe winters in recent years and disruptions in railway communications with the distant areas have also contributed to the malaise.

The country's economy is still developing and production of consumer goods is as yet embryonic. A significant fraction of the wood harvested is used as fuel and only one third ends up in the form of finished products. Surplus production available for export is likely to be further hit by rising domestic demand in the coming decades. Quoting a report in a U.S. journal, *World Wood* predicts that: "if Russian supplies falter, western Europe will have to look elsewhere to meet its growing demand for softwood."[59]

The Tropical Rain Forests: Limited and Non-Renewable

Since World War II the developed world has become extraordinarily dependent upon wood from the tropical forests. Between 1950 and 1973 imports of tropical hardwoods rose from 5.2 to 52 million m^3, and between 1961 and 1975 their value increased eightfold to 4 billion dollars. Europe is the second largest importer after Japan, which takes 30 million m^3 a year, and in the ten years up to 1978 the E.E.C. increased its imports by nearly a quarter to 12 million m^3.[61] Tropical hardwoods account for nearly all of the 70 per cent of British hardwood consumption which has to be imported,[14] most in the form of high quality sawn timber and wood panels that because of their high price were worth 17.4 per cent of the total value of imports in these categories in 1976.[44] The U.K. however went against E.E.C. trends and reduced its imports of sawn hardwoods by 26 per cent between 1968 and 1978.[61]

Despite the importance of tropical forests in the developed nations the future of supplies is very uncertain. In the last 30 years we have seen one nation after another in South-East Asia take over the limelight as major producer. The forests of the Philippines and Peninsular Malaysia are now largely exhausted, and the Malaysian state of Sabah has wisely decided to cut production and log exports before it undergoes the same fate. Indonesia is the current number one country in tropical logging, although it expects that by the mid-1980s 40 per cent of the wood which it exports will be in the form of sawn timber or wood panels which bring in greater revenue.[62]

The start of large scale logging sets in motion a chain of events whose effects are to the advantage of neither the producing country nor the developing nation in the long term. Forest clearance for agriculture becomes endemic as traditional agricultural systems are disrupted, and up to 15 million hectares of forest are lost in this way every year. The new colonisers are assisted by the roads which loggers had to build in order to extract their logs, and ease of access combined with lack of government infrastructure to protect the logged forest, means that regeneration is threatened by poachers who come to fell some of the trees which the loggers have left behind, as well as by encroaching cultivators. Poor forest management combined with the growth of domestic demand undermines long term export supplies. This has been the case in the Philippines, and in West Africa which was the leading producer of tropical hardwoods until South East Asia took over. Nigeria, for example, has slipped from the position of a major exporter to become a net importer of forest products.[63]

After the South East Asian forests are exhausted what next? The quality of the wood in the Amazon forests is only a pale reflection of those in Indonesia, and vast distances from logging site to river bank for transport to the sawmill, and the economic and physical obstacles to extraction and transport by road in the rainy seasons, would make logging these forests very expensive. Latin America's population is expanding more rapidly than that of any other continent and is going to need all the wood it can produce. Brazil is the largest wood producer in the tropics but bans the export of logs and only exports a small quantity (0.5 million m^3) of sawn timber. One possible source of wood is the still largely untouched 149 million hectares of rain forest centred on the Congo Basin in Central Africa. Gabon is the only significant producer, but its exports are a mere 5 per cent of those of Indonesia.

Supplies could be prolonged if more of the timber trees in the forests could be traded on the world market. Of more than 3,000 species in the Indonesian forests, for example, only 107 are utilised and just a quarter of the growing stock is available for extraction. Timber merchants are however very conservative about changing or expanding their species ranges. Establishing plantations of fast growing hardwoods could be another way of maintaining supplies: about 5 million hectares of these could supply 25 per cent of the demand by the year 2025. With their far greater productivity per hectare (up to twenty times that of a natural forest), they would be far more cost effective and help save the destruction of large areas of natural tropical rain forest. There are pilot plantations, e.g. in Africa, but many questions still remain to be answered

Countryside Commission

before plantations can be established on a large scale.

The tropical rain forests are more like logging's last stand than its last frontier. Projections of future world wood supply which include these forests in their calculations usually present a grossly over-optimistic picture. They use official estimates of forest areas and growing stock which may be ten years out of date by which time a third of the trees may have vanished. The maximum sustainable production (or 'allowable cut') assumes a non-depreciating growing stock, and that after the first logging the same amount of wood may be produced in a rotation time that has probably been worked out on the back of a civil servant's envelope rather than by scientific experiment.

No account is usually taken of the fact that only a small fraction of the growing stock may be commercially extractable, that some areas are more valuable than others, or may not be economically loggable because of inaccessibility or high transport costs. At the moment we must consider the tropical rain forests as a limited and non-renewable resource that is certainly not going to be the salvation of developed nations which have not taken proper care of their forests, (see *The Ecologist*, January 1980, for a full discussion of the threat posed by development to the world's tropical forests).

Reforestation and Realignment

Whatever may be the future demand for wood in the world, it looks as though the major producing countries, upon which Britain depends for most of her imports, will find it difficult to maintain their exports even at present levels, and supplies from the tropical rain forests should certainly not be regarded as being very reliable. Statistics used in the calculations of potential supplies make those predictions just as questionable as those of likely demand.

We may see producing and consuming countries splitting into more recognisable trading blocks, e.g. Canada and the U.S.A. looking to supply their own needs rather than continuing their previously high levels of exports; Japan depending largely upon South East Asia, Australia and New Zealand, as well as North America with whom it would share supplies of Asian tropical hardwoods; the Eastern Europe/Warsaw Pact countries continuing exports on their own terms, and the E.E.C. countries taking steps to establish a strong joint forestry policy which must include close collaboration with Scandinavia and possibly considerable economic help to West African countries to enable expansion of hardwood production from plantations.

Britain's Present Wood Needs

While Britain's farms can supply one out of every two of our population with food, our forests can only provide one person in every ten with the 0.72m³ which he needs every year.[44] This is one and a half times the volume of an average tree of Sitka spruce being produced by the Forestry Commission's plantations,[64] and similar in size to the boot of the new Austin Mini Metro. The £3 billion worth of wood products which we import every year[44] represents one third of all European wood imports and 10 per cent of world trade in wood.[63] Wood is the third most expensive raw material import after oil and food and number four in the list of manufactured goods imports after cars and trucks, chemicals, and non-metallic mineral manufactures.[65] Despite the size of our wood imports, a high powered symposium held a few years ago to discover ways of making Britain more self sufficient did not even mention wood.[66]

Sawn Timber — Softwoods Dominate Consumption

More than a third of all wood consumed in Britain is in the form of sawn timber, and the quantity of 8.5 million m³ (equivalent to 14.5 million m³ of roundwood) is little different from what it was in 1960, despite substantial fluctuations in the intervening years. British forests at the moment can supply only 8 per cent of the sawn softwood which accounts for 87 per cent of total demand for sawn timber. While we are 95 per cent self suficient in sawn mining timber and 25 per cent self sufficient in pallet wood, in the crucial high value sector of constructional sawn timber we have only 1 per cent of the market.

About a quarter of the sawn hardwood we use comes from British trees. Production of elm timber has almost doubled in recent years because of the glut of dead trees, and accounted for about half of the output of English sawmills in 1978.[67] The influx of elm has been beneficial in that it has led to some mills being modernised, and even to new ones being built. However with elm production now declining as the mills just receive the smaller and lower quality trees, Dr Geoff Elliott (University College of North Wales, Bangor) believes that we could see a short term shortage of hardwoods in the next few years, and a greater dependence on tropical hardwoods.[67] Mr Roger Keys, the senior vice-president of the Home Timber Merchants Association of England and Wales thinks that we could even see a scramble for all of the remaining hardwoods, with prices rising as "too many of us chase too little timber."[68] The situation is not helped by a lack of knowledge of just how many hardwood trees we have left, although the Forestry Commission has just embarked on a nationwide census.

British Hardwoods

Unfortunately, as with softwood, British hardwood sawn timber only has a small share of the higher end of the market. Only 11 per cent was used for furniture and joinery (compared with 65 per cent of imported timber) and 76 per cent is used to make pallets and mining timber.[69] At the moment the most popular hardwoods after elm are: oak, beech, and ash, with sycamore, cherry, and walnut having a smaller share.[67,70]

Wood Panels — The Cheap and Popular Wastesavers

Only half the volume of a felled log can be converted into sawn timber, and to improve the efficiency of utilisation the waste wood is broken up into chips (or even smaller fibres) which are then bonded together and enclosed within thin sheets of veneer to form particle board (chipboard) and fibreboard (hardboard) respectively. Alternatively hundreds of veneers may be peeled from one log of oak or teak and then three or five (depending on quality) may be laminated together with crossed grains to give the third main type of wood panel — plywood.

Wood panels, especially particle board and plywood, have increasingly replaced sawn timber in the manufacture of furniture and for do-it-yourself purposes. While imports of raw wood and sawn timber fell from 18.3 to 13.6 million m³ between 1960 and 1976, imports of wood panels increased by over a half to 3.7 million m³, to account for one eighth of all wood product imports. But although wood panels mean lower prices in the furniture shops, they are a heavy burden on our import bill as they cost us half as much again per cubic metre as our imports of logs and timber.[44]

Volume of U.K. Imports and Production of Wood and Wood Products
1960-1976 Actual 1985-2025 Forecast
(units x millions m³ roundwood, underbark)

	Imports					U.K. Production	
Year	Sawn Wood	Pulp	Paper	Wood Panels	Total Vol.	Vol.	%
1960	18.3	11.7	3.5	2.5	36.0	2.7	7.5
1965	18.6	12.7	4.5	3.3	39.1	3.0	7.6
1970	15.9	13.7	7.3	3.4	40.3	3.2	7.9
1975	10.3	9.4	7.9	3.3	30.9	3.2	10.3
1976	13.6	10.7	8.9	3.8	37.0	3.5	9.4
1985	16.4	— 27.4 —		7.5	51.3	5.4	10.5
2000	15.4	— 36.7 —		12.4	64.5	8.3	12.8
2025	13.5	— 59.0 —		19.6	92.1	10.6	11.5

Source Forestry Commission statistics

Imports are expensive

The worrying thing is that over the last decade we have been importing proportionally more of the highly processed and more expensive wood products. As Rankin has said: "£1 in the forest may become £5.50 from the sawmill, £19 from a particle board mill, and £29 from a paper mill."[71] In the early 1970s Britain did expand its manufacturing capacity to meet the growing demand for particle board. Two new factories were built, Scotboard's existing factory at Irvine was expanded, and at one time we were 43 per cent self sufficient.[72] Scottish Timber Products' chipboard plant at Cowie near Stirling was the largest single unit of its kind in the U.K. and the fourth largest in Europe, consuming in 1976 220,000 tonnes of wood raw material, of which half was roundwood and half residues such as sawdust, chips, roundwood slabs and offcuts.[73] As Dallas Mithen, Forestry Commissioner for Harvesting and Marketing has commented: "the chipboard industry's basic raw material is other people's waste,"[72] and an active wood panel industry is a vital ingredient in the efficient utilisation of home-grown wood.

By 1977, however, cheap imports from the Continent, which had also expanded its capacity,[74] had captured two thirds of the market, posing a severe threat to home production. The Cowie plant went into receivership,[72] but was re-opened in April 1978 as Caperboard Ltd, under German ownership and with Government assistance. S.T.P. was not alone in its difficulties: of the six remaining chipboard mills only two are now owned by their original shareholders.[75] However, Sweden and Spain have agreed to raise their prices to alleviate dumping and it is hoped that Finland, Rumania, Norway, Portugal and other countries will follow suit.[72]

Pulp and Paper Hit Hard Times

Paper accounts for a quarter of all the wood we consume and import, and its share is growing. Britain can be proud of recycling 46 per cent of its waste paper — twice as much as the U.S.A. — but our needs are still staggering.[44] A single issue of the *Daily Mirror* requires 460 tonnes of paper or 1384 m³ of roundwood.[76] Even if half of this demand is met by waste paper, assuming that a plantation averages 10 m³ of growth every year and that half of this could be used for pulping, one issue consumes the entire year's pulpwood growth of 138 hectares of plantations, and in one year the *Daily Mirror* relies on the production of some 43,000 hectares — a forest 12 per cent larger than the Isle of Wight.

Until the early 1970s Britain managed to produce 65-70 per cent of its requirements for paper and paper products,[20] but in the last decade our pulp and paper industry went into a decline that seems to be worsening rather than improving in the 1980s. This may have been part of a deliberate commercial strategy on the part of Scandinavia and Canada. The C.A.S. Report states that: "There is a strong indication that in recent years the timber exporters, such as the Scandinavian countries, have been raising the price of the basic raw material (i.e. woodpulp) much faster than the price of the finished product (i.e. paper). The price of 'market pulp' rose 35 per cent over the 18 months from March 1974, but the price of imported paper did not move significantly in relation to cost input over this period."[44]

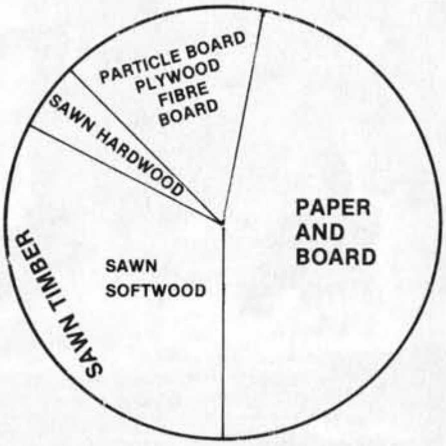
Between 1970 and 1977, imports and domestic production of pulp both fell by a quarter, and paper imports increased by the same proportion as more than 150 paper machines were closed down.[77] But it wasn't until 1979 that a decline rapidly accelerated into a collapse. Wiggins Teape announced in April of that year that it was closing its loss-making pulp mill at Fort William in Scotland, with the axing of 450 jobs.[78] The mill was the major consumer of plantation thinnings in the

Major End Uses of Forest Products in 1972
(units x 1000 m^3)

	Sawnwood		Wood Based Sheet Materials		
	Conifer	Broad-leaved	Plywood	Fibre Board (units x 1000 tonnes)	Particle Board
Total Imports	8630	889	936	306	665
Per cent end use					
Construction					
Total	78.7	39.3	36.0	38.3	33.6
of which					
New Housing	(27.2)*	(2.4)	—	—	—
Schools, Hospitals, Industry, Commercial	(14.7)	(4.7)	3.0	—	—
Repair & Maintenance	(14.5)	(2.3)	—	—	—
Civil Engineering	(6.5)	(2.3)	—	—	—
Sheds and Fencing	(7.5)	—	—	—	—
Agric. Buildings	(2.1)	—	—	—	—
Shop Fitting	(1.3)	(5.2)	5.0	—	4.2
Marine Works	—	(0.6)	1.5	—	—
Joinery	—	(21.8)	15.0	—	2.0
Other construction	(4.9)	—	—	—	1.7
Furniture	3.9	43.0	10.9	15.1	41.6
Pallets & Packaging	11.4	—	11.4	—	0.6
Mining	2.0	—	—	—	—
Transport	—	6.7	6.8	5.3	—
D.I.Y.	2.8	2.1	3.5	17.6	8.9
A.V. Equipment/Toys	—	—	—	6.5	1.2
Coffins	—	1.1	—	—	2.4
Miscellaneous	1.2	7.8	6.9	17.2	3.8

* Figures in parentheses refer to % within construction. Source U.C.N.W., various 1971-1977

THE PATTERN OF WOOD CONSUMPTION IN BRITAIN



Each person in the U.K. consumes the equivalent of one and a half Sitka spruce trees every year — enough wood to pack into the boot of the new Austin Mini Metro.

north and west of Scotland (150,000 tonnes a year) and its pulp formed the feedstock for an adjacent papermill which is still profitable and is not being shut down.

Wiggins Teape said that they were planning to build a new £100 million newsprint plant on the same site in conjunction with Consolidated Bathurst of Canada, thereby preserving domestic wood processing capacity. The Government offered about £30 million in aid to get the project off the ground, but would not agree to sell wood to the new plant at half the current market rate (as was apparently requested) and so the whole scheme was abandoned.[79]

Even with more concessions it is doubtful if the project would ever have seen the light of day. U.K. newsprint production fell from 780,000 tonnes in 1965 (when it accounted for more than half of domestic demand) to about 300,000 tonnes in 1980 when self sufficiency was down to 20 per cent. The announcement by Bowater in August 1980 that it was going to shut down its integrated pulpmill and newspring plant at Ellesmere Port on Merseyside was a further body blow to the forest industry because it virtually halved our remaining newsprint capacity to about 200,000 tonnes, reduced self sufficiency to 14 per cent, removed the market for 270,000 tonnes of home grown timber, and cost 1600 workers their jobs on Merseyside alone.[80 81]

Two days later Reed International, the only other remaining newsprint producer, decided to shut down the smallest of its three machines in Kent (45,000 tonnes capacity). Two other machines were axed at the Aylesford site — one making 80,000 tonnes of multi-ply liners for corrugated cases and another making 6,000 tonnes of hard tissues. Another 700 jobs were added to the list of 30,000 lost in the paper and associated industries in 1980.[82]

The U.K. paper industry went into a rapid nose-dive because of three vital factors: high energy costs, the high value of sterling, and expensive wood raw material. Bowater's Mersey Mill was losing money at the rate of about £6 million a year and U.K. chief executive Dr Ingram Lenton claimed that the company was having to pay £7.5 million more for its coal and electricity than its overseas competitors.[80] The mill used about the same amount of energy as a small town, and although the Government came forward with a last minute offer of cheap coal that would have chopped £3 million off the fuel bill, it was too little and too late.[82]

In a few years the situation may improve. There is the prospect of large cuts in the production of British Columbia's forests, and competition between pulpmills and sawmills for Sweden's annual wood harvest could lead to more wood being converted into more profitable sawn timber.[83 84] The British Government might heed the calls of industrialists and reduce the prices which they have to pay for oil and other fuels. Recent closures do not mean that there will never again be a viable newsprint industry in Britain and so we should seriously consider, in co-operation with the rest of the E.E.C., taking short term measures to safeguard its long term future.

Our commendably high level of waste paper recycling could also be hit hard. Reed made its newsprint predominantly from waste paper, which was slightly more expensive than home grown timber, but efficient recycling and reliable supplies depend upon a vast network of collectors all over the country who are now being forced out of business as prices plummet. Once gone, you could not press a switch and make them appear again as rapidly as a mothballed paper mill could be restored to normal working.

Integrating Farming and Forestry in the Uplands and Lowlands

Forestry is for the future. It demands a long term vision that has been noticeably lacking in Britain in recent years, a much more advanced approach to land use, and a commitment to establish a sound base of renewable resources for our descendents. Having already made considerably progress towards re-establishing our forest capital, we need to reassess the role of conifer plantations, investigate ways of integrating forestry and farming, and look at the new trees which we could be planting, with particular emphasis on hardwoods. At this critical moment of transition into the 21st century, it is time to plan the forests of the future.

The Uplands

Hill farming is the major source of income in the uplands and fulfils an important function in raising lambs for finishing on lowland farms. But it is an unprofitable activity, and without the £21 million of exclusive subsidies (1976-77) which may account for a third of an average farmer's income, the local economy and culture would collapse.[44] As it is, the population is declining as older people die and the young leave for jobs in the towns.

The Hill Livestock Compensatory Allowances which the farmers receive are what keep the small upland communities going, but they are used to subsidise income and are spent as income.[86] Because there is little left over for capital improvements, the Government grants are more like drugs which make the users dependent upon them rather than curing the disease.

The unprofitability of hill farming stems from the fact that it is an extensive form of land use in which each sheep needs about two hectares of land on which to graze. Sheepmeat prices have always been low because of competition from cheap New Zealand lamb, although now these imports have ceased and we are quite competitive with farms in other E.E.C. countries. The number of animals a farm can support is limited by the relatively small area of good ground on the lower slopes where the sheep have to spend the winter. Employment is low, with one shepherd having to look after an average of 405 hectares.

In the short-term, profitability could be improved by fertilising land and seeding with high quality grasses, and gaining better control over flocks by building fences and laying roads. As the sheer scale of investment required is beyond most farmers' means — it may cost £3000 to build just one mile of road — profitability declines even further. Lambing percentage in many areas is now as low as 50 per cent[87] and up to a quarter of the lambs on a farm may die from hypothermia in a severe winter with more than a million lambs lost in an average year.[88]

Faced with such a gloomy future, some farmers have had little choice but to sell part of their land to the Forestry Commission in order to raise capital to improve the remainder. Selling half of a 3000 hectare farm, for example, could make about £166,000 available for reinvestment after allowance for capital gains tax[89]. But while a Forestry Commission cheque may be the pill to cure all of a farmer's problems, it may have deep cultural repercussions in the area because control of the land is being taken out of the hands of local people.

Is Integration the Answer?

A number of landowners in the Highlands have decided that forestry should not just be regarded as a cure-all for the limitations of sheep farming, but be seen as an essential part of the upland farm economy. One of the pioneering experiments in integration has taken place at Fassfern in Invernesshire, where a 2,000 hectare hill farm has been afforested under the direction of Lord Dulverton, whose family trust owns the estate.

The forests occupy the middle ground on hills which rise in places to 2000 ft, the lower parts have been converted into a more intensive type of sheep and cattle rearing operation, and the hill tops have been left for neighbours' deer. The lower hill was divided into several paddocks that were seeded with grass and clover and fertilised to give a better pasture. Although the numbers of ewes and cattle has been reduced, production compared with that obtained before conversion has been increased from 200-300 lambs and 30 calves to 500 lambs and 33 calves by using just one fifth of the area.[90]

The remaining 1600 hectares have been afforested with Sitka spruce, Scots pine, Lodgepole pine, Hybrid and Japanese larch, and Douglas fir, whilst retaining old hardwoods for amenity purposes. Tree planting began in 1955 and has continued ever since. The forested part is split up into blocks intimately associated with the farmland so that both benefit from roads and fences. There are also small patches of trees on poorer ground in the lower part of the farm.

The sheep are thus sheltered by the plantations from the strong winds that sweep across this very exposed area, and can also be wintered amongst the trees when the young plantations are old enough not to be harmed by the animals, although the forest has to be closed in after about ten years. Sheep mortality has been reduced and lambing percentage is about 100 per cent.

