1 Forestry in the Long Sweep of History
(Keynote Address)

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The title of this chapter is stolen, shamelessly but I think appropriately, from a paper of a similar name by Marion Clawson (Clawson, 1979) – perhaps one of the two most important papers ever written about forest economics, the other being 'A view from John Sanderson's farm' by Hugh Raup (Raup, 1966). My comments rely heavily on the half a century of path-breaking work on resource economics done by Clawson and his colleagues at 'Resources for the Future', so the title is meant to invoke the spirit of these contributions. I am not going into any of the mathematics in this chapter. Instead, I intend to translate the mathematics into English and, based on that analysis, draw some conclusions about the logical and desirable directions for the forest sector and for forest policy.

I begin by describing the long-term economic dynamics of the forest sector. The depletion of natural forests drives these dynamics. The dynamics rely heavily on both technological innovation and capital/resource substitution – the substitution of capital for timber in the manufacture of forest products, and the substitution of capital for land in the production of timber. Based on this analysis, I examine two areas of contemporary forest policy – the appropriate role of timber plantations in timber supply, and the appropriate role for forests in climate-change policy.

First let me be clear on what I mean by 'forests', 'forestry' and 'the forest sector'. The first written definition of 'forest' was published, not surprisingly, in the first dictionary of the English language, Samuel Johnson's, printed in 1701. Johnson defined a forest as

> a certain territory of woody ground and fruitful pastures privileged for wild beasts and fowl of forest, chase and warren to rest and abide in, in the safe protection of the king for his pleasure.

By implication, this also defined forestry. A forester's sworn duty was to protect the 'vert and venison', that is, the wildlife habitat and the wildlife itself. According to the Assize of Henry, the forester's failure to do so was punishable by flogging or death. I doubt that even Greenpeace would support such tough sanctions for violations of forest practice laws today!

In many ways, this definition is as relevant today as it was 300 years ago. Forests in their totality must respect and support a wide variety of uses.

- Forests where human interference is absent, or nearly so, provide important spiritual, ecological and cultural values.
- Forests help to regulate key global biogeochemical cycles.
- Forests are the inspiration for poets and artists.
- For billions of us, forests form the core of our recreational activities and the backdrop for everyday life.
- Forests provide wood, one of the most ubiquitous and important sources of raw materials and energy in the world today.
- Millions of aboriginal people have another word for forests – they call them 'home'.

In my terminology, the forest sector encompasses this broad array of goods and services, and any useful policy concerning the forest sector must recognize and support the entire spectrum.

Timber Depletion and Transition in the Forest Sector

Two factors distinguish the timber side of the forest sector: a long production cycle for forests and the presence of a standing inventory of timber that is large when compared with annual usage. As a result of these two factors, the forest sector possesses an unusual degree of temporal momentum, which is present in few other aspects of human endeavour. This momentum permits us to foresee the outline of developments over the next few decades, even if the details are unclear and uncertain.

To describe the dynamics of forest sector development, consider forests on a global scale and in the 'long sweep of history', as promised in the title of this chapter. I will take the economist's perspective of holding everything else constant, recognizing, of course, that the real world is made of a much richer fabric of complications. The underlying story is the transition from the hunter–gatherer stage of forestry to the husbandry-stewardship phase.

For agriculture this transition began about 10,000 years ago, when some of our ancestors wandered over a mountain ridge top in ancient Mesopotamia and discovered einkorn wheat growing wild in what is now known as the Fertile Crescent. Prior to that discovery, human existence required us to glean sustenance from numerous wild organisms. Now most of us get virtually all of our food from about ten domesticated plants and five domesticated animals. In developed countries, a few of us still scavenge the wild earth, but only for sport or other atavistic reasons; the wild landscape is the source of only a tiny fraction of our food. So, for agriculture the transition is now complete. Since the production cycle for trees is long when compared with that for annual crops, and the inventory of standing timber is large relative to annual consumption, the transition in our use of forests will take a much longer time than it did for agriculture. This transition still has a few more decades to run, but it explains much of our situation today.

