Sustained yield, timber mining, and the concept of eclogical rotation; a British Columbian view

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Rendement soutenu, exploitation à la façon minière, et le concept de révolution écologique: coup d'oeil d'un Colombien Britannique. *La légitimité du concept du rendement soutenu en tant que pierre angulaire de l'aménagement forestier nord-américain a été mise en question par certains aménagistes et économistes forestiers. Leurs arguments prônaient surtout un manque de liberté dans la régularisation du rendement sans restriction par rapport aux fluctuations du marché. La question, à savoir si, oui ou non le rendement soutenu est un principe écologique sain sur lequel on peut se baser pour aménager tout terrain forestier est demeurée fortement sans question ni réponse. On soutient que le principe de base du concept pour un rendement soutenu réside dans le fait qu'il s'agit d'une richesse renouvelable. Par contre, on rapporte que bon nombre de superficies forestières ne constituent pas en elles-mêmes une richesse renouvelable et que le rendement soutenu, dans ces cas, représente un concept inapproprié dans ces régions. La récolte de ces superficies n'est ni plus ni moins qu'analogue à l'exploitation minière. On suggère alors que ce genre d'exploitation ne devroit pas, à priori, être considéré comme un tel mal social ou professionnel. Le danger réside alors lorsqu'il se déguise sous ce nom de rendement soutenu. Les richesses forestières devraient être écologiquement cartographiées afin d'en évaluer leur renouvellement en les classant suivant 1 ou 2 catégories. Dans un premier classement, l'aménagement pour un rendement soutenu effectué sous la surveillance de forestiers expérimentés consistera généralement en la meilleure utilisation possible. Dans une deuxième catégorie, les décisions sur ce qui constitue le meilleur emploi de la resource forestière, devraient être prises par des équipes multidisciplinaires travaillant en coopération avec les développements politiques. Cette révolte, analogue à celle de l'exploitation minière, devrait être uniquement réalisée comme résultat de cette deuxième catégorie.*

The profession of forestry has evolved in one form or another at various times and places in man's cultural history. In every case the motivating force behind its development has been to sustain the supply of a variety of desired goods and services provided to the contemporary society by forest cover. The Ford-Robertson (1971) definition of forestry reflects the same notion of sustained provision of forest products or non material values: "Generally, a profession embracing the science, business and art of creating, conserving and managing forests and forest lands for the continuing use of their resources, material or other." It is not surprising, therefore, to find the classical sustained yield timber management concept deeply entrenched in the philosophy of forest land management in North America.

The continued existence of the sustained yield concept owes much to its rather general acceptance by most practising foresters. Many economists and economically biased forest managers have energetically attempted to debunk the concept (e.g. Gould 1962, Thompson 1966, Nautiyal and Smith 1967, Haley 1966 and 1968, Smith 1969, Naysmith 1970, Smith and Haley 1970, Pearse 1970) but with little success to date. There have been many champions ready to carry the scarf for sustained yield, and it has generally carried the day (e.g. Holt 1967 and 1968, Moss 1970, Thirgood and Haddock 1970, Travers 1970).

Without wishing to appear as an ecological turncoat, I would suggest that in agreement with the former group above (but for different reasons which will be explained below) the concept of sustained yield does indeed require a very penetrating examination before we continue to blithely accept it as a universal ideal. The idea that sustained yield timber management should be applied to every acre of forest may perhaps be ecologically as well as economically unrealistic. While most of the arguments over sustained yield have concerned themselves with the degree of flexibility of yield control, I will be dealing mainly with the question as to whether or not all of our forest lands are **capable** of sustained yield timber production.

Sustained yield and the concept of ecological rotation

Just as sustained yield is a characteristic of forestry in most parts of the world, so the failure to recognize the spatial and temporal variability in the ecological characteristics of our forest resource is a common denominator of our profession in many parts of the world. Practices such as clearcutting and broadcast slashburning, which are ecologically sound management tools on some sites, have been applied ubiquitously and uncritically, often with highly undesirable results. Similarly, the assumption that the concept of sustained yield is equally germane on all sites is ecologically naive. That this assumption is frequently made by my fellow members of the forestry profession is evidenced by the management of virtually all forests (except parks) in British Columbia according to this philosophy.

