Planning for TIMBER-TRACT DEVELOPMENT

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THE DEVELOPMENT PROBLEM

ONCE a forest owner has decided to develop his property for timber production,[1] his first concern is for the direction of development. This involves questions of species composition, method of management (even-aged or uneven-aged), and type of products to manage for. After these decisions are made, two basic problems arise.

The first problem is to determine the optimum level of development for the ownership. This involves the questions of how much growing stock to carry; how far to go in trying to establish, protect, and improve growing stock; and how much investment in roads and other physical improvement is justified. The second problem is to decide how fast to move toward this optimum level of development.

Development in Theory

The physical and biological characteristics of the timber tract determine how annual growth is related to growing-stock volume or basal area. Duerr (1960)[2]—has illustrated this relationship for a forest tract in southern Arkansas (table 1). Duerr's data show that, as growing-stock volume and value increase, the volume and value of annual growth rises as well, but at a decreasing rate.

[1] We recognize that an owner may have objectives for his forest property other than timber production. He may wish to manage his woods partially or primarily for other outputs, in which case the development problems would be quite different.

[2] Duerr, William A. FUNDAMENTALS OF FORESTRY ECONOMICS. 579 pp., illus. McGraw-Hill, New York. 1960.

Table 1. — ***Relationship between the volume and value of growing stock and of annual growth for a selection forest on a good site in southern Arkansas***[1]

(All values on a per-acre basis)

Growing stock		Annual growth		Marginal increments			
Volume	Value	Volume	Value	Added annual growth	Value of added annual growth	Cost of added growing stock	Rate of return
Board feet	*Dollars*	*Board feet*	*Dollars*	*Board feet*	*Dollars*	*Dollars*	*Percent*
5,000	210.00	486	21.46				
6,000	257.30	534	25.00	66	3.54	47.30	7.5
7,000	306.50	592	28.20	58	3.20	49.20	6.5
8,000	357.40	638	31.06	46	2.86	50.90	5.6
9,000	410.10	676	33.54	38	2.48	52.70	4.7
10,000	464.70	704	35.62	28	2.08	54.60	3.8
11,000	521.00	722	37.26	18	1.64	56.30	2.9

[1] After Duerr (1960), page 122.

The rate of return earned by increasing growing-stock levels can be determined by comparing the value of the additional growing stock with the value of the additional annual growth it generates. For example, table 1 shows that when the growing stock level is increased from 6,000 to 7,000 board feet per acre, growing-stock value will rise by $49.20 per acre, and 58 board feet per acre will be added to annual growth, with a value of $3.20. So this particular addition to the growing-stock investment yields a 6.5 percent rate of return.

By raising the level of growing stock, the owner of a timber tract may receive an additional increment in annual output. As the growing-stock investment is increased, a point is eventually reached at which the rate of return on the next increment in growing stock will have fallen to an unacceptable level. This point marks the optimum level of investment in growing stock. Owners differ on what constitutes an acceptable rate of return according to their current financial needs. This means that identical timber tracts may have contrasting optimum levels of growing stock for different owners.

Foresters can influence the value of growing stock and of annual production by means other than simply altering growing-stock volumes. They can change its composition as well. The type and frequency of harvest cutting, and the amount of effort expended in establishing, protecting, and tending young trees all influence the amount and value of the annual growth available from any given volume of growing stock, and the value of that growing stock as well.

Timber-management activities are designed to increase average tree value by favoring trees of more valuable species and better grades. Another objective of management is to increase growth rates (and to some extent quality increment) through spacing control. And, by timely cutting and stand-improvement measures, cull and mortality may be reduced. Investments in physical improvements also can influence the value of growing stock and of annual production. For example, roads make extraction less costly and so increase stumpage value.

So, instead of there being only one way to change the level of investment in the tract, there are many. All these investment paths

—increases in the size to which trees are grown, improvements in species composition and grade distribution, increases in spacing-control efforts, increases in establishment and protection practices, and increases in physical improvements—are available to the tract owner. In theory he would pursue each of these, and any others of which he may be aware, to the point where further investment would not yield an acceptable return. And at this point the owner would have exhausted all acceptable possibilities for tract development. No shift in investment from one path to another would improve his returns, and the tract would have been developed to the optimum.