Timber depletion drives the transition. Early on, timber prices are low, and forest land is more valuable for other uses, especially the production of food. So the trees are removed and not replaced. In an old-growth forest, the accumulation of merchantable timber is low or negative, especially on the economic margin where all the interesting economic action occurs. As a consequence, any harvest at all causes the standing inventory to decline. As the standing inventory declines, timber becomes increasingly scarce.

For an economist, increasing scarcity means rising prices. Timber prices rise for two reasons. First, as logging moves into more difficult terrain, increased costs push prices up. Second, as Hotelling taught us, the markets for natural resources are connected with the markets for capital. In the absence of biological growth, equilibrium between these two markets requires that timber rents increase at the rate of interest. Long-term trends in US timber prices are consistent with this theoretical model.

Three factors limit the inevitable upward pressure on timber prices. The first factor is a shift in the extensive margin. As prices in one region increase, it becomes economical to operate in other regions that harbour primary forests. For example, the relatively high timber prices in the USA in the late 1960s and early 1970s opened the door for expanded timber production in the British Columbia interior. Of course, once the infrastructure was in place, supply did not contract as prices fell again because the costs of entry were already paid. Similarly, higher prices in British Columbia opened the door for the Russian Far-East to expand production into Asian markets. Such interregional shifts in the extensive margin obviously comprise only a finite response to timber scarcity. There are only so many new regions to be exploited, and each one is apt to be more costly than the last.

Secondly, as prices rise for timber in natural forests, the purposeful husbandry of planted forests becomes economic. Examples abound around the world, but probably none of them are clearer than what we see in the southern states of the USA. The first step is usually the exclusion of wildfire and the protection of natural regeneration. Such management actions evolve into the quite sophisticated agronomic practices we observe in many regions of the world today. These practices can supply wood at a relatively modest cost.

Dennis Neilson, a forestry consultant in New Zealand, recently completed a comprehensive and definitive study of the costs – including land rental, silvicultural costs and interest on capital – of producing timber in modern plantations. Across nearly 200 site/species combinations, he found the median cost to be about \$7 m^{-3} for teak, \$8 m^{-3} for eucalypts, and \$20 for southern pine. These costs are far below current stumpage prices for natural forests in much of the world. For example, current stumpage prices in the southern USA are in the range of \$40 to \$50 m^{-3}. The gulf is even wider for hardwoods. Timber depletion has driven timber prices to a high enough level so that the remaining natural forests in the world will be protected by the most prosaic mechanism of all – it will simply be too costly to log them, given the availability of lower-cost plantation-grown fibre.

Finally, increases in timber prices drive technological innovation. On the supply side, higher timber prices and higher land costs force innovations in tree-growing technologies. Despite 10,000 years of agricultural innovation, maize yields are still increasing at about 2% per year. I have seen no good data for forest plantations, but anecdotal estimates by scientists at Westvaco Corporation suggest that specific timber yields may be increasing at about 3% per year – a reasonable figure given the relative infancy of timber production technologies.

On the demand side, higher timber costs lead to resource conservation in manufacturing. For example, over the last decade the lumber recovery factor (the amount of lumber produced per unit of log input) in British Columbia – the only place where I have seen good data – has increased by an average of 1.4% per year, despite a deterioration in log quality. The increase has been steady over the 13-year history of the data series. That represents phenomenal technical progress, and has an enormous impact on the demand for timber. As an another example, engineered wood products use wood more efficiently than traditional wood products. Parallam® and Timberstrand® recover 60–90% more of the tree as usable product than does lumber. Wooden I-beams now command perhaps one-third of the North American floor joist market, displacing wide-dimension lumber. An I-beam floor-joist system uses about half as much wood fibre as the traditional 2 × 10 system.

The Rise of Environmental Services from Forests

What about the other important element of the forest sector – environmental services? Forest sector development and timber depletion affect the supply/demand balance for these services. The demand for most environmental services is highly correlated with personal income. The evidence for a connection between income and the demand for environmental services is very well established for some aspects of the environment – clean air, clean water and outdoor recreation – and I believe the relationship is more generally true as well.