Employment has also been boosted. The two shepherds employed previously have been retained, while overall employment has increased six-fold. The forestry workers are available for occasional work on the farm and the two enterprises share the use of specialist machinery. Working conditions for the shepherds have been improved, and this may be an important way of attracting young people back to working in the hills.[91]

The Fassfern forests are just producing their first thinnings, but not far away one of the early Forestry Commission plantations now coming into maturity gives some idea of what Fassfern can look forward to in another 25 years time. The £600 worth of thinnings extracted previously from each hectare have covered the costs involved in getting the plantation to the stage now where it has 300 tons of timber per hectare worth £3000 (1978 prices) ready for harvesting.[86]

Lord Dulverton is conscious of the need to properly integrate new forests into the landscape, and has criticised the way in which whole hill-ranges have been blanketed by uninterrupted masses of conifers that cut off valley bottoms from hill pastures and block the essential movement of wild and domestic animals up the hills. He has tried to avoid unsympathetic angular blocks of trees and to mix his species.[92]

OF MORE THAN 6 MILLION HECTARES OF LAND IN THE UPLANDS, AT LEAST 1.8 MILLION HECTARES ARE SUITABLE FOR AFFORESTATION, MORE THAN TWO THIRDS OF WHICH ARE IN SCOTLAND.

Fassfern demonstrates the ideal answer to improving land use and prosperity in the uplands, and expanding our forests without reducing agricultural production. There has been capital investment in both the livestock and forestry operations which will bring rewards of greater income in the future. Employment is also higher, because forestry needs one man for every 40 hectares on average (compared with one man per 400 hectares on an unimproved sheep farm) with a bonus of another job created in a far away saw mill.[91]

While Fassfern represents an optimum pattern of land use which is both economically and ecologically attractive, it is a special case because the owners had the money and the time to completely replan the estate along efficient lines. Elsewhere, Mr Walter Elliott, Chairman of the British Wool Marketing Board has afforested 11 per cent of his 3000 acre Dumfriesshire hill farm by planting up spare land such as is found lying idle on most farms. Production of wool and meat have been maintained and Mr Elliott considers that with hindsight afforestation could have been as much as 20 per cent without causing agricultural output to drop.[93]

The National Farmers' Union of Scotland is very much in favour of closer integration between farming and forestry, but does not want to see a large scale ex-

The Value of Hedgerows

Every year, Britain's farmers grub up some 4000 miles of hedgerows. The process is encouraged by government grants and justified by civil servants and farmers alike as a move towards more 'efficient' farming. Hedges, it is argued, take up potentially productive land — 3000 square feet for every hundred yards of hedge — and make ploughing more difficult: their removal saves both time and energy. But what of their ecological benefits? Are these not a factor which should be taken into account?

Numerous studies have shown the value of hedges in providing shelter to both livestock and crops. Just how effective a hedge is in reducing wind speeds depends to a large extent on how impermeable it is. Dense hedges, through which the wind can pass only with difficulty, tend to create an eddy on their lee side; although the speed of the wind is reduced, the resulting turbulence minimizes the shelter provided. If, however, the hedge is semi-permeable, then wind speeds can be reduced by as much as 80 per cent at distances up to five times the height of the hedge away. Where such protection is present, yields are increased, largely by preventing damage to crops through high winds and by reducing evapo-transpiration. Indeed, the gain in production can be between two and four times greater than the loss incurred by keeping the land beneath the hedge out of production. In Canada, yields of Summer Wheat were found to be 24 per cent higher in areas with windbreaks than in those without; in Denmark the apple crop was 167 per cent higher in sheltered orchards; and in Hungary, grass growth was found to be 68 per cent higher.

Those figures emerge from a study of hedgerows undertaken for the Council of Europe by F. Terrasson and G. Tendron of the Natural History Museum, Paris. Terrasson and Tendron also point out that hedgerows act as vital shield against erosion, either by wind or rain, because run-off is significantly reduced. They note, too, that storms appear to be less severe in hedgerow country: indeed, according to a survey by a French insurance company, 80 per cent of some 4000 claims for damage received after a major storm in February 1970 came from areas where extensive hedgerow clearances had taken place.

But perhaps the most overlooked benefit of hedgerows lies in the habitat they provide for wildlife. Although hedgerows harbour some insects and fungi which can harm crops (the bean aphid and wheat rust are two examples) the greater part of their population are the natural allies of the farmer — from the bumble bee which plays such a vital role in pollinating flowering crops to birds of prey and insect predators which keep farm pests in check. Once the habitat for these natural enemies of farm pests has been destroyed then, as Terrasson and Tendron are quick to point out, "the only course open is to resort to pollutant chemical treatment." One need hardly reiterate the effects of today's insecticides and herbicides on the environment.

If domesticated livestock is included as part of the hedgerow ecosystem then, argue Terrasson and Tendron, the case in favour of hedgerows is still more overwhelming. "Veterinary surgeons," they report, "have found that the disappearance of hedges in stockfarming areas has caused an increase in bovine tuberculosis and bronchitis, as well as a rise in mortality due to sunstroke in the summer. Vets (also note) an extension of grassland tetany and brucellosis coinciding with the disappearance of hedgerows. While the causes of these outbreaks are not always clear . . . the existence of hedges seems to be essential to break the cycle of parasitic disease.

Unfortunately, it is only when hedgerows are uprooted that such natural benefits are discovered. And then it is too late.

Nicholas Hildyard

F. Terrasson and G. Tendron, *Evolution and Conservation of Hedgerow Landscapes in Europe*, Council of Europe, 1975.

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pansion of plantations, as has been the case in the past. But it says that: "If, however, integration at the farm unit level is to be achieved on a widespread scale, then the proposition must be made attractive to the farmer. There is no doubt that the farmer's present lack of interest in forestry is based in part on the lack of immediate financial return from investment for shelter or timber production. A funding arrangement financed by Government should be introduced whereby the small planter could obtain advances on a crop of trees while the plantation is maturing." There should be better coordination of administrative arrangements governing farm and forestry grants and the latter "should also be weighted to encourage planting integrated with agriculture."

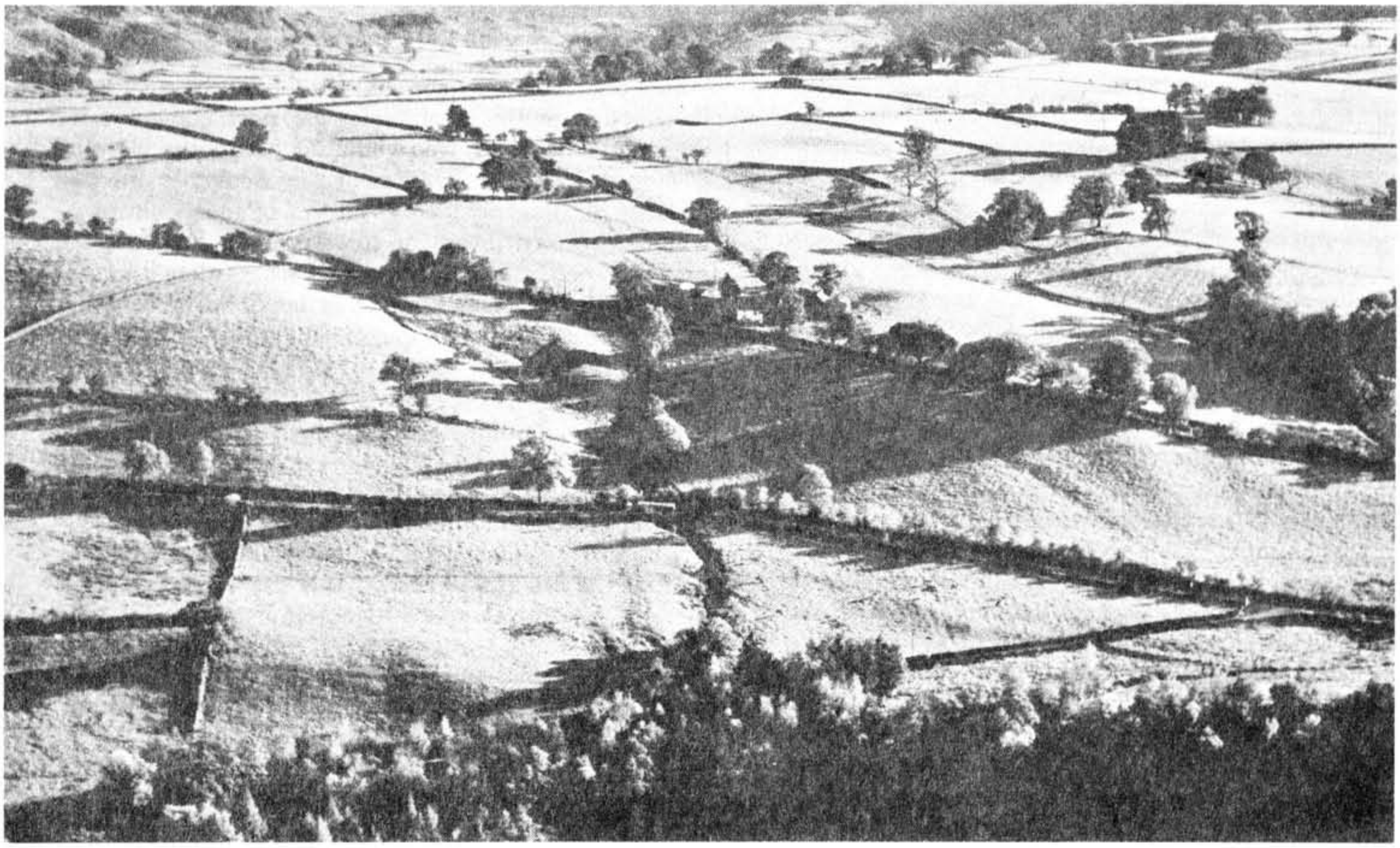
The Union thinks that the Forestry Commission should adopt a less "heavy-handed" role, by leasing land for afforestation or offering a management and marketing service in the same way that private forestry groups do. It argues that "if it became accepted practice for the Commission to undertake comprehensive development schemes — planting their trees in a pattern agreed with, but not dictated by, the farmer — much more land would be on offer to the Commission than there is at the present time."

So instead of buying a single large block of 400 hectares, the Forestry Commission would negotiate with local farmers and purchase five blocks of 80 hectares each, which could be planted so their boundaries could be used as a basis for establishing grazing parks for sheep. The extra costs of planting the smaller blocks would be met by the farmers. The Forestry Commission would derive great benefit from more integration, especially if it means fewer gigantic plantations of the sort which have given it such a poor reputation in the past.[94 95]

Forestry therefore holds the key to the future prosperity of the uplands in much the same way that the uplands are crucial to the expansion of Britain's forest estate. The National Farmers Union of Scotland has developed the most advanced set of proposals for integrating farming and forestry yet seen, and its proposal to have an N.F.U.S. representative as a Forestry Commissioner would, if implemented, serve to develop a strong bond of cooperation between these two key elements in the upland economy. It would seem far better to extend institutional forms of cooperation, and to break down the barriers existing between farmers and foresters by having courses on forestry at agricultural colleges as Mr John Mackie, Chairman of the Forestry Commission has suggested,[96] than to preserve or intensify the barriers by introducing statutory controls on forestry.

The Lowlands: the value of Shelterbelts

In the lowlands, besides restoring their small wood-



lands to production, farmers could well be finding that there is gold in the hedgerows. Afflicted by Dutch elm disease, the expansion of fields and farmers' apathy, many of the hedgerow trees are overmature and senescent, even though they represent one third of the nation's timber reserve. But they are a long term investment which is not to be sneezed at: with a good hedgerow oak fetching around £200 these days, just ten trees around a ten acre field would be worth 10 per cent of the value of the land at current prices.[97]

Another factor to be taken into account is the increase in crop yields obtained when a field is protected by the shelter of trees (see Box: Hedgerows). Well designed shelter belts have increased German root crop and cereal yields by at least 20 per cent, with grass yields increased by half as much again. The Germans reckon that with 5 per cent of a farm's cultivated land under shelter belts, they can rely on a net yield increase of 15 per cent. There are many such examples, but Germany was chosen since conditions there are more comparable with those in Britain. In large open plains like the prairies of the U.S.A. and Canada and the steppes of the U.S.S.R., where conditions are very exposed, trees may increase yields by up to 40 per cent.[98]

Shelter belts work by reducing the wind speed in their lee by up to 75 per cent, thereby reducing evaporation from crops, increasing atmospheric humidity and soil moisture and preventing growth inducing carbon dioxide (which usually settles near the ground) from blowing away. Significant reductions in wind speed can be found for a distance to leeward of up to 12 times the height of the trees, but an economical spacing for shelter belts is between 15 and 20 times their height. If the latter is 10 metres, then this gives a recommended field size of 4 hectares (10 acres). Mr F.M. Darby of Methwold Hythe in Norfolk reduced the sizes of the fields on his farm to 10 acres and planted shelter belts to guard against long term decline in crop yields owing to soil erosion. When the strong blows came in 1968 many of the neighbouring hedgeless farms suffered very badly but he escaped serious damage.[33]

A return to coppicing is also on the cards. Hazel used to be the usual underwood in a coppice-with-standards woodland but is now too expensive to maintain. Chestnut is the only tree still actively coppiced on any scale in South East England. Production is very profitable because little maintenance is required and the poles that are harvested every 12 years are used for fences, hop poles, posts and stakes[99]. Poplar, which until now has been grown on 20-25 year rotations for match wood could be coppiced on very short rotations (1-5 years) for conversion into paper or particle board.[92] But with oil prices rising all the time, it seems as though it will be energy plantations producing fuelwood which will bring coppicing back into vogue.

New Types of Silviculture

To most people, establishing more forests means more dreary conifer monocultures, but although the Forestry Commission has concentrated on such plantations, it should be pointed out that private forests are far more imaginative in design and diverse in species composition. There have been improvements in the ways in which new plantations are introduced into the countryside, although their fundamental character has not changed. What problems do monocultures pose? And how must silvicultural practices change if they are to be overcome?

The Danger of Disease

Half of the existing plantations are composed of Sitka spruce, a very hardy tree which thrives in high rainfall areas (2500 mm) in Wales and on the west coast of Scotland where it is lashed by fierce salt-laden gales. It gives way to Lodgepole pine on the very anerobic and deep peats in northern Scotland and to Scots pine on the heather moors of the much drier (750-1500 mm) eastern half of Scotland. Scots pine is also planted in the west together with Norway spruce and Japanese larch, but not in very exposed areas near the coast, and Douglas fir is planted in sheltered valleys in the east.[100]

This great reliance on Sitka spruce means that our whole state forestry enterprise could be put in jeopardy if the tree was attacked by pests and diseases in the same way in which Lodgepole pine has been hit by the pine beauty moth (*Panolis flammea*) in recent years. The moth, which is actually indigenous to Scots pine, destroyed 243 hectares in 1976 and 1977, and a further 80 hectares in 1978, which led to the aerial spraying of 4860 hectares with Fenitrothion[101 102]. This is an extremely questionable pesticide which in New Brunswick did not manage to stem infestation of spruce-fir forests by spruce budworm but did have serious effects on the health of local people.[103] The U.S.A. Forest Service, after a storm of protest about similar action in Maine's forests, decided in May 1980 not to continue funding spraying operations.[104]

Susceptibility to insect attack is likely to lead to smaller plantings of Lodgepole pine in the future.[100] It is difficult to say whether the incidence of pests and diseases threatening Sitka spruce would be reduced were it to be mixed with one or two other species either in the same stand or split into smaller stands of monocultures.

Biological Control

Could methods of biological control make monocultures more stable? In Germany, von Berlepsch has claimed that the placing of 2 nest boxes per acre in a wood threatened by pine looper moth (*Bupalus piniarius*) resulted in only 50 caterpillars inhabiting each tree compared with 5,000 in unprotected areas, and enabled one block of forest to stay green while another was defoliated.[105] The Forestry Commission tried to control the pine beauty moth by spraying 1300 acres with a bacterial specific bacterial preparation in 1977 (the year before pesticide was used) but without success.[101] Even if effective methods of biological pest control were developed, however, this would not justify the planting of monocultures. As readers of *The Ecologist* are well aware, the objections to any form of monoculture — whether in agriculture or forestry — are numerous; they do not need to be reiterated here. Suffice it to say, if we wish our forests and farmlands to be healthy, there is no alternative to good husbandry.

Fire

Conifer plantations are very susceptible to damage by fire, especially in their early years. In the first 5 months of 1980, fire destroyed over £1 million worth of timber, mostly Sitka spruce: 590 hectares of the Gwydyr Forest in Wales were lost, and in Scotland 200 hectares at Carrick and 120 hectares of the Areleoch Forest also went. More than 400 hectares of privately owned woodlands were destroyed too.[106] If plantations were planted less intensively — with more space between trees — the likelihood of fire would be greatly reduced.

Making Plantations More Irregular

Could it be, as Stevens has claimed[107], that "intensive forestry, whether of indigenous or exotic species, runs a serious risk of 'overstressing' the ecosystem and possibly doing irremedial harm"? Consider, for example, the case of conifer plantations. In West Germany Dr H. Kopp has stated that: "As a result of increasing knowledge of soil and site potential more and more areas that formerly only supported coniferous trees are being replanted with mixtures including hardwoods. This is especially so in state forests."[108]

Dimbleby has suggested that[109], in Britain, deep rooting broadleaved trees like alder and birch could be planted between conifers to help replenish the top soil with nutrients (if the conifers are not able to do this sufficiently) and make the humus less acidic. He actually initiated some experiments in the 1950s to test out his ideas, but a Forestry Commission experiment in Thetford Forest has shown that after 22 years the soil under alder has become more acidic[110], while 28 years after Dimbleby established his birch trials on Silpho Moor in Yorkshire, J.E. Satchell of the Institute of Terrestial Ecology has found that a highly acidic (pH 3.4) layer of litter, raw humus, and roots has built up[111]. Page has suggested[112] that soil conditions under both broadleaved and coniferous plantations could vary quite considerably during a rotation whilst coming back to some kind of mean towards the end.

Alternatively we could think of changing the species grown in the second rotation, since the improved soil and microclimate could tolerate less hardy conifers or even broadleaves. In West Germany Ulrich has reported that: "In the north of the country, where pine was planted extensively in the last century, Douglas fir and oak may now be used, with Scots pine being restricted to areas of poor soil."[111]

The extent to which plantations could be made more irregular would be limited by commercial considerations, but even Dr David Johnston, the Forestry Commission's Head of Research, has said that: "Despite the lack of firm evidence about the biological benefits of irregularity, apart that is from a specialised aspect of conservation, most foresters feel intuitively that it is undesirable from the point of view of prudent management and of aesthetics to create large areas of very uniform forest."[113]

In Czechoslovakia, the forests consist of mixed stands, worked on a partial-cut silviculture system with an occasional longer-than-usual rotation, both artificial and natural regeneration, with reforestation distributed over a number of small areas. Operating such a system is very costly,[114] and this would apply also if we had an intimate mixture of a number of species in each stand. We might find with mixtures of conifers and broadleaves, as with alder and sitka spruce [110],that one of them (in this case spruce) shades out the other. On the other hand Lord Dulverton grew beech interplanted with larch hoping for an eventual hardwood crop, only to see his beech struck down by disease and have to let the larch grow through to maturity.[115] John Workman has pointed out that 3 rows of spruce alternating with 3 rows of pine might be objectionable on aesthetic grounds since seen from a distance the plantation would resemble striped pyjamas![116]

David Johnston thinks: "The answer is surely that the unit of variability is not the stand but the forest. A variable forest can comprise a large number of uniform stands of different ages and specific compositions, the scale of variability depending upon a number of factors, including the size of the forest, the nature of the landscape, the variability of the site, the climate, and the objectives of management."[112]

Having a mosaic of different species, planned according to the distribution of soils over the forest site, will prevent the outbreak of disease or pest attack in areas of poor growth that are inevitable if a single species is planted indiscriminately, and can also serve as insurance against a fall in demand for a particular species or growth being threatened by a plague of insects as in the case of the Lodgepole pine. We should be putting a lot of research effort *now* into developing irregular silvicultural systems that make both economic and ecological sense.

One possibility is the Bradford Continuous Cover System, developed by Lord Bradford as an alternative to continental selection methods (such as those in Czechoslovakia) which have been found inappropriate to this country (see: *The Ecologist*, June 1980). The woodland area is zoned, according to natural boundaries, into a number of compartments, each of which is split up into a number of uniformly sized units containing 9 plots. Each plot is 6 metres square, large enough to grow a mature tree of the desired size and age, and so there are 30 units and 270 trees per hectare.[117]

With 9 trees, each grown on a 54 year rotation, one tree per unit can be felled every 6 years, in a spiral sequence that makes best use of the available light. The plot, after felling, is replanted with up to 9 young trees.

If we wish our forests and farmlands to be healthy, there is no alternative to good husbandry

The main species grown are Douglas fir, Western red cedar (*Thuja plicata*), Western hemlock (*Tsuga heterophylla*), Norway spruce, Coast redwood (*Sequoia sempervirens*), and southern beech (*Nothofagus procera*). All are shade tolerant, a vital precondition for the system, and nothofagus, while a broadleaved tree, can add 5-6 feet a year and match the conifers for growth. After felling a nothofagus only one tree, together with a cedar or hemlock nurse, is needed to replace it.

"This kind of hardwood-softwood mixture is particularly satisfying to me," says Lord Bradford, "and appears ecologically sound." The continuous tree cover reduces water and wind erosion of soil, a very important factor in the uplands generally and on the steep gradients found in most of Lord Bradford's Tavistock Woodlands where the system is being tried out. The uniform heights of even aged plantations are avoided, there is now more protection and hence greater survival of trees after planting and no more late spring frost damage. The flora and fauna are more varied, possibly introducing more biological checks on outbreaks of pests and diseases. Highly skilled management, felling and extraction are required, but Lord Bradford sees this as offering challenges to foresters that they wouldn't get in a conifer monoculture plantation.

Current research will enable us to be much more sophisticated in the silvicultural systems we employ, so as to ensure continuing production without undesirable effects on soils like deep peats, and also the acid brown earths which are found quite extensively in the uplands.[116,117]

Growing More Hardwoods

The role of the skilled forester will also be essential if we are to meet the future demand for high grade British hardwood. Forestry Commission hardwood expert Rod Stern says that: "Proper maintenance is absolutely vital . . . we should look much more at individual trees in the crop and spend much more time and effort on maintenance of these . . .Individual treatment of 100-200 trees per hectare should not be too costly." The days are gone when it may have been possible to plant several thousand oak or beech per hectare, then shut the gate and come back 30 years later.[118]

Broadleaved trees have been upstaged by conifers in recent decades and a good deal of effort will have to be put into modifying traditional silvicultural practices to present day requirements before bringing our 300,000 hectares of neglected broadleaved woodlands back into production. Mr Stern favours the growing of timber trees at wide spacings and, with the old coppice-with-standards methods appearing to fit the bill very nicely, Mr George Holmes, Director General of the Forestry Commission, has called for more research and development to bring them up to date.[119] The Commission's Research Station at Alice Holt Lodge in Surrey is doing a lot of development work on hardwood trees, e.g. experimenting with wide-spaced oak silviculture and doubling the rate of oak seedlings by surrounding them with transparent 3-4 metres high plastic tubes.[110]

New Trees for New Forests: Oak

Oak is the premier British tree but planting it does involve commercial risks because after waiting 100 years one might find that while some trees have high quality timber useful for furniture or boats, others may only be suitable for making pit props. Of 165 trees sold recently in the Darnaway Forest the average price was £29, while the best tree fetched £568. Neil Paterson[120] and Peter Wood [121] believe that we need a national oak development programme to select high quality cultivars, for if new oaks are grown from cuttings of trees which have previously produced sound timber, we would be confident of increasing the average final value by at least eight times, and there is also the possibility of reducing the rotation time to 50-65 years without loss of wood quality.