Even in theory there can exist some limitations on the speed with which this optimum position is approached. Physical and biological factors often limit the pace at which stocking on a depleted tract can be built toward its optimum level and composition. And the imposition of a limit on the amount of new investment per year or decade can slow development.

Development in Practice

In practice the forest manager usually does not know the optimum level and mix of investment, but instead gropes toward this optimum position by trying out a little heavier (or lighter) stocking, by figuring out what a few more miles of road would cost and what they would buy, and by trying to determine whether to thin his poletimber or use some similar silvicultural practice.

This "cut-and-try" planning is often necessary because we do not have enough information to define the optimum development level for various kinds of timber properties and owners. And, in any situation a certain amount of adjustment and revision would be necessary because of the continual changes in timber-growing methods, cost of management, and product prices. Fertilization, for example, is a new timber-growing practice that eventually may cause profound changes in what is most advantageous in growing-stock levels.

In addition to the frequent changes in wage rates for labor, and frequent improvements in equipment and materials used in timber-growing, management costs are profoundly affected by going rates of interest. The availability of good investment opportunities elsewhere makes some woodland owners anxious to reduce growing-stock levels, and to forego the less-productive cultural measures for a quick profit. Changes in timber prices are frequent and sometimes severe, and this sort of change has often turned the casual ownership of timberland without thought of profit into a substantial and unexpected gain for the owner. New markets and changes in the relative value of various products also can change both the optimum species composition and the best growing-stock level.

The timber producer's response to changes in methods, costs, and prices is gradual and partial in practice, because these changes cannot be foreseen accurately. The timber producer is further delayed in adjusting to these changes because production responds slowly, even to prompt changes in management direction.

The practical response to the 30- to 80-year production lag is to concentrate on long-term trends in techniques, costs, and prices in development planning; to take advantage of unusually favorable market conditions by liquidating growing stock rapidly; and never to attempt under these circumstances actually to reach the optimum level of investment. Then, even if worst comes to worst, the marginal investments may not show too low a return.

Working Toward the Optimum

Assuming, then, that some optimum management program is at least envisioned, and that the whole development project is not aborted by markets much poorer or much better than expected, the question remains of how rapidly to work toward this optimum condition.

The speed with which investment for development proceeds depends to a great extent on the owner's investment resources. Some timber tracts are purchased on credit, and the new owner has to cut enough timber immediately to liquidate his debt. This owner may well end up with a tract even further from the optimum than when he purchased it. Other owners may buy a tract for the annual income it will provide. If they need less annual income than the value of annual growth, there is at least some margin for further investment that will eventually provide improved annual income for the owner. Investment proceeds most rapidly under the unusual circumstances where the owner can forego income for a decade or two and has spare cash to invest as well.

In practice the answer to how fast to move toward the optimum development is simply: as fast as you can afford to move.

AN EXAMPLE OF DEVELOPMENT PLANNING

The timber tract used here to illustrate development planning is a 600-acre compartment of the Fernow Experimental Forest operated by the U. S. Forest Service near Parsons, West Virginia.

The Sample Tract

This tract of timber is rather typical of the mountain hardwood stands on better-than-average sites found throughout the Appalachian region.

This area was first cut over about 1905 in a commercial clearcutting operation or a heavy high-grading. As a result, by 1958 the tract contained about one-half of its volume in held-over trees, many of which were partially or wholly defective. The remainder of the tract was composed of second-growth small sawtimber and poletimber. The stands on this tract were well stocked with good growing-stock trees. A 10-percent inventory showed 8,723 board feet per acre in merchantable trees over 11.0 inches d.b.h.[3] Total merchantable volume for the tract was approximately 5.2 million board feet.

The sawtimber component of the tract had the following species composition: northern red oak, 40 percent; yellow-poplar and cucumbertree, 22 percent; white oak, 7 percent; sugar maple, 6 percent; red maple, 6 percent; basswood, 4 percent; white ash, 3 percent; black cherry, 2 percent; and other, generally low-valued species, 10 percent.

Seventy-three percent of the merchantable sawtimber stand was in factory-lumber logs while 27 percent of the logs were below factory-log grade. The distribution by log grade was as follows:

[3] International ¼-inch kerf rule to an 8-inch top d.i.b.

log grade one, 27 percent; log grade two, 13 percent; log grade three, 33 percent; and below factory grade, 27 percent.