A fundamental tenet of sustained yield is that the resource is renewable: that we can harvest a

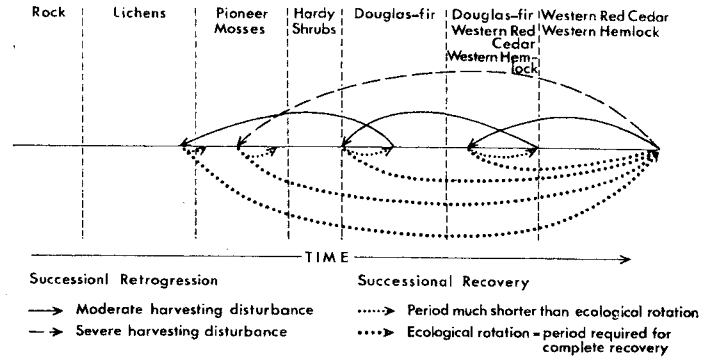

Fig. 1. Ecological rotation in terms of successional recovery. The figure depicts the successional consequences of either excessive or moderate harvesting disturbance in conjunction with rotations equal to or less than the ecological rotation.

forest with justifiable expectations that in the near future we will once again be able to enjoy the timber, wildlife, watershed protection, recreational and other values generated by forest cover.

I have pointed out elsewhere that the concept of resource renewability is socio-economic and not biological in nature (Kimmins 1973a). It has to do with the time span involved in the recovery or redevelopment of the resource to the point at which it once again generates the socio-economic values that we seek. When this time span is greater than contemporary society's time scale, the resource would be considered non-renewable, even though it is obvious that eventually the resource will be reformed (after all, it is only 11,000 years since most of BC's magnificent forest lands were under 6,000 ft — 1,800 m — of ice). I have also suggested that the time for resource reformation, and thus its renewability, is a function of the flux of energy through the system in which the resource occurs. Anything which reduces the efficiency of the energy capture and transfer processes within the ecosystem will reduce this flux and thus reduce the resource renewability (see Kimmins 1973a for details of the argument).

There are many forests being harvested today, or scheduled for harvesting in the future, under the banner of sustained yield which cannot legitimately be considered as renewable resources. Let me explain by way of a discussion of the "ecological rotation".

Rotations can be calculated in a number of ways. For example, a technical rotation is that period required to produce a specified type of product. An economic rotation is the period over which mean annual return on investment is maximized. A maximum volume rotation is the period over which mean annual increment is maximized. An ecological rotation, on the other hand, would be the period required for a given site managed with a given technology to return to the pre-harvesting ecological condition. As an example I will dicuss ecological rotation in terms of 1/ ecological succession (for background reading, see Kimmins 1972 and Kimmins 1973b or similar material), and 2/ site nutrient capital.

Whenever a forest is harvested, the site is reverted to an earlier stage of the sere (defined as the sequence of plant and animal communities which successively occupy a site over a period of time). This is often both ecologically sound and economically desirable in order to favour a particular species (e.g. Douglas-fir in a predominantly western hemlock area). However, if the disturbance is excessive it can be disastrous in terms of future forest productivity. Figure 1 shows the successional consequences of either a very high degree of logging disturbance or a slight to moderate degree of logging disturbance coupled with a rotation shorter than the ecological rotation. The earlier stages of most seres are frequently prolonged and unproductive of trees, and so it is easy to designate the high degree of disturbance as undesirable. The moderate degree of disturbance may be deliberate and desirable in the first rotation, but if repeated at intervals shorter than the time required for complete successional recovery can result in a gradual retrogression, ultimately reaching the same nonproductive condition produced by the high degree of disturbance. Thus, a technique which produces moderate but acceptable disturbance over the first few rotations may suddenly produce highly undesirable results if not coupled to a rotation of appropriate length.

In terms of the renewability of resources, the high degree of disturbance in Figure 1 immediately impairs the energy flux through the system, rendering the resource non-renewable. The moderate disturbance coupled to the sort rotation initially sustains the energy flux, changing only the species involved, but eventually produces the same effect as the excessive disturbance.

A second example of this principle might be the depletion of the site nutrient capital accompanying harvesting. Amongst other things, trees need certain nutrients in certain proportions in order to grow. The forest has a certain capital of these nutrients which exists as a dynamic equilibrium between inputs from the atmosphere and soil weathering, and losses in streamwater or other pathways. Harvesting inevitably results in some depletion of the site nutrient capital through losses in harvested materials (Rennie 1957, Weetman and Weber 1972), as the result of disruption of nutrient retention mechanisms, and/or as the

result of such post-logging site treatments as slashburning. These losses are replaced in time, however, and for a given loss of nutrients on a given site there will be a given nutrient recovery period which might be referred to as the nutrient recovery rotation.