That humans value aesthetic aspects of the natural world more once their material needs are satisfied is not surprising. In his excellent review of the human relationships with forests in antiquity, the historian John Perlin commented

> Seneca articulated the romantic view of forests shared by many of the leisure class of his time. 'If you ever come upon a grove that is full of ancient trees, which have grown to unusual height, shutting out the view of the sky by a veil of pleated and intertwining branches, then the loftiness of the forest, the seclusion of the spot, and the thick, unbroken shade on the midst of open space, will prove to you the presence of God'.

One cannot help but note the similarity of this comment made two millennia ago with contemporary descriptions of old-growth forests.

Of course, most environmental services operate outside formal markets, either because they are public goods or because society has simply chosen not to allocate them through markets. It is a simple truism that, because they are not priced, such goods are systematically over-consumed and under-produced. Market-based patterns of land use do not and cannot reflect the societal values of these inputs and outputs. Forest sector development may decrease supply of these environmental services, and increased income (ironically, created in part by exploitation of forests) will increase the demand for them. So we have a reduction in supply and an increase in demand, but there are no prices available to signal relative scarcity and to induce socially appropriate changes in production and consumption. Once the mismatch between supply and demand for environmental services becomes great enough, governments intervene through forest practice regulations and land set-asides.

These are just the broad outlines, but these predictable trends have three important implications for thinking about forest management and policy. First, price increases for timber are limited by the availability of plantation technologies to grow industrial roundwood and by our capacity to substitute wood-saving technologies and other materials for traditional wood products, so timber prices will not continue to rise forever.

Secondly, the implicit price of environmental goods and services provided by the forests is not bounded. There are no limits on increased income – or so economists say – so there is no limit on demand for environmental services, especially if there is no charge for them. In addition there are few, if any, technical substitutes for environmental services of the forest.

The third point follows from the first two. Forest land has become scarce. That is, there are many competing demands for forest land. It is therefore logical to substitute other factors of production, especially capital and technology, for land. This is particularly true for industrial timber production because it is easier to do so for this purpose than for production of the environmental goods and services of forests.

These facts have important implications for forest policy. Space does not permit a comprehensive treatment of such a broad and important topic, so as a consequence, I will only discuss a couple of specific issues, important in their own right and as exemplars. The first relates to enhancing the role of plantations in timber production. The second relates to the carbon sequestration services that are available from forests.

Enhancing the Role of Plantations

The challenge for contemporary timber production is to craft management approaches that respond affirmatively to the overarching economic imperatives already outlined. Broadly speaking, there are two sources of timber supply – natural forests and plantations. As I have argued, the general trend in the sector is for supply to shift from the former towards the latter. Management and policy interventions could fruitfully work to accelerate this transition.

I have argued elsewhere that natural forest management technologies face daunting challenges – they are too costly, they cannot reliably produce positive environmental outcomes, they are not economically sustainable – to name just a few. However, if natural forest management is not the answer, where are we going to get our wood? Timber plantations permit foresters to substitute capital and technology for land. That is exactly what the economic forces are telling us to do. This is an extraordinarily powerful tool.

Studies initiated by John Gordon in the early 1970s examined maximum theoretical timber yields based on the biochemical efficiency of trees in turning sunlight and water into economically usable plant parts. The Weyerhaeuser Company applied these models to two sites where they manage lands about as intensively as anywhere in the world – one in the Pacific Northwest and one in the southern USA. Yet on these sites, best management practices achieved only 40–50% of the modelled maximum yields. And on those same sites, natural stands produced only 10–25% of the maximum yields. When examined across the globe, two- to fivefold increases in specific timber yields appear to be technically feasible and economically attractive.

Plantations for timber production are appealing due to this large capacity to free natural forests from intensive exploitation for industrial purposes. Within a region every hectare of plantation forest can free up to 5 ha of natural forest from industrial use. The substitution is far greater across regions with, for example, 1 ha of timber production on plantations in Brazil substituting for perhaps 20 ha of land in Siberia or the Canadian interior. Combined with sophisticated wood-products technology, the plantation-grown wood can substitute for most, if not all, of the products obtained from the natural forest. Indeed the uniform and possibly custom designed fibre characteristics of plantation-grown wood make it more desirable for many products. The use of sophisticated engineering concepts and small amounts of non-wood materials in such products as laminated veneer lumber or oriented-strand lumber will obviate the need for the thing we now call a sawlog.