Birch

The potential of birch has been greatly underestimated because most of the good trees were cleared for agriculture, charcoal and bobbin wood a few centuries ago so that only an impoverished genetic resource remains. Finland has been breeding fast growing and good quality birch for over ten years, and although the timber is not that strong, it can be fabricated into plywood and the first batches came off the production line in 1980.

Inspired by the Finnish experience, an improvement programme for Scottish silver birch (*Betula pendula*), sponsored by the Aberdeen timber firm of John Fleming (Northern) Ltd., has just got under way at the University of Aberdeen, where Kennedy and Brown are looking towards producing 30 cm diameter birch on a 30 year rotation that is good enough to be turned into plywood.[122] In natural conditions birch spreads easily, but is known to be difficult to establish artificially. Dimbleby secured good growth from directly sown seeds, and after research the Forestry Commission is now obtaining higher seedling survival rates.[109]

Willow and Alder

Could trees become a major energy source again when oil runs out? A Swedish research team at the University of Uppsala, led by Professor Gustaf Siren, has been selecting fast growing varieties of willow for use in energy plantations. Out of about 3,000 clones from Siberia, Sweden, Finland and Canada, he has selected just ten, and is obtaining annual yields of 16-18 tonnes per hectare from the Q666 hybrid between *Salix caprea* (goat willow) and *S. viminalis* (osier). Sweden has no coal or oil and the possibility exists of using wood as the feedstock for power stations and for conversion into liquid fuels. With the 30 tonnes of wood that could now be harvested every other year being equivalent in fuel value to 10 tonnes of oil, Professor Siren estimates that Sweden could be self sufficient in energy if 7 per cent of the country were to be covered with 'energy farms' containing trees such as his fast growing willows.[123]

Although Britain has substantial coal reserves the Department of Energy is studying the potential that such energy farms have in this country. Certainly one quite likely market for 'superwillows' would be, as a replacement for elm wood, used by the more than 100,000 new wood burning stoves which have been installed in Britain in recent years.[124 125] The Henry Doubleday Research Association is conducting trials of the ten Swedish hybrids at 5 sites all over the country to see how well they grow here. Because the hybrids were originally selected to survive harsh Swedish winters,[123] they may not be suitable for Britain, but with conifers known to grow twice as fast in Scotland as in Sweden, Professor Siren's research may spur on a British team to do even better by starting with British stock.

There is certainly no shortage of land in Britain that would be suitable for growing willows, whether it be the inevitable "damp and useless" patch to be found on almost every farm, or large areas of derelict land on the banks of the Thames Estuary. Waterlogged areas in the hills could be planted with alder, and present varieties can be used not only just for fuelwood but for the production of hardwood pulp in place of eucalyptus. Hornbeam produces a high proportion of burnable wood [100] and its high heat of combustion was much valued in previous centuries by London bakers who used to buy wood for their ovens that was poached from Epping Forest.

Nothofagus

Southern beech (*Nothofagus spp.*) is quite a remarkable hardwood tree, native to Chile, Argentina, Australia and New Zealand, that has been pioneered in this country by Lord Bradford and which the Forestry Commission has found will grow as fast as conifers in the Welsh uplands. Used as a structural timber in Chile, it is expected to produce wood similar but slightly inferior to that of beech. Growth trials are now taking place in different parts of the country, and initially it appears that *Nothofagus procera* prefers wetter lowland areas while another deciduous species *N. obliqua* grows better in the eastern half of the country. Although nothofagus is an 'exotic', Britain could soon boast a really fast growing hardwood tree which is very similar in appearance to some of our native species.[126 127 128]

There is therefore a tremendous potential for developing 'new' trees to grow in our forests, but as George Holmes has warned, by introducing extensive cultivation of cloned hardwood species we could be establishing new kinds of monocultures that would be very vulnerable to attack by pests and diseases[129]. Great care must be taken to ensure that we can make the most of our trees without exposing ourselves to the risks of another massacre such as happened with Dutch elm disease.

How Much Land is Available?

There is plenty of land which could be used for the establishment of new forests. Farmland accounts for 80 per cent of our total land area, but is not being utilised to its best advantage. Between 1970 and 1975 an average of 20,000 hectares of top quality farmland was being swallowed up by the towns, factories, suburbia and motorways of the concrete jungle every year, with half a million hectares lost in this way between 1933 and 1963. According to Miss Alice Coleman, Director of the Second Land Utilization Survey of England and Wales, if we carry on like this we will lose most of our farmland within 200 years. Surrey will lose most of its agricultural land in 130 years, South Essex and North Kent in 87 years, and Merseyside in only 39 years.[130]

While our richest land is being thrown away, the poorest land is going to waste through neglect. There are about 6.145 million hectares of uplands, most of which are classified as rough grazing, and of which 70 per cent is in Scotland. But when Miss Coleman took a look at the 2 million hectares of England and Wales classified by the Ministry of Agriculture as rough grazing, she found that only half carried pasturable vegetation. The area of land going to waste in the English and Welsh uplands is therefore greater in size than the area under forest in the two countries![131]

The largest part (212,000 hectares) of this one million hectare wasteland is covered by bracken, the noxious fern that is spreading voraciously over moorlands, is lethal to grazing animals and therefore renders an area virtually sterile as far as farmers are concerned. Mat grass is also non-nutritious and unpalatable to animals and is also taking over large chunks of overgrazed areas (189,900 hectares). Both are difficult to eradicate but can be suppressed by fast growing conifers. There are 180,000 hectares of purple moor grass (marginal pasture); 149,100 hectares of damp ground covered by rushes (*Juncus spp.*); 27,911 hectares of gorse, 35,000 hectares of scrub woodland of brambles, briars and hawthorns; and 26,000 hectares on which *Festuca* rough grazing has been infested with scrub.

The Forestry Commission has located most of its plantations in the uplands (they account for a half of all forests overall), and is keen to establish more. The land is marginal for agriculture and therefore cheap to buy, and fairly good yields of timber can be obtained. After taking into account the 1 million hectares of land over 700 metres which are too high; 965,000 hectares classified as National Parks or Areas of Outstanding Natural Beauty; and 1.35 million hectares of watersheds draining into major reservoirs; there are 1.8 million hectares suitable for forestry but outside all areas where environmentalists and water authorities might find them objectionable.[44]

As many as possible of the new plantations need to be established in the next 30 years before an increasing amount of effort has to be expended in replanting existing plantations now approaching the end of their rotation. The maximum rate of planting is estimated to be 49,000 hectares a year between now and 2010 and at half that rate until 2030. Such planting rates are not so different from those achieved between 1970 and 1975, but since then the area of new forest established every year has been halved to 25,491 hectares in 1977-78.[44]

One of the main reasons for this decline is the slump in private planting, down to a third of what it was in 1974-75 and very serious when the private sector usually bears an equal share of the planting burden with the Forestry Commission. But the Commission itself has had difficulty in buying suitable land,[132] and while this may be due to temporary factors in the market, it does raise the question as to whether the theoretical amount of potential forest land can actually be translated into plantations.

Unfortunately it is also true to say that many landowners do not want to improve their lands and are content for them to lie idle. There are, for example, about 810,000 hectares of crofters' common grazings in Scotland, belonging to 700 townships of which most are moribund. One estimate is that there are over 404,000 hectares of such land in the hands of the Crofters' Commission which could be converted to forestry.[133]

There is such a huge area of deer forests — treeless areas like the old chases where red deer is bred and hunted — that the Government does not issue any official statistics about them, although the C.A.S. estimates that there are some 2.5 million hectares of sporting estates of which up to half are capable of afforestation[44]. Grouse moors, many being run in conjunction with low productivity sheep farms, account for another 1.2 million hectares. Some Scottish landlords are opposed to their tenants improving their properties by using lime, fertiliser, slag, and grass seed (as they are supposed to disturb the nesting of grouse) that the Highlands and Islands Development Board is seeking powers to protect the economy of these areas by encouraging farm improvement.[134]

"It is not to be denied," says the Board, "that sporting uses may have value to the local economy in some circumstances. However the figures of employment are very small and highly seasonal, and in many cases the revenue does not circulate to any appreciable extent in the local community." The Board is so concerned with fragile areas where community life is endangered by the "indifference and neglect of 20th century feudal lords" that it may even seek powers of compulsory purchase if all else fails.

Some Ecological and Economic Advantages of Growing Sweet Chestnuts

The loss of trees in Great Britain during the last decade has turned many regions into prairies. It is imperative, therefore, that the renewal of trees be implemented with vigour if our countryside is to hold any attraction for future generations of citizens, as well as for the many foreign visitors who rightly regard it as beautiful. To this end, it is worth taking a look at the sweet chestnut (*Castanea sativa*).

This species has for long been acclimatised in England. Sometimes called the Spanish chestnut, possibly because its nuts were imported from Spain, it was nevertheless introduced by the Romans who made a practice of sowing the nuts throughout their conquered lands. In Italy, Sicily, and other Mediterranean countries it is extensively grown as a forest tree, and in Spain it is so highly regarded as to be named the King of Trees.

Until about a hundred years ago, sweet chestnut was planted abundantly in England. It grows well in the warmer south and west, but splendid specimens are also to be found growing on the clay soils of Warwickshire and Gloucestershire. Faster growing than oak, it can quickly transform a bare landscape and, being deep-rooted, hardly ever topples in a gale. It therefore thrives as a single tree as well as within a forest.

As a species, it has a number of advantages. It produces a durable timber, especially if the trees are harvested before full maturity is reached. In the past, chestnut wood was extensively used for beams in large buildings and, because it is almost indistinguishable from oak, except in transverse section, certain buildings were once said to have beams of chestnut whereas, in fact, they were of oak. Westminster Abbey is a case in point. Nevertheless, there are plenty of examples, in churches and tithe barns, where the beams of chestnut are in as good a state as when they were first pegged together centuries ago. It seems to be the case that the wood is less prone to insect and fungoid attack than oak, for it is rare to find old chestnut beams riddled with the burrows of the death-watch beetle.

The trunk of the sweet chestnut is sturdy, deeply furrowed, and often spiral in form. Its full life can be as much as five-hundred years, but this often arises because of the union of several growths into one. For instance, the famous chestnut of Tortworth in Gloucestershire had a girth of 52ft. when measured in 1820. This same tree was referred to by John Evelyn (1620-1706) in his famous *Sylva*, and he also noted that in King Stephen's time (1135-1154) it already bore the title of Great Chestnut of Tortworth. Other huge specimens are to be found in Hatfield Park, Hertfordshire, and at Kew. The wood from such old trees, of course, is unfit for timber. In an open grate, sweet chestnut does not burn very well, but in a modern, closed wood-burning stove it is a useful fuel.

In the past, when about halfway towards its maturity, chestnut timber was used for wine casks. The hoops, also of chestnut, were in use on barrels made from oak because they did not rot when the barrels were stored in damp cellars.

Apart from the usefulness of its large timber, the sweet chestnut has another important economic advantage. It can be farmed for its fencing material. In Kent and Sussex some woods are still worked on an eight or ten year rotation. This means that the chestnut is coppiced in blocks, and each year one (the oldest), is cut for fencing. It is then left to grow again for the length of the rotation while the next block is harvested the following year; and so on until the first block comes into the rotation at the end of the eight or ten years. Yields per acre can be high and economically viable. Splitting the stakes and wiring them together to form the familiar fencing used on farms for a variety of purposes, or for temporary enclosures of building sites or public gardens, constitute skilled craftsmanship. Such fencing has a long life because it does not rot easily.

When chestnut cut in this way begins to show signs of deterioration, regeneration can be accomplished through layering branches from the old stools, or by replanting.

In some cases, coppicing is done in conjunction with the growing of standard trees for timber. In this way, the trees add to the beauty of the skyline, for they have magnificent crowns supported by downward-sweeping, stout branches, covered with dark green glossy leaves with toothed edges. A rich flora and fauna in the ground layer of such a wood is usually to be found in springtime, for the chestnut leaves and flower tassels create a rich soil. Ecologically, the tree has additional advantages in that the nuts provide food in autumn and winter for several species of birds, as well as for small mammals living in the undergrowth.

Most of the nuts which we traditionally use for stuffing the turkey at Christmas are imported. Trees growing in the south and west of England, however, yield a crop most years. Even in Gloucestershire, after the indifferent summer of 1980, one tree provided my household and those of several neighbours with enough nuts for all our culinary purposes. An amusing anecdote, again from Evelyn's *Sylva*, reads:- "The nut is a lusty and masculine food for Rustics at all times, and of better nourishment for Husbandmen than cole (a kind of cabbage) and rusty bacon, yea, and beans to boot! . . . ground into flour and made into bread it is a robust food and makes women well-complexioned."

There are still a few more advantages accruing from the sweet chestnut. Bees gather large quantities of pollen from the male flowers, and this is a boon to beekeepers. Unfortunately the female flowers do not carry nectar, but rely upon wind pollination for their fertilisation. They are therefore of no use to bees. As a tree, the sweet chestnut is relatively free from diseases, and so makes a reliable replacement for elms.

Archer Hilton

Funding the Forests

A large-scale reforestation programme could be implemented immediately given the political will. Unfortunately forestry's place in the British economy has been devalued in this century by cheap petroleum-based substitutes. Nevertheless, between 1967 and 1977 timber prices held their own against inflation[135] and can be expected to do at least as well in the future, bearing in mind the fact that wood is likely to be in increasingly shorter supply. Forestry does not yield quick profits, but in a world in which maintaining the value of one's assets is a constant pre-occupation for many people, the steady capital growth over 50 years (with an internal rate of return between 3 and 6 per cent) is a very attractive proposition for investment.[135]

Government economists can make forestry *seem* uneconomic[136] by means of what Price calls "a conceptual confusion between *rate* of output and *timing* of output". As Helliwell has commented: "If one adopts a discount rate of 10 per cent . . . even if it costs as little as £100 to produce a crop which will be worth £2000 in 50 years' time (at today's prices), it will be not economic to do so, as the interest charges will amount to more than £10,000."[136] It is possible to expect a handsome return on investment in (say) the extraction of coal or North Sea oil within a relatively short time because these are *non-renewable* resources that are already formed, whereas it takes time to establish a forest *renewable* resource before timber can be extracted. if, as in our case, our forest capital has been squandered and needs to be recreated.

Since our non-renewable resources are running out, it makes sense to use some of the proceeds from their utilisation for creating new renewable resources. Russell Fairgrieve M.P. has suggested in a Conservative Discussion Document[137] that national investments in forestry "could be financed out of North Sea oil revenues . . . thereby using the income from a finite resource to build up a renewable resource for the future." Stockbrokers Wood, Mackenzie have forecast recently[138] that in 1985 the Government will be receiving over £17 billion in oil revenues, and George Holmes has estimated that by investing an amount of money equal to half the value of a year's forest products imports (about £1.5 billion) we could reckon on saving half a billion pounds on imports every year in the future.[139]

At the global level Mr John Campbell, chief executive of the Economic Forestry Group has called for a proportion of OPEC oil revenues to be recycled into a World Forestry Fund.[140] Since oil, gas (and coal) came originally from the forests of hundreds of millions of years ago, it would only seem right to invest some of the profits accruing from their utilisation into the creation of the world's "third forest" of man-made plantations now that the second or natural forests are rapidly being used up.

Mr Campbell's plan for spending 5 billion dollars a year on reforestation for the next 20 years would cost overall the equivalent of the OPEC countries' current account surplus in one year (100 billion dollars in 1980)[141], and so is well within the bounds of possibility. The OPEC countries would find forestry a very secure investment and perhaps the one way of perpetuating their new found economic power, while the world monetary system would benefit from not having quite so much spare cash flowing around. Mr John Spears, Forestry Advisor to the World Bank, has estimated that for tropical countries to continue to supply the world with tropical hardwoods next century they will need to establish 150,000 hectares of new plantations every year (over 3 times the current level) at an annual cost of 150-200 million dollars.

The World Bank committed itself in August 1980 to spending nearly £6 billion over the next five years to help developing countries develop their own energy resources, in order to reduce the crippling costs of oil imports[142] which drove total current account deficits to an estimated £26.5 billion in 1980.[143] The Bank foresees the need to establish 50 million hectares of fuelwood plantations over the next 20 years to meet the demands for cooking and heating fuel in developing countries.[142]

Even a moderately successful reforestation programme in Britain will depend on how much encouragement is given to private growers. Grants, last substantially increased in October 1977, at present cover about 25 per cent of establishment costs,[144] and there has been an encouraging response to the Basis III scheme for forests composed mainly of hardwood trees, and to the Small Woods scheme which is aimed specifically at preserving woods of less than 10 hectares.[133] Russel Fairgrieve has called for grants to be increased, possibly to 90 per cent of costs, and for a system to be established by which farmers can draw regular advances on the final income from the forests they plant.[137] It has been suggested that some of the major clearing banks could introduce special schemes to promote investment in forestry, just as the Government has recently announced plans to sell North Sea oil bonds, and advances for growers could form an integral part of such schemes. However, E.G. Richards has argued that such advances would involve fairly high administrative expenses and it might be preferable to increase grants, either by means of a higher planting grant or extra grants for fencing and road construction.[145]

At the moment the planting of new forests is encouraged by a combination of grants and tax incentives. Part of the decline in private plantings in the 1970s must be attributed to Capital Transfer Tax (CTT), and while the Treasury has given some concessions in the last year or so,[146] there is still room for improvement. Mr John Peyton M.P. has suggested that the valuation of timber for deferred C.T.T. should be at the time of death, when the property is deferred, and not at the date of felling as at present.[147] The last Labour Government impeded the implementation of the draft E.E.C. Forestry Directive, which sought to give grants for up to 90 per cent of costs, because this would conflict with our present mixed tax incentives/grants system.[144]

Righting the wrongs of the Past

The forests of the future will depend upon the vision that we have today. To achieve parity with other European countries, we require a forest cover of at least 25 per cent and Richard St. Barbe Baker, Founder of Men of the Trees, considers that the optimum proportion is one third.

Forestry is not a lame duck industry which needs to be constantly subsidised, but neither is it a source of quick profits like North Sea Oil. Foresters, unlike oilmen, have to *produce* their resource before they can extract it, but once a forest is established it is a *renewable* resource which wil go on for ever, instead of a non-renewable resource like oil or coal that is finite and once used up is gone for good.

All the more reason, then, to use our North Sea oil revenues to right the wrongs of our ancestors — to establish a substantial forest capital for our children and our grandchildren. They will have to live in a 21st century that will be very different from the world we know today. The black gold of the oil sheikhs will have disappeared out of the end of our car exhaust pipes, and it will be the green gold of forests which will once again be a major source of wealth. We shall no longer be able to rely on the beneficence of nature, which took hundreds of millions of years to make the oil we are squandering today, but by planting trees we shall be able to establish a sound economy within the limitations imposed upon us by the finite resources of a finite planet.

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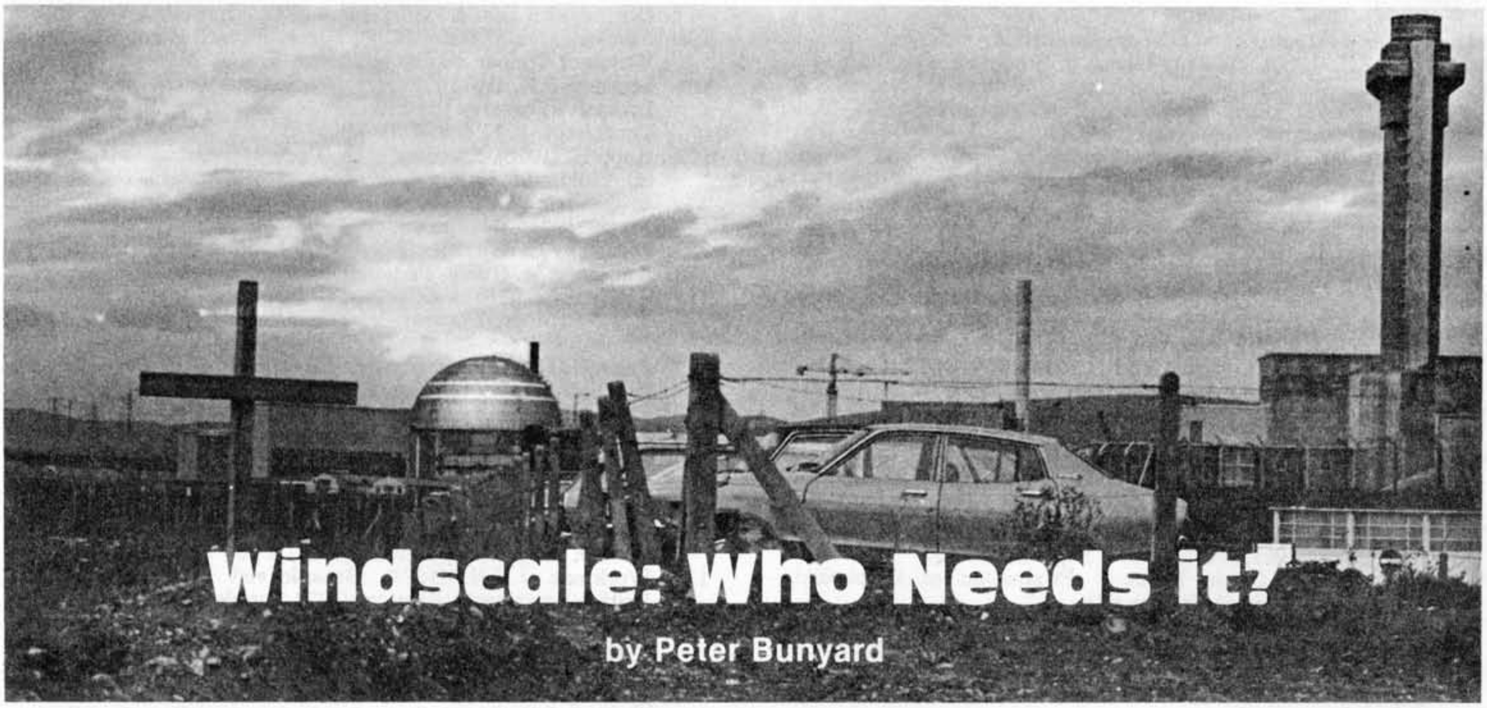


Windscale: Who Needs it?

by Peter Bunyard

Earlier this year, British Nuclear Fuels invited the editors of *The Ecologist* to their Windscale reprocessing plant. Peter Bunyard reports on the visit and the problems of reprocessing. How does Windscale compare to its French counterpart at Cap de La Hague? And is reprocessing really necessary?