This timber tract has a better than average site quality, ranging from 60 to 90 feet at 50 years for oak, and having a weighted average oak site index of 74. The tract is located in steep mountain terrain with slopes averaging 40 percent, but ranging from flat ridge tops to slopes as steep as 70 percent.

The Trial Management Program

An early step in development planning is to prepare a trial management program for the development period. Timber tracts like the sample tract can be managed by either an even-aged or an uneven-aged system. Under the former system such desirable intolerants as yellow-poplar and black cherry would be favored while the latter system would favor the tolerant, aggressive (and also desirable) sugar maple.

For the long-range management system it was decided to use a compromise: a patch cutting or group-selection system with a 10-year cutting cycle. Past experience indicated that this system provides good control over species composition and grade distribution, while providing for adequate regeneration of the more intolerant and valuable timber species. It was further decided to manage this tract for the production of sawtimber.

Because this timber tract initially had a large volume in old residuals—left over from the 1905 harvest—that were mostly financially overmature and in many cases defective, the first task was to apply a conditioning cut designed both to harvest old growth and to provide improved growing condition for subsequent production. The next harvest operation was planned to follow the conditioning cut in 15 years, with subsequent harvests at 10-year intervals.

This management program is aimed at an equilibrium condition where residual volume is maintained at 7,000 board feet per acre; growth at about 300 board feet per acre per year, and species and grade distributions such that the average stumpage value for harvest volume approaches $25 per thousand board feet at 1964 prices.

The basis for computing all costs and returns was local going rates in 1964.

The Road System

The managers of this Experimental Forest do their own logging on this tract, using tree-length skidding to log landings where trees are bucked and loaded on trucks. This system, using a tractor and arch, is well adapted to the steep mountain terrain. Tree-length logs are winched to skidroads in this operation, and the tractor and arch does not leave the skidroads. Winching distance is held to 200 to 300 feet in most cases. The equipment consists of an International TD-9 crawler tractor and a rubber-tired sulky arch. All felling and bucking is done with power saws. Skidding distances are held to ½ mile if at all possible, and ¼ mile is the average distance aimed at.

This sort of a logging operation, then, calls for a year-round truckroad and dry weather truckroad spurs to allow access to within ½ mile of any point in the tract, as well as skidroads at about 600-foot intervals. Three miles of truckroad were constructed at a cost of $2,000 per mile.[4] Skidroads and log landings cost another $3,700 for a total initial cost of $9,700 for the road system. Of this total cost some $2,400 is depreciated during each harvest operation. This depreciation consists of: (1) the cost of truckroad spurs and skidroads that will be abandoned or relocated at the next harvest, (2) the cost of maintaining the main truckroad during harvest, and (3) the cost of after-harvest care for skidroads. The net continuing investment in the road system, then, is about $7,300, and a further cost of $2,400 at each harvest operation. In addition there is a general overhead expense of $100 per year annual maintenance cost for the truckroads, to allow access between harvest operations.

The Conditioning Cut

The first harvest operation was carried out on this tract in 1958. About 2.7 thousand board feet per acre was removed in this cut-

[4] The roads were actually constructed years before, and the cost figures are approximations that experience has shown to be the amount needed for building logging truckroads in this area.

Table 2. — *The conditioning cut in the trial development program, 1958*

Income or cost item	Actual value per thousand board feet
Lumber value	$ 76.45
Loading and hauling costs	7.00
Milling cost	30.00
Allowance for profit and risk (11%)	8.41
Gross income	$ 31.04
Marking cost	$ 1.00
Felling, limbing, and topping cost	3.98
Skidding cost	9.20
Bucking cost	.81
Grading and scaling cost	1.33
Road system depreciation and maintenance cost	1.48
Logging supervision cost	.68
Forester's supervision cost	.05
Net income	$ 12.51

ting, made up of 13 or 14 trees per acre averaging 18 inches d.b.h. In addition about three culls per acre were marked for deadening. The average value per thousand board feet for the harvested material was about $12, and total income from the harvest exceeded $20,000. Of this amount $7,300 represented the residual value of the road system; some $500 or $600 was spent on cull-tree deadening, and over $12,000 remained as cash income.

Some pulpwood, charcoal wood, post, and rail stumpage was sold to local operators, producing a net income of a little over $300. These small-product sales took place over approximately only 120 acres of the 600-acre tract, partly because small-products have positive stumpage values only when there is a truckroad within 150 or 200 yards.