This idea is presented in the upper part of Figure 2, which shows nutrient recovery rotations for nutritional losses of different magnitude on sites which vary in their rate of recovery. The length of the recovery period is a function of two things: the degree of site nutrient depletion accompanying harvesting and the rate of replacement of the losses. On a site receiving nutrients in seepage water or having large reserves of readily weatherable soil minerals, even substantial losses may be replaced rapidly. On a site with very slow replacement and/or poorly developed nutrient accumulation mechanisms, even a small loss may take a substantial period for replacement.

The lower part of Figure 2 shows the effects of operating a rotation shorter than the nutrient recovery rotation on a site which is generously supplied with nutrients and on one for which available nutrients are only slightly above the level at which they become limiting to yield. Site nutrient capital will be gradually depleted since harvesting losses are not totally replaced before the site experiences further losses at the subsequent harvesting. Initially, this depletion may not be reflected in loss of tree growth, but if continued will eventually depress the site nutrient capital (or some individual nutrient) below some critical level, and site productivity will fall. On a nutritionally poor site (where the initial site nutrient capital is only marginally above the critical level) loss of growth may occur in the second or third rotation, while on the richer site there may be no obvious effects for four or five rotations.

There are substantial areas of forest in the world in which the application of the current technology of the region will result in either excessive successional retrogression, excessive depletion of the site nutrient capital, or some other ecological change which will seriously impair the ability of the site to grow trees. On these sites the differential between the ecological rotation with current technology and the financial or volume rotations which are anticipated is likely to be so great as to render the forests non-renewable resources which cannot be managed for timber under the sustained yield concept.

Timber mining

Timber mining might be defined as the utilization of a timber resource which has accumulated over a number of years with no justifiable expectation that the resource can be re-harvested within society's contemporary time scale. In other words, timber mining is the harvesting of a non-renewable forest resource.

If my contention is correct that many forests being managed on the basis of sustained yield are indeed non-renewable resources, what are the implications? Perhaps one of the most serious is the danger of over-cutting in the truly renewable forests. Frequently, the former are less accessible than the latter, with the result that much of the logging to date has occurred in areas of eminently renewable timber. The sustained yield rate of logging of these forests has been set on the assumption that forests growing under conditions such as thin soils over rock, steep slopes, high elevations, in areas of climatic extremes, and in avalanche areas, for example, are in fact renewable resources capable of sustained yield. I suspect that this constitutes fallacious reasoning, that there may be over-cutting of lower elevation, valley bottom, and otherwise more productive forests as a result, and that a significant reduction in the sustained yield allowable cut may be required in some areas in the not-too-distant future. At the very least, a radical change in our management techniques may be required to prevent the conversion of marginally renewable forests into non-renewable forests.

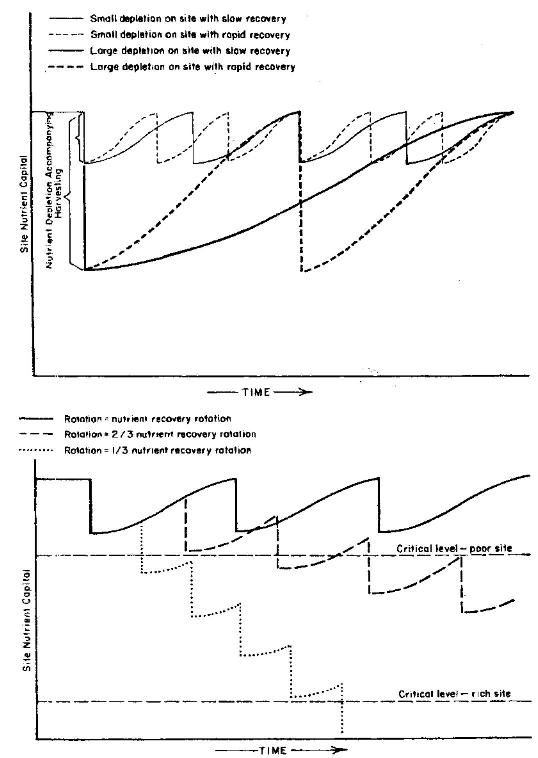

Fig. 2. Ecological rotation in terms of site nutrient capital. The upper half of the figure shows the recovery from nutrient depletion accompanying harvesting on two sites varying in rate of nutritional recovery, and for depletions of two different magnitudes. The lower half of the figure depicts site nutrient depletion accompanying rotations equal to either one or two thirds the length of the ecological rotation.