During the last war, the government built a munitions factory on the western reaches of Cumbria, choosing a site between the coastal plains on the Irish Sea and the fells and lakes which make for some of Britain's most spectacular scenery. And it is on that same site, still shrouded in the Official Secrets Act, that Windscale's nuclear complex stands with its reactors, cooling towers and reprocessing works. Over the years the site has grown and developed to accommodate new projects such as the Advanced Gas Reactor prototype, a fast reactor fuel fabrication facility and storage space for spent fuel and its wastes. Nothing much has vanished from the site; it is easier for the time being to leave contaminated buildings intact, and the massive twin concrete towers that once funnelled huge draughts of air through the plutonium producing piles of the 1950s still stand stark against the skyline, sombre reminders of the Windscale fire of 1957.

By any standards Windscale is an imposing place. Hard driving from Cornwall had brought us to the fells by early evening and having left their shadowy masses behind us we could clearly see the orange glow of Windscale's arc lights as we approached nearby Seascale along the coastal road. Dense vapour plumes from the cooling towers of Calder Hall's four reactors gave the lie to reports that the station had been shut down. Early next morning, having arrived at the wrong entrance, we were given clearance to follow a BNFL police car through a maze of dirt tracks, past one construction site after another.

In sharp contrast to other industries throughout the country which are being affected by the economic recession, BNFL is clearly expanding its activities and taking on new labour — an expansion which underscores the company's confidence in Britain's nuclear venture. Indeed our hosts at BNFL had no illusions about the role that nuclear power would have to play in safeguarding Britain's fortunes. John Mortimer, the company's external public relations officer, saw social disintegration as a real possibility should society be deprived of sufficient energy. Whilst admitting that nuclear power would be a dangerous embarrassment in a society which had collapsed to the point that law and order could no longer be maintained, he argued that nuclear power would be the only sure source of energy to tide Britain over the inevitable decline of oil and gas production. Other countries could opt for softer technologies, those with a higher solar input for example, but if Britain spurned the atom, then come the energy crisis, it would be impossible to hold together the social fabric.

His colleague, Dr. Clelland who had journeyed especially from BNFL's head office at Risley near Warrington, went further. "We must come to terms with new ideas," he said, "We're moving out of the fossil age into a new era, and the public must learn to accept new technologies, such as the silicon chip, computers and nuclear power."

"Reprocessing is part of that technology, and it is the sole means of retrieving plutonium from spent reactor fuel. Turning one's back on plutonium would be sheer folly", Clelland insisted. "In the next century, countries which control plutonium will be among those on top. I don't want to be on the side which fails."

The Doubts Remain

Clelland's hard-hitting pragmatism is consistent with the case that BNFL presented at the Windscale public inquiry. At the time, the company argued that reprocessing was the only reasonable option for a country bent on nuclear expansion, not only because it produced plutonium in a useable form, but also because it provided the most satisfactory means of dealing with spent fuel. Mr Justice Parker, who chaired the inquiry, accepted BNFL's arguments and assurances that it could cope with any problems that were likely to arise from handling the technology of reprocessing high burn-up spent oxide fuel. He gave little credence to those who argued that the disadvantages of reprocessing far outweighed the benefits.

Yet the criticisms of Windscale and reprocessing technology remain as strong as ever; indeed recent government reports of radioactive leaks at the Windscale site raise doubts whether such operations can ever be made acceptably safe. And if BNFL is experiencing problems, so too is its counterpart on the Continent, the French Company COGEMA. Early this year COGEMA had to extinguish a fire in a high active waste silo at its Cap de la Hague plant on the Normandy coast. That fire follows an earlier, potentially more serious fire in a mains transformer one year ago. Meanwhile the Confederation Francaise Democratique du Travail (CFDT), the equivalent of the TUC, has taken COGEMA to task for putting its commercial interests before the safety of its workers and the general public by rushing ahead with the construction of thermal oxide reprocessing plants — French THORPs — before the technology and safety of an industrial size plant have been adequately proved. As at Windscale, spent thermal oxide fuel from overseas is already arriving at Cap de la Hague for storage in special cooling ponds.

The CFDT argues that the whole philosophy behind reprocessing rests on a series of dangerous assumptions: that the technology will work when scaled up; that workers' exposures to radiation will not increase, despite the greater radioactivity of the spent fuel; that discharges to the environment will be kept within reasonable authorisations; that the plutonium to be derived from spent fuel is actually needed, given the present-day surplus of reasonably cheap uranium; that reprocessing is the best solution for dealing with spent thermal oxide fuel. Since Windscale and Cap de la Hague are comparable in so many features, including each's commitment to take on the reprocessing of spent fuel from overseas, and in particular from Japan, the same doubts and questions remain in force for both.

Corrosion Problems

During the Windscale inquiry, BNFL made much of the need to reprocess spent fuel because of uncertainties over its being kept for extended periods under water in cooling ponds. Such a rationalisation was particularly relevant to the spent fuel from Magnox reactors which had been found to deteriorate quickly if kept for more than a year under water. Corrosion of the Magnox cladding thus caused it to become pitted and cracked so that the fission products, in particular caesium-137, were able to escape into the pond, which then became heavily contaminated. Reprocessing as soon as possible after extracting the spent fuel from the reactor seemed the obvious way around the corrosion problem. Within a year was the target.

But BNFL has run into difficulties with its B.205 magnox reprocessing plant, in particular with the decanning part which strips off the magnix cladding, like peeling a banana, from the spent uranium metal fuel. Consequently the company has failed to keep pace with the amount of spent magnox fuel being generated, and has had to stockpile it for longer periods than it would like in cooling ponds. Indeed in the mid 1970s the situation had got so bad that BNFL had to shut down the Calder Hall number one reactor and use its cooling pond as temporary storage for the overflow of spent fuel. BNFL now has more than 2000 tonnes of spent magnox fuel in pond storage awaiting reprocessing.

The unforeseen corrosion problems have led to an increasingly dirty discharge into the Irish Sea, the quantities of caesium-137 discharged alone going up more than a hundredfold in less than 20 years to 120,000 curies. Attempts are now being made to control caesium discharges by pumping the contaminated pond water through ion-exchange units.

Bread and Butter Plant

The magnox programme is now halfway through its expected life, the first reactors having come on stream in the early 1960s, and the last one, Wylfa, some ten years later. Accordingly BNFL anticipates having to reprocess a further 20,000 tonnes of spent magnox fuel in addition to that already reprocessed, the programme coming to an end by the late 1990s.

Certainly too the magnox reprocessing plant has been a profitable venture for BNFL and one which the company would not wish to see cut short. From that point of view it will be interesting to see what happens to the CEGB's magnox reactors in which cracks have been discovered in the carbon dioxide coolant circuits. Three magnox stations are now shut down while the cracks are repaired, at a probable cost of more than £200 million. For the CEGB, with its very large surplus generating capacity, it might make more sense to keep the disabled reactors permanently shut down rather than spend such vast sums on their repair, especially when they are more than halfway through their expected lives. But the government undoubtedly needs the plutonium which such reactors generate with comparative efficiency — some 600 kilograms for every 1000 MW - years of power, compared with 250 kilograms of inferior quality plutonium from light water reactors. Meanwhile BNFL needs an input of spent magnox fuel to maintain the profitability of its Windscale venture.

What are the Costs?

Because of the corrosion problem the reprocessing of spent magnox fuel is a necessity, furthermore because the capital costs of the B.205 plant have been virtually paid off, reprocessing can be carried out relatively cheaply. Thus reprocessing costs at present amount to a relatively small proportion of total fuel cycle costs. In its forecasts of the costs of operating advanced gas reactors, and presumably those of light water reactors should a series be built, the CEGB reckons on the fuel cycle costs remaining very much the same as for magnox reactors despite inflation. Thus the generating boards do not anticipate substantial increases, real or otherwise, in the cost of reprocessing the high burn-up thermal oxide fuel from

Of Pay-Packets and Mona Lisas

Earlier this year, BNFL invited Nicholas Hildyard and myself to visit Windscale — or at least those parts of it considered safe and accessible to visitors.

With a morning spent seeing fuel flasks delicately manoevered into cooling ponds and high active waste tanks under construction, we finally set off for lunch, passing the AGR prototype on the way.

It was just about the time that the three labour MPs had returned from their visit to Afghanistan and had commented how well the Russians were behaving themselves and how all must be in order since they had seen no signs of trouble. I remember saying that I felt a bit like them — that everything we had seen was extremely impressive, a veritable tour de force of modern engineering. We too had seen little sign of trouble but then we were not taken on a guided tour of the leaking silo, nor of the building where a sump with high active waste had been overflowing because no-one had bothered to empty it.

And even when we saw half a dozen men clad from head to toe in radiation suits, with masks and all, our guides did much to make light of the incident. "Oh, nothing to worry about," Nicholas Hildyard was told. "Possibly just a little airbourne contamination. More likely, they're wearing radiation clothing because it's a cold day — and they get paid double when they wear it."

During the visit, BNFL made no bones about the problems Windscale has experienced — the leaks were well publicised anyway — but was instead at great pains to show us how the company was getting its house in order, preparing itself for the great leap forward into Britain's nuclear future.

But is all the new technology going to work as well as expected? And at what cost? Without doubt, BNFL exudes a confidence about what it is doing which has certainly convinced those in government who control the purse strings and who are still happy to see a few billion spent here and there in these times of recession. And the technology will work we were told; just a simple matter of finalising the details on whether to use British or French processes or perhaps better still an amalgam of the two. In fact, the engineer who took us around Windscale was full of praise for British technology and, while we clambered up the scaffolding around a high active waste tank in the throes of being built, told us that we were looking at a 'Mona Lisa' of technology — a tank costing up to £5 million to build, with seven different cooling systems in case one or more should fail. And all to keep those deadly radioactive wastes safe from us until BNFL has perfected its Frenchified vitrification process.

We wondered what Da Vinci would have made of it all. Indeed, Mona Lisa's enigmatic smile may well be a prophetic comment on the whole venture.

Peter Bunyard

AGRs and LWRs, even though THORP has yet to be built and made operable.

Various critics, Vince Taylor in the United States, Colin Sweet in the UK and the CFDT in France, for example, have now shown from figures gleaned from the nuclear industry, that fuel cycle costs are likely to comprise a significantly higher proportion of overall nuclear costs, which themselves are rising rapidly once oxide fuel reprocessing and waste disposal are included. In fact, until such time as commercial size thermal oxide reprocessing plants are in operation, all the costs must remain speculative. But if past experience is anything to go by, they are likely to be exorbitant.

Past Attempts a Failure

The first-ever attempt at the commercial reprocessing of oxide fuel was carried out in New York State by the Getty-owned Nuclear Fuel Services company. NFS operated for seven years between 1966 and 1973, but soon ran into difficulties with the licensing authorities for excessive contamination both of the workforce and of the environment. The plant originally cost 32 million dollars to build and was supposed to have a capacity of 300 tonnes a year. In fact, during the time when it was working it reprocessed some 600 tonnes of oxide and metal fuel, the average burn-up being 6000 megawatt-days per tonne, and therefore some six-fold higher than the average burn-up of Windscale's reprocessed fuel. Its operating efficiency was therefore barely 30 per cent of that designed. In 1975 Getty claimed that he would need to spend 600 million dollars to modernise the plant so that it could comply with the current operating standards. In fact he abandoned the plant leaving New York State with some 600,000 gallons of high level waste to deal with, costing several million dollars a year in maintenance and a possible bill of more than one billion dollars, or more than 30 times the original cost, to decommission the plant and dismantle the site. Total clean up will probably be impossible owing to plutonium contamination of the site.

When Nuclear Fuel Services first came into operation, the press hailed it as a "breakthrough in remote operation", nevertheless by 1973 its 350 workers were receiving more than 7 rems a year whole-body dose from radiation, thus 14 times the 'safe' level recommendation of the International Commission on Radiological Protection. Meanwhile its discharges to the nearby Cattaraugus and Buttermilk Creeks were contaminating the waters far beyond the limit set by the State Authorities.

Another reprocessing plant at Morris, Illinois, which set out to use a novel 'dry' chemical aquafluor process to separate out plutonium and uranium from their associated fission products cost 64 million dollars to build but was found to be inoperable, and never functioned.

In the United States, stricter licensing laws have also prevented the Allied General Nuclear Services plant at Barnwell in South Carolina from ever operating although most of the construction work had been completed by 1975 at a cost of 250 million dollars. In fact the Nuclear Regulatory Commission insisted that an additional facility be built for converting liquid plutonium nitrate into plutonium oxide before a licence would be granted. Allied General estimated in 1977 that the plant would cost more than one billion dollars before it would comply with the regulations. Consequently the facility has remained shut down.

In 1974 the US Atomic Energy Commission maintained that the reprocessing of oxide fuels would cost some 30 dollars per kilogram. Two years later estimated costs had shot up seven fold, and that taking account of inflation. Expected costs of reprocessing thermal oxide fuel are still rising rapidly. In essence reprocessing costs will depend on how well the new plants operate; if they achieve no better than 50 per cent of their anticipated performance, then costs will naturally double. The German part of United Reprocessors, which has unsuccessfully tried to get planning permission granted for a giant spent fuel facility at Gorleben, in Lower Saxony, believes that a reasonable load factor will be obtained only by building in multiple redundancy in those parts of the plant most likely to clog up and breakdown. Such redundancy will add greatly to capital costs.

The French trade union, the CFDT, by dint of consultation with scientists working for the Atomic Energy Commission (CEA), points out that a major problem with the high burn-up of fuels of either light water or fast reactors, is radiolytic breakdown of the Purex solvent used for extracting out plutonium and uranium during reprocessing. In addition, high burn-up fuel contains proportionately greater quantities of ruthenium and zirconium, both of which inhibit the action of the tributylphosphate solvent, as well as breaking it down radiolytically. According to the CFDT: "These two phenomena combine and have to be counteracted by extremely sophisticated chemical processes. Meanwhile the efficiency of the process is affected and the quantities of insoluble products formed can create serious problems. The effect of all these factors is to diminish still further the load factor of the large industrial reprocessing plants."

Uncertain Technology

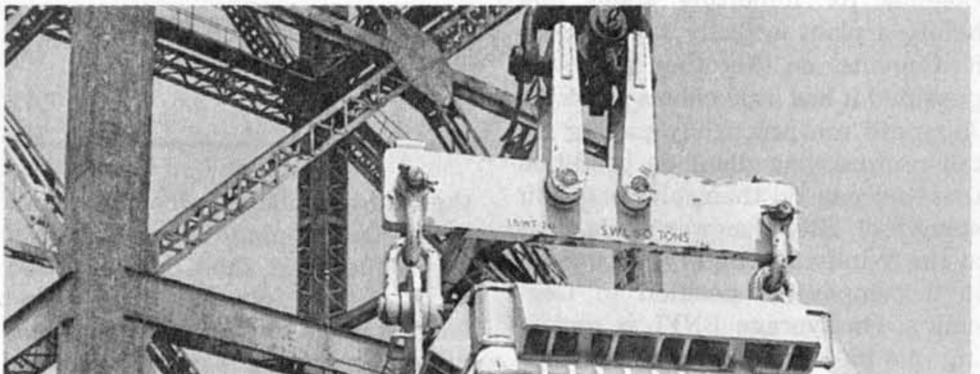
At the Windscale public inquiry, BNFL indicated that THORP would use pulsed columns as well as mixer settlers. The two technologies are comparable in that both aim to have the organic kerosene-based solvent passing in counterflow to the aqueous solution of dissolved spent fuel with its uranium, transuranics and fission products. The advantage of the pulsed column is that it offers a larger surface area of contact between the counter streams and hence should be more efficient in its use of space and of organic solvent. Its disadvantage lies in the complexity of scaling up to industrial size from a pilot plant and in its sensitivity to problems of radiolysis and of clogging up with insoluble radioactive fission products.

According to Dr Clelland, BNFL has not yet decided on the design parameters for utilising pulsed column in THORP; from what we gathered, the company may just stick to a series of mixer settlers comparable to those used in the existing B.205 magnox reprocessing plant.

Ultimately the efficiency of extraction will determine how much of the fission products and actinides get discharged from the reprocessing plant. The Cap de la Hague plant in France at present discharges some four per cent of the total radioactivity passing through the installation, some 30,000 curies per year getting flushed into the Channel. The French authorisation stands at 45,000 curies, which includes alpha, beta activity and tritium. As pointed out in *The Ecologist* (Nuclear Power The Grand Illusion) in May 1980, Windscale's discharges are more than six times greater overall, even though the throughput of spent fuel is just over double. BNFL has a particularly poor record with alpha discharges which are 66 times greater than those discharged from Cap de la Hague. Cogema in fact avoid such appallingly high alpha activity discharge by passing the effluent through a treatment plant which picks up plutonium and the transuranics. The plutonium-containing sludges which are formed as a consequence of this special treatment have then to be disposed of, generally by solidifying them in bitumen and embedding them in concrete, prior to dumping.

Can BNFL Keep Pace

Both Britain and France are stock-


BNFL

Unloading fuel flasks. Each flask contains some two tonnes of spent oxide fuel.

piling spent oxide fuel from overseas in preparation for starting up such reprocessing in earnest, the idea being at BNFL at least, that THORP will be ready by the time a year's throughput of spent oxide fuel will have accumulated in the cooling ponds. Both BNFL and Cogema have been building new cooling ponds, with all the latest equipment for pulling the spent fuel bottles out of the transport flask, and then for stacking the spent fuel under water for as long as is required. The entire operation in Windscale's new cooling pond is computer controlled, with an automated recovery system.

With a dearth of reprocessing plants of any magnitude elsewhere in the world, both BNFL and Cogema have set out to corner as much of the overseas market as they can. Dr Clelland was quite explicit that BNFL would like to manufacture nuclear fuel for foreign customers, irrespective of the reactor type used, and then get the fuel back for reprocessing.

The CFDT is extremely critical of Cogema for importing spent fuel before a plant is ready to reprocess it. Cogema, on the other hand, argues that it has little choice since the Japanese are practically paying for the reprocessing plant on condition that they can rid themselves of their spent fuel. BNFL, as was made clear at the Windscale Inquiry, sees itself in a comparable position to Cogema's. On average BNFL is receiving one flask from abroad every few days, each flask containing some two tonnes of spent oxide fuel. Britain's present AGR programme of five stations should, when all reactors are in operation, give rise to some 300 tonnes of spent fuel a year. Meanwhile Cogema is having to handle an ever increasing volume of spent oxide fuel both from France's rapidly expanding nuclear programme and from overseas. Indeed by 1988 the volume of spent fuel from France's PWRs will amount to some 1000 tonnes each year, and from overseas to 500 tonnes each year.

How much of that spent fuel will accumulate in the cooling ponds will depend on the speed with which Cogema's new reprocessing plants can be commissioned and on their load factors. Cogema's first reprocessing plant at La Hague, its UP2 plant, came into operation in 1968, its function being to treat the natural uranium metal fuel from France's magnox reactors. In 1974 a 'high activity oxide' or 'head-end' plant was built onto UP2 in order to adapt it for reprocessing thermal oxide fuel. The French government had taken the decision only a few months after the accident in the head-end plant at Windscale in which 35 workers were contaminated with ruthenium. The most heavily contaminated of all, Stanley Higgins, has in fact recently died of a massive heart attack at the age of 50, his thyroid having packed up in the years following the accident.

Cogema's head-end plant consists of a unit for receiving and emptying

> **"It's not only electricity they want from nuclear power. They also want the waste, the plutonium"**
>
> *Didier Anger, French ecologist*

the oxide fuel flasks, a cooling pond, a unit for snipping the zircalloy clad spent fuel into short lengths, and then a cell for dissolving those lengths in hot nitric acid. The hot solution, containing some 600 grams per litre of dissolved spent fuel is then diluted down to 300 grams per litre before being directed into the UP2 plant. Cogema was anticipating that UP2 with its head-end plant would be able to handle either 800 tonnes of magnox fuel each year, or 400 tonnes of the much higher burn-up oxide fuel; thus a ratio of two to one. The CFDT disputes that ratio and states that, on the contrary, "given the activities to be dealt with, and for a similar cooling period, one tonne of spent oxide fuel is equivalent to 3.2 tonnes of spent magnox fuel." Using that equivalence, the CFDT finds that the load factor of the UP2 plant averaged out at some 25 per cent from 1968 to 1974, and with marked fluctuations has just about doubled since then. As the union points out, Cogema's ratio of 2 to 1 would give a much poorer load factor figure in the years since 1976 when attempts were made to reprocess oxide fuel in addition to magnox. In 1976 Cogema treated 218 tonnes of spent magnox and 14.4 of thermal oxide fuel, in 1977, the figures were respectively 351 and 17.3; in 1978 372 and 36.9 tonnes. During 1979, Cogema treated 77.1 tonnes of oxide. Thus altogether, from May 1976 until March 1980 Cogema managed to treat 200 tonnes of spent oxide fuel from light water reactors, a figure to be compared with the 400 tonnes per year official capacity of the plant.

Cogema is now planning on sending all the spent magnox fuel to its other reprocessing plant at Marcoule which has been in operation since 1958. To date Marcoule has handled low burn-up miltary fuel, and critics wonder how the ageing plant will cope with much higher burn-up fuel from the French magnox reactors. Meanwhile the UP 2 plant no longer to be used for magnox fuel is to have its capacity doubled to handle 800 tonnes per year of spent thermal oxide fuel. In addition Cogema is building a new plant, UP3, to handle 1600 tonnes of spent thermal oxide fuel a year. With all that added capacity Cogema reckons that it will keep abreast of demands which will top out at 1500 tonnes per year. Thus, by 1990, Cogema expects to have a total capacity of close to 2,500 tonnes.

The CFDT believes that Cogema's plans are extravagant, unrealistic and dangerous. Since it takes a minimum of eight years to construct a new reprocessing plant, and then another two years to test it out before passing hot material through it, the union anticipates that it will be 1988 before the extended UP2 is in operation. On the assumption that the existing UP2 will clear 150 tonnes per year, the CFDT points out that by 1990 some 11,500 tonnes of spent oxide will have accumulated on the Cap de la Hague site. Cogema is proposing to build three cooling ponds, each of 2000 tonnes capacity. CFDT wonders where the surplus spent fuel is going to be stored. Should Cogema achieve 200 tonnes of reprocessing each year, then the accumulated stocks will be barely below 11,000 tonnes — still an embarrassing amount.