The residual stand averaged 6.0 thousand board feet per acre with an average stumpage value of about $9.28 per thousand board feet. This conditioning harvest operation is detailed in table 2.

Subsequent Harvests

The next harvest[5] is scheduled for 1973, 15 years after the conditioning cut, when the tract should have an average volume of about 10.5 thousand board feet per acre, and an average value of about $14 per thousand board feet. The harvest will take about 3.5 thousand board feet per acre with an average value in excess of $17 per thousand board feet, for a total net income of about $37,000. Of this total about $400 will be spent on deadening cull trees and the remainder will be available as cash income. No additions to the basic road system are contemplated. The residual stand will have about 7.0 thousand board feet per acre with an average value above $12 per thousand board feet.

The third harvest is scheduled for 1983 and will be similar to the second except that average value of the stumpage will increase because of continuing improvement in species composition, tree size, and grade distribution. Costs for cull-tree removal will have

[5]Growth rate and quality change information were available from the record of uneven-aged management compartments on the Fernow Experimental Forest and were used to arrive at future values on the study area.

Table 3.—*The second harvest in the trial development program, 1973*

Income or cost item	Projected value per thousand board feet
Lumber value	$ 82.71
Loading and hauling cost	7.00
Milling cost	30.00
Allowance for profit and risk (11%)	10.09
Gross income	$ 35.62
Marking cost	$ 1.00
Felling, limbing, and topping cost	3.98
Skidding cost	9.20
Bucking cost	.81
Grading and scaling cost	1.33
Road system depreciation and maintenance cost	1.14
Logging supervision cost	.68
Forester's supervision cost	.05
Net income	$ 17.43

Table 4. — *The final harvest in the trial development program, 1983*

Income or cost item	Projected value per thousand board feet
Lumber value	$ 88.76
Loading and hauling cost	7.00
Milling cost	30.00
Allowance for profit and risk (11%)	10.78
Gross income	$ 40.98
Marking cost	$ 1.00
Felling, limbing, and topping cost	3.98
Skidding cost	9.20
Bucking cost	.81
Grading and scaling cost	1.33
Road system depreciation and maintenance cost	1.33
Logging supervision cost	.68
Forester's supervision cost	.05
Net income	$ 22.60

leveled off at about $300. These harvest operations are detailed in tables 3 and 4. The assumption is that equilibrium in harvested values will be reached at the third harvest—unless management objectives change.

No changes in costs—except for cull killing and road systems—are provided for with succeeding cuttings. In practice there probably would be cost changes and the trend would perhaps be to lower costs in the latter cuttings.

Evaluating the Trial Program

The basic facts of the trial program are summarized in table 5. This table includes an estimate of total tract value at various points in time. The initial value for the tract is based on an average of five independent appraisals made of the tract by two consulting foresters, an industrial forester, and a tax assessor, and one resulting from the application of Forest Service appraisal procedures. The various appraisals of the growing stock ranged from $35,000 to $98,000, indicating the diversity of appraisal

Table 5. — *Summary of the trial development program, 1958-83*

Year and item	Per-acre volume	Value per thousand board feet	Tract land value	Tract growing-stock value	Road-system value	Total tract value	Net income	Reinvested		Cash income
								In road	In cull treatment	
	Thousand board feet	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
1958 Purchase inventory	8.7	10.34	3,600	54.000	—	57,600	—	—	—	—
Conditioning cut	2.7	12.50	—	—	—	—	20,580	7,300	567	12,713
Residual inventory	6.0	9.28	3,600	33,420	7,300	44,320	—	—	—	—
1973 Pre-cut inventory	10.5	14.02	3,600	88,326	7,300	99,226	—	—	—	—
Harvest	3.5	17.43	—	—	—	—	36,917	—	420	36,497
Residual inventory	7.0	12.24	3,600	51,409	7,300	62,309	—	—	—	—
1983 Pre-cut inventory	10.0	16.00	3,600	96,000	7,300	106,900	—	—	—	—
Harvest	3.0	22.60	—	—	—	—	40,724	—	270	40,724
Residual inventory	7.0	13.10	3,600	55,006	7,300	65,906	—	—	—	—

methods and viewpoints taken by the various appraisers. The bare land was valued uniformly at $6.00 per acre.