At Hancock Timber we recently did some aggregate simulations of global timber supply and demand in order to understand the role of planted forests in the future balance. The simulation assumptions were simple – extend current rates of plantation establishment and productivity. The only innovation was to permit the plantations to become more productive over time – based on the Westvaco experience mentioned earlier. We imagined that demand would first be met by plantation supply, and only then by natural forests. With these assumptions, by 2025, logging on natural forests would fall by more than half – from about 1.3 billion m^3 today to about 600 million m^3 then. As a point of reference, this latter quantity of wood could be supplied by taking half the current harvest of natural forests in the eastern USA, and half the current harvest from natural forests in Europe. Under this scenario, we would plant about 100 million ha of degraded agricultural lands for timber plantations. About two-thirds of this area would be used for timber supply, and the remainder would be devoted to restoring and protecting riparian areas, and creating landscape-scale biodiversity. Under this scenario, there would be no need to log the old-growth forests of Canada, Russia or the tropics. From an environmental perspective, this is a most attractive proposition. It also offers the forestry industry a stable, uniform and perhaps less controversial source of fibre. Finally, it offers forestry investors a reliable source of returns – biological growth and technical innovation.

To achieve this vision, the forest sector needs a global agreement among conservation organizations, government and industry on the pivotal role of intensively managed plantation forests in achieving an economically, ecologically and socially sustainable forest sector. This agreement should include such factors as the critical need for plantation projects to maintain and enhance landscape-scale biodiversity, with perhaps 20–30% of the landbase of plantation projects devoted to the ecological services of forests. We see fine examples of such management at the Klabin and Aracruz operations in Brazil, and at Westvaco's forests on the South Carolina coast. The agreement should include the careful and close control of the off-site impacts of plantation-based timber production – especially the movement of silt, fertilizer or herbicides into waterways or groundwater. The agreement should include an acceptable regime for using yield-enhancing chemicals such as fertilizers and herbicides, focused on minimizing use and maximizing impact. The agreement should support the use of genetically modified organisms (GMOs) only in circumstances where it can be clearly demonstrated that gene flow out of the plantation is not possible (for example, in asexual trees). As with New Zealand's Tasman Forest Accord, the agreement should include a commitment not to log old-growth forests.

Enhancing the Role of Forests in Carbon Sequestration

In the early 1950s, Roger Revelle wondered what was happening to the by-products of all the oil, coal and natural gas that humans were consuming. To find out, he went to the top of Mauna Loa in Hawaii, where the air was free from local industrial pollution, and began careful measurements of the concentration of CO_2 in the atmosphere. The data have two components, an upward trend and significant within-year fluctuations. The five decades of these measurements clearly demonstrate that CO_2 concentrations are increasing. Interestingly, the intra-annual fluctuations also clearly demonstrate the significant effect of the summer-time growth of the plants that occupy the large land masses of the northern hemisphere.

Theoretical models of global heat flux indicate that the Earth's surface should warm as a consequence of these higher levels of CO_2, with CO_2 playing the same role in the atmosphere as glass does in a greenhouse. A paper published recently compares satellite measurements of incoming and outgoing radiation made in the early 1970s with contemporary ones. These comparisons clearly demonstrate that more of the incident solar radiation is being absorbed now than was the case three decades ago, just as the heat-flux 'greenhouse' models would predict. Despite George Bush's recent proclamations to the contrary, it becomes ever more difficult to doubt that the well-documented and unarguable build-up of CO_2 in the atmosphere will produce higher global temperatures and, therefore, probably changes in precipitation patterns and perhaps also the frequency and intensity of storm events.

Such matters concern foresters in several different ways. In the first place, the clearing of forests for other uses is estimated to contribute about one-fifth of the total increase in CO_2. In the second place, increases in atmospheric concentrations of CO_2 – an important plant food – will tend to increase forest growth. In the third place, changes in climate are apt to change the range of particular forest types, and the productivity of forest lands;

some of the changes will be positive, and some negative. Finally, trees comprise one of the only technologies available to reduce atmospheric levels of CO_2 – and at a comparatively low cost.