Pollution from Discharges

On present performance Cogema will reach its authorisation to discharge 45,000 curies each year of alpha, beta activity and tritium on reprocessing some 250 tonnes of spent oxide fuel each year. Clearly it will have to improve its overall decontamination of the discharge by a factor of at least six once it begins reprocessing some 1500 tonnes each year. On the other hand the French government might increase its authorisation. A precedent for such action was indeed set by the British government which increased the permitted discharges from the Windscale site into the Irish Sea by a factor of three. When operating THORP, BNFL claims that discharges into the Irish Sea from Windscale will be kept within present authorisations, the necessary decontamination being achieved through a system of filters, ion-exchange units and through a presumed more efficient solvent action on the dissolved spent fuel. There was talk too, at the Windscale Inquiry of putting in some form of extractor to capture krypton, which at present is released in its entirety into the atmosphere, together with tritium gas and carbon-14. In fact, it is most unlikely that either THORP or the French reprocessing units will have any provision for krypton capture. In West Germany meanwhile the licensing authorities are insisting that the reprocessing plant proposed for Gorleben must be fitted with some means of containing krypton.

The liquid discharges from Cap de la Hague, while not nearly as large as those from Windscale, must be taken well clear of the coast in order to facilitate their dispersal. The pipe used on land, prior to being submerged in the sea, is made of plastic which has stood up appallingly badly to conditions of use; indeed it ruptured at least 39 times during 1976 to 1977, on one occasion contaminating the water reservoir which supplies the reprocessing plant. The submerged part of the pipe is made of metal and is 5,500 metres long. The actual release of the radioactive discharge into the sea is made 1,700 metres from the coast and at a depth of 28 metres. In order to test for any leaks, samples of algae are taken along the length of the pipe, and are then assayed for various isotopes, including ruthenium, strontium-90 and caesium-137. On the last day of the year in 1979 one such analysis indicated a leak. Two days later divers found a break in the pipe which was then repaired. Two weeks later the pipe began to leak again, the director of the reprocessing plant informing the press that the hole was no bigger than a 5 franc piece, and the contamination of the shore area trivial.

The episode then took on all the farcical aspects that have become associated with radiation leaks into the environment; the establishment for its part offering to consume a load of sea food for one year from the contaminated area to show the public how little there is to fear; and the CFDT and other representatives of the people's interests coming up with rather different figures. The man sent down by the Central Service for Protection against Radiation — the SCPRI — was a certain Professor Marc Doucet, who on completing his investigation announced that he was "personally ready to eat shell-fish from the contaminated area for a year", that the risk was comparable to that which "I take when I spend 15 days in Brittany in coming from Paris", and that to prevent people fishing in the contaminated area would be "like forbidding people to live on the 20th floor of a tower block where they are subjected to higher levels of cosmic radiation than those on the ground."

"In the next century, the countries which control plutonium will be amongst those on top."

BNFL Official

The CFDT was curious to know why Professor Doucet had been sent as an independent investigator when he in fact worked for the Atomic Energy Commission, and why his supposed impartiality always led him to choose the smaller of two figures concerning the concentration of radionuclides in certain organs of the body. As a consequence of Doucet's glaring bias, the CFDT decided to set up its own investigation, sending marine samples to separate laboratories. The results showed that fishermen eating produce for a year from the contaminated area would get a whole body dose one fifth that of the maximum permissible, but nonetheless ten times higher than that announced by the learned professor. While the figures did not seem particularly alarming in themselves, the CFDT was concerned at the discrepancy between its investigation and the official one. Was the public being duped on every occasion after a radiation leak?

Silo Fire at La Hague

In fact, the silo fire at La Hague, in January of this year, and one year after the discovery of a break in the waste pipe, is another telling example of the management's efforts to cover up a serious contamination incident. The CFDT claims that the fire in a silo containing pieces of magnox cladding and graphite began eight hours before the officially accepted time, and had contaminated the air around certain buildings to levels far above the maximum permissible concentrations for the general public, as much as two hours before the internal fire service went into action. Meanwhile the raised radiation levels in the air had triggered alarms at the main gate two kilometres downwind from the silo, the management raising the threshold levels on the alarms to switch them off.

The fire service, when it did get to the site of the fire, tried putting it out with water, only to raise clouds of radioactive steam, which contaminated as many as nineteen of the firemen. The fire service then had to wait another eight hours for a tanker containing liquid nitrogen to arrive, the nitrogen being successfully used to put the fire out. Because the management refused to admit to generalised contamination of the site, many of the workers drove home with contaminated cars and clothing, thus taking radioactivity into their homes. Since the accident safety engineers at Saclay have assessed that some 50 curies of caesium-137 were given off, 60 per cent of which fell-out on the site, and the rest on surrounding farmland. Despite the play-down by the French authorities, the Dutch government has been asked in parliament to ban all dairy products from Normandy, at least temporarily.

Leaks at Windscale

In recent years, BNFL has also been embarrassed by discoveries of serious leaks from various installations. The silo leak was first noticed in October 1976 when BNFL found high levels of radioactivity, washed by heavy rains, in the excavations that had been dug for an extension silo. The leaking silo had come into use in 1964 as a receptacle for the contaminated cladding stripped from spent magnox fuel, and by 1976 its six compartments were already full. Because there is a possibility that magnox fragments, particularly in the form of dust particles will catch alight if exposed to air, the contents of the silo are kept under water. However the magnox strips tend to corrode under water, the reaction yielding heat and hydrogen, which has to be ventilated out from the silo. Later silos have been built with cooling circuits to keep the temperature of the concrete down to ambient levels.

In retrospect, BNFL suggests that the leak may have begun in 1972, since in August of that year, it had evidence that the concrete overheated through a 'corrosion excursion'. Since then as much as 50,000 curies may have leaked out, nearly all of it caesium and just five per cent strontium. Indeed some pockets of soil exposed during the excavation are giving off absorbed dose rates of up to 1200 rads per hour into the air, but a more general level is 500 rads per hour. Altogether BNFL reckons there to be 130 cubic metres of contaminated soil, but it has still to decide where to dump it. Meanwhile a small amount of radioactivity has made its way to the boundary of the site in the groundwater system. Whether that contamination is from the silo leak or from other operations at Windscale is not known.

What to do with the leaking silo and its radioactive contents? The nuclear installations inspectorate admits that it is at a loss, and in its report stated that "the positive and preferred method of stopping the leak is to empty the silo, but no equipment for safety doing this exists at present."

The Inspectorate takes BNFL to Task

But if BNFL could not foresee that magnox cladding should give it so many headaches, it should have avoided the bungling that went on between buildings B.212 and B.701. The first sign of a leak was in April 1978. As a consequence of the silo leak discovered a few months earlier, BNFL had called on the Institute of Geological Sciences to carry out a thorough investigation of the contours of the water table beneath the site and the direction of flow of groundwater. In the course of its survey, the Institute sunk a borehole near to the northeast corner of building B.212 and discovered that water collecting in the hole was radioactive.

Immediate testing of the water showed that it had become contaminated with fission products which by their constitution must have been irradiated in a reactor twenty years previously. According to BNFL a spill of high active waste liquor on its way to be tested at Harwell for vitrification experiments had occurred at that very spot and time.

A second test was then carried out, and to everyone's astonishment showed that the radioactivity now in the hole was such that it must have come from a reactor only two years previously. Clearly there were two separate contamination incidents, one of them very fresh and with no obvious explanation. To find out if the leaks were from the nearby buildings, BNFL bored holes in the walls to insert video cameras. In fact the high radiation levels in both buildings made it impossible for personnel to enter and see what was happening. Nothing wrong was found in B.212, but in B.701 a sump beneath a high active waste storage tank was found to be brimming full with liquor and near to flowing above the top of the metal clad surface in the base of the building. On analysis the liquor proved to have the same isotopic composition as that found in the borehole.

In its investigation of the leak the NII discovered that the last time building B.701 had been in use was in 1958 when the final consignment of radioactive liquor was sent to Harwell. The building had been designed specifically to allow high active waste to be diverted into it for sending away to Harwell, the diversion taking place by means of either one of two special manually operated 8-way diverters in building B.212.

The sump in B.701 is designed to capture any radioactive waste spilled or overflowing from the tank above in case of an acccident, and its capacity is about 70 litres. Plant operating instructions demand that the sump vessel should be emptied when the level of liquor in it reaches 30 centimetres and that indeed was the practice with records being kept until 1973 when through oversight they were stopped. In 1976 BNFL renovated the gauges indicating the levels of liquor in the tank and sump and by the end of November 1977 was again taking and recording readings.

Before April 1971 the sump used to be emptied at least every week, but then something went wrong and sump would not empty. Instead of investigating what was amiss and repairing it, BNFL allowed the liquor in the sump to arise out of the vessel and into the area surrounded by the metal cladding. Sump levels were then recorded as being over the top of the calibrated gauges.

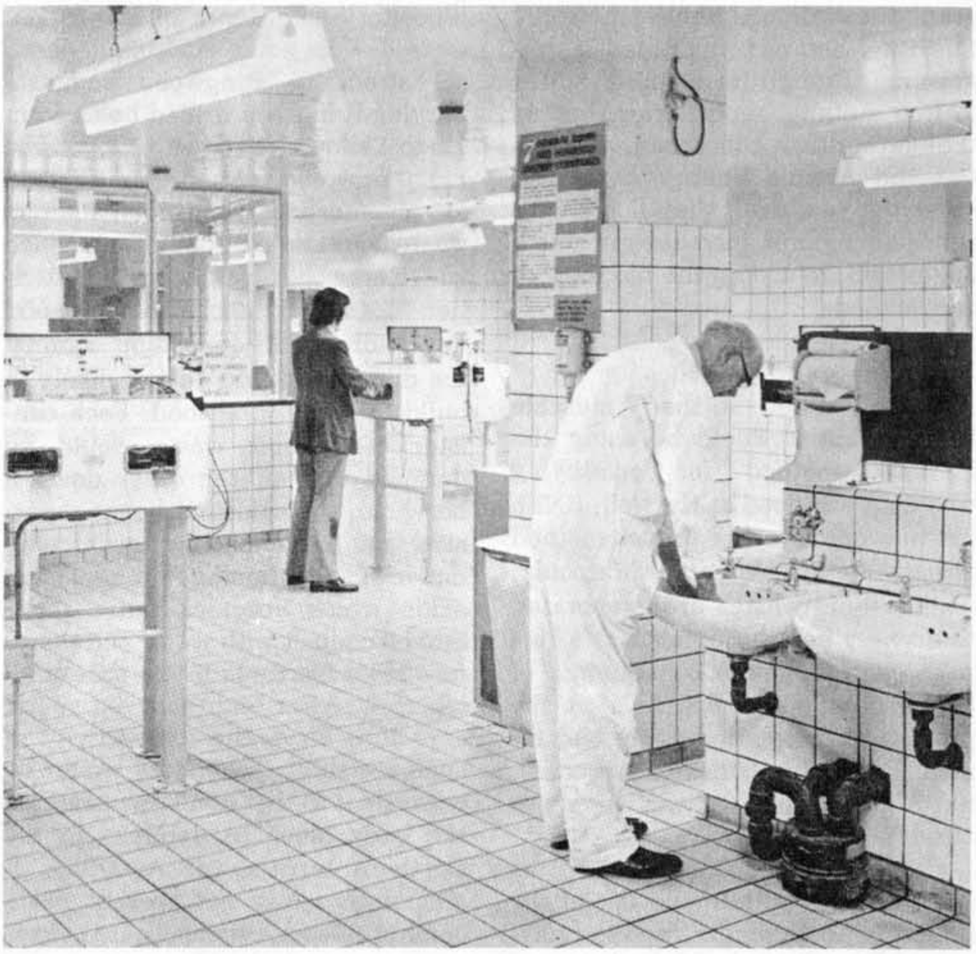
In tracing back what had gone wrong, and might be a possible cause of the present leak, the NII discovered that at some time in the past the sump emptying line had been cut and capped. BNFL's excuse for that aberration was that it had thought the line to be for taking samples and not for emptying the sump, and that since the building was no longer in use, the liquor inside the building was non-radioactive.

In March 1979, the sump level gauge showed that the liquor was well below the top of the sump, however when BNFL set up its video camera, it discovered to its surprise that far from being at a safe level, the liquor was well above the sump vessel and within a few centimetres of the top of the metal cladding. It then replaced the gauge with one capable of larger measurement which confirmed the high reading. In its report the Inspectorate suggests that "the pointer on the original circular 0 to 50 centimetre gauge had, in fact, been traversing the gauge on its second circuit. BNFL has since carried out tests which confirm the feasibility of this."

The radioactive liquor was found to have got into the sump by splashing over the divider when the diverter was set to the adjacent channel. The splashed liquor then ran into the tank in B.701 but that was completely full and therefore drained automatically into the sump. Since BNFL already had experience that radioactive liquor would splash over the divider in the diverters, and since it knew too that the sump lay beneath a full high active waste tank, the NII finds it hard to understand BNFL's careless attitude in the period prior to the discovery of the leak. As to the fitting of a gauge which was half the size it should have been, so that the needle went round twice, it was a demonstration of dangerous incompetence. The NII took the management of BNFL to task for "lacking in the level of judgement and safety consciousness expected." Nevertheless it did not intend to presecute the company.

The leak to the outside was through a defect in the metal cladding, and BNFL estimated that more than 10 cubic metres of radioactive liquor, containing more than 100,000 curies had escaped. In its survey of the outside contamination BNFL found maximum radiation levels of up to 600 rads per hour at a depth of four to five metres.

In reply to the NII asking whether B.701 could be taken out of commission BNFL pointed out that it would be faced with certain technical problems and that it could lead to excessive irradiation of the workers involved. It would first have to build a full-scale model on which to test pipe-cutting and welding techniques. Just what it proposed to do with the full storage tank in B.701 it did not say. The contents of that tank will remain dangerously radioactive for thousands of years, given the plutonium contamination of high active waste; meanwhile the high levels of strontium and caesium in the wastes would remain active over a period of more than 500 years.



CEGB

Checking for contamination. Between 1971-75, workers at Windscale received average radiation doses of 1.20 rems/year — nearly three times the ICRP's 'safe' level. By comparison, the average dose received by La Hague workers was .38 rems/year. Does La Hague's lower throughput explain the difference?

Ultimate Disposal: the Big Question Mark

At the present time BNFL has some 1000 cubic metres of high active waste stored in double walled stainless steel tanks, the latest models fitted with seven different cooling circuits including one between the two steel layers. In general BNFL is now filling one 150 cubic metre tank every 18 months. For safety purposes, in case a tank has to be evacuated in a hurry, for every three tanks put in use, one is left empty. The tanks which are made of special high chromium steel, and are rigorously inspected during their construction, cost up to £5 million each. So far, according to BNFL, no high active waste tanks have failed at Windscale. By way of contrast, a number of tanks have leaked at the US Hanford site in Washington State, with serious contamination of the ground beneath the tanks, and finally of the Columbia River itself. BNFL claims that the failures came about because the Americans were using a mild steel during the late 1940s and 50s, together with an alkali rather than acid process for dissolving spent fuel.

The conventional approach to the problem of ultimate waste disposal is first to solidify the liquid wastes in such a way that they will remain stable and trapped, and then to find a suitable geological repository in which to dump the solidified wastes, presumably for all time. However immediate solidification of the high active wastes is not a solution because of the heat generated by the radioactive block, which in the first few years after reprocessing would be sufficiently intense to melt the binding material. The strategy therefore is to let the hot wastes simmer for some years in the tanks before solidifying them and then to keep the solid blocks in an artificially cooled environment — preferable gas-cooled — to prevent the possibility of the block leaking its contents into water. Only when the block has reached a low enough heat production so as not to melt itself when no longer artificially cooled will it be safe for ultimate disposal. But which geological structures to use? Clay, granite, salt domes, the sea bottom? The EEC has now instituted a programme through its member states to find suitable repositories, but as the authorities concerned, in Britain the Atomic Energy Authority, set out to test drill, they find themselves up against increasingly active opposition, including the blocking of access roads.

Vitrification and its Critics

Having stated at the Windscale Inquiry that it would be using the Harvest method for solidifying wastes, developed at Harwell, BNFL has now opted for the French method already being tested at Marcoule, where liquid wastes are evaporated to dryness before tipping into a furnace containing the constituents of borosilicate glass. BNFL is in the process of completing a test bed for an industrial vitrification process, but will use non-radioactive simulated waste.

Glass vitrification of the wastes has its critics both in and out of the industry. Several years ago the physicist Jean Rossel referred to experiments at the University of Grenoble in France which indicated that the blocks would in all likelihood disintegrate long before their supposed lifetime of millennia. After 10 years of interim storage under forced air cooling, a block of 200 litres would give off some half million curies and produce 3 kilowatts of heat. Later, when deposited underground, the block would irradiate the surrounding rock with some 10,000 million rads per year. The evidence suggested that the salt or rock would disintegrate under such bombardment and that as a consequence its capacity to transfer heat would be impaired. The vitrified block would then begin to overheat and Rossel suggested that temperatures of 600°C might be reached inside the block, at which point the glass would begin to melt.

Another critic of vitrification is the Australian physicist, Ted Ringwood. He suggests that waste be encapsulated into a solid ceramic material called SYNROC, which according to him will have far more stable properties than glass. The ceramic material will then be contained in metal canisters some 3 metres long and half a metre in diameter. But instead of putting the canisters in a mined-repository at a depth of 500 to 700 metres — in some suitable geological strata — Ringwood suggests burying it in deep drilled holes from 1.5 to 4 kilometres down.

There would therefore be no need for a centralised repository and the waste could be dumped over a much wider area than has been the intention to date. By decentralising solid waste disposal, opposition against the dumping would be less likely to build up, says Ringwood. Each canister of ceramic waste would be dumped one on the other down a borehole, the canisters being separated by a compacting cushioning material containing magnesium oxide which becomes water resistant on contact with water and therefore seals fractures in the surrounding rock. After one thousand years, says Ringwood, the radioactivity of such a string of canisters would be equivalent to that of a large uranium ore body, such as Jabiluka in the Northern territory of Australia. It should therefore not present particular problems, especially as the ceramic material is akin to the more stable rock materials found naturally. However BNFL is scathing of the SYNROC process, believing that the scientific basis for its working is virtually non-existant. "Ringwood has been good at two things," Dr Clelland told us, somewhat scathingly. "Having first criticised the vitrification process, he then went out to promote his own."

Recycling Plutonium; Can we Afford it?

Although such solutions, whether vitrification or ceramication, have the appearance of being neat and simple and of tidying up the dirty loose end of the nuclear fuel cycle, they are studded with obstacles and pitfalls. The evaporation and solidification of wastes must take place at high temperatures and inevitably radioactive gases are given off. These have to be trapped and contained. Furthermore the equipment must work efficiently and safely despite a barrage of radiation. Pilot points and bearings have to be kept lubricated and maintained, even though materials do not wear well in an intense radiation field.

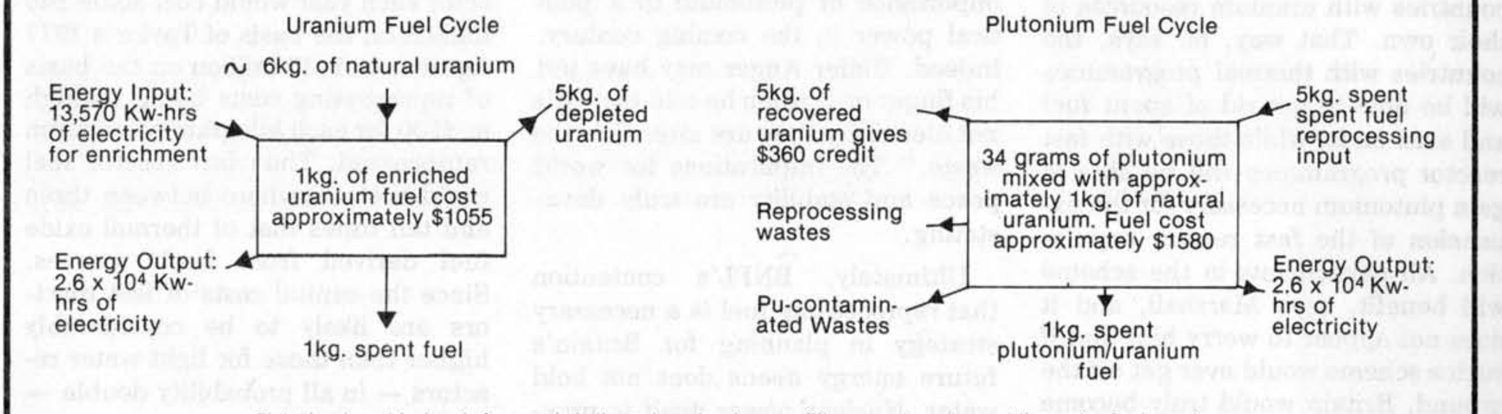
Why should the nuclear industry go through all such a palaver to deal with wastes? As a number of people have pointed out, thermal oxide spent fuel is already in solid form when it comes out from the reactor and is stable in water, unlike magnox fuel. Would it not be better to keep it in that form, rather than go through the extraordinarily complicated, dangerous process of liquifying the waste and releasing radioactive gases into the environment?

At the Windscale inquiry, BNFL put the case that the extraction of plutonium and uranium from spent fuel was a sensible course of action both because it considerably decreased the length of time that high active waste would remain dangerously radioactive, and because of energy conservation. Thus the plutonium and uranium gleaned from spent fuel would provide an additional 40 per cent of energy if recycled in a thermal reactor system.

On the face of it, the recycling of fissile material from spent fuel would seem to make economic and practical sense; in reality nothing could be further from the truth. Naturally enough the economics of recycle depend on the real price of uranium; yet at the present time there is a glut of uranium on the market because of faltering nuclear power programmes in the world, particularly in the United States where no new reactors have been ordered for three years, and many other existing orders have been cancelled.

The next point is the actual cost of the reprocessed uranium and plutonium compared to an equivalent amount in energy terms of enriched uranium, the uranium being freshly mined. In 1977 Vince Taylor of Pan Heuristics calculated that the cost of utilising one kilogram of uranium enriched to 3.4 per cent would be 1055 dollars. That cost included mining and milling, conversion to hexafluoride prior to enrichment, enrichment and fuel fabrication of uranium oxide. To extract out an amount of plutonium that would provide an equivalent amount of power would cost 1,580 dollars. That cost included reprocessing, plutonium nitrate conversion to its oxide, and fuel fabrication. In neither case did Taylor include the costs of storage and disposal, although he reckoned that the vitrification pathway needed after reprocessing would be more costly than dealing with untreated spent

Throwaway versus Recycle



Plutonium-based fuel cycle for recycle in thermal reactors incurs a fifty per cent greater cost than using fresh uranium. (Adapted from Vince Taylor, 'Swords from Plowshares', University of Chicago Press, 1977. All dollars are at 1977 value.)

fuel. In deriving the figure for plutonium extraction, Taylor gives a credit for the uranium gained, which in fact is slightly enriched over and above natural uranium, one kilogram of uranium from spent light water reactor fuel being equivalent to 1.1 kilograms of natural uranium.