From what you have read so far, you might expect at this point that I would unequivocally condemn the practice of timber mining. If that is the case, then I will disappoint you. I believe the following to be a better solution.

From the albeit inadequate information available on the ecological nature and functioning of forests, it is often possible to make predictions concerning the response of forest ecosystems to management and to draw conclusions as to whether or not they constitute renewable resources. Three types of areas might thus be identified: 1/ Forests which constitute renewable resources under current practices and using current technology. 2/ Forests which constitute non-renewable resources under current practices and using current technology, but which could be renewable resources if managed in a manner which explicitly recognized their ecological characteristics. 3/ Forests which do not constitute renewable resources under any presently known practices or technology (remember that resource renewability is a socio-economic and not a biological concept).

Having made this identification the "best use" of the resource should be considered. In most areas of eminently renewable forests (category 1 above), some form of sustained yield timber harvesting is likely to be the best use of the area. In areas on which current technology is inappropriate (category 2 above), if the best use is for timber production or for other resource values closely related to a well forested ecosystem, new management methods and technologies must be adopted. Failure to do so should result in reservation of these areas until such time that appropriate methods and technologies are physically available and economically realistic. In areas which carry non-renewable forest cover (category 3 above), timber mining may be acceptable *if* the best land use is associated with a non-forested or scrub forest condition and *if* the timber mining does not threaten other resource values of significance (e.g. watershed, wildlife, fisheries, range, aesthetics, or recreation). If these conditions cannot be satisfied, then the area should be reserved for values other than timber production.

The decision as to whether or not timber mining should be permitted in any particular situation should not be at the sole discretion of the forest manager. He should be (although, sadly, this is not always the case) the best qualified professional to identify the potential renewability of the timber resource, but he is only one member of the multi-resource team which should identify the capability of a particular area for a variety of alternative uses. The final decision on timber mining should be political in nature, since only by this means can an appropriately educated society express its desires concerning how its resources should be managed.

Discussion

The forest environment presents us with a mozaic of species, age classes, stand conditions, site types, and productivities. The application of any management practice or concept to this mozaic without careful consideration of its relevance to the specific ecological characteristics of each site type (ecosystem type or biogeocoenosis) is unlikely to produce the level of environmental management which I believe is necessary today.

Site-specific decisions must be made before the application of techniques such as clearcutting and slashburning, and similarly, each site must be evaluated as to whether or not, or in what manner, it can be managed under the sustained yield concept. All areas on which sustained yield is ecologically (and this often means economically as well) inappropriate must be excluded from the sustained yield cut calculation and the sustained yield forest management decision-making process. Such forests must be placed in a separate category for which management decisions can only be made by a multi-disciplinary team operating through the political process.

Lest the reader might somehow have concluded by now that I ascribe to the philosophy which would abandon the concept of sustained yield as an anachronism (e.g. Smith 1969), let me firmly set the record straight. Unfortunately for those economists who would manage the forest in response to short-term market fluctuations, a forest is a highly complex, four-dimensional biological system. It is not a two-dimensional area on a map nor a figure in a volume table. The ecological consequences of harvesting are myriad in number, and their social acceptability is a function of both the kind, rate, extent, location, and spatial distribution of the harvesting. For a wide variety of reasons, I believe that the concept of sustained yield is both sound and desirable, and I willingly lend my support for its retention and application *to those forest areas in which it is ecologically realistic*. The only basis on which I question its application is the non-renewability of some forest resources.

In these days of environmental awareness the profession of forestry is under increasing scrutiny from a critical public. It becomes increasingly important that we retain a professional credibility, and the denuded non-renewable forests which are our heritage from our past activities stand as a mute testimony that in some areas our expectations of sustained yield are often over-optimistic. If we foresters are to retain our current role as decision-makers in the forestry domain, it is important that we do not claim to be practising sustained yield when we are not. It is important that we show that sustained yield management is environmentally the best way of managing renewable forest resources and restrict the concept to such forests. Harvesting of non-renewable forests probably constitutes timber mining and this should be made explicit. The danger of timber mining for our profession is not inherent in the practice itself, but only when it occurs consciously or unconsciously in the name of sustained yield. To do so only further diminishes our credibility in the eyes of the public and the scientific community.

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