The Kyoto Protocol seeks to reduce atmospheric levels of CO_2. Under the not-yet-ratified protocol, certain countries agreed to reduce their contributions to the build-up of CO_2 and other greenhouse gases, either by reducing their carbon emissions or by enhancing the sequestration of CO_2. The total agreed-upon reduction was about 4 billion tonnes (t) of CO_2-equivalents. Articles 3.3 and 3.4 of this protocol deal with the potential role of trees in helping to reduce the build-up of carbon dioxide in the atmosphere. Article 3.3 relates to afforesting lands that were not covered by trees in 1990. Article 3.4 relates to carbon fixed in all other forests, and all other forestry activities. The Clean Development Mechanism, if extended to forests, would permit those in the developed world to invest in creating new forests in the developing world.

The forestry community has been deeply divided in its support of the Kyoto agreement. Some argue for so-called 'wall-to-wall' accounting for forest-sector-related carbon. Under this approach all carbon fixed by all forests, including carbon sequestered in forest products, would be included in national accounting. For the USA, this approach would offset about one half of the country's Kyoto commitment. Because the carbon sequestered under this accounting rule is, arguably, not truly additive to the baseline, this approach is widely opposed in the international community. Others, especially those from parts of the environmental community, argue that no carbon dioxide sequestered in forests should credited. They base their position on two arguments: (i) the carbon sequestered in forests is difficult to measure and may be lost through natural disturbances, and (ii) forest-based sequestration takes away from the real business of reducing emissions.

I suggest a modest, positive, step-by-step approach. First, the USA should develop and adopt a policy framework that would enable private actions related to carbon sequestration in forests. This policy framework should include a carbon accounting standard, first for plantations and then for the more complex issues related to natural forests. It should enable a registry of carbon credits (either public or private), and the associated legal framework to attach 'carbon covenants' to land deeds. It should agree to credit 'early action' against any mandatory reductions that might subsequently be imposed. None of this is rocket science, indeed, much of this infrastructure is already in place in other countries such as Australia. All of this is very conservative and very Republican – simply create the rules so that private market transactions can take place. Because such actions reduce regulatory uncertainty, they would receive wide support among the enlightened elements of the energy industry as well as from the conservation movement. Those of us in the forest sector should actively support this modest first step.

Secondly, the forestry community should support Article 3.3 activities, and the inclusion of forests under the Clean Development Mechanism, and this support should be unconditional on the outcome of Article 3.4 discussions. Recall that a key feature of forest sector development is the substitution of capital for land. Establishing the 100 million ha of new forests mentioned in the simulations above will require about \$250–500 billion. Even if forest-related sequestration is capped at 10% of the total committed reduction, with the right policy framework, carbon credits could pay for perhaps half of this. This would comprise perhaps the largest single capital injection into the sector ever.

Conclusions

In the long sweep of history, the objectives of forestry have changed little. They are the same as they were when Johnson penned his definition quoted at the beginning of this chapter: stewardship and husbandry of forest lands for the wide range of values that forests provide. But time has passed, natural forests are being depleted, and predictable economic adjustments are taking place. Important among these are the rise in timber prices and a cascade of associated adjustments. Technical innovation – in tree growing, in forest products manufacturing and in the kinds of wood products we use – is a major force in the development of the sector. The autonomous economic dynamics of the sector tend to force us to substitute capital for natural resources: capital for timber in the production of forest products and capital for land in the production of timber.

It is logical and appropriate that forest policy responds and adapts to these new circumstances. In situations where goods are private and externalities few, a key objective of forest policy is to enhance the efficacy of markets in allocating resources. For timber production, this means greater reliance on planted forests and far less on natural forests. Natural forests will, naturally, be the source of many environmental services and products. In situations where such public goods are at stake, governments have a useful role in establishing the rules so that markets can help to mediate the supply and demand of these needed outputs. In the case of carbon sequestration in forests, the result could be a huge influx of capital into the sector. Interestingly, in this particular case, provision of the public good will enhance provision of the private one.

References

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