Clearly the economics of recycling uranium and plutonium will depend principally on the price of uranium and on the cost of reprocessing. Taylor used a figure in 1977 of 300 dollars per kilogram of spent fuel. The CFDT in France today reckons on a figure that is four times higher — in other words some £500 per kilogram.

Contamination Problem from Plutonium Recycle

But there are other fundamental problems associated with the recycle route. Thus each time uranium passes through a reactor it becomes contaminated with newly made uranium isotopes and with transuranics. Some of these, namely, uranium-236 and neptunium-237, absorb neutrons and therfore tend to poison the chain reaction; meanwhile both neptunium-237 and uranium-232, of which there are traces in the recycled uranium, give out considerably more radiation than fresh uranium and pose problems in terms of radioprotection during the enrichment and fuel fabrication stages. Both neptunium and plutonium also tend to block the diffusion barriers during enrichment. The costs of overcoming all these problems have not been clearly defined.

The plutonium extracted during reprocessing is also not absolutely pure, and has fission products as well as small quantities of uranium associated with it. The presence of fission products — even as low as 8 millicuries per kilogram of plutonium — add considerably to the problems of plutonium fuel fabrication. The plutonium from light water reactors is likely to double the radiation dose to the workers, compared with the plutonium from magnox reactors. Furthermore each time the remaining plutonium is recycled, the proportion of isotopes heavier than Pu-239 increases; thus the plutonium gradually becomes less fit as fissile material.

Walter Marshall, now director of the UKAEA, agrees that plutonium recycle through thermal reactors is an uneconomic proposition, and only of partial benefit in terms of the gain in energy. The point he is making is that the plutonium should be used in fast reactor systems, where the energy to be gained is ultimately far greater. Moreover, since the plutonium gained in fast reactor systems comes from the blanket region through the transmutation of uranium-238, its quality will be similar to the plutonium derived either from magnox systems or military reactors. Hence the problems of plutonium gradually poisoning itself through constant recycling, as would occur in thermal reactors, will not apply.

The Costs of Plutonium Recycle

Yet aside from questions about fast reactor safety, the costs of plutonium fuel are likely to be staggering, given high reprocessing costs. In fact some four tonnes of plutonium are required to start up a 1000 MW (e) fast reactor of the Super-Phenix type. On the basis of Taylor's 1977 figures — four tonnes of plutonium would cost £185 million. The enriched uranium fuel to start up a light water reactor would cost approximately half that. Since then reprocessing costs have escalated and the cost of fast reactor fuel is likely to be double if not treble. The same escalation does not apply to thermal reactor fuel.

In the end, the reprocessing of fast reactor fuel will provide the plutonium to fuel fast reactors. As pointed out in *The Ecologist* (May 1980), the reprocessing of fast reactor fuel is not likely to be any cheaper compared with reprocessing thermal oxide fuel. Indeed the higher burn-up of fast reactor fuel, together with the high plutonium content will create particular reprocessing problems, especially in industrial-sized plants. The other problem in any proposal for operating fast reactors is the loss of plutonium within the system brought about through reprocessing. In a collation of all the evidence to date on plutonium losses from different reprocessing plants throughout the western world, the CFDT finds that such losses are likely with present technologies to be greater than the plutonium gains created within the blanket region of the fast reactor.

The Marshall Plan

The rationale of BNFL accepting overseas custom has been taken to an extraordinary logic by Walter Marshall. Because he foresees a plutonium shortfall in the first year of establishing a fast reactor programme, he argues in *Atom* that countries such as Britain without indigenous resources of uranium should offer to buy spent fuel from countries with uranium resources of their own. That way, he says, the countries with thermal programmes will be able to get rid of spent fuel and earn on it, while those with fast reactor programmes will be able to gain plutonium necessary for the expansion of the fast reactor population. All participants in the scheme will benefit, says Marshall, and it does not appear to worry him that if such a scheme would ever get off the ground, Britain would truly become a nuclear dumping ground.

In fact Marshall's proposals seem to turn all accepted economic notions on their heads. Can anyone imagine BNFL actually paying the Japanese for their fuel instead of getting a large part of THORP paid for by its overseas customers?

As it happens, the Japanese are becoming increasingly concerned about the poor image they are getting in the world through the export of spent reactor fuel. Increasingly people are demonstrating wherever ships such as Pacific Fisher, with their loads of nuclear waste, put into port. Last year, the Japanese sent a delegation to France to look into local anti-nuclear feeling around the Cap de la Hague reprocessing plant. According to Didier Anger, the ecology candidate from the nearby Flamanville area, they told him of their concern that Japanese car sales might suffer if people equate Japan with nuclear dumping. Rather than jeopardise their car industry, they preferred, he said, to build their own reprocessing plant.

According to Jun Ui of the Faculty of Urban Engineering in Tokyo, Japan is planning on building a massive reprocessing plant on one of its relatively uninhabited southern islands in the Pacific. The plant is to have a capacity of 1735 tonnes, enough to reprocess the fuel from other nuclear plants in South East Asia. Probably the plant will be built in the Mariana Islands because they are under US administration.

Why should countries such as Japan want to get involved in a dirty and dangerous technology as reprocessing when it appears to make economic nonsense? Why would they want to subject a population of workers to radiation, and why antagonise a large proportion of the Japanese people? The answer perhaps lies in Clelland's remark about the importance of plutonium to a political power in the coming century. Indeed, Didier Anger may have put his finger on it when he told us: "It's not electricity they are after, it's the waste." The implications for world peace and stability are truly devastating.

Ultimately, BNFL's contention that reprocessing fuel is a necessary strategy in planning for Britain's future energy needs does not hold water. Nuclear power itself is proving an excessively expensive energy source if used for anything other than providing electricity for premium purposes. Indeed, as far as the new AGR stations are concerned, the CEGB is unlikely ever to recoup its costs. Nor will the costs of establishing a reprocessing plant with all its associated facilities — the storage ponds, decontamination areas, high active waste tanks, and vitrification plant — be justified for Britain's relatively small programme of reactors which utilise thermal oxide fuel. As we have seen, the extra fissile material gained through reprocessing for recycle in thermal reactors costs considerably more than the cost of fabricating fuel from fresh uranium. On Taylor's figures there is a 50 per cent difference, the recycled fissile material costing 1580 dollars (1977) and the fresh uranium pathway, 1055 dollars for a kilogram of enriched fuel. More recent figures, put out by the French Electricity Board (EDF) suggest that while fresh uranium fuel for a year's operation of a 1000 MW light water reactor — with 3.4 per cent uranium enrichment — will cost approximately £15.5 million, the mixed oxide plutonium enriched fuel from recycling spent light water reactor fuel will cost more than double that at £38 million. If we apply the CFDT's reprocessing costs, which are double those used by BNFL and EDF at the time of the Windscale Inquiry, then clearly the difference between the two pathways will be greater still.

Meanwhile Walter Marshall has tried to justify reprocessing thermal oxide fuel as a means of establishing a fast reactor programme. Without taking fuel fabrication into account, which is considerably more expensive for plutonium-based fuels than for uranium, the two tonnes of plutonium needed to refuel a fast reactor each year would cost some £45 million on the basis of Taylor's 1977 figures, or £150 million on the basis of reprocessing costs being as high as £500 for each kilogram of uranium reprocessed. Thus fast reactor fuel could cost anywhere between three and ten times that of thermal oxide fuel derived from fresh sources. Since the capital costs of fast reactors are likely to be considerably higher than those for light water reactors — in all probability double — the likelihood of any country being able to afford fast reactors on anything other than a small experimental scale seems extremely remote. Nevertheless Britain now spends more on the fast reactor in research and development than on any other single energy project.

But it is not simply the reprocessing costs that militate against such treatment of spent fuel. The technology itself is fraught with difficulties and dangers, and not only is reprocessing the point in the fuel cycle where most environmental contamination occurs, it also leads to the highest exposure of workers to radiation. Windscale's record may not be as bad as that of the now defunct Nuclear Fuel Services of New York State, but it is still considerably worse than that of La Hague. Indeed the average radiation dose to workers at Windscale is more than double that at La Hague and is considerably above the 'safe' level of 500 millirems per year, as laid down in ICRP-26.

At the present time BNFL has embarked on a massive programme to tidy up Windscale and improve its image. Aside from THORP, the costs of building the new storage ponds, the new high active waste tanks, and the refurbishing of the ageing Magnox reprocessing plant, are amounting to some £1000 million. But can Britain really afford that money and the technology?

Some of the material for this article is taken from my forthcoming book NUCLEAR BRITAIN, £1.50. New English Library, Barnards Inn, Holborn, London EC1.

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Cancer and Nutrition

by
Ross Hume Hall

In searching for a wonder cure for cancer, scientists have overlooked the role that diet can play in preventing the disease.

The human embryo shortly after union of sperm and egg becomes a little knot of cells. Much like a golf ball, this gastrula consists of an inner core and a middle layer all covered with a skin of ectodermal cells. The two inner layers evolve into one's organs, muscles, bones, glands. The outer layer develops into the sense organs, the nose, hair, parts of the skeleton and the nervous tissue. With further division, the gastrula begins to contort, folding into itself. This invagination becomes the alimentary canal from the mouth to anus and other inner surfaces.

The embryonic origin of these tissues persists into the finished human. The ectodermal cells of the gastrula become the sheets of epithelial cells that line the gut, the ducts for glands such as breast, pancreas, thyroid, the lung tissue and, of course, one's entire outer skin. These cells are exposed to sunlight, everything that enters mouth or nose, and the fluids secreted by the glands. They wear quickly. In contrast to one's neurons, which, never divide after the age of six months or adult liver cells which divide only rarely except in response to chemical damage, cells of these tissues constantly renew themselves. Those of the intestinal mucosa, for example, turn over every two to three days.

All this cellular activity of the body's inner and outer surfaces proceeds with great regularity and precision over the 80 odd years of one's life. From a cellular point of view, the number of cell divisions is astronomical and indeed only with the rarity of a comet colliding with earth, a single cell out of all these divisions breaks loose from the normal restraints of tissue order. If it does it runs amok, becoming a cancer. In view of the billions of cell divisions, for the entire individual the event is far from rare. One out of four of us will contract cancer and three-quarters of us who do will succumb to the disease. Cancers can indeed arise from any tissue in the body, but about 95 per cent of all human cancers arise from those active epithelial cells.

Is cancer something ordained by an unlucky gene? Or perhaps we are all like so many agitated balls in a bingo machine, awaiting random selection by some mysterious force as a one-in-four victim. Until recently, it seemed one could do nothing to tip the chances in one's favour. But, note that cancer starts mainly in the rapidly dividing epithelial cells, those in direct contact with external substances. Could it be that external agents are in fact that mysterious force?

This theory is directly supported by the studies of Dr. John Higginson, an epidemiologist from the Internation Cancer Research Center, Lyons, France. After an exhaustive review of cancer statistics, he concluded that 80-90 per cent of all human cancer is caused by environmental factors under human control. Higginson's conclusions announced in the 1950s were generally accepted by the 1960s. They suggest that if one could identify causative factors, one could with certainty tip the chances of avoiding cancer in one's favour.

One's outer epithelial tissue, the skin, for example, is susceptible to the sun. Fair-skinned persons living in Australia, southern United States and other sunny climates, have an almost 70 per cent chance of contracting skin cancer by the age of 65. Such cancers don't threaten one's life, they are readily visible and can be avoided just by wearing clothing. Would that all cancer causes were as easily identified and dealt with. A cancer of one's internal epithelial tissue is quite another matter. Invisible, unfeeling, it originates, grows and threatens life long before the host or any modern medical technique can detect its presence.

If skin cancer can be avoided by wearing clothing, what can one do about internal exposure? The alimentary system of each of us must push a ton of moist food every year down its length. We drink every year about a hundred gallons of pop, water, milk, beer, etc. It was not surprising, therefore, when scientists at the National Cancer Institute (NCI), (Bethesda, MD) refined Higginson's data by concluding in 1977 that 60 per cent of all female cancers and 40 per cent of all male cancers could be attributed to the diet.[2] Moreover, their data suggest that by choosing one's diet more judiciously, one could substantially reduce the risk of cancer.

Diet and Causes of Cancer

What sort of information do cancer scientists have that led them to this optimistic conclusion? If cancer was something inherent in human genes or it resulted from some mysterious force randomly applied to all then one would expect the same incidence of cancer the world over. Such is not the case. Both the amount of cancer and body sites varies tremendously from one ethnic group to another. Take, for example, deaths from cancer of three body sites, bowel, stomach and female breast. Table 1 shows a great disparity between

Risk of Cancer

Site of Cancer		Death rate per 100,000 population U.S.	Japan
Intestine	Male	17.2	4.6
	Female	19.3	5.0
Stomach	Male	9.0	57.4
	Female	5.6	36.2
Breast	Female	29.6	5.4

Source: WHO, 1973 data

Americans and Japanese. Whereas American males win on stomach cancer, they lose on bowel cancer. Japanese women win by far with respect to breast cancer but, like their husbands, lose disastrously with stomach cancer. These differences have little or nothing to do with genes. Japanese assimilated into the North American life style have the same cancer patterns as citizens of European origin. It is this type of observation that led cancer epidemiologists to the conclusion that cancer is basically an environmentally-induced disease. It is all very well to say this, but what does it mean for the consumer? Looking at the data in Table 1, we might hope to combine the best of both American and Japanese diets so as to reduce substantially the risk at three sites of bowel, stomach and breast. We are stymied, however, because cancer scientists are unable to say precisely what it is in diet that causes cancer.

Moreover, according to Dr. Gio Gori, Director, Diet, Nutrition and Cancer Program, NCI, diet is not a cause *per se*, but simply a factor that may abet or retard the functioning of other cancer promoting factors.[3]

Seventh Day Adventists and Cancer

If cancer scientists remain mystified, there are groups that are partially winning a personal war against cancer. The Seventh Day Adventists, a group with a conservative life style, avoid alcohol, tobacco, coffee, tea and meat. Even after subtracting the cancers well-known to be associated with smoking and alcohol, their cancer incidence is still about 60 per cent that of the Canadian and U.S. average[4]. The Seventh Day Adventists data are often cited as proof that appropriate adjustments in life-style can markedly reduce the risk of cancer.

Cancer scientists, however, are not at all certain what it is about the Seventh Day Adventist life-style that reduces the risk of cancer. Is it the total life style or certain facets? If so, what are the facets and could they be followed in other life styles? Moreover, if such aspects could be identified, it might be possible to work out an acceptable life style that lowers the cancer rate far below the 60 per cent level achieved by this religious group.

Scientists and Cancer

These questions are not easy to contemplate, let alone answer. Moreover, they are not popular questions among cancer researchers or the agencies that support their work. In contrast to the resources lavished on finding a cure for cancer, money and facilities for studying diet and cancer are but a pittance.

Nevertheless, some information is available about what aspects of diet may affect the risk of cancer. This information, together with commonsense, offer guidance for those who believe the best way to deal with cancer is not to get it in the first place.

Initiation and Promotion

Much of the scientific effort in this field is devoted to identifying specific agents in the diet that induce cancer (carcinogens). The process of carcinogenesis is poorly understood, although some progress is being made in sorting out the cellular events.

Carcinogenesis at one time was thought to be quite straight-forward. One forced a rat, for example, to smoke cigarettes and it developed cancer. Tobacco smoke was simply deemed carcinogenic.

The cancer-inducing process, however, is turning out to be much more complex. It frequently starts out innocently as the body tissues try to deal with the many foreign substances ingested. The body must deal with everything that enters and if a substance is not a nutrient then the body automatically classes it as a poison. Our body possesses versatile mechanisms for excreting or changing unwanted substances into harmless compounds. This body defense mechanism is not exactly flawless and many substances which, by themselves are not very poisonous, are converted by our cells into substances that can induce cancer.

This mistake, if one might call it a mistake, can occur with naturally-occuring substances, but what has happened in the last few decades is that the chemical industry has increased enormously the amount and types of chemicals in the human environment. The body has had no prior experience in handling these new chemicals so it is not surprising that in attempting to deal with them, the body inadvertently turns a high percentage into potentially lethal carcinogens.

This activation, however, is only the beginning of a long complex process. Over the last thirty-five years Drs. Elizabeth and James Miller, of the University of Wisconsin, have done more than anyone else to unravel what happens[5]. The activated carcinogen acts as an initiator, turning a susceptible cell into a cancer cell. The initiating substance having done its job, like a gun launching a bullet, need no longer be present. Thus, one may be exposed only a short time to an initiator, say early in life. The target cell becomes a tumor cell by some unknown means. Having undergone this transformation, every new division doubles the number of tumor cells. The initiated tumor cell, however, may not divide unless stimulated by an entirely different substance, a promoter.

The distinction is important because whereas the initiation step is irreversible, promotion is reversible. Thus, if there is something in one's diet promoting an already induced cancer, removing that promotor later in life could slow down or stop tumor growth. What it means is that a tumor once started does not necessarily have to grow into a fatal cancer[6].

The concept of a three stage process, activation-initiation-promotion is a view that has emerged in the last decade. It is based mostly on animal experimentation, although some observations on human cancer fit the concept. It does offer some help in developing a personal strategy to minimize one's risk of getting cancer.

Fat and Cancer

A substance that might qualify as a promotor is fat. Dr. Kenneth Carroll, of the University of Western Ontario, has plotted the incidence of human breast cancer in different countries against per capita consumption of dietary fat. His plot shows a clear correlation. Moreover, this correlation seems to relate more to animal fat consumption than vegetable fat[7].

Dr. Carroll concluded that dietary fat appeared to fall into the promotor category. These data are not easy to interpret because if one eats less fat one eats more of something else. In particular, those peoples at the low end of the breast cancer correlation are those eating a high grain diet. If fat is bad, then is grain good?

Is it the fat itself or could it be something in the fat? The incidence of breast cancer has been rising slowly in North America over the last several decades, yet consumption of animal fat has remained static since the early 1900s. Many substances known to be carcinogenic dissolve in fat. Meat animals exposed to environmental carcinogens and drugs in their feed accumulate residues in their body fat to be passed on to the consumer. Plants doused in insecticides and herbicides, likewise can accumulate traces in their oils. The variety and quantity of these foreign substances in animal fat has risen drastically in the last few decades. They, in turn, accumulate in human body fat, there to slowly dribble into one's metabolic system — a constant 24-hour threat.

Another consideration is the way animal and vegetable fat is handled before it reaches the consumer. Meat animals are crowded, stressed and gorged continually on high-energy food. Few studies have been done on the effects of producing meat under such conditions, but common sense suggests that such unnatural conditions are bound to have deleterious effects on the animal's physiology and that this could be reflected in the quality of meat.

Meat consumption per capita has actually jumped substantially over the past few decades. The reason total animal fat consumption has not risen is that the rising meat consumption has been offset by a drastic decline in butter consumption. There has been a dramatic switch to margarine, and vegetable shortenings.

These substances are manufactured from vegetable oils using a chemical process called partial hydrogenation. The process wrecks the delicate molecular architecture of natural fatty acids. Grouped under term *trans* fatty acids, they can constitute up to 50 per cent of the fat in margarine or vegetable shortenings. Eaters of these products don't appear to suffer any ill-effects, or do they? Studies done on animals show that the *trans* acids are incorporated into cells causing a loss in efficiency. Overall, they deplete the amounts of essential fatty acids and Vitamin E[8]. In short, at the cellular level, stresses occur, although the animal may appear to be quite healthy.

"Prevention, like an octopus in a washing machine, is too tangled, too slippery for cancer bureaucrats to grasp."

We mention these aspects of fat production and consumption, not because detailed proof exists that they are associated with cancer, but to indicate that a simple fat-cancer correlation is only the start, the real answers lie in a much deeper examination. Yet, strangely, although this general correlation has been known for several years, relatively few scientific studies are currently being done on the question of dietary fat and cancer.

Nutritional Stress and Carcinogenesis

We could wish for more detailed experiments, but studies have significantly shown that dietary stress (nutritionally inferior diets) enhance the risk of cancer. Experiments, for example, showed that rats given as much food as they wished — but which was nutritionally unbalanced (for a rat) — became highly susceptible to cancer induced by the carcinogen, dimethybenzanthracene. The tumor incidence was much lower when the animals were fed nutritionally balanced food and better still when the nutritionally balanced food was restricted.[9,10]

These experiments and others support the general conclusion that the cells of a properly nourished individual are better able to detoxify harmful substances and to resist the carcinogenic process.

Dietary Fibre

Good nutrition is more than a balance of vitamins, minerals and other known dietary components. It also depends on the form in which the food enters one's alimentary tract.

The highly refined western diet deletes much of the natural fibre in foods. One consequence is that it takes 2-3 times as long for the hard-worked intestines to push the contents from stomach to anus. During transit, which for many people is three or more days, all sorts of interactions occur in the mass, including production of carcinogenic substances. One theory suggests that prolonged contact with the produced carcinogens accounts for the high incidence of colon cancer in western countries, compared to the incidence in countries where people don't eat refined food.

Rather than accept the fact that lower cancer incidence is associated with a diet of unrefined food, some authorities have concluded that all that is needed is to speed up the transit time. If that were the case, why not recommend a daily laxative as an anti-cancer measure? As a sort of compromise between taking a drug and eating natural food, they have recommended adding fibre to one's highly refined diet.

Certain breakfast cereals and bread tout the benefits of their high added fibre content. In the case of Fresh Horizons® bread it is wood pulp. Fibre however is a complex substance that stimulates different types of intestinal activity depending on the source. Who can say what form of fibre is best? The experiments have not been done. In view of the ignorance, it would make more sense not to remove the fibre from foods in the first place, giving consumers' bowels the benefit of the natural interplay between all components of unrefined food.

Prevent Now

Cancers of the human alimentary tract, breast and prostate appear to be linked to diet and evidence suggests that these forms of cancer could be substantially reduced if we just had the detailed information to manipulate our diet.

These observations are now several years old, but a lack of interest by cancer researchers means that we are not going to obtain that detailed information in the forseeable future. The lack of research effort frustrates those few scientists searching for answers. Dr. John Weisburger and colleagues of the American Health Foundation, Valhalla, N.Y., for example, vented that frustration; "We now have begun to have research tools with which to mount a concerted, effective effort to reduce risk for these important, high incidence cancers." (Their reference is to cancers of the colon, prostate and breast). "The time to redirect our research efforts and to apply the results of those efforts to prevention is NOW".[11]

The Body's Three Lines of Defense

Cancer may be a part of the cosmos, something living organisms have always had to contend with, but in making cancer part of life, nature gave humans strong defenses against that very affliction. The body battles against a cancer from the very outset all the way to the end. Moreover, these defenses were designed by nature specifically for this purpose and they can be most effective — if used. The sensible strategy then is to try and enhance these natural defense lines.

The first and obvious line of defense is human wisdom, having the wisdom to avoid those substances, aspects of diet and excesses of lifestyle that may initiate or promote cancer. The promotion theory suggests that patients with known cancers might be able to retard their growth by avoiding foods containing suspected promotors.

In describing the second line of defense, we return with wonder to the question: Why, with the astronomical number of cell divisions during the life of a human, does transformation of a single cell into a cancerous one happen so infrequently? Part of the answer lies in an exquisite verification mechanism resident in each cell. Transformation from normal to the cancerous state involves a genetic change, a change that is copied faithfully in each subsequent cell division of the growing tumor.

It turns out that the genetic change that creates a cancerous cell actually occurs fairly frequently. To combat these unwanted genetic changes, the cell has a mechanism that constantly scans its genome and if a mistake occurs that might produce the cancerous state, the mechanism quickly snips out that section and replaces it with the correct genetic information.

This self-correcting mechanism works very efficiently and few cells ever become a permanent cancer cell. If, however, a mistake slips by and the newly-transformed cancer cell starts to divide, the third line of defense comes into play — the immune system. The host, so to speak, recognizes cancer cells for what they are, rogues, and tries to contain or destroy them through immunological processes. This struggle continues throughout the course of cancer.

Doubling Time

Thus, from the point of view of the body, one's cancer starts from formation of the first unrestrained cancer cell. One, however, is not aware of this beginning cellular struggle that some day may take one's life. The cancer cells and the body's defense mechanisms struggle for 10-40 years or more before the individual becomes aware that he or she has the disease. Cancer, thus, seems to burst suddenly into awareness after which it may progress rapidly. Its time course seems like an iceberg — decades of invisible growth and cellular struggle followed by a few years of visible disease.

Tumors grow by doubling their cells. The first rogue cell becomes two, then four. The next division yields eight. Not until 25 divisions occur does the tumor reach the size of a small pea. Not until this stage do modern medical techniques have any hope of detecting the growth. The next four or five divisions, because of doubling, are all it takes, however, to become a large invasive mass that can fatally affect normal functions of the host.

Another phenomenon occurs generally long before the tumor reaches the 25 division mark — metastases. Satellite cancers may start throughout the body, each as life threatening as the primary cancer. It is for this reason that destruction of the primary tumor frequently does not affect the outcome.

Cancer does not become a disease in medical terms until it has reached the 25 division mark. Thus, medical science really deals only with the last three or four cell divisions out of 28 or so. It enters the scene in the final stages when the tumor has started to affect noticeably body functions. Can nutritional therapy play a role in managing cancer at this stage, once it becomes identified? The answer is a big yes.

Nutrition — Neglected by Doctors

The medical community, however, is not able to provide much enthusiasm or help to the patient seeking nutritional advice. Whereas cancer specialists are trained in the high technology of cancer therapy, radiation, surgery and chemotherapy few have the know-how to use nutrition skilfully. Perhaps one of the main reasons for this all-thumbs approach to nutrition is the general disdain medicine holds for nutrition. Medical schools have not included nutrition in their curriculum. That may be slowly changing, but a generation of medical practitioners who have had no formal training in nutrition now advise and treat cancer patients.

Lack of professional help is no joke for the patient wishing to weigh the odds as much as possible in favour of controlling his or her cancer. The cancer patient and family in most instances will have to take responsibility themselves for the nutritional aspect.

Nutritional Support

To help do this, consider the following aspects known about cancer and nutrition.

As the cancer grows (past 25 divisions) it often profoundly affects the function of the hosts' organs. The overall result is weakness, redistribution of tissue components and severe loss of appetite. Not only does appetite disappear, frequently the food eaten is incompletely absorbed. Many patients lose a significant fraction of their body protein (muscles) developing a condition akin to starvation. The severe loss of protein and tissue mass as in the case of Kwashiorkor does not always mean loss in body weight because the patient retains fluid.

The poor nutritional state impairs ability of the body to fight back. The immune system begins to collapse and in the final stages the patient frequently succumbs to an infection. Fortunately, this impairment can be reversed - through good nutritional support.[12]

If many physicians find it difficult to recommend or use nutritional therapy as part of their weaponry against cancer it is because they lack precise information. Medical science skews its enormous resources in favour of trying to perfect its high technology of cancer treatment. In spite of the massive effort, the outlook for cancer patients present and future has not improved over the past 25 years — hardly deserving of a gold medal. Nevertheless, this one-basket effort continues. Medical science has yet to give the low-key approach of nutritional support, either by itself or in combination, a scientific evaluation.

Cancer Politics

There obviously is a great fog of ignorance covering the relationship between nutrition and cancer and one could wish for more precise information. What hope is there that this fog will be lifted? Research on cancer attracts some of the best scientific minds in the world. It is supported generously by cancer societies and government tax monies. In the United States alone some 7,000 senior scientists plus supporting personnel work on cancer. Surely all this effort will give us the information we need; or will it?

Cancer research in the United States became a highly focussed activity with declaration of war in 1971 by an act of Congress, signed

Sixty per cent of all female cancers, and forty per cent of males ones, have been attributed to diet

into law by President Nixon. Cancer researchers buoyed at that time by what they considered key discoveries, were saying "Give us a billion dollars a year (since inflated by a factor of 2) and we will give you the answer in ten years."

Money Corrupts

The large infusion of money, however, rather than providing answers made some scientists realize how ignorant they really were. Nobel Laureate, James Watson candidly acknowledged his own enthusiasm in the 1960s that more intense research would soon "bring a halt to the horrors of cancer." Now more sober, he said ". . . the more we learn about normal higher cells and their cancerous equivalents, the more staggering the task I realize we cut for ourselves"[13].

Favoured areas of reasearch in the 1970s were viruses, immunology and chemotherapy. The Conquest of Cancer plan, devised at the time Nixon's 'War Against Cancer' was declared, ranked 35 areas to support, with most of the money going to the above three. Nutrition was not even mentioned.

The lack of interest in nutrition incensed Senator George McGovern, formerly Chairman of the Senate Committee on Nutrition and Human Needs. He could never reconcile the fact the National Cancer Institute (the designated agency for directing the war on cancer) could spend over a billion dollars a year and leave out nutrition even though NCI scientists had concluded that about half of all cancers were attributable directly to the diet.

After learning in 1976 that NCI had spent only 0.2 per cent of its budget on nutrition he exploded, calling the NCI war a severe billion dollar failure, claiming that an adult's chance of being cured had not changed significantly since 1940[14]. Three billion dollars and two years later he put Dr. A.C. Upton, Director, NCI, on the witness stand of a Senate Hearing to find out what NCI was doing.

Upton explained that NCI had come up with nutrition guidelines that, if followed, would reduce the risk of cancer. The guidelines, however, looked suspiciously like the kind of advice kindergarten teachers might hand out to their pupils.

Cancer and Vested Interest

Upton acknowledged that while knowing in general about the diet-cancer link, NCI had discovered few details[15]. Another reason for its extreme caution was that the government serves many constituencies and no matter what it recommended, complaints would be loud and forceful. To suggest people eat less meat infuriates the cattleman's association. To suggest people eat less candy angers the confectioner's associations. To suggest people eat more fresh vegetables throws the canner's association into fits.

What these constituencies were saying was: "If you don't have concrete proof that this or that aspect of diet causes cancer, don't say anything." Such proof is impossible to obtain because it is the whole diet that affects the individuals health outlook and it is impossible to separate out one or two aspects and cite them as *the* cause.

Cure Crazy

Seeking *the cause* is one of two major mental blocks infecting the cancer research establishment. The belief long held is that cancer, like pneumonia, is due to a single identifiable cause. The thought is that once identified the cause will be rapidly cancelled by a cure. Identifying cancer causes, however, is much more complex than finding a neat little pneumococcus. The truth is more like saying eating causes cancer, not a particularly satisfying conclusion.

The second major block is that the whole cancer establishment is cure crazy. Cancer scientists secretly harbour the ambition to be recorded forever in history along with such luminaries as Pasteur, as the one who discovered *the* cure. Big money and high prestige ride on the search for a cure. As a consequence, prevention rates low in prestige, low in interest and low in ideas. There is just a general unwillingness to think about prevention.

Thus, the announcement of evidence of the link between nutrition and cancer was greeted with cynicism. The cancer research establishment is like a huge rhinoceros, galloping full speed towards a constantly receding goal of cure. It is too ponderous, too narrow-eyed and too thick-skinned to turn towards other objectives.

These remarks are not to suggest that research in the cancer field has no value. On the contrary, it has revealed much of great interest about the lives of cells and about the human body. In terms of solving a social scourge, however, the rhinoceros analogy holds. The public wants answers and one answer that bounces off the tough rhinoceros hide is that much of cancer could be prevented.

Ideas of Low Quality

Prevention, however, is not strictly a scientific problem. For that reason, it does not make sense to put all the public resources into seeking solely a scientific solution. Diet and cancer, for example, is a complex mix of science, social habits, politics and pressure groups. It is the kind of problem our current scientific-political-social institutions seem incapable of resolving. Seeking the cure for cancer in asceptic laboratories threatens no-one — except by draining resources and attention from alternative ways of dealing with the disease. Prevention, in contrast, is seen to threaten establishment commercial and industrial practices, cherished products and medical perogatives. Moreover, prevention, like an octopus in a washing machine is too tangled, too slippery for cancer bureaucrats to grasp.

The vagueness of the problem is matched by the low quality of ideas. In addition, researchers still treat the problem as a laboratory one. People don't eat laboratory diets, they eat commercial food, a ton a year of hamburgers, french fries, pickles, catsup and beef-a-roni.

A workshop convened by NCI to study the relationship of dietary fat and carcinogenesis, for example, discussed different types of fat, but almost totally ignored the way fats are commercially processed. The workshop didn't consider the context in which fats are eaten. Again, people don't eat pure oils and fats, they eat lunches of hamburger and french fries, 50 per cent fat. How does that other 50 per cent contribute to the effect of the fat on the eater or vice versa? These researchers will never find out because they are not prepared to examine food as people eat it[2].

Medieval monks used to argue brilliantly over whether a pail of hot water weighed more than a pail of cold. No one thought to put the problem to the test. Whatever mental quirk prevented the monks from actually doing an experiment seems to prevent the cancer establishment from studying people and the food they actually eat.

Personal strategy for Avoiding Cancer

Almost 800,000 people in the U.S. and Canada have become victims of cancer this year. Four hundred thousand of those need not have become victims if they had been given the advantage of knowledge presently available. And, if the cancer research establishment were to take prevention seriously, new ways to reduce the incidence further could undoubtedly be found. That is unlikely to happen. Dr. Gori, in a recent interview with *The Journal of the Nutritional Academy*, said NCI still spends less than one per cent of its budget on nutrition. The authorities moreover, timidly refuse to assemble existing information and share it with the public.

In personal terms, one can cut the risk of contracting cancer by about one half by following a two-fold strategy. First, reduce as much as possible your exposure to carcinogenic substances and x-irradiation (keep dental and medical x-rays to the absolute minimum). True, the cells have marvellous defenses against carcinogens, but like a besieged medieval castle, the longer and more intense the carcinogenic bombardment the more likely the walls will crumble. Second, upgrading one's nutrition improves the body's ability to defend and to contain incipient cancers that may have started.

Upgrading requires a multifaceted approach. No one facet ensures freedom from cancer but in combination they should reduce your risk by half.

1. *PROCESSED FOOD:* The more a food is processed the more inferior its nutritional quality. In addition, processed food rich in additives is more likely to be carcinogenic. Few food additives have been subjected to rigorous examination to find out whether or not they are carcinogenic. And, absolutely none have ever been tested in the context of a food as eaten by people. General studies show that a very high percentage of synthetic chemicals are carcinogenic, so in absence of information to the contrary, the smart person suspects all additives.

Cooking, including home cooking, may risk formation of carcinogenic substances. In particular, fats in foods or added as a cooking aid when exposed to high temperatures undergo changes that may result in carcinogenic products. Dr. William Lijinsky, Cancer Research Center, Frederick, MD, has cautioned against using leftover food due to the formation of nitrites during storage.

2. *MEAT, FISH:* In view of the stressful conditions under which commercial meat is produced, we recommend that you reduce consumption. If one can obtain meat from animals that are free-ranged

and not force fed, so much the better.

Fish, like wild game, should be a superior source of food. But man, careless of his inner and outer environment, has allowed contamination of natural resources. As a fish biologist colleague reminded us as we sat down to a lunch of Lake Ontario whitefish "Your meal is the equivalent of drinking a million litres of Lake Ontario."

3. *VEGETABLES:* Plants of the *Cruciferae* genus such as brussels sprouts, cabbage, cauliflower and broccoli contain specific substances that protect against chemical initiation of mammary and stomach tumors in animals[16]. Whether they do so in humans remains unknown, but it makes good sense to include them and a variety of other fresh vegetables in your diet.

4. *VITAMIN C:* This vitamin has been aggressively promoted by Drs. Linus Pauling and Ewan Cameron for treatment of cancer. They recommend supplementing the diet of cancer patients with about 10 grams a day[17]. The added vitamin will not harm and if taken in conjunction with a high quality diet, could benefit the patient.

Vitamin C, although not necessarily in such a high amount, also protects one against the formation of nitrosamines in one's intestinal tract. Nitrosamines are a highly carcinogenic group of substances formed from dietary nitrite or nitrate. Processed meats and certain vegetables, spinach for example, contain a high level of nitrite (although extraordinarily high amounts seem to be due to a high level of artificial fertilizer). Nitrites, or nitrate, by itself doesn't appear to represent a danger, but when it gets in the stomach it reacts with a variety of other substances in foods, forming the deadly nitrosamines. The natural vitamin C content of spinach assuming it is not destroyed by overcooking, prevents this chemical reaction (see *The Ecologist,* May 1979).

Nitrosamines are not only the carcinogenic substances produced *in situ.* Dr. Robert Bruce, Ontario Cancer Institute, Toronto, Canada, has studied formation of mutagenic substances in the human bowel. Mutagenic substances are not necessarily carcinogenic, but 80-90 per cent of known mutagens are also carcinogenic. In any event, the level of mutagens varies according to diet. The more unprocessed foods such as salads the fewer mutagens produced. Dr. Bruce also found that vitamin C and E reduced mutagen formation. He noted, however, that the best protector is a good well-balanced diet which, in his view, should provide sufficient quantities of the two vitamins.

5. *VITAMIN A:* This vitamin seems to play a special role in maintenance of epithelial tissue. It was particularly effective for example, in preventing development of breast and bladder cancer in experimental animals[18].

6. *ALCOHOL:* The smoking link to cancer has been well publicized. The alcohol link has perhaps been less well publicized, but ample evidence shows excessive drinking increases substantially the risk of cancer of the mouth, pharynx, larynx and esophagus, liver and lung. Drinking and smoking together seem to be synergistic with respect to those tissues over which the smoke passes[19].

A Life Saving Strategy

Cancer is woven into the fabric of our total life style. There is just so much one can do at the personal level. We believe, as stated above, one can reduce the risk by a factor of two. That risk could be reduced further through action at the collective level. Instead of trying to cure the incurable, which is like trying to cope with a rusting car by painting over the decay, society would do well to think of the extraordinarily high cancer incidence as nature's red warning light. We need to make some adjustments in our collective life style.

Cancer research continues to carve its rut ever deeper. If not searching for the cure, it searches for the cause. Thus, as nutrition became a legitimate area for study, the cancer community merely extended this approach and began looking for specific cancer-inducing factors. Certainly, such factors exist, but the interplay between quality of nutrition, initiators, promotors and environmental factors is so complex, it will be decades, perhaps centuries before scientists have sorted things out. In the meantime, cancer keeps rolling up its toll. If specialists were not so buried in their cause-and-effect rut, and looked at the cancer problem from a broader perspective, an answer would be self evident.

One doesn't seek a cause or a cure, one seeks a strategy. The scientific evidence that has emerged so far on top of our fundamental understanding of cellular processes clearly points to one simple strategy: throughout your life treat your body to a high level biological environment in and out.*

* *Dietary strategy is explained in detail in En-Trophy Review, No. 12.*

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Leaden Minds

LEAD OR HEALTH?, by Derek Bryce-Smith and Robert Matthews, Conservation Society, £3.00.

". . . we have seen no firm evidence that lead from petrol has caused harm . . ."

The Lawther Report

What is a safe concentration of lead in soil? Experts are not prepared to specify because plant absorption of lead varies so much with factors such as soil pH and organic humus content, the latter increasing a plant's resistance to absorption of soil lead. The situation is not helped by sewage sludge routinely spread on British farmland which contains an average 400 ppm — that is ten thousand times the naturally occurring concentration of plants. One would have thought that this was cause for alarm, but the 1980 *Lead and Health* government report gave the fact only a passing mention: "The use of sewage sludge as fertiliser may also result in some contamination of crops by lead."

C.L. Patterson in her study of how lead moves through natural ecosystems emphasises the extremely low concentrations of lead occurring naturally in living organisms. It hardly seems to be an element which living things require. For example in some ocean fish (tuna) Patterson found less than one nanogram per gram (1/1,000 ppm) to be present. Also of interest is her conclusion that lead body burdens of average persons in the U.S. appear to be more than a hundred times above prehistoric or natural levels.

It is stated in *Lead and Health* and repeated in a recent article in the BMJ ('Is low level lead pollution dangerous?' by Daphne Gloag), that daily food intake for adults in this country is well below the specified WHO limit. But as the authors of *Lead or Health* point out the Working Party omitted to mention that children were specifically excluded from the WHO criteria.

Evidence for behavioural effects of lead upon children falls into three categories: surveys correlating mental retardation or lowered IQ with raised body lead (measured from blood, hair or teeth); surveys showing disturbed behaviour such as reduced ability to concentrate in the classroom linked to raised body lead — this comes under the general and not very satisfactory term 'hyperactivity', and animal experiments showing reduced problem-solving ability in animals with body lead slightly raised but still within the range of concentration found in normal children.

As well as these behavioural effects there are also some physiological effects of which the most important is the raised body lead in stillborn children. Since this subject was reviewed in *The Ecologist* ('The Lawther Report: Whitewashing leaded petrol', August 1980) another survey has been published confirming these findings. Since lead has been used as an abortificant for centuries the effect which it is now having in the general population is no cause for surprise. At this point it is worth emphasising the uniqueness of lead as a toxin: there is no other pollutant whose range of concentrations in the general population overlaps the level at which its toxic effects begin. With mercury, for example, there are a couple of orders of magnitude between its mean level in the population and the level at which it is considered toxic.

The recent DHSS report *Lead and Health* accepts 0.35 blood lead (35 microgrammes per 100ml of blood) as a safety threshold, for children as well as for adults. In retrospect the most remarkable single thing about this report is surely that a group of experts should accept as 'safe' a threshold higher than that at which behavioural impairments have already been demonstrated in animals. Customarily it is the other way round. The safety threshold for humans being lower than that at which behavioural impairment has been demonstrated in experimental animals. For any food additive, for example, it is standard practice for the ADI (acceptable daily intake) to be defined as one thirtieth the level at which *first* toxic effects are noticeable in comparable experimental animals.

It is a remarkable fact that since the appearance of *Lead and Health* last year, no major medical or scientific journal has published any substantial criticism of it. From them one would get the impression that its contents were generally acceptable. Were it not for the tireless and totally unpaid efforts of a small group in the Conservation Society, there would be, it is scarcely an exaggeration to say, no lead debate in this country.

At the heart of the matter is the question: Are our children having their brain growth retarded by lead? Unfortunately the scope for doubt on this issue is diminishing, and the question now seems rather to be: *To what extent* is child intelligence in this country being retarded by excessive exposure to lead? The authors of *Lead or Health* attempt an estimate of the extent to which child intelligence in Britain is presently reduced as follows: The shape of the IQ distribution curve is such that a net displacement downwards by five points would result in a more than 100 per cent increase in children classified as mentally retarded, that is with an IQ under 70. From 1950 to 1976 institutionalised education subnormality increased by more than three times.

Corroboration of this thesis comes from many investigations showing raised body lead in mentally subnormal groups of children. As regards the time-honoured answer to such studies, that such children are more likely to chew paint with lead in it and so on — the authors of *Lead or Health* point out that the Scottish study by Moore found a correlation between mental subnormality and blood lead measured several days after birth. It is fairly plain in this instance that the raised lead must have been at least a partial cause of the mental subnormality, which only became apparent years after the measurements had been made.

Recent surveys in Australia and

the U.S. confirm the correlation of raised lead levels with non-adaptive classroom behaviour, showing that antisocial or delinquent children normally have raised blood lead levels. Why have no comparable investigations been carried out in Britain? Given the millions the Medical Research Council (MRC) has spent, supposedly investigating these problems, why has no one studied the extent to which a lead gradient exists across the ability ranges of school children in this country?

I asked Dr Russell Jones about this, and he expressed the view that any educational survey of deviant behaviour which did not take account of lead would be 'largely invalid'. Glasgow, he said, had the highest lead levels of any E.E.C. city, and also the most severe inner city problems as regards delinquency and vandalism.

We may now have reached the situation where a person convicted for a crime of violence ought to have a body lead check as a matter of course. As the authors of *Lead or Health* point out the largest increase in crime over the past couple of decades has come from the fourteen to sixteen age group. To continue ignoring this dimension is to court disaster.

Amongst the recommendations made in *Lead or Health* are: the complete removal of lead from petrol at the earliest possible date; the restricting of lead permitted in paint (at the moment paint used for toys may still contain up to ¼ per cent lead); the labelling of tinned food to say that it is lead-enriched and therefore unsuitable for children or pregnant women — few mothers are aware that tinned food will normally contain in the region of 5ppm lead, at least twenty times the limit for baby food; and the checking of blood lead of pregnant women as a routine part of antenatal care.

In their conclusions, Bryce-Smith and Matthews summarise the Conservation Society's view of *Lead and Health* as follows:

> Concerning the Lawther Report, we welcome its recognition that a problem may exist. But we find its discussion of key aspects so deeply flawed, and its failure to include some of the most important areas of evidence so stultifying, as to render it not just largely useless, but in central features dangerously misleading as an assessment of the present state of knowledge''.

This is a fair assessment. The Lawther Working Party has been described as 'the most formidable team of scientists ever to scrutinise the evidence'. In that case how is it possible that they missed the point so completely? This once again raises the question of the degree to which prior political commitment is involved. Essentially a few members of the Conservation Society are challenging the combined weight of the largest multinationals in the Western hemisphere . . . They are to be congratulated on coming out with their clear verdict on the Lawther Report, when other public bodies supposed to be concerned with public health have accepted it without criticism. There is likely to be considerable public demand for *Lead or Health* as individuals realise that they will not get the facts from government publications. With this in mind the authors might consider including an index in their next edition, it would be very useful.

Nicholas Kollerstrom

Sources of Energy

THE GOVERNMENT STATEMENT ON THE NEW NUCLEAR PROGRAMME Vol. I, HMSO (No.HC 114-1), £5.30.

On December 19th 1979 the Secretary of State for Energy, Mr David Howell, made a statement on the government's intentions as far as a nuclear programme was concerned. It is this that the Select Committee on Energy spent almost a year studying and in the course of it it interviewed the energy institutions, namely the CEGB, the Atomic Energy Authority, the SSEB, the manufacturers, the Nuclear Installations Inspectorate and a considerable number of independant experts.

The report has 91 recommendations. It is the most important document emerging from a public body on energy since the Flowers Report of 1976. However it is focused on a much narrower field namely the public acceptibility in terms both of economics and of safety of the current nuclear power programme. It also makes estimates and judgements and reservations about the 15 gigawatt PWR programme which is the most important part of the government's energy programme as it now stands.

The report is refreshingly serious about the use of economic resources in the nuclear programme. Through its many recommendations it develops a critique of the lack of any proper concern by the electricity supply industry for the economic costs of the programme that it proposes and its disregard of the public interest. The language sometimes even gets sharply critical, as for example in recommendation 26 they say, ''we find the CEGB's cavalier attitude to price comparisons profoundly unsatisfactory. It is simply not good enough, in our view, when billions of pounds are at stake for the board to avoid 'showing bias' between different reactors for purely tactical reasons.''

The Select Committee began its work by studying the estimates for energy demand which form the framework of the nuclear power programme. It had to summon the CEGB a second time because the figures which the Board gave them on the first occasion proved to be inaccurate and misleading. In fact the CEGB presented the Select Committee with a set of figures on estimation of electricity demand which were out of date when they were presented. The CEGB had in fact revised its estimates downwards with considerable consequences for the validity of a large nuclear power programme. The Select Committee sharply criticised the CEGB for this sleight of hand, pointing out that ''the credibility of much of the CEGB's subsequent evidence was undermined by this omission and we trust that this will not occur in the future''. (section 2 para 3).

The Committee then say that much depends upon the reliability of the cost estimates and that this in turn has to be investigated in terms of the amount of generating capacity and the other important factors that the additional or replacement capacity, to be contributed by each proposed nuclear power station, should be carefully evaluated on its own economic merits.'' This point is important because the CEGB uses an accounting system and a method of systems cost analysis which is so unique that nobody else can understand it. The Select Committee itself says that its members cannot understand it and expresses the view that the CEGB ought to revise its method of assessment. In particular the Select Committee rejects the existing presentation of the advantages of nuclear power by the use of what it calls 'net systems cost'. In its place they want to see the board introduce a specific assessment and test for each nuclear power station before it is approved. If this was done it would bring a radical change in the CEGB's presentation of its information and would allow a proper economic comparison to be made between nuclear and other energy forms.

With regard to the year by year figures produced by the board in evidence that nuclear power is the chief option the Committee say ''the historic cost method used by the board to justify past investments distorts the effects of inflation on capital costs, rendering resultant figures highly misleading as a guide to past investment decisions and entirely useless for appraising future ones''. (section 4 para 11).

On the validity of the 15 gigawatt programme the Select Committee has some pertinent things to say. First of all it has doubts about the necessity of the programme itself. And it links this point quite properly with the actual cost of the programme as it is or might be perceived. In general its view is summarised in the following quotation ''we remain unconvinced that the CEGB and the government have satisfactorily made out the economic and industrial case for a programme of the size referred to by the Secretary of State in his statement to the House in December 1979.'' (section 4 para 18). But then the Select Committee gets its teeth into the subject of real costs, evaluating the board's estimates for capital costs for the AGR and the PWR programmes. The current CEGB estimate of a £1000 per kilowatt capital construction cost, means that a large station would cost £1300 million. While this figure is almost certainly an underestimation the Select Committee does not query the figure as such but compares it with the alternative figure for an American Pressurised Water Reactor: indeed it interviewed a representative of the American Bechtel Corporation and compared the two figures. The Bechtel Corporation estimate is £365 per kilowatt or one third of the British figure. After having generously allowed all the additional costs which the CEGB suggested explained the difference between the two they still found that there was a large gap between the two estimates and concluded by saying ''the most worrying aspect of these figures is that the board are apparently resigned to a cost penalty of some 34 per cent for building a PWR under UK conditions.''

Perhaps it should be mentioned at this point that the Select Committee are not against the nuclear programme. They are, in principle, in favour of a nuclear option but their qualifications are so many that the CEGB, the Atomic Energy Authority and most of the press have interpreted their report as being anti-nuclear. The Committee is particularly critical of the decision to order two more advanced gas cooled reactors. They believe that the internal review made by the think tank and ordered by Mrs Thatcher ought to have been published. The members guess, probably quite rightly, that the main reason for ordering the AGRs was to keep the domestic nuclear plant industry going.

With regard to public confidence in nuclear power they make a comment which will find a warm response from many readers of *The Ecologist*. ''It seems to us'' the committee says, ''that some of those who derive their livelihood from the industry exhibit an intolerant attitude towards people who question the safety or economics of nuclear power.'' Indeed the committee suggests that four months should be allowed after publication of licence applications to allow objectors to study evidence and get expert advice.

Finally it is important to draw attention to the matter of public accountability which goes far beyond types of public inquiries. The Select Committee is unusual in insisting on some rigorous economic tests as a part of public accountability. It is not convinced about the ordering of the two AGRs; it is decidedly sceptical about the large programme of 15 gigawatt PWRs and clearly has very little confidence in the ability of the nuclear industry to build anything without incurring excessive cost. But it pushes the argument one stage further — particularly when it looks at the role of the CEGB — namely the effect on the consumer of all this mismanagement.

Summing up its views on the nuclear power industry it says ''what these factors have in common is the additional and wholly avoidable financial burden they have imposed directly on the electricity consumer and indirectly on the tax payer.'' (para 119 page 64). The Committee certainly questions the nuclear cost estimates that have been produced and goes on to connect the high cost of nuclear power with electricity costs. This is the first time a public body has made such a connection to my knowledge. ''Unless the CEGB are able to effect considerable reductions in their own costs this country will continue to produce electricity more expensively than need be the case, whichever reactor is eventually chosen.'' (section 3 para 27). By arguing thus the Committee distances itself from those who argue that the PWR is a better economic proposition than the AGR and therefore that the PWR should be licenced. The Select Committee is not convinced that either of them will do anything to improve the bad position in the UK on electricity prices. It also draws attention to the importance of looking at alternatives. It criticises the board for thinking only in terms of coal versus nuclear. To quote ''We would have greater confidence in the board's argument if we were convinced that it addressed itself as rigorously to the economic case *when investing in a programme at all*, as it does to the relative merits of coal and nuclear.'' (section 3 para 23). Earlier the Committee had made an extremely interesting proposition that the cost of building a nuclear power station should be compared with the cost of energy conservation or rather that there should be some cost effective test which would show which

which influence costs. It notes the existence of "the current large plant surplus on both the CEGB and the SSEB systems" (section 2 para 7); and suggests that "it is important was the most beneficial and it said "we were dismayed to find that, seven years after the first major oil price increases, the Department of Energy has no clear idea of whether investing around £1300 million in a single nuclear plant (or a smaller but still important amount in a fossil fuel station) is as cost effective as spending a similar sum to promote energy conservation." And it further adds "the Department of Energy should assess in future as it should have done in the past the economics of public expenditure to promote energy conservation with the same rigour as that required for the economic appraisal of new generating plant." (section 2 paras 16 and 17). Some readers may regard that as being the most far sighted observation of the Select Committee, because it shows that it is beginning to consider energy supply as an open ended system in which the cost of not producing energy should first of all be compared with the cost of producing energy. If the Department of Energy could get such an approach into the centre of its thinking, a quite different energy policy might even become possible.

Colin Sweet

Wheeling and Dealing

CIRCLE OF POISON: Pesticides and People in a Hungry World, by David Weir and Mark Shapiro. Institute of Food and Development, $3.95.

One of the first decisions taken by Ronald Reagan when he came to power was to revoke an executive order — issued five days before President Carter left the White House — clamping down on the export to the Third World of pesticides banned in the United States. Reagan's decision is consistent with his view, voiced time and again throughout his election campaign, that US industry is 'over-regulated' and that recent social legislation (much of it initiated by environmental pressure groups) is in large part responsible for the recession now gripping the US economy. His philosophy is grounded in the most hard-bitten of laissez-faire principles and has a simple logic: if only environmentalists would keep from meddling in the affairs of the nation's boardrooms, then industry could get on with creating wealth — wealth which it could then put to protecting the environment.

All of which must be music to industry's ears. The argument, however rests on the assumpton that industry is not only prepared to put the welfare of the environment high on its list of priorities, but also that it is actually concerned about the environmental consequences of its activities. *Circle of Poison* makes such assumptions hard pills to swallow. Take, for example, the comment of one executive when asked about the impact of the 1979 ban by the US Environmental Protection Agency on DBCP, a worm killer, on his company's business: "There was no problem with the ban on DBCP. In fact, it was the best thing that could have happened to us. You can't sell it here anymore but you can still sell it anywhere else. Our big market has always been exports anyway." Thus the Third World became a dumping ground for a chemical which the US authorities felt was too dangerous to market at home — a chemical which clinical tests had shown to cause not only sterility but also cancer.

It is this use of the Third World as a dump site — a sort of glorified Love Canal — that is the subject of *Circles of Poison*. The careless use of pesticides in the Third World, often by peasants who are quite unaware of the chemical dangers involved, results in one pesticide poisoning every minute of the day — and, according to The World Health Organisation, one death every hour and three-quarters. Most of the pesticides used have been banned in the United States as health hazards and yet American companies are largely responsible for supplying them, even now, to the Third World countries. The result is often massive contamination of the local environment. "Here pesticides are the dish of the day," one South American farmer told the authors. "One swallows more poison than food." Indeed, studies now reveal that people in Nicaragua and Guatemala carry thirty-one times as much DDT in their blood as the average American. DDT levels in cow's milk in Guatemala is ninety times higher than that permitted in the USA.

The problem does not stop there, however. Food imported into the USA from Third World countries frequently contains residues of banned pesticides in excess of permitted US federal standards. Thus, in 1976, the US Department of Agriculture had to refuse entry to about half a million pounds of DDT contaminated beef from El Salvador, while peppers from another South American country were found to contain twenty-nine times the permitted level of pesticide residue. It is this contamination of food eaten within the USA (the law does not permit customs officers to sieze the contaminated imports and consequently they get sold regardless) that completes the 'circle' that gives the book its title — a circle that starts with the poisoning of those manufacturing the chemicals, goes on to include those using them, and ends with the poisoning of the US consumer.

For their part, the pesticide companies justify the export of pesticides — banned or legal — by claiming that they help to boost food production and thus feed a hungry world. That argument, claim the authors, is a dangerous and cynical myth. They point out that almost all the pesticides exported to the Third World are used on 'luxury, export crops' and not on those foods eaten by the local population (for that they may be thankful!).

The book, based on a series of articles in *Mother Jones* which won the authors the National Magazine Award, deserves to be widely read. The export of banned pesticides not only makes a mockery of the victories won by environmentalists in the sixties and seventies but also of the spirit, if not the letter, of the law. That this worldwide scandal should be allowed to continue — apparently with the blessing of the newly elected President — does not bode well and one is left wondering just what hope there is for the now embattled US environmental movement.

Nicholas Hildyard

Letters

Opening up Secrets

Dear Sir,

Brian Martin has hit many nails squarely on their heads. His review is of particular concern to scientists working in fields related to environmental questions because the basic arguments can increasingly be perceived as what he calls 'paradigm disputes'. Martin's cases are drawn from Australian experience, and it is desirable that the analysis be now broadened. This is not merely to add cases, of course, but to enrich our understanding of what is going on, and to help us counter the forms of suppression to which he refers.

I am a fisheries biologist, one of a small number that in the years immediately after the second world war laid the foundations for the application of population dynamics in this field. Scientific findings here challenge the basic tenets of the exploitation of renewable resources for profit. During 25 years of employment with the Food and Agricultural Organization of the U.N. from which I retired this month — I have watched the forms of suppression Martin describes in operation, and in recent years particularly the singling out of 'environmentalists.' During that time I have been able to secure documents showing how individuals and governments have sought to interfere with the due process of science, when findings threaten policies and prevailing paradigms.

For the past ten years I have been concerned with the conservation of whales, which as we all know is an emotionally charged subject. In many countries scientists whose work has shown that whale populations are more threatened than is 'officially' considered to be so, by the International Whaling Commission, for example, have had to seek funds from 'environmental organizations' to continue their work. This has, of course, increased their exposure to smear campaigns and other forms of attack enumerated by Martin. Dealing with the situation of being in a small outspoken majority is a matter of personal psychology; some are more easily able to cope than others. However, when it can be perceived that such a situation is not unique to one's particular field of operation, it becomes possible to contribute more positively to the process of overturning prevailing paradigms when this is necessary for scientific progress. I hope therefore that this discussion will not end with Martin's article and a couple of responding letters. Perhaps The Ecologist *can undertake a project to bring this matter more fully into the open. In doing so it will be found, I am sure, that more of the scientific community is in accord with the ideas which you propagate monthly thank you think; more of our insecure colleagues will be persuaded to change trains.*

Yours faithfully,
Sidney Holt,
St. John's College, Cambridge.

Pen Mightier than the Sword

Dear Sir,

Victor Prochaska takes you to task for not telling us "what to do and how to do it" (Jan-Feb issue). He pleads for "a blueprint for survival for the family and individual," and suggests that appropriate actions might be to boycott beef, live in a communal house, and walk five miles to work in secondhand army boots.

He is not alone in wondering "what to do about it."

I suggest we remember the adage "The pen is mightier than the sword", and extend it to the fact that the tongue is mightier still.

Writing and talking about the subjects ventilated in The Ecologist *are likely to have more far-reaching effects than boycotting beef and the like. But to write or talk to good purpose means studying the subjects we write or talk about, and keeping up to date.*

During the last decade or so there has been an encouraging change in public knowledge and concern about ecology and allied subjects. Writing and talking [knowledgeable!] have helped this come about.

But chatting about yesterday's weather or the mating hazards of royalty isn't the kind of talking I have in mind!

Yours faithfully,
Sir Kelvin Spencer,
Branscome, Devon.

Classified

MISCELLANEOUS

SCIENCE, PROGRESS, EDUCATION: Can you live without these myths? Don't want your children indoctrinated? Then the matriarchal community needs you. Literature 45p from Lux Madriana (E), 40 St. John Street, Oxford.

MAGION IONISERS. Remove smoke, bacteria, static, from air. Benefits health. Only £35 inclusive. SAE to Biophysical Research, 126 Bevan Street, Lowestoft, Suffolk.

COME TO THE OFFA'S DYKE HERITAGE CENTRE. Of interest to Archaeologists, historians, students of architecture, geologists and school outings. Equipped with books and maps the centre stands on the mid point of the Offa's Dyke Path. For further details write to Offa's Dyke Heritage Centre, Canolfan Offa, West Street, Knighton, Powys, Wales. Tel: (0547) 528192.

NUCLEAR POWER? NO THANKS — smiling sun symbol available from: SCRAM, 2a Ainslie Place, Edinburgh 3, Tel. 031 225 7752 or from Friends of the Earth, 9 Poland Street, London W1, Tel. 01 4341 684.

TUNBRIDGE WELLS WORLD FAIR — in aid of FoE's 10th anniversary celebrations, the Tunbridge Wells group are organising an environmental fair with exhibitors, entertainment, films, games and food. Venue is the Trinity Arts Centre, Church Road, Tunbridge Wells on May 4th (May Bank Holiday) from 11-5pm. Bring the community.

CONFERENCES AND COURSES

WEEKEND ECOLOGY COURSE IN THE LAKE DISTRICT

9th-11th October 1981
Accommodation and Food provided
£15 to £20
For further details send SAE to
Low Gillerthwaite, Field Centre, Ennerdale, Cleator, Cumbria CA23 3AX

LANDSCAPE INSTITUTE CONFERENCE 1981

Silsoe Conference Centre, National College of Agricultural Engineering, Silsoe, Bedfordshire, 16, 17 + 18 September 1981.
Conference theme — EFFECTIVE LANDSCAPE including 'Land Analysis', 'Politics of Achievement', 'Successful Planting Associations', 'Role of Landscape in the Urban Environment', 'Parks from Minimum Resources'.
Speakers invited — I. McHarg, E. Kemp, F. Lloyd Roche, Sutherland Lyall.
For further information contact B. Ede, c/o Central Landscape Unit, Milton Keynes Development Corporation, 671 Silbury Boulevard, Milton Keynes MK9 3EB.

BOOKS AND PUBLICATIONS

WORLD WEATHER PATTERNS are changing! Follow them monthly in new journal **Jet Stream**. Sample free, first issue £1.74, annual £13.20. Westwind Services, 60 Talfourd Avenue, Reading.

PERSONAL

I'd really like to meet an UNATTACHED MAN, late twenties-ish, in London, to genuinely share life with, having the same interests and attitudes as myself, (environment, conservation, disarmament, Brandt, appropriate technology, etc.), sincere human values, and a desire to move towards these things and develop our knowledge together. Most men I know are into consumerism, big business etc. Ring 01-834-9989.

FORTHCOMING EVENTS

The Rural Development Programme at Emerson College announces: A Four Week Summer Course on Intensive Small Scale Biological Food Production. Dates: 16 July — 12 August, fee incl. full board and lodging £200. Write to: Rural Development Programme, Emerson College, Forest Row, Sussex RH18 5JX, England.

Third International Congress of Ecology INTECOL to be held in Warsaw, Poland, September 5-11, 1982. Further details from: Dr. Tadeusz Prus, Institute of Ecology, Dziekanow Lesny near Warsaw, P.O. Lomianki, 05-150, Poland.

Second International Environment and Safety Exhibition and Conference, September 2-4, 1981 at Wembley Conference Centre, London, England. For further details write to: I E & S, Labmate Ltd., Newgate, Sandpit Lane, St. Albans, Herts AL4 0BS, U.K. Tel: 0727 51993/31337.

The Vegetarian Society are holding a one-day Symposium on 2nd May 1981 at the Commonwealth Institute Theatre, Kensington High Street, London W8, entitled 'A New Deal for Animals'. Tickets at £1.50 are available from the Vegetarian Society, 53 Marloes Road, London W8 (SAE please).

ASHTON Medieval Faire — June 13 + 14 1981. Further information from The Publicity Office, 2b South Road, Oundle.

The 1981 National Co-ops Fair will be held on 10th, 11th, 12th July at Beechwood, Leeds. For more details contact Freer Spreckley at Beechwood College, Leeds 720205.

First Assembly of the Fourth World to be held in London July 29-31 1981. Details from: 24 Abercorn Place, London NW8, England. Tel: 01 286 4366.

Tunbridge Wells World Fair — see under Miscellaneous.

DUNAMIS/TURNING POINT. All-Day Meeting, Saturday 9th May 1981 at St. James's Church, Piccadilly, London W1. Security and Survival: New Perspectives in the Defence Debate. Write to: Dunamis, St. James's Rectory, 197 Piccadilly, London W1V 9LF.

MARCH AGAINST CRUISE AND TRIDENT — Mass demonstration for European Nuclear Disarmament on Saturday 18th April, in Leamington Spa. Details from: Madeleine Thompson, 9 Church Terrace, Cubbington, Leamington Spa, Warwicks.

The Medical Association for Prevention of War is holding a one-day conference at The Royal Society of Medicine on Saturday April 11th 1981, 10.30 a.m. — The North-South dialogue (Brandt Report): Is it our concern? 11.30 a.m. — A View from the Edge of the Abyss: An assessment of the present state of the nuclear arms race. Speakers: Evan Luard and Professor M. Pentz. Further details from: Helen Lang-Brown, 57B Somerton Road, London NW2 1RU. Tel: 01 450 4785.

ECOLOGY PARTY SUMMER GATHERING 1981, 28 July — 2 August at Worthy Farm, Pilton, Nr. Shepton Mallet, Somerset. Cost £1.00 per day, children free. All enquiries to: Christina Crossingham, 11 Stanley Road, Redland, Bristol, BS6 6NP. Tel: 0272 43086.

CALL FOR PAPERS — 7th Canadian Symposium on Remote Sensing. Winnipeg, Manitoba, Canada, September 8-11, 1981. Theme: Down to Earth Management. Write to: Mr. D. Pearson, Registration, Box 1106, Winnipeg, Manitoba, R3C 2X4 Canada.

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BAD NEWS!

DAILY Mirror

Tuesday, March 11, 1990 £1.40

2,000 DIE IN NUCLEAR DISASTER

CLOUD OF DEATH

A CLOUD OF DEATH from the devastated Sizewell nuclear power station closed over Ipswich last night – swathing one of East Anglia's principal towns in a blanket of deadly radioactive gases.

Already more than 2,000 people have died in Britain's worst-ever peacetime disaster.

And experts fear that the lives of 50,000 people are now "seriously at risk" as the radioactive cloud drifts across the densely-populated area. Late last night, all roads from Ipswich were choked with panic-stricken refugees fighting to escape the atomic cloud.

More casualties were reported when three lorries carrying evacuated hospital patients crashed on the A12 London road.

From BRYN JONES in Colchester

Inside the city, troops in special protective clothing were battling to contain the looting. But fires are raging out of control in the centre and telephone reports from residents still trapped inside the doomed city say large areas have been gutted.

Disaster struck at 3.41 pm yesterday afternoon, after a cooling failure at Sizewell caused a cataclysmic melt-down in the central reactor core.

In the massive explosion that followed, vast quantities of deadly radioactive gases were released into the atmosphere. Two thousand people died immediately – including 300 children at a nearby school.

But Civil Defence authorities say tens of thousands more have already been fatally contaminated.

A TERRIFIED mother flees the poison cloud with her child – but is it already too late for them both?

THE CATACLYSM AT SIZEWELL BACK PAGE AND INSIDE

Published by Greenpeace

Copies of this poster (size 11¾ x 14¼ inches, black and red) are available from Greenpeace price 50p including postage and packing.

YESTERDAY HARRISBURG — TOMORROW SIZEWELL?

Greenpeace is fighting back today:
with direct action, by using the law, by encouraging organised resistance.
Fighting to stop:
the PWR programme, spent fuel shipments to Barrow, plutonium nitrate shipments to Workington, cancers in Cumbria, radioactive discharges from Windscale.

Your donations to the Greenpeace anti-nuclear fighting fund are urgently required. Send your contributions now to:
Greenpeace Limited, Dept. TM, 36 Graham Street, London N1 8LL.

HELP GREENPEACE NOW BEFORE TODAY'S FICTION BECOMES TOMORROW'S FACT!