The median appraised value of the property in 1958 was $57,600. The 1958 cutting provided a net cash income of $12,713, so that the net investment in the property after the conditioning cut was $44,887. A net cash income of $36,497 is expected in 1973, and a further income of $40,724 is anticipated in 1983. After the 1983 cutting, investments in the road system and improvement in the quality of growing stock will have increased the value of the property to $65,906. There is an administrative cost for the property of about $600 per year. This is made up of an annual tax bill of about $325, the $100 road-maintenance cost, and other miscellaneous overhead and administrative expenses.

If this tract had actually been purchased at $57,600, and the expected future expenses and income occurred, then the investment would return 4½ percent before income taxes during the 25 year development period. Thereafter the investment return would be about 4.2 percent. If a potential purchaser of the tract felt he needed an 8-percent return during the development period he would not have purchased the tract unless it had been available for $33,384 or less.

Adjusting the Trial Program

A 4- or 4½-percent return on investment is a respectable return in the timber-growing business, but it may be possible to adjust the trial management program to improve the financial return. For example, the trial program may specify a level of stocking well beyond the optimum. Residual stocking is held to 7.0 thousand board feet per acre in the trial program. It is possible that this could be reduced to 6.0 thousand board feet without sacrificing much in the way of growth or average value.

If the conditioning cut were increased 1.0 thousand feet per acre, its cash income might well increase to $20,213, and the net investment in the tract after the cutting would be $37,387 rather than $44,887 of the trial program. It is assumed that incomes from the subsequent harvests would remain about the same and property value at the end of the period would be $58,060 rather than $65,726. Under these conditions the average rate of return for the investment during the development period would increase to about 5.1 percent, and to about 4.7 percent afterward. This is a substantial improvement, and it would certainly be worth while to investigate the effect of stocking level on returns more thoroughly. Also, the revised stocking level allows the prospective purchaser who wants an 8-percent return to offer as much as $46,137, an increase of almost $13,000. This shows how important it is to plan tract development as a prelude to establishing tract value.

Almost any owner would be in favor of an adjustment like the one in stocking levels. Another way of improving returns, however, calls for added investment during the development period to improve returns subsequently. Cull-tree removal has been the only out-of-pocket investment made in timber culture. Another investment possibility is to do pre-commercial release of potential crop trees in the group-selection openings. This practice can increase growth, give further control over species composition, and improve grade yields. However, these effects will probably not be felt until after the development period when released trees are harvested.

A PLANNING OUTLINE

The following brief outline may be helpful in planning for timber-tract development.

Step 1: Inventory.—This initial phase in planning requires the mapping and inventory of the timber tract, the assembling of biological growth and yield information, and an assessment of timber markets and ownership objectives and restraints. The markets for timber products, both current and long-run, have an important influence on development planning; and current and prospective prices for timber products should be established with care. The manager must be aware of the owner's management objectives for the tract. Such considerations as what income is required from the property at which intervals, what minimum rate of return is acceptable, and under what conditions the owner might wish to disinvest, are all necessary planning data. At the end of this first step the planner should have at hand most of the information about the timber tract, timber markets, and owner objectives that he needs to undertake preliminary planning.

Step 2: Trial development program.—The second step in development planning is to set up a trial management program for the development period. The first task is to prescribe a stable growing-stock condition toward which to aim, and a complementary set of physical improvements. The target growing-stock condition must be attainable within the development period and be geared to prospective markets. The kind of growing stock also ought to be set up with regard to what is justifiable from the economist's point of view as well. Physical improvements in the property should be limited to what is necessary to implement the management program required to secure and maintain the target growing-stock condition. When the trial development program has been specified, it is to be evaluated by determining all the costs and income it will occasion and by computing the rate of return these costs and incomes indicate.

Step 3: Adjustment.—The final step in development planning is to test marginal changes in various aspects of the trial program for their effect on returns. The planner can adjust both the target growing-stock and physical-improvement goals and the time needed to obtain these goals. In some cases the trial program will require more investment than the owner is willing to make, return smaller incomes than he desires, or provide an unacceptably low return on his investment. These deficiencies will point the way to needed adjustments. In other cases the trial program may be acceptable to the owner, but the planner should still try some of the more obvious changes that might be made to see whether an improved return can be had. Contemplated changes are traced through the development program; their effect on growth and yield and on costs and incomes is estimated, and the revised program is re-evaluated to determine the net